

March 18, 1969

K. H. HAHNE

3,433,883

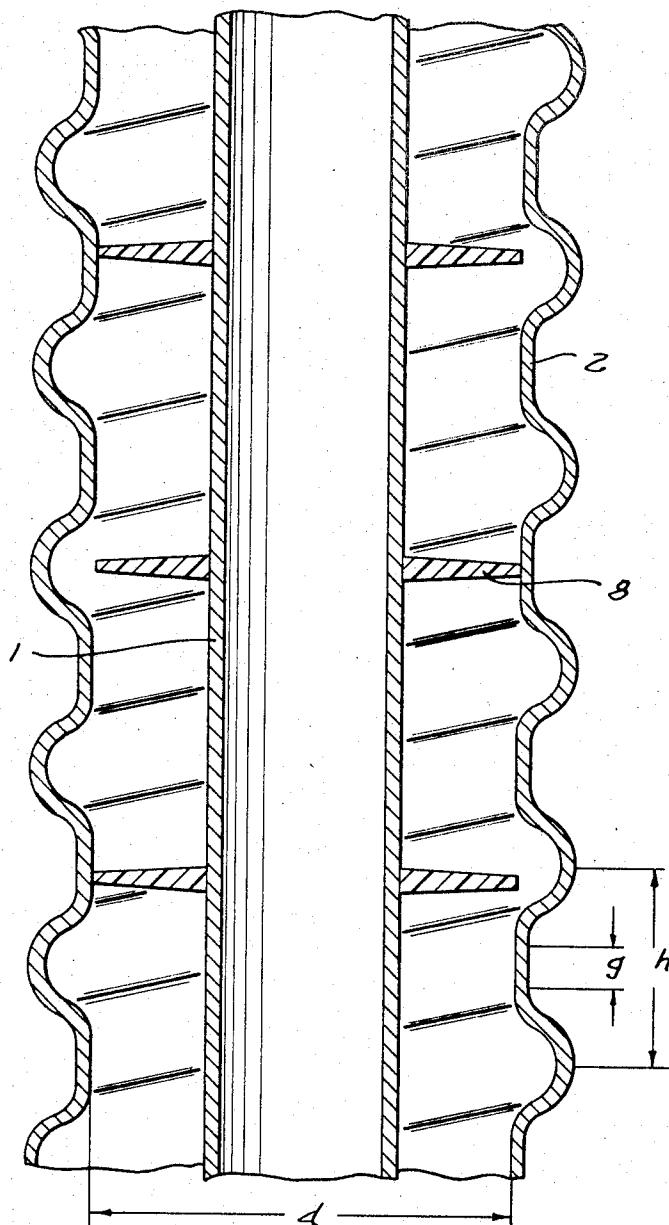
CABLE CONSTRUCTION

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FIG. 1

PRIOR ART



INVENTOR
Karl Heinz Hahne
BY
Michael S. Shaker
ATTORNEY

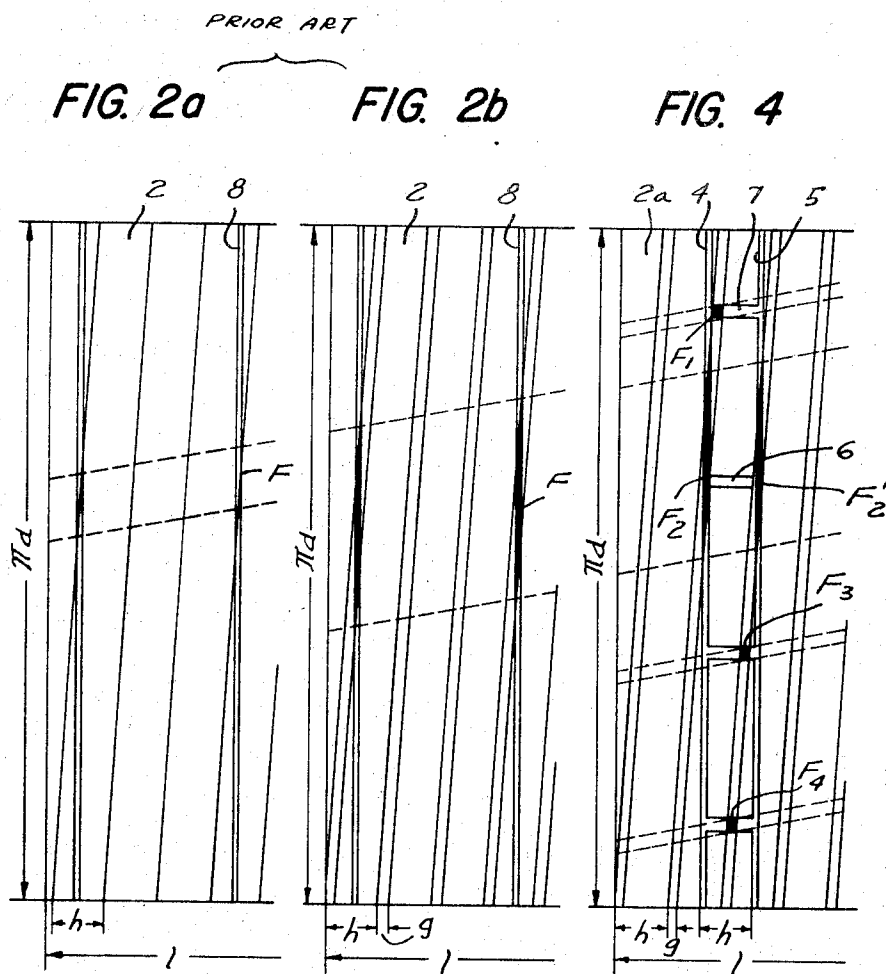
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INVENTOR:
Karl Heinz Hahne
BY Michael S. Steiker
ATTORNEY

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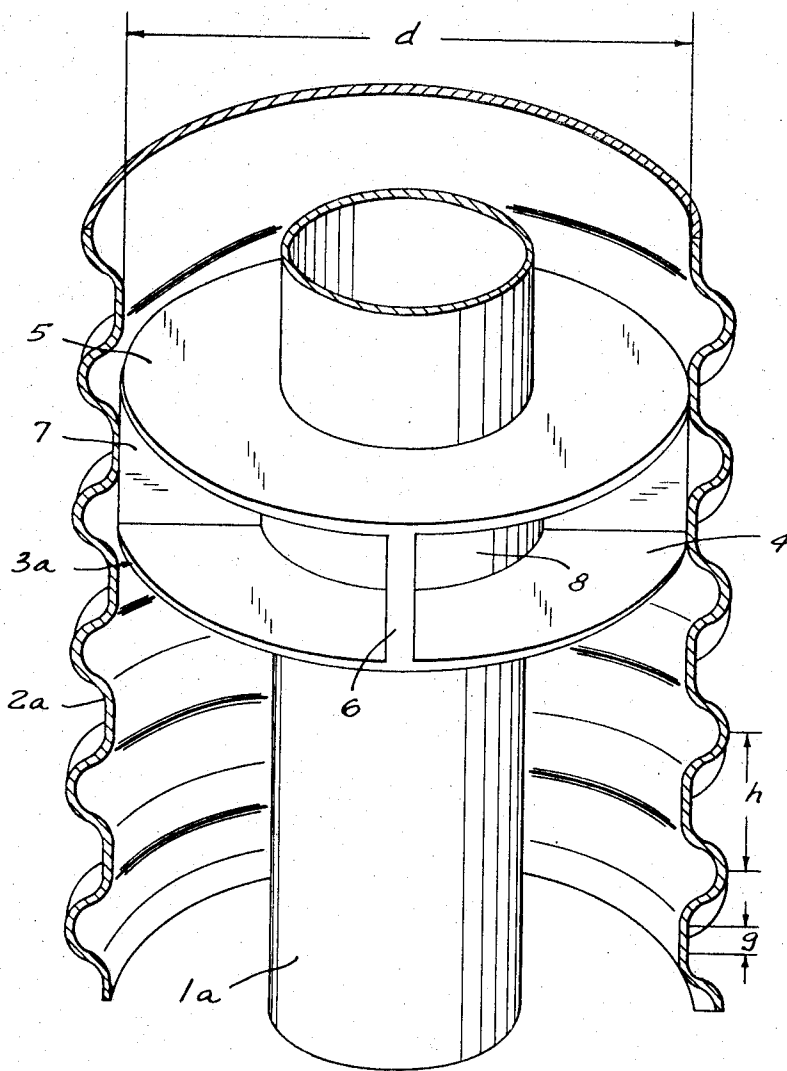
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FIG. 3



INVENTOR:
Karl Heinz Hahne
BY
Michael S. Stricker
ATTORNEY

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3,433,883

CABLE CONSTRUCTION

Karl Heinz Hahne, Blecher uber Bergisch Gladbach, Germany, assignor to Felten & Guillaume Carls-
werk Aktiengesellschaft, Cologne-Mulheim, Germany
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9 Claims

ABSTRACT OF THE DISCLOSURE

A coaxial cable includes an elongated inner conductor and an elongated corrugated outer conductor which coaxially surrounds the inner conductor with clearance. Spacing elements space the inner from the outer conductor and each consist of two discs surrounding the inner conductor and extending to the outer conductor, the discs being spaced in the longitudinal direction of the conductors, and wall portions which extend between the discs, being connected thereto, and which define with one another a cross so that they extend radially of the discs and of the inner conductor to the outer edges of the discs.

Background of the invention

The present invention relates to a cable construction in general, and more particularly to a coaxial cable. Specifically, the present invention relates to spacing elements in a coaxial high frequency cable.

Coaxial high frequency cables consists, as is well known, of an elongated metallic inner conductor of cylindrical configuration, and an outer conductor which coaxially surrounds the inner conductor with clearance and is similarly metallic. The outer conductor may be and remain cylindrical; however, it is evident that in the majority of applications of cables the cable structure must be capable of bending, it being rarely possible to install a cable in such a manner that it need not be bent or deflected at all. It is therefore customary in most applications of such cables to corrugate the outer conductor so as to impart thereto the requisite flexibility.

However, in high-frequency coaxial cables it is essential that, whenever such bending or deflecting occurs, the spacing between inner and outer conductor be precisely maintained. Insulation introduced into the clearance between the inner and outer conductor could assure the maintenance of such spacing. The selection of such insulation, particularly in high-frequency cables, is governed by considerations having to do with the efficiency of the cable, and particularly with the energy loss taking place within the cable. Such energy loss should obviously be kept to the lowest possible factor and is governed by the attenuation in the cable. This attenuation decreases proportional to the increase in the proportion of insulation which is constituted by air, air having the smallest dielectric losses and the lowest dielectric constant. Therefore, air is generally considered the most suitable insulation for coaxial high-frequency cables under the majority of circumstances. Of course, it will be necessary under the circumstances to employ suitable spacing elements for maintaining the inner and outer conductors spaced from one another at requisite distance because obviously air itself cannot perform this function.

It is therefore known in conventional high-frequency coaxial cables to surround the inner conductor at longitudinally spaced locations thereof with individual discs consisting of material having the required dielectric characteristics, which discs abut the inner surface of the outer conductor and thus maintain the latter centered with

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reference to the inner conductor. Such discs are produced on the inner conductor in the most economical manner by injection-molding the discs directly onto the inner conductor. This also assures the best possible seating of the discs on the inner conductor. For this purpose a section of the inner conductor is introduced into a mold whose disc-shaped cavity surrounds the section of the inner conductor. The insulating material, which may be in heated or in cold state, is now injected into this mold and, when it is set, the mold is withdrawn, placed about another section of the inner conductor which is longitudinally spaced with reference to the thus-produced spacing disc, and the injection process is repeated. Evidently, the mold must be capable of opening and closing in a radial plane of the discs.

After the inner conductor has been provided in this manner with the necessary spacing discs, it is introduced into the cylindrically configured outer conductor which may have the form of a metallic tube whose inner diameter is greater than the diameter of the spacing discs. Subsequent to this introduction the outer conductor is corrugated whereby the maximum inner diameter of the conductor is of course reduced. Upon completion of the corrugation the outer conductor engages the radially outer edges of the spacing discs with its inwardly projecting ridges, that is in those areas where the outer conductor has been provided externally with inwardly extending depressions. It has been found advantageous in this connection to so select the corrugation that the inwardly projecting ridges are provided with a flat substantially cylindrical inwardly facing surface because this increases the area of contact with the spacing discs.

However, for reasons which will become evident subsequently, this type of arrangement has been found less than satisfactory because the spacing discs provide insufficient support, that is insufficient engagement with the outer conductor.

Summary of the invention

The present invention overcomes these disadvantages.

More particularly, the present invention provides a coaxial high-frequency cable with spacing elements between the inner and outer conductors which assure significantly better spacing between the inner and outer conductor, and which therefore greatly reduce problems which heretofore have arisen upon bending or flexing of a cable of the type in question.

In accordance with one feature of my invention, I provide a coaxial cable which includes an elongated inner conductor and an elongated outer conductor coaxially surrounding the inner conductor with clearance and being corrugated. A plurality of spacing elements surround the inner conductor and are longitudinally spaced from one another. In accordance with the invention each of these spacing elements includes a pair of discs spaced in the direction of elongation of the conductors by a predetermined distance corresponding at least to the pitch of the corrugation of the outer conductor, and having outer edges which engage the outer conductor. A plurality of wall portions are provided which connect the discs with one another and which extend radially of the inner conductor to the outer edges of the discs.

With my novel construction the problem in question is solved in a simple and inexpensive manner, and the production of the spacing elements is very uncomplicated.

Another feature of my invention provides for surrounding that portion of the inner conductor which is located between the two discs of each spacing element with a sleeve, with the wall portions extending from this sleeve radially to the outer edges of the discs. This sleeve not only assures greater rigidity of the construction, but also increases the resistance of the cable to arcing.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

Brief description of the drawing

FIG. 1 is a longitudinal section through a portion of a prior-art high-frequency cable using individual spacing discs;

FIGS. 2a and 2b illustrate the areas of contact between the outer conductor and the spacing discs of the construction illustrated in FIG. 1;

FIG. 3 is a view similar to FIG. 1, but illustrating a construction in accordance with my invention; and

FIG. 4 illustrates for my novel construction shown in FIG. 3 the same relationships which have been identified in FIGS. 2a and 2b for the prior art constructions.

Description of the preferred embodiments

Discussing firstly the prior art as illustrated in FIGS. 1 and 2a-2b, so as to facilitate understanding of the problem with which the present invention is concerned, it is pointed out that in the illustrated prior art cable the inner conductor is identified with reference numeral 1 and the outer conductor which coaxially surrounds the inner conductor is identified with reference numeral 2. The outer conductor is corrugated with a corrugation having a pitch h and the depressions in the corrugation having the width g . A plurality of individual insulating and spacing discs 8 are secured on the inner conductor 1, for instance by being injection-molded thereonto.

FIG. 2 indicates that the zone of contact between the discs 8 and the outer conductor is constituted by a cylinder having the diameter d . The developed circumference of this cylinder, as seen in the direction from the bottom towards the top of FIGS. 2a and 2b, is identified with πd , and the longitudinal extension of the cable portion illustrated in FIG. 1 is shown in FIGS. 2a and 2b by the arrow 1. The innermost surfaces of the outer conductor 1 are identified as inclined straight lines or areas in FIGS. 2a and 2b. FIG. 2a is assumed to show an outer conductor 1 provided with a symmetrical corrugation ($g=0$). As will be seen, the cylindrical having the diameter d incorporates in this arrangement only the innermost lines of the inwardly extending ridges which correspond to the outer corrugation depressions, which lines have a distance corresponding to the pitch h . The illustration shown in FIG. 2 assumes that the corrugations are of the type wherein the inwardly extending ridges are bounded by flat substantially inner surfaces and it will be seen that here these flat surfaces have a width g with their center-to-center spacing again corresponding to the pitch h . The location of the discs 8 is identified by the vertical double lines in FIGS. 2a and 2b.

It will be seen in both of these illustrations that, when the cable is bent, for instance by being wound onto a cable reel, it will contact this reel along a line which extends on the cable circumference in the longitudinal direction in parallelism with the cable axis. In a plane intersecting this line and the cable axis, the pressure and counterpressure established between the inner conductor and the outer conductor by the bending around the cable reel, will act.

Given a cable of the prior art construction which is here under discussion, the areas of contact F which develop during such bending between the discs 8 and the outer conductor 1 are bounded by the dashed lines in FIGS. 2a and 2b and will extend helically about the cable with a pitch which depends upon the relationship between the pitch of the corrugation and the distance between successive discs. This means that the area be-

tween the dashed lines, whether they be in FIG. 2a or FIG. 2b, is the area which the discs 8 contact the corrugated outer conductor 1 and serve to space the same from the inner conductor. It is evident that in the construction of FIG. 2b this area is larger, and the spacing effect therefore, than in FIG. 2a. However, in neither construction is it possible to achieve the optimum solution according to which each individual disc 8 is to be active in engaging the outer conductor and spacing the same from the inner conductor in any bent condition of the cable. Because of this lack the inner and outer conductor in the constructions of FIGS. 2a and 2b have a tendency towards a polygonally configured deformation upon undergoing bending, and this deformation is highly undesirable because it adversely influences the electrical characteristics of such cables.

All of this is avoided in the construction according to the present invention as illustrated in FIGS. 3 and 4. FIG. 3 is substantially similar to the illustration in FIG. 1. The inner conductor is identified with reference numeral 1a, the corrugated outer conductor, whose inwardly extending ridges are bounded by flat substantially cylindrical inner surfaces as illustrated in the drawing, is identified with reference numeral 2a and the spacing element is identified with reference numeral 3a. The pitch of the corrugation of the outer conductor 2a is identified with the designation h , and the width of each depression in the corrugation is identified with reference designation g .

Unlike the aforementioned prior art constructions, however, the spacing arrangement 3a identified with reference numeral 3 consists of two spacing discs 4 and 5 which are spaced from one another in the direction of elongation of the conductors 1a and 2a. The two discs 4 and 5 are connected with one another by wall portions, which in the illustrated embodiment consist of a pair of sections 6 extending diametrically of the discs, and another pair of sections 7 also extending diametrically of the discs but normal to the sections 6. The sections 6 and 7 therefore define with one another the shape of a cross having arms of identical length. The sections 6 and 7 are connected to, preferably by being integral with the discs 4 and 5. It is advantageous, in accordance with another feature of my invention, to provide a sleeve 8 which surrounds a portion of the inner conductor 1a intermediate the discs 4 and 5 with which it is connected, just as it is connected with the sections 6 and 7. In the illustrated embodiment this sleeve 8 will be integral with the discs 4 and 5 and the sections 6 and 7. It is clear that the mechanical strength of this arrangement is considerably greater than that of a single disc used in the prior art constructions. Furthermore, the sections 6 and 7 extend to the radially outer edges of the discs 4 and 5, thereby supporting the discs and reinforcing them so that they obtain a load-carrying capability over their entire radial width which is not present in the single discs according to the prior art.

In accordance with the invention it is important that the spacing between the discs 4 and 5 be so selected as to be at least equal to the pitch h of the corrugation in the outer conductor 1. The presence of the sleeve 8 not only contributes to the mechanical stability of the spacing arrangement, but also serves to increase the resistance of the cable to arcing.

As already pointed out before, FIG. 4 identifies for the novel invention of FIG. 3 the same relationships which have been shown in FIGS. 2a and 2b for the prior art construction shown in FIG. 1. In other words, the areas of contact between the spacing arrangement and the outer conductor 1 are delimited by the dashed lines. It will be seen that, unlike the prior art situation illustrated in FIGS. 2a and 2b, in FIG. 4 each of the spacing structures contacts the outer conductor 1 not in a single area of contact, but in a plurality of areas of contact, and more specifically in the areas F_1 , F_2 , F_3 and F_4 .

This means that the outer conductor is engaged and supported against deflection with reference to the inner conductor in four areas of contact which, because the pitch h and the spacing of the spacer structures are assumed to be the same as the corresponding relationships in FIGS. 2a and 2b, describe a helix about the cable axis. This means that, regardless how the cable is now bent, the spacing construction according to the present invention will always engage and support the outer conductor 1a with reference to the inner conductor 2a over at least one area of contact, or over two areas of contact whose maximum distance from the line along which the bending occurs is at most 45°. In other words, each and every one of the spacing constructions according to the present invention participates in spacing the outer conductor from the inner conductor under any and all conditions of bending of the thus constructed cable, thereby providing the desired improvement and avoiding the aforementioned disadvantages.

It is to be noted that the spacing construction according to the present invention can be applied onto the inner conductor by injection molding in the same manner in which this has been described before with reference to the prior art in a mold which is separable in the radial plane of the construction. Because of the considerable strength inherent in the spacing construction according to the present invention the individual portions thereof, namely the discs and wall portions, as well as the sleeve, may be relatively thin. This makes it possible to have a comparatively small increase in the volume of solid material which is introduced into the space between the inner and outer conductors. The slight volume increase which does exist over the prior-art constructions, and which of course reduces the volume of air which can be accommodated in this clearance between the inner and outer conductor, need not adversely influence the dielectric characteristics of the cable construction because the spacing between the spacing structures according to the present invention can be selected greater than the spacing between the individual discs common in prior art constructions inasmuch as each and every one of the spacing structures according to the present invention will participate in supporting the outer conductor with respect to the inner conductor in any condition of bending, unlike the individual discs of the prior art constructions.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in a high-frequency coaxial cable, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are

intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. A coaxial cable comprising, in combination, an elongated inner conductor; an elongated outer conductor coaxially surrounding said inner conductor with clearance; and a plurality of spacing elements surrounding said inner conductor and being longitudinally spaced from one another, each of said spacing elements comprising a pair of discs spaced in direction of elongation of said conductors by a predetermined distance and having outer edges engaging said outer conductor, and a plurality of wall portions connecting said discs with one another and extending radially of said inner conductor to said outer edges.

2. A cable as defined in claim 1, wherein said outer conductor is provided with corrugations having a predetermined pitch, said predetermined distance being at least equal to said pitch.

3. A cable as defined in claim 2, wherein said spacing elements consist of electrically insulating material.

4. A cable as defined in claim 3, wherein said electrically insulating material is a synthetic plastic material.

5. A cable as defined in claim 1, wherein said wall portions comprise a first wall portion, and a second wall portion extending normal to said first wall portion, both of said wall portions extending diametrically of said discs.

6. A cable as defined in claim 5; further comprising a sleeve portion surrounding said inner conductor intermediate said discs and being connected to the same, said wall portions extending radially outwardly from said sleeve portion and being connected thereto as well as to said discs.

7. A cable as defined in claim 2, wherein said corrugations are circumferential corrugations defining on the inner side of said outer conductor alternating radially outwardly recessed circumferential grooves and radially inwardly projecting ridges.

8. A cable as defined in claim 7, wherein said ridges comprise inwardly directed circumferential surfaces of cylindrical configuration.

9. A cable as defined in claim 1, wherein said spacing elements each constitute a rigid structure.

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LEWIS H. MYERS, *Primary Examiner*.

A. T. GRIMLEY, *Assistant Examiner*.

U.S. CI. X.R.

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