May 20, 1958 L. J. COLBERT 2,835,724

SHEATHED ELECTRICAL CABLES

Filed Dec. 21, 1953 2 Sheets-Sheet 1

Fig. 1.

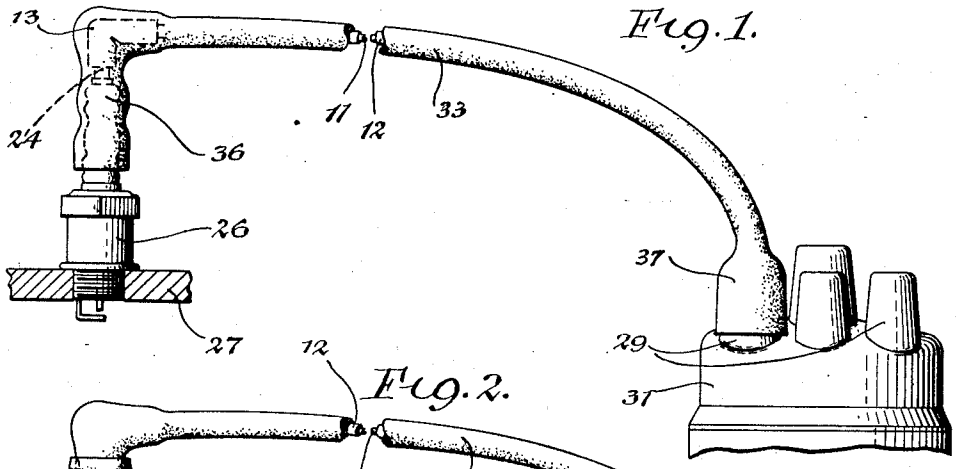


Fig. 2.

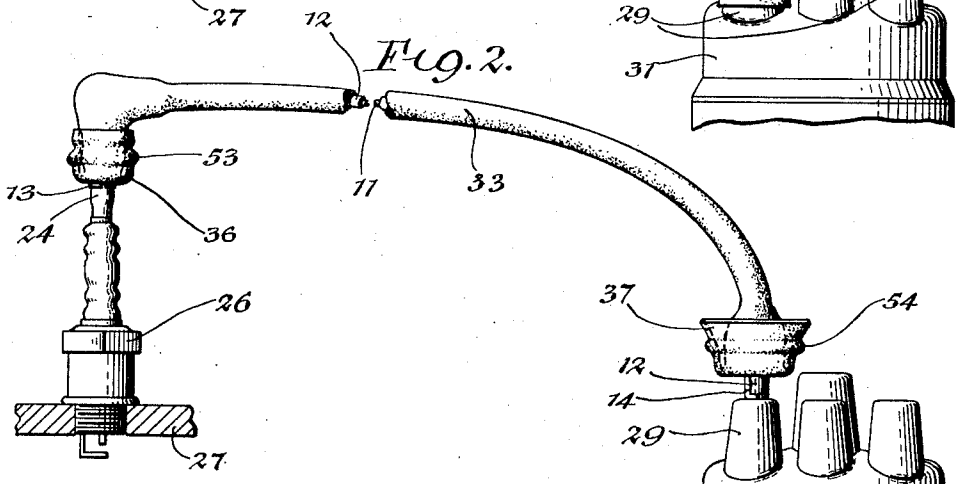
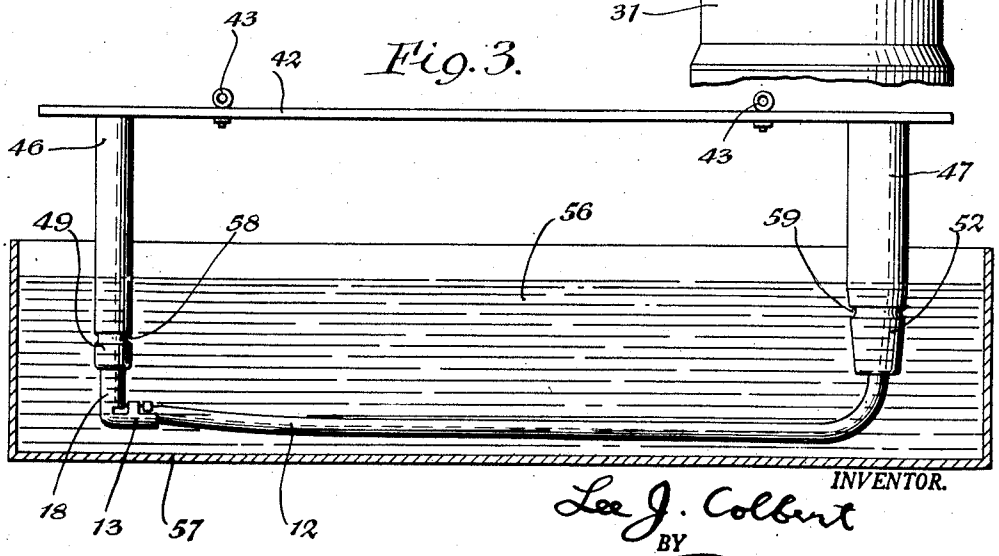


Fig. 3.



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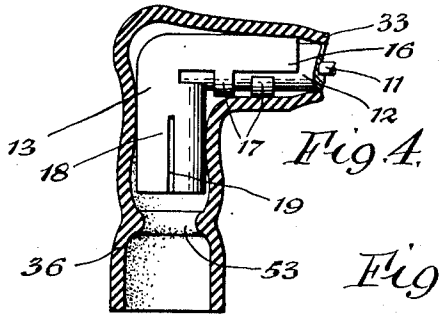


Fig. 4.

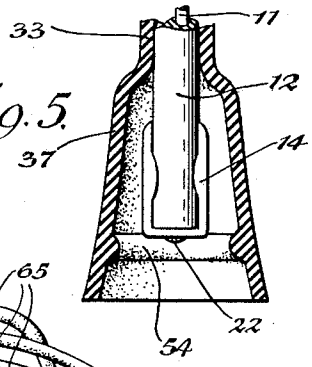


Fig. 5.

Fig. 6.

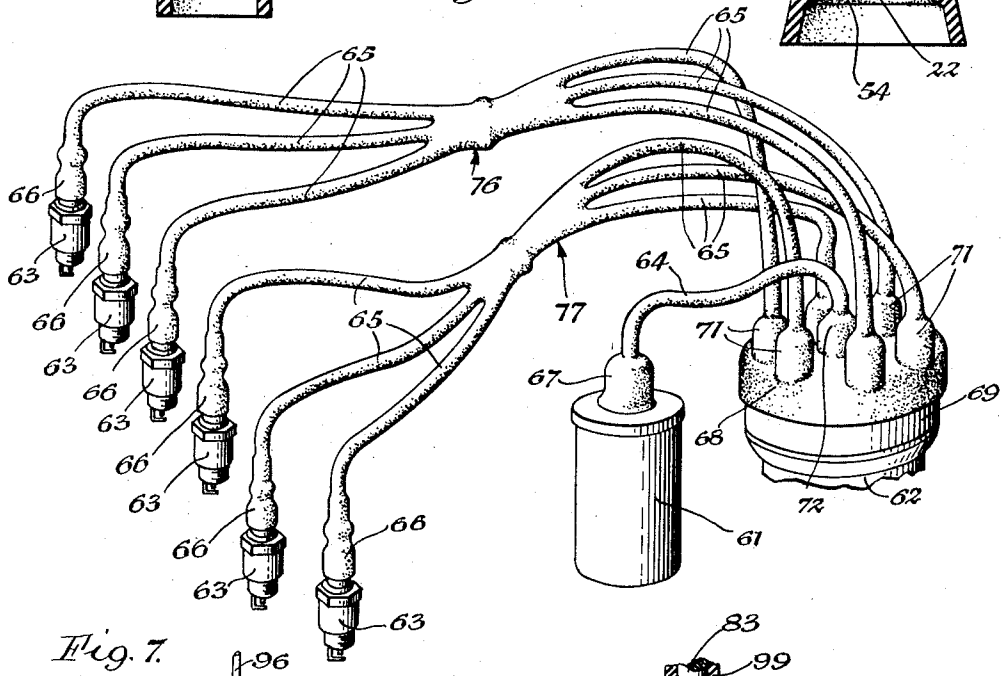
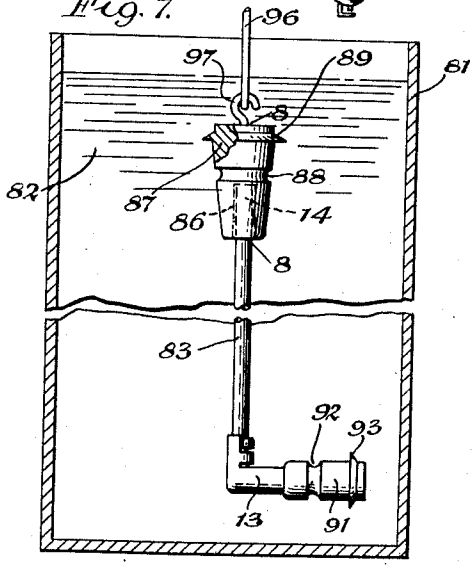


Fig. 7.



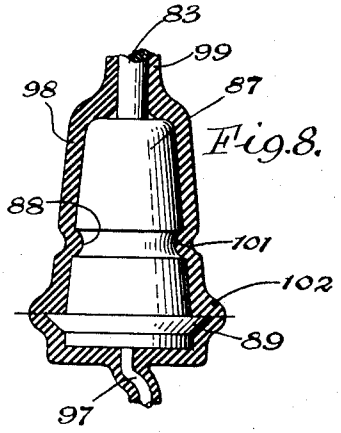


Fig. 8.

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SHEATHED ELECTRICAL CABLES

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4 Claims. (Cl. 174—113)

This invention relates to sheathed electrical cables adapted for use in completing circuits between electrical devices and is particularly concerned with detachable ignition cables of the type commonly employed in the high voltage ignition systems of internal combustion engines.

It is an object of the present invention to provide a cable of the character described which is provided with a protective and insulating covering or sheath having a high resistance to the fluids commonly used around internal combustion engines such as gasoline, acids, and oils of both the hydrocarbon and synthetic types.

Another object of the invention is to provide a cable of the character described in which the sheath is resistant to chafing and is flexible throughout a wide range of temperatures including temperatures well below 0° F.

A further object of the invention is to provide a cable of the character described which has means for protecting the electrical contact members of terminals at the ends thereof from mechanical injury and from moisture.

Another object of the invention is to provide a cable of the character described in which the sheath is provided with integral means for sealing the electrical connections formed with the terminals at the ends thereof to prevent access of moisture thereto and shorting or leakage of current resulting from such moisture.

Another object of the invention is to provide a cable of the character described in which the sealing means provided for the electrical connections may be turned back to facilitate the making of such connections.

Still another object of the invention is to provide a cable of the character described which is free from danger of fire or explosion resulting from current leakage.

A further object of the invention is to provide novel means for making electrical cables and groups of cables or harnesses embodying the features described above.

Other objects and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a fragmentary elevational view showing a sheathed ignition cable according to the present invention installed between a distributor terminal and a spark plug;

Figure 2 is a view similar to Figure 1 with the terminal elements of the cable partially withdrawn from their cooperating contacts and with the flexible caps or hoods at the ends of the cable sheath turned back;

Figure 3 is a side view of apparatus which may be used in producing a protective sheath on electrical cables in accordance with the present invention;

Figure 4 is an enlarged sectional view of one end of the sheathed cable shown in Figure 1 illustrating the arrangement of the metallic terminal within the hood at that end of the sheath;

Figure 5 is an enlarged sectional view of the other end of the cable shown in Figure 1 illustrating the arrangement of the plug terminal within the hood at that end of the sheath;

Figure 6 is a perspective view of an ignition harness comprising a plurality of ignition cables embodying the invention of the present application;

Figure 7 is a side view of another form of apparatus by means of which sheathed ignition cables according to the present invention may be made; and

Fig. 8 is a sectional view on line 8—8 of Figure 7.

In the drawings the invention of the present application is exemplified as applied to an internal combustion engine ignition system. In Figures 1 and 2 the reference character 11 designates an electrical conductor which is surrounded by or embedded in insulation 12. The conductor 11 may be of any suitable and desired type, i. e. solid wire, a stranded conductor formed of a plurality of small wires, either twisted or braided, or metal tape. The insulation 12 may be either molded or extruded over the conductor 11 and may be of any desired shape in cross section. At its ends the conductor 11 is provided with suitable terminal elements 13 and 14 (see Figure 2). Although such terminal elements of any desired type or construction may be used depending upon the kind of electrical contacts with which the cable is employed, the elements 13 and 14, which are shown more clearly in Figures 4 and 5 are typical elements of the types used for spark plug wires on internal combustion engines.

In Figure 4 the terminal element 13 is a 90° socket which is provided with a clamping portion 16 having fingers 17 adapted to embrace the insulation 12 around the conductor 11 and a socket portion 18 that may be slotted as at 19 to permit expansion and ensure tight contact with a cooperating terminal element. The conductor 11 is fastened, such as by crimping or soldering, to the terminal element 13 interiorly thereof. In Figure 5 a plug type terminal element 14 is shown. This element comprises a metal cap which fits over the end of the insulation 12 and is attached, as shown at 22, to the conductor 11 therein, such as by crimping or soldering. In the use of the ignition cable illustrated in Figures 1 and 2 the terminal element 13 is connected to the center terminal 24 of a spark plug 26. The latter is shown mounted in the cylinder head or wall 27 of an engine. The other terminal element 14 is shown inserted in one of the outlet sockets 29 on a distributor cap 31. An electrical circuit is thus established between the spark plug 26 and the ignition system that is periodically connected to the terminal in the socket 29 of the distributor cap by the distributor rotor (not shown).

In addition to the conductor 11 and insulation 12 the cable of the present invention comprises a non-metallic, protective, insulating sheath 33. It is formed of a flexible, elastic material and, as shown in the drawings, extends for the full length of the conductor and projects outwardly beyond the ends of the terminal elements 13 and 14. As best seen from Figure 4 and 5 the ends of the sheath 33 are formed as caps or hoods 36 and 37 covering the elements 13 and 14, respectively. The shapes of the hoods 36 and 37 are generally those of the devices with which they are to be used. Thus, the hood 36 beyond the end of the terminal 13 is generally cylindrical and adapted to fit over the upper end of a spark plug porcelain. The cap 37, being intended to cover an upwardly extending outlet socket on the distributor cap, is somewhat bell shaped like the exterior of the socket. In the interior of the hood 36 there is formed a circumferential bead 53 integral with the wall of the hood. This bead provides a restricted portion in the hood and insures a tight grasp on the spark plug porcelain and sealing of the connection. A similar bead 54 is formed in the interior of the cap or hood 37 to provide a seal on the socket 29.

The sheath 33 is, as previously mentioned, formed of a flexible, elastic material. Preferably it retains its

flexibility over a wide range of temperatures and is resistant to fluids of the type used around internal combustion engines, such as gasoline, acids, and oils of both the hydrocarbon and synthetic types. The sheath should also have high electrical resistance thereby serving as auxiliary insulation for the conductor contained therein. It has been found that neoprene is a very satisfactory material from which to form the sheath **33**. Other synthetic elastomers may, however, be employed when their characteristics are suitable and, in applications where elasticity of the sheath is of minor importance, some flexible plastic materials of the vinyl type may be used.

It is of great importance in connection with the cable of the present invention that the walls of the flexible sheath, including the walls of the terminal hoods thereof, be of uniform thickness. It has been discovered that such uniformity of thickness may be conveniently secured by forming the sheath around the conductor and terminals by a dipping process. Apparatus by means of which the formation of a cable sheath by dipping may be conveniently carried out is illustrated in Figure 3.

This apparatus is simple and comprises a plate or board **42** provided with suitable means such as eyebolts **43** for suspending it. Depending from the plate **42** and fastened thereto in any suitable manner are two spaced form members **46** and **47**. The outer ends of the forms **46** and **47** are shaped to correspond to the shape of the electrical devices with which the sheathed cable is to be employed.

Thus, the outer end of the form **46** has an end portion of reduced diameter (not shown) which is the same size and shape as the terminal of the spark plug with which the cable is to be employed and is adapted to be received in the socket of the element **13**. Adjacent the end portion of reduced diameter the form **46** has a portion **49** which is of the same diameter as the spark plug porcelain. The outer end of the form **47** has a frusto-conical shape like the outlet sockets **29** on the distributor cap **31** and is provided with an axial hole (not shown) to receive the terminal element **14** of the cable.

To form a protective sheath on the conductor with the apparatus shown in Figure 3 an insulated conductor having terminal elements **13** and **14** attached thereto is mounted on the plate **42** by attaching the terminal elements to the forms **46** and **47**, respectively, in the manner above indicated, the plate being supported by any suitable means (not shown) attached to the eyebolts **43**. The cable and the outer end portions of the forms **46** and **47** are then dipped into a bath of neoprene **56** in liquid form contained in the vessel **57**. Upon raising the plate **42** the cable and forms are withdrawn from the latex bath and there remains over the insulation on the conductor, the terminal **13** and **14**, and the ends of the forms **46** and **47** an even, continuous film of neoprene. The neoprene film may be coagulated in any suitable known manner as, for example, by drying or by use of a coagulant. Alternate dipping and coagulation may be continued until the sheath has attained the desired thickness. The neoprene may, of course, have mixed therewith other ingredients to impart specific desired physical properties thereto or to modify or assist in curing.

When the sheath has reached the desired thickness it may be given a final vulcanization or cure by heating for a period of time at a temperature of about 250° F. or above in accordance with known practice in curing neoprene. The completed cable may then be removed from the plate by disengaging the terminal elements **13** and **14** from the forms **46** and **47**. If desired, the ends of the hoods **36** and **37** formed on the form portions **49** and **52** may be trimmed. Obviously, the outer ends of the forms **46** and **47** must be formed from or coated with a suitable material to which the dried neoprene film does not adhere in order to remove the hoods therefrom. Further, it is preferred to have the sheath non-adherent to the metallic terminal elements. Whether or not the sheath adheres to the insulation **12** is not in general important. It will be understood that when adhesion of the sheath is required it may be secured according to known practice by providing on the part or parts where adhesion is desired a coating of a primer.

As shown in Figure 2, the hoods **36** and **37** may be turned back to expose the terminal elements **13** and **14**, thus facilitating the making of electrical connections with those elements. It has been found that a wall thickness for the sheath, including the hoods, of approximately $\frac{1}{16}$ inch is optimum for small cables such as are used in internal combustion engine ignition systems. Hoods of such thickness are easily turned back when desired. Furthermore, when desired the sheath may be pushed back, when not adherent to the terminal elements, to expose such elements, thereby permitting repair or replacement thereof. When rolled down after making connections the hoods fit closely on the apparatus to which the connections are made, thus preventing entrance of moisture or other foreign matter around the connections. In this connection it has been found desirable to provide in the interior of the hoods **36** and **37** circumferential beads **53** and **54**, respectively. These increase the tightness with which the hoods grip the apparatus and improve the seals around the connections. The beads **53** and **54** may be molded in the hoods by providing grooves **58** and **59** in the forms **46** and **47**, respectively.

If desired a plurality of cables may, according to the present invention, be grouped into electrical harnesses. This is illustrated in Figure 6 where a plurality of cables is shown assembled to provide electrical conductors for a complete high voltage automobile ignition system including the connection **64** from a spark coil **61** to a distributor **62** and connections **65** from the distributor to a plurality of spark plugs **63**. It will be observed that a common, unitary sheath is provided for all of the conductors and that this unitary sheath includes individual hoods **66** covering the terminal elements (not shown) for attachment to the spark plugs **63**, a hood **67** for the conductor terminal element which is connected to the spark coil **61**, and a single hood **68** that covers the top of the distributor cap **69**. The hood **68** is provided with nipples **71** and **72** that cover the terminal elements (not shown) on the various conductors which are used for making electrical connections to the distributor contacts in the outlet sockets or bosses and the central inlet socket on the distributor cap. The nipples **71** and **72** fit closely over the sockets on the distributor cap **69** and seal the connections therein from access of moisture.

The hoods **66** are carried by the connecting cables **65** which, as shown, may conveniently be combined in two groups **76** and **77**. Such combination may be accomplished by binding together the conductors in each group, as with the usual wire, tape, or a bulkhead connector as is common with a group of high tension wires, prior to forming the sheath thereon. The sheath covering the whole harness may be produced with the apparatus shown in Figure 3 in the same manner as described above in connection with the cable shown in Figures 1 and 2, it being necessary merely to provide the proper number of forms of desired size and shape on the plate **42** and to mount on such forms by their terminal elements the necessary flexible conductors of proper length. It will be understood that the invention comprehends the making of electrical harness having fewer or more cables than are shown in the embodiment of Figure 6 so as to permit the use of such harnesses with engines having any number of cylinders and therefore requiring more or less spark plugs or distributor cap connections.

Figures 7 and 8 illustrate an alternative method of forming flexible, sheathed, spark plug cables such as those shown in Figures 1 and 2. In Figure 7 the vat or tank **81** contains a bath **82** of suitable film forming material, such as liquid neoprene, from which a unitary

sheath is to be provided on the insulated conductor **83** suspended therein. The conductor or cable **83** is provided at one end with a terminal element **13** and at its other end has a terminal element **14**. The element **14** is inserted in the axial bore **86** of a form **87**. This form is shaped like an outlet socket **29** on the distributor cap **31** but is provided with a peripheral groove **88** and a sharp-edged peripheral cutting flange **89**. A second form **91** is employed with the terminal element **13**. This form is shaped like the upper portion of a spark plug and includes an end portion (not shown) that fits into the socket of the element **13**, a peripheral groove **92** and a sharp-edged peripheral cutting flange **93**. The grooves **88** and **92** result in internal beads in the hoods formed on the forms **87** and **91**. The cable **83** and forms may be suspended from a wire or cable **96** as by a hook **97** secured to the form **87**.

The apparatus shown in Figure 7, although somewhat simpler, is used in substantially the same manner as that shown in Figure 3. A sheath of uniform thickness is formed by alternately dipping the forms and cable into the neoprene bath to obtain a film and coagulating the film thus obtained. When the sheath has reached the desired thickness it is, if desired, cured or vulcanized by heat and the sheathed cable may then be removed from the forms **87** and **91**. Since the forms are completely immersed in the bath it is necessary to cut the sheath to remove it. This may be done conveniently by applying pressure to the forms around the sharp-edged cutting flanges **89** and **93**. The result of this is shown in Figure 8 where a hood **98** integral with the sheath **99** on the cable **83** is shown in place on the form **87**. It will be noted that the hood has an internal bead **101** and that the outer edge thereof has a peripheral lip **102** resulting from the cutting flange **89**. The lip **102** may be found useful in grasping the hood to turn it back. After the sheaths are cut the hoods may be turned back and the terminal elements **13** and **14** disengaged from the forms thus providing the desired sheathed cable.

From the foregoing description it will be seen that the present invention makes available flexible sheathed cables which not only may be used in connection with the ignition systems of internal combustion engines, but also wherever there is need for providing electrical connections with or between apparatus and protecting such connections from moisture and/or other objectionable vapors, gases or liquids. The protective sheaths surrounding the cables are unitary with the hoods that cover the terminal elements of the cable and tightly engage the adjacent portions of the apparatus to which the terminal elements are attached. Thus, a complete seal of the electrical connection is possible. This is a valuable safeguard against ignition failure.

The sheaths are preferably formed of an elastomer, such as neoprene, and are therefore very durable and resistant to vibration, extremes of temperature, chafing, and to attack by molds and fungi, moisture, gasoline, acids, oils and other common liquids. Since they are flexible and elastic the hoods at the ends of the sheaths may be turned and/or pushed back to facilitate the making or breaking of connections as well as repair or replacement of terminal elements. They also protect the terminal elements from mechanical injury. Further, since the neoprene is an insulator, current leakage through defective insulation on the flexible conductors is prevented. Indeed, if desired, sheaths according to the invention may be provided on bare wires or cables.

It is also to be noted that the formation of the sheaths according to the present invention is a simple and inexpensive process and that electrical wiring harnesses containing one or more different groups of conductors may be conveniently provided with a common sheath of uniform thickness which includes unitary individual and/or joint hoods for the terminal elements. Such harnesses are much more compact, durable, and satisfactory than the harnesses produced by previously known methods and are easily and quickly installed. Moreover, no auxiliary caps, waterproofing compounds, or protectors are required.

Obviously, many changes in and variations from the precise structures and shapes described and shown may be made without departing from the spirit of the present invention. It is to be understood, therefore, that the invention shall be interpreted as broadly as permitted by the appended claims.

I claim:

1. In an electrical wiring harness, a plurality of flexible conductors, each of said conductors being covered with electrical insulation for substantially the entire distance between its ends and having a terminal element attached to each of said ends, and a single protective sheath of flexible, elastic, insulating material surrounding all of said conductors and insulation, the terminal element on at least one end of each of said conductors being covered by an independent and separate flexible hood unitary with said sheath and each of said hoods being adapted to be turned back into face to face contact with that portion of the sheath surrounding the adjacent end of the conductor to facilitate connection of said last-mentioned terminal elements to electrical apparatus.

2. In an electrical wiring harness, a plurality of flexible conductors, a first set of terminal elements, each of said conductors being covered with electrical insulation for substantially the entire distance between its ends and having a separate one of said terminal elements of said first set attached to one of said ends, a second set of terminal elements, each of said conductors having a separate one of said terminal elements of said second set attached to the other end thereof, a protective sheath of flexible, elastic, insulating material surrounding said conductors and insulation, the terminal elements of said second set being jointly covered by a flexible hood integrally formed with said sheath, said hood being adapted to be turned back to facilitate connection of said last-mentioned elements to electrical apparatus.

3. An electrical wiring harness as set forth in claim 2 in which each of said terminal elements of said first set is covered by an independent and separate flexible hood unitary with said sheath.

4. An electrical wiring harness as set forth in claim 2 in which at least two of said conductors are jointly covered, intermediate their ends, by said sheath.

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