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H. V. WODTKE

2,186,793

ELECTRIC CABLE

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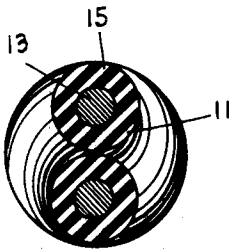


FIG. 1

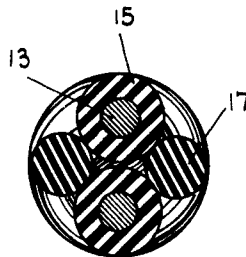


FIG. 2

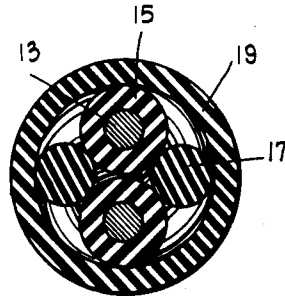


FIG. 3

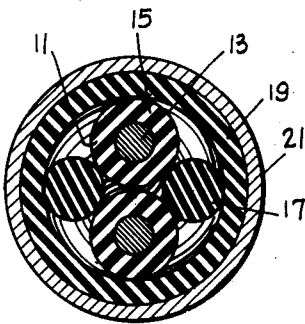


FIG. 4

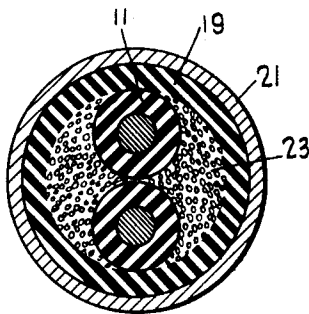


FIG. 5

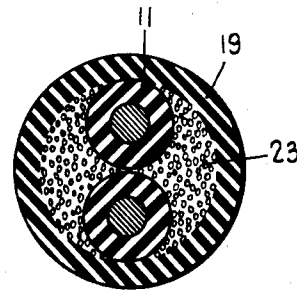


FIG. 6

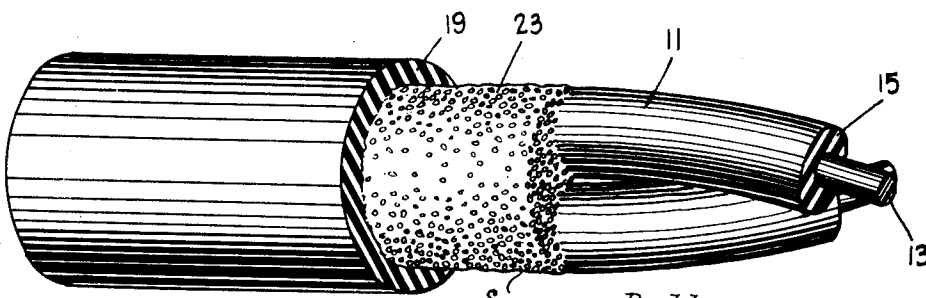


FIG. 7

INVENTOR
HANS V. WODTKE
BY *Richard M. Shinn*
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRIC CABLE

Hans V. Wodtke, Dobbs Ferry, N. Y., assignor to
Anaconda Wire & Cable Company, New York,
N. Y., a corporation of Delaware

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5 Claims. (Cl. 174—116)

This invention relates to a new and improved type of multi-conductor electric cable which is provided with flexible, moisture-resistant and stable fillers occupying the voids between the individual conductors. The invention also relates to the novel method herein disclosed for making this improved cable.

One of the primary objects of the present invention is to provide a multi-conductor cable in which the voids between the individually insulated conductors and the outer jacket are completely filled with a flexible compound of cellular formation which resists the penetration of moisture.

In the past these void spaces have been packed either with a fibrous filler such as cotton or jute or with a rubber compound similar or identical to those designed for insulating the conductors. If cotton or other fibrous material is used for this purpose moisture will tend to penetrate into the body of the insulation since the threads form a wick which draw the water along the interior of the cable. A rubber filler is not open to this objection but is somewhat unsatisfactory in that it increases the resistance of the cable to deformation and is therefore undesirable in cables which require a high degree of flexibility, as for example those used with portable machines.

In producing an improved type of cable having features of flexibility and moisture-resistance, I have developed a method of forming the completed structure so as to give it these and other desirable properties. This process involves several steps which are fully explained in the following specification and the accompanying drawing.

In the drawing I have shown certain preferred embodiments of my invention but it will be understood that the exact product and process chosen for explanation can be greatly modified and that the description is not to be construed as defining or limiting the scope of the invention.

In the drawing:

Figure 1 is a vertical section through two individually insulated electric conductors which have been twisted together.

Figure 2 illustrates the conductors as shown in Figure 1, with the addition of fillers in the unvulcanized state.

Figure 3 is a vertical section of the structure of Figure 2, to which has been added an outer unvulcanized rubber jacket enclosing the whole assembly.

Figure 4 is a vertical section through the structure of Figure 3 to which has been added an outer lead jacket.

Figure 5 illustrates in vertical section, the structure of Figure 4 after vulcanization.

Figure 6 is a vertical section through the completed cable.

Figure 7 is a perspective view of the cable shown

in section in Figure 6 the parts having been broken away progressively to reveal the internal construction.

Referring in detail to the drawing, two insulated electric conductors 11, which comprise a solid or stranded metallic conductor 13 and a jacket of rubber compound 15 are twisted together as indicated in Figure 1. As will be apparent from this figure, the cross-section of the cable at any point at this stage of manufacture is a figure 8 and since the completed cable must be circular in form, a surface equal to half the surface area of the cross-section is open and unfilled. In the usual process of manufacture, strands of cotton or jute or a preformed rubber strip, shaped to fill the void, would be stranded in with the conductors 11 so that the completed assembly would be approximately circular in cross-section.

Instead of this, I propose to lay in the filler strands of unvulcanized rubber compound which, upon curing, give off a large amount of gas thus forming a spongy rubber that will entirely fill the void spaces between the individual conductors and the outer jacket. As indicated in Figure 2, these strands of compound 17 when originally laid up with the conductors may be circular in shape and of considerably smaller cross-sectional area than that of the void which is to be filled.

There are many compounds which provide a satisfactory spongy, porous rubber and I have found the following composition to be suitable for this purpose.

Parts by weight	
Pale crepe	100
Stearic acid	5
Petrolatum	5
Antioxidant	1.5
Zinc oxide	5
Whiting	30
Carbon black	2
Sodium bicarbonate	6
Accelerator	1
Sulphur	3

In some cases a cellular oil-resistant filler may be desired and the following recipe, employing the polymerized hydrochloride addition product of mono-vinyl acetylene, commonly known as "Neoprene", is recommended for this type of service.

Parts by weight	
Neoprene	100
Light calcined magnesia	10
Wood rosin	5
Cumar resin	10
Cottonseed oil	10
Sodium bicarbonate	15
Sulphur	1
Zinc oxide	10
Factice	100

The function of the sodium bicarbonate in the

above compositions is to generate carbon dioxide gas in small globules throughout the composition upon curing. In this way the composition, if unrestrained, will be expanded to several times the volume occupied in the unvulcanized state. Ammonium carbonate and ammonium bicarbonate are also suitable as "blowing" agents, in place of the sodium bicarbonate.

After the unvulcanized fillers have been laid within the filler spaces an outer annular sheath or jacket is placed over the entire assembly. The compound used for this purpose is of course free from any blowing agent and is preferably a composition such as the following which, when vulcanized, possesses high resistance to abrasion and mechanical wear.

Parts by weight	
Smoked sheet.....	100
Pine tar.....	3
20 Stearic acid.....	4
Antioxidant.....	1
Zinc oxide.....	5
Carbon black.....	50
Sulphur.....	3
25 Accelerator (Mercaptobenzothiazole).....	1

As a final step in the assembly of a cable an outer lead sheath 21 is placed over the rubber jacket 19. The purpose of this sheath is two fold; first to provide a smooth polished surface against which the jacket will be vulcanized and, second, to restrain the compound during curing and thus prevent excessive expansion of the outer jacket due to the blowing of the rubber compound in the filler spaces.

At this point the completed assembly is reeled upon a drum and placed within a vulcanizing chamber in which the jacket 19 and the porous fillers 17 are vulcanized by the application of heat and pressure. Due to the presence of the sodium bicarbonate in the filler compound the strands 17 expand during vulcanization to form a porous mass 23 which completely fills the space between the conductors 11 and the outer jacket 19. Since a sponge rubber compound of the type given will expand from four to five times its initial volume during vulcanization if unrestrained, considerable pressure is exerted on the interior of the annular sheath 19 as the unvulcanized strand will preferably fill approximately half the total void spaces. This feature is important since it results in a jacket of exceptionally high characteristics due to the fact that it is vulcanized under both internal and external pressure. In addition the jacket is distended to fit the interior of the lead sheath exactly and is maintained in an absolutely circular position during the curing period. With a compound such as that given for purposes of explanation, occupying before vulcanization approximately one-half of the void spaces, it is estimated that the internal pressure on the sheath is approximately 35 pounds per square inch.

It may also be pointed out that any gas which remains within the cable after vulcanization is carbon dioxide and that all oxygen has been excluded or combined to form this inert gas. This feature is of particular importance when the cables are to be operated at high potentials since it precludes the possibility of formation of ozone to corona. As it is well known, ozone is extremely destructive to rubber compounds and comparatively small concentrations will entirely destroy the dielectric value of the insulating jacket.

After completion of vulcanization, the lead

sheath 21 is stripped from the rubber jacket and the cable is now completed and ready for use. Preferably the insulating coatings 15 of the individual conductors 13 are vulcanized before they are stranded together to form a cable and therefore the spongy filler mass 23 will not bond to them during vulcanization. This permits a certain amount of relative movement between the filler and the jackets of the individual conductors which permits a maximum degree of flexibility. Since the outer jacket 19 and the filler 23 are cured at the same time, however, these portions will be vulcanized together providing a substantially unitary assembly and anchoring the filler mass in place within the cable.

While this invention has been described primarily in terms of a rubber filler in connection with rubber insulated conductors and an outer jacket of the same material, it will be apparent that the insulation and jacket may be of any composition, provided only that the material has sufficient heat resistance to withstand the temperature required to activate the blowing agent in the filler. Other variations and modifications which do not depart from the scope of the invention may be apparent to those skilled in the art.

What I claim is:

1. A multi-conductor electric cable characterized by its high degree of flexibility comprising a plurality of metallic conductors, a layer of vulcanized rubber compound surrounding each of said metallic conductors and of sufficient thickness to insulate said conductors one from another, an outer sheath of vulcanized rubber compound characterized by its resistance to abrasion, and rubber compound fillers of cellular formation occupying the spaces between said insulated conductors and said sheath, gas in said rubber fillers equal to at least fifty percent of the volume of said fillers, said fillers and said sheath being bonded together during simultaneous vulcanization.

2. A multi-conductor electric cable characterized by its flexibility comprising a plurality of metallic conductors, a layer of vulcanized rubber compound free from all but microscopic pores surrounding each of said metallic conductors and of sufficient thickness to insulate said conductors one from another, an outer sheath of vulcanized rubber compound characterized by its resistance to abrasion, and fillers of sponge rubber occupying the spaces between said insulated conductors and said sheath, said fillers and said sheath being bonded together during simultaneous vulcanization, the pores of said sponge rubber fillers being filled with gas.

3. A multi-conductor electric cable characterized by its high degree of flexibility comprising a plurality of metallic conductors, a layer of vulcanized rubber compound surrounding each of said metallic conductors and of sufficient thickness to insulate said conductors one from another, an outer sheath of vulcanized rubber compound characterized by its resistance to abrasion, and rubber compound fillers of cellular formation occupying the spaces between said insulated conductors and said sheath, the volume of gas in said rubber fillers being equal to at least fifty percent of the volume of said fillers, said fillers and said sheath being bonded together.

4. A multi-conductor electric cable characterized by its flexibility comprising a plurality of metallic conductors, a layer of vulcanized rubber compound free from all but microscopic pores surrounding each of said metallic conductors and

of sufficient thickness to insulate said conductors one from another, an outer sheath of vulcanized rubber compound characterized by its resistance to abrasion, and fillers of sponge rubber occupying the spaces between said insulated conductors and said sheath, said fillers and said sheath being bonded together, the pores of said sponge rubber fillers being filled with gas.

5 5. A multi-conductor electric cable characterized by its high degree of flexibility comprising
10 a plurality of metallic conductors, a layer of vulcanized rubber compound surrounding each of

said metallic conductors and of sufficient thickness to insulate said conductors one from another, an outer sheath of vulcanized rubber compound characterized by its resistance to abrasion, and rubber compound fillers of cellular formation occupying the spaces between said insulated conductors and said sheath, the volume of gas in said rubber fillers being equal to at least fifty percent of the volume of said fillers, said fillers and said sheath being vulcanized simultaneously.

HANS V. WODTKE.