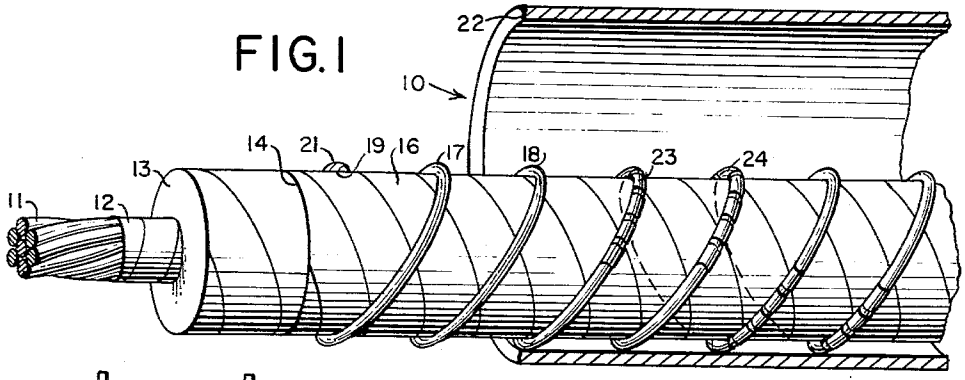
Nov. 23, 1965 V. F. VOLK 3,219,501

MANUFACTURE OF HIGH-VOLTAGE CABLE

Original Filed May 16, 1961

FIG. 1



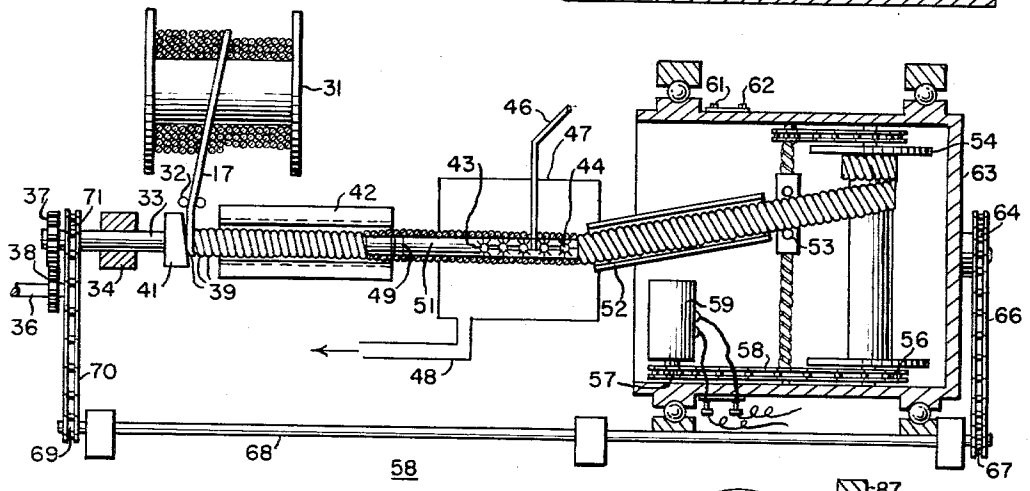


FIG. 2

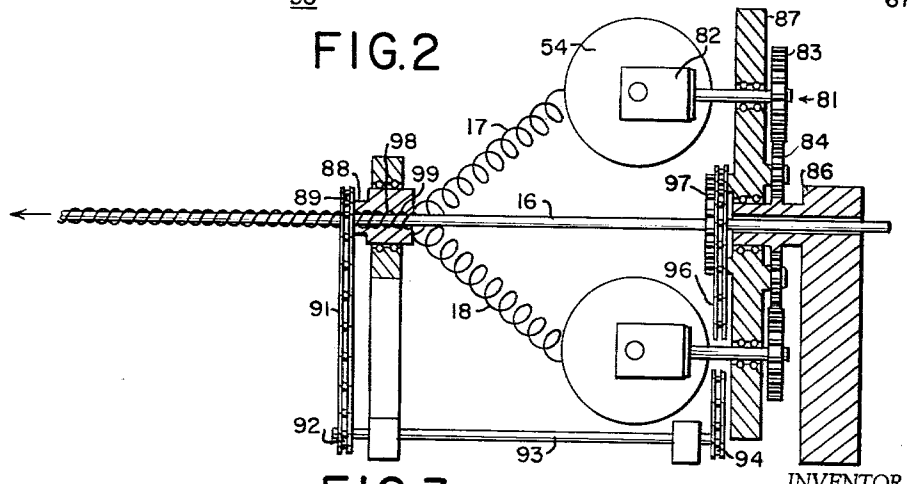


FIG. 3

INVENTOR

Victor F. Volk

United States Patent Office 3,219,501 Patented Nov. 23, 1965

3,219,501

MANUFACTURE OF HIGH-VOLTAGE CABLE

Victor F. Volk, Hastings on Hudson, N.Y., assignor, by mesne assignments, to Anaconda Wire and Cable Company, a corporation of Delaware

Original application May 16, 1961, Ser. No. 82,819, now Patent No. 3,080,446, dated Mar. 5, 1963. Divided and this application May 28, 1962, Ser. No. 205,815

2 Claims. (Cl. 156—53)

My invention relates to pipe-type cable and particularly to the manufacture of pipe-type cable having the insulation thereof protected by a dielectric skid wire.

In the manufacture of high voltage cables of the type where electric conductors are wrapped with a plurality of layers of insulating material such as, for example, a plurality of paper tapes and subsequently pulled into a steel pipe which is then filled with an insulating fluid, such as hydrocarbon oil or pressurized nitrogen it is known to protect the cable cores during the pulling operation with spiral windings of bronze skid wires. These known skid wires are most conveniently formed in half-round sections with the flat side laid against the insulation and the rounded surface making low-friction contact with the inner walls of the pipe.

Cables of the type described in my application and in my application Serial Number 82,819, now U.S. Patent No. 3,080,446, of which the present application is a division are generally known as "pipe-type cables" and will be so styled in this application although it will be understood that my invention is not limited by the nature of the enclosure comprising the containing element of my cable. Most commonly, said containing element is an eight-inch steel pipe but it may be comprised of a non-metallic material such as cement or plastic and may have various degrees of flexibility.

The known construction of pipe-type cables having bronze skid wires has proven to be satisfactory in almost all respects but has the one serious shortcoming that the currents induced in the skid wire may constitute a serious power loss accounting, in some instances, to as much as 2% of the power losses in the cable.

It is an object of my invention to provide a pipe-type cable wherein the skid wire is free from induced current losses.

It is another object of my invention to provide a pipe-type cable in which the skid wire will remain wrapped around the insulated conductor in the event of an accidental severing of the skid wire during installation.

I have invented a high-voltage electric cable comprising a conductor, electrical insulation surrounding said conductor, and a dielectric skid wire applied spirally over the insulation. The outer surface of my skid wire is preferably in compression so that the skid wire grips the insulation and will not unwind from the insulation even if it should be broken at some point. The insulated conductor and the skid wire of my cable are surrounded by a tubular container, overall. In a preferred embodiment of my invention the skid wire is comprised of linear polyethylene and in another preferred embodiment it is comprised of nylon. My cable has an electric shield over the insulation and in a preferred embodiment a plurality of conducting means are spaced at intervals along the skid wire making electrical contact between the shield and the tubular container which in this embodiment is metallic. The conducting means will preferably extend for a complete turn of the skid wire so as to be certain to contact the container regardless of the position of rotation of the insulated conductor.

I have also invented a process for manufacturing a pipe-type cable comprising the steps of insulating an electrical

conductor, extruding a length of dielectric skid wire, forming the skid wire into a helix with an inside diameter not substantially larger than the diameter over the insulated conductor and wrapping the skid wire around the insulated wire while compressing the outer surface of the skid wire. Advantageously, the skid wire is annealed and cooled while in a helical form. When the skid wire is comprised of linear polyethylene, I prefer to anneal it at a temperature of 220–230° F.

A more thorough understanding of my invention will be obtained from a study of the appended drawing.

In the drawing:

FIG. 1 is a lengthwise cut-away view of a cable made in accordance with my invention.

FIG. 2 is a schematic plan view of a process for forming the skid wire of my invention.

FIG. 3 is a schematic elevation of a process for applying the skid wire of my invention.

Referring now to FIG. 1:

A pipe-type cable designated generally at **10** has a conductor **11** wrapped with strand shielding **12** of semiconducting carbon black paper and insulated with a heavy wall **13** built up of a plurality of layers of insulating paper. The wall of insulation **13** is covered with a conducting shield **14** of copper tapes. The shield **14** is shown applied directly over the insulation **13** but there may be intermediate layers of carbon black tape or of impervious tapes applied for the purpose of preventing moisture from entering the insulation **13** during the processes of storing, shipping, and installing the cable. The conductor **11**, strand shielding **12**, insulation **13**, shield **14**, and any intermediate layers between the insulation **13** and the shield **14** constitute a unit **16** that I shall hereinafter call an insulated conductor. Over the insulated conductor **16** I have applied two skid wires **17, 18**, 180° apart. Although I have chosen to apply two skid wires my invention is not restricted to this number. For example a single skid wire might be applied at ½ the pitch that I have chosen for my two wires or a larger number such as three or four might be applied having a longer pitch.

The skid wires **17, 18** have each a substantially flat surface **19** facing the insulated conductor **16** and a rounded outer surface **21**. A steel pipe **22** constitutes a tubular container for the insulated conductor **16** covered by skid wires **17, 18**. Although for the sake of simplicity I have shown only one insulated conductor **16** in the pipe **22**, three such insulated conductors are generally inclosed in the pipe, each of the conductors being identical to the insulated conductor **16** and having skid wires applied identically to the skid wires **17, 18**. The pipe **22** is filled with an insulating fluid such as an insulating oil which can penetrate the insulation **13** or a gas such as nitrogen maintained under super-atmospheric pressure.

It is a feature of my invention that the skid wires **17, 18** are comprised of a dielectric, or insulating material of which linear polyethylene is a preferred example. The purpose of the skid wires **17, 18** is to protect the shield **14** and the insulation **13** from the effects of abrasion against the pipe **22** during installation. The method of installation requires that the insulated conductor **16** be unwound from reels and dragged into the pipe **22** by means of a cable fastened to the conductor **11**. Commonly three insulated conductors such as the one designated **16** are pulled into the pipe **22** simultaneously from three different reels.

Prior to my invention bronze armor wires similar to my skid wires **17, 18** were wrapped around the core **16** to protect the insulated conductor during installation. These known armor wires had the disadvantages that they readily picked up induced electric currents from the conductor **11**, that they added considerably to the weight of the insulated conductor **16**, and that they had a relatively high coeffi-

cient of friction against the walls of the pipe **22** compared to the skid wires **17, 18** of my invention. My skid wires **17, 18** are formed of a tough, resinous material which will not transmit electric current, has high resistance to abrasion, and has a very low coefficient of friction. Polyethylene may be used for my skid wires **17, 18** or the vinyl resin known as rigid polyvinyl chloride. However, I prefer to form my skid wires from linear polyethylene or from nylon. By linear polyethylene I refer to polyethylene resin with a pressure of about 0.941 or higher. This polyethylene is made by a low density process such as the Ziegler process and is extremely tough and abrasion resistant.

Nylon is a generic term for a family of polyamide resins characterized by high tensile strength, toughness and abrasion resistance and by a low coefficient of friction. Both the linear polyethylene and nylon which I prefer for the skid wires of my invention are well known materials of commerce for which I make no claims of invention as such.

Where the pipe **22** is a metallic pipe and it is considered desirable to ground the shield **14** periodically along the length of the cable, one or both of the skid wires **17, 18** are wrapped at spaced intervals with metal bands **23, 24**. The bands **23, 24** are conveniently applied to the skid wires **17, 18** at spaced intervals prior to the application of the skid wires to the insulated conductor **16**. Although I prefer to use bands **23, 24** made from bronze or stainless steel it will be understood that helical windings of metal wire may be substituted for the bands or the surface of the skid wire may be coated with conducting paint. One of the principal advantages of my invention resides in the high electrical resistance of the dielectric skid wires **17, 18** as compared with the bronze armor wires known to prior art. This high electrical resistance prevents induced electrical currents in the skid wires. It is important, therefore, that the conducting bands **23, 24** should be applied only at spaced intervals on the skid wires **17, 18** and not from a continuous conducting path along the cable. By spacing my conducting means **23, 24** I effectively prevent any appreciable power losses from induced currents. The pipe-type cable **10** constitutes relatively expensive engineering installation requiring considerable advance planning and preparation for a successful installation. If, in the course of pulling the insulated conductor **16** into the pipe **22**, any accident were to befall the conductor **16** requiring the withdrawal of the conductor from the pipe and its return to the factory the financial losses would be great. Such an accident would be the severing of one or both of the skid wires **17, 18** due to cutting edges on the inside of the pipe **22** or to foreign objects in the pipe. If the skid wires **17, 18** were merely wrapped around the insulated conductor **16** the outside surface **21** of the skid wires **17, 18** would be under tension and the inside surface **19** would be under compression in accordance with well known bending formulas and the skid wires **17, 18** would spring away from the insulated conductor **16** at any point where a break should occur and would, indeed, become loose for the full length of the cable. It would be impossible to make repairs in the field where the skid wires **17, 18** had become loosened over any long length of the cable. It should be further noted that the skid wires **17, 18** protect the cable not only during the process of pulling the insulated conductor **16** into the pipe **22** but also after the pipe has been filled with insulating fluid and the cable energized the skid wires **17, 18** are relied upon to protect the shield **14** and insulation **13** during the writhings that take place because of expansion in the conductor **11** caused by current loading. If the skid wires **17, 18** were applied so as to produce tension in the outside surface **21** not only would the skid wires tend to spring open if they were broken but any small cuts or abrasions of the surface would become focal points for tearing under the influence of the tension or stretch in the surface and such tearing might eventually extend through the entire thickness of the skid wire and result in a break. I have overcome the above mentioned obstacles by so applying the skid wires **17, 18** that the outer surfaces are in compression rather than tension. This has the twofold advantage of making the skid wires more resistant to abrasive action and of guaranteeing that they will remain snugly bound to the insulated conductor **16** even though a break may occur at some point. If a break should occur in a skid wire in the field it is a relatively simple matter to repair it so long as the skid wire does not spring open and the delay and expense of returning the cable to the factory is avoided.

In order to produce compression rather than tension in the outer surface of my skid wires **17, 18** I first form them into a helix and anneal them in this form. This can best be understood by reference to FIG. 2. In FIG. 2 the skid wire **17** that has preferably been formed by extrusion into a half-round or similar section is paid from a reel **31** through vertical guide rolls **32** onto a polished mandrel **33**. The mandrel **33** is mounted in a bearing **34** and driven through the shaft **36** by spur gears **37, 38**. The shaft **36** is, in turn, driven by a motor, not shown. As the polished mandrel **33** rotates, turns **39** of the skid wire **17** form around the mandrel and are urged to the right by the wedging action of block **41**. As the turns **39** slide down the mandrel **33** they pass through an oven **42** which heats them to a temperature sufficient to anneal the skid wire **17** but not sufficient to cause distortion or to cause the turns **39** to adhere to each other or to the mandrel **33**. In the case of linear polyethylene the length and temperature of the oven **42** are sufficient to raise the linear polyethylene skid wire to a temperature of 220–230° F. As the turns **39** of the skid wire **17** leave the oven **42** they pass under a cooling spray **43** of water from a spray head **44** fed by a water pipe **46** to a source of cooling water not shown. The cooling spray **43** is caught in a trough **47** drained by a pipe **48**. In order to prevent the cooling water from cooling the mandrel **33** in the oven **42** an insert **49** of material having a low heat conductivity divides the mandrel **33** from a polished extension **51** which supports the turns **39** while they are in the cooling spray. The insert **49** has the same diameter as the mandrels **33** and **51** and is preferably made of Teflon which is a good heat insulator, and also has a low coefficient of friction to permit sliding of the turns **39**. As the turns **39** slide from the cool end of the mandrel **51** they are guided by a chute **52** through a traverse **53** onto a reel **54**. The reel **54** is driven by means of the sprockets **56, 57** and chain **58** by the motor **59** powered through the slip rings **61, 62**. The reel **54** is housed in a frame **63** driven through a sprocket **64**, chain **66**, sprocket **67**, shaft **68**, sprocket **69**, chain **70**, and sprocket **71** to rotate at the same speed as the mandrels **33, 51**. The mandrel **33, 49, 51** has a diameter less than the diameter of the insulated conductor **16** and is so chosen that when the skid wires **17, 18** are wrapped around the insulated conductor **16** the outer surface **21** of the skid wires will be in compression and the tension on the inner surface **19** of the skid wires **17, 18** will not be so great as to cause tearing at this surface. With a half-round skid wire **17** of ¼ inch diameter, I prefer to use a mandrel diameter about 80% of the insulated conductor diameter but I do not wish to be limited to this ratio since the optimum dimensions will be influenced by the particular material of the skid wire, by its cross-sectional dimensions, and by the pitch at which the skid wire is applied to the insulated conductor.

The skid wires **17, 18** are applied to the insulated conductor **16** by means of a planetary cabler **81** (FIG. 3) with the reel **54** mounted in a cradle **82** which remains horizontal or rotates slowly as desired, because of the planetary gear **83** rotated through the idler **84** against a fixed gear **86** by the mounting plate **87**. The size of the fixed gear **86** can be varied in relation to the planetary gear **83** to compensate in known manner for the difference between the diameter of the insulated conductor **16** and

the coil **17**. The skid wire **18** is shown similarly mounted on the cabler **81**. A rotating die **88** is driven through the sprocket **89**, chain **91**, sprocket **92**, shaft **93**, sprocket **94**, chain **96** and sprocket **97** (which is itself driven by a chain and motor not shown) at the same speed as the mounting plate **87**. The die **88** has helical grooves **98**, **99** which guide the skid wires **17**, **18** in helical form around the insulated conductor **16**. Because of the grooves **98**, **99** in the die **88** the skid wires **17**, **18** are firmly gripped during the wrapping operation and the necessary force is easily applied to increase the diameter of the helix and put the outer surface of the skid wires in compression.

I claim:

1. In the process of manufacturing a pipe-type cable comprising an insulated conductor having a predetermined diameter, the steps of:

(A) extruding a length of dielectric skid wire,

(B) continuously wrapping said skid wire around a mandrel to form a helix having a diameter smaller than the diameter of said conductor,

(C) continuously sliding said helix from said mandrel,

(D) while on said mandrel continuously annealing and, while on said mandrel, subsequently cooling said helix,

(E) and then immediately continuously taking up a length of the helixed wire on a reel, said length being great compared to the length of said mandrel, and

(F) wrapping said skid wire around the insulated conductor while compressing the outer surface of said skid wire.

2. In the process of manufacturing a pipe-type cable comprising an insulated conductor having a predetermined diameter, the steps of:

(A) extruding a length of linear polyethylene skid wire,

(B) continuously wrapping said skid wire around a mandrel to form a helix having a diameter smaller than the diameter of said conductor,

(C) continuously sliding said helix from said mandrel,

(D) while on said mandrel, continuously annealing said helix at a temperature of 220°–230° F. and, while on said mandrel, subsequently cooling said helix,

(E) and then immediately continuously taking up a length of the helixed wire on a reel, said length being great compared to the length of said mandrel, and

(F) wrapping said skid wire around the insulated conductor while compressing the outer surface of said skid wire.

References Cited by the Examiner

UNITED STATES PATENTS

Re. 24,468	8/1947	Roberts	156—144 XR
2,425,294	8/1947	Morgan.	
2,628,214	2/1953	Pinkney et al.	
3,091,261	5/1963	Waddell	156—143 XR

EARL M. BERGERT, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,219,501 November 23, 1965

Victor F. Volk

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the drawing, line 3, and in the heading to the printed specification, line 6, for "May 16, 1961", each occurrence, read -- Jan. 16, 1961 --; column 3, line 10, for "pressure" read -- density --; line 11, for "density" read -- pressure --; line 39, for "from" read -- form --.

Signed and sealed this 2nd day of August 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents