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Copp

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[54] WOVEN FLAT CONDUCTOR

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[73] Assignee: **Surprenant, Inc.**, Jaffrey, N.H.
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[52] **U.S. Cl.** ....**174/117 F**, 174/112, 139/425 R
[51] **Int. Cl.** **H01b 7/08**
[58] **Field of Search** ....174/117 R, 112, 115, 117 F, 174/117 FF, 117 M, 72 TR, 113 R; 139/425; 338/212

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[57] **ABSTRACT**

A woven flat cable. The cable is woven with a warp consisting solely of conductors. The conductors are fed through a warp feeding unit to be woven on a shuttle, needle or other loom under constant tension. Each cable may comprise diverse conductors, may be woven differently and may be printed after it is woven.

7 Claims, 4 Drawing Figures

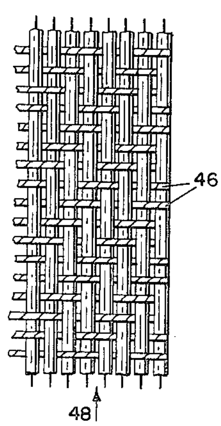

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FIG. 1

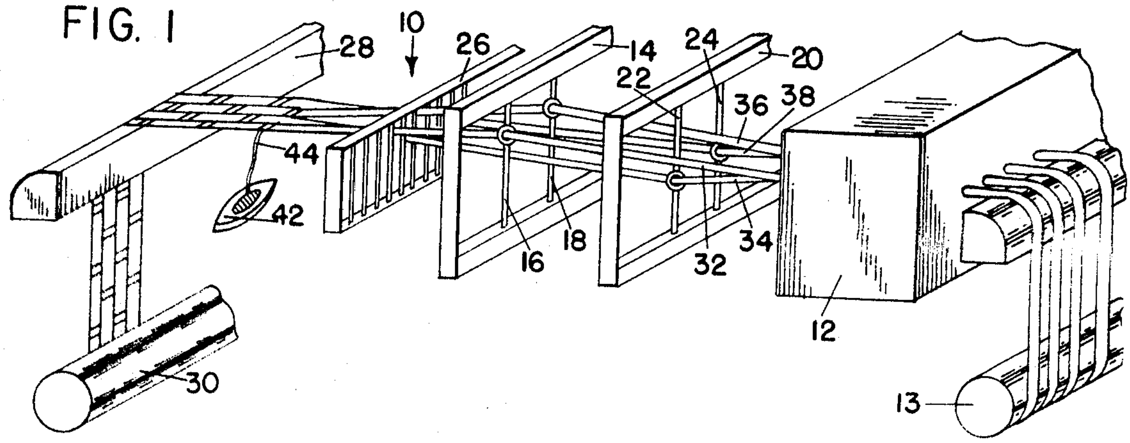

FIG. 2

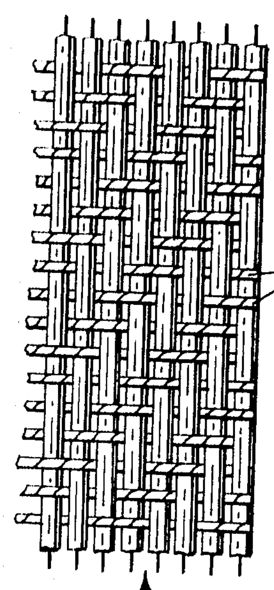

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FIG. 3

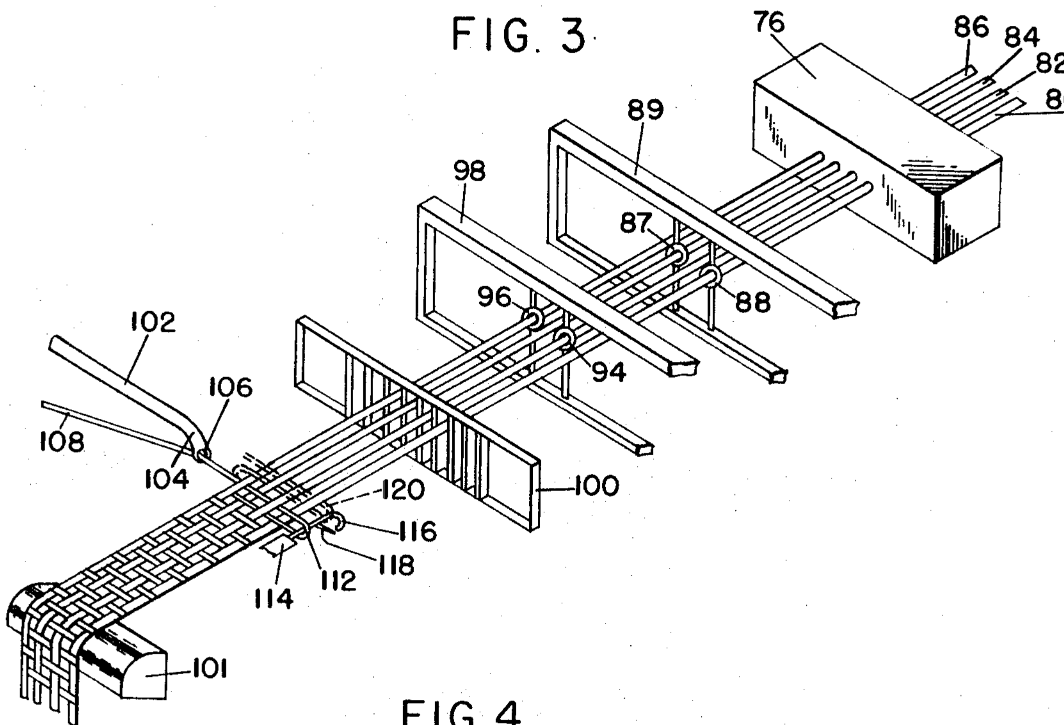
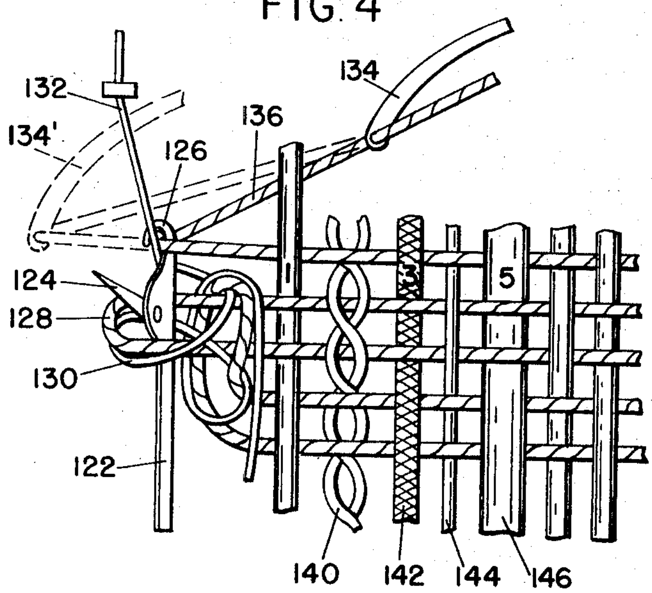


FIG. 4



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WOVEN FLAT CONDUCTOR

BACKGROUND OF THE INVENTION

This invention generally relates to cables comprising conductors and more specifically to woven flat cables.

In accordance with conventional weaving techniques, first threads, known as warp threads are individually fed through eyelets or heddles mounted on one of several movable frames or harnesses. All warp threads are kept under tension during the weaving process. Each harness can separate the warp threads threaded through heddles on that harness from the remaining warp threads by being displaced from the other harness transversely to the warp threads. The separated warp threads constitute a shed. After a single harness or combination of harnesses make a shed, a weft thread is carried through the shed between the separated warp threads. Then the harnesses move and change the shed to weave the weft thread into the warp.

Weft threads are carried through the shed differently on different looms. With a shuttle loom, apparatus throws a shuttle through the shed to position a single weft thread between the separated warp threads each time the harnesses change the shed. The shuttle traverses the warp in alternate directions after each shed is made.

A needle loom has a carrier. The carrier passes through the shed from a first edge of the warp, known as a selvage, with a weft thread and retracts after the weft thread is caught by apparatus at the second selvage. Each carrier operation disposes a double weft strand in the shed. This carrier sequence follows each shed change.

These weaving techniques are used to manufacture flat cables of electrical conductors, optical conductors, or hydraulic tubing. In the following description, all these elements are referred to as "conductors". In the prior art, the warp comprises parallel textile threads and conductors. Only the textile threads are actively involved in the weaving process. The conductors are only passively involved; that is, they are surrounded by the weaving process, but are not a part of it.

These prior cables pose several manufacturing and installation problems. In manufacturing, the warp threads and conductors must be kept parallel and maintained at different tensions. The process of warping, or threading, the loom with both threads and conductors can increase the warping time significantly in certain applications and thus reduce manufacturing efficiency. Also, when the cable is later connected to some device, some weft thread is removed to facilitate connecting the individual conductors to the device. In most applications, the resulting loose warp threads are cut manually to avoid damaging the individual conductors. This significantly increases the connection time and the cost of making such a connection.

Therefore, it is an object of this invention to provide a woven flat cable which can be manufactured more efficiently than the prior cables.

Another object of my invention is to provide a flat woven cable which simplifies connection procedures.

SUMMARY

Flat cables woven in accordance with my invention comprise warp and weft as in prior cables. Unlike the prior cables, however, the warp consists of conductors only. There are no separate textile warp threads. The weft threads are woven directly into the conductors to form the final woven cable.

This invention is pointed out with particularity in the appended claims. The above and further objects and advantages of an electrical cable formed in accordance with my invention can be obtained by referring to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates a shuttle loom for weaving cables in accordance with this invention;

FIG. 2 shows a cable woven on a shuttle loom;

FIG. 3 schematically illustrates a needle loom for weaving cables in accordance with this invention, and

FIG. 4 shows a cable woven on a needle loom.

DESCRIPTION OF AN ILLUSTRATIVE EMBODIMENT

Prior flat cables woven on conventional textile weaving apparatus include both warp threads and parallel conductors despite the previously described disadvantages. Apparently, it was thought that harness motion alters the warp tension sufficiently to permit the conductors to undulate if only conductors form the warp. Therefore, textile warp threads have been incorporated as active weaving elements because their relative elasticity keeps the warp tension relatively constant as the harnesses move. The conductors are more readily maintained at a constant tension because they are not bent transversely with the warp threads as the sheds are formed and this largely eliminates undulations in the finished cable.

Other known textile weaving techniques for overcoming tension problems are not practical when applied to weaving cables with conductors as the warp. For example, the active length of a textile warp can be increased to reduce the percentage of warp elongation when sheds are made. If this approach is adapted for weaving conductors, a considerable quantity of expensive conductor material is lost because the portion of warp thread which is not woven increases. Although leaders can be tied to both conductor ends to eliminate these losses, the costs for individually tying each warp conductor and leader is prohibitive.

A shuttle loom **10** in FIG. **1** includes a unit for maintaining constant warp tension and for weaving flat cable in accordance with my invention. The shuttle loom **10** is conventional except as modified by the addition of a warp feeding unit **12**. The warp conductors from a supply unit **13** pass through the warp feeding unit **12**, a harness **14** including representative heddles **16** and **18** and a harness **20** including representative heddles **22** and **24**. After passing through selected heddles, the conductors pass through a reed **26** and across a breastbeam **28** to a cloth beam **30**. Four representative conductors **32, 34, 36** and **38** pass through the heddles **16, 22, 18** and **24**, respectively.

As previously indicated, the warp feeding unit **12** in FIG. **1** maintains each conductor under substantially constant tension. There are several devices or units which can maintain a substantially constant warp tension of conductors as a harness rises. For example, the conductors may be fed through pinch rollers. Alternatively, weights may be suspended from warp conductors to compensate for changing harness positions. As still another alternative, the warp threads for each harness may be wrapped on a separate counterweighted supply unit such as the unit 13. Any of these or other approaches cause the entire warp conductor to extend as the tension tends to increase to thereby keep the warp conductor tension substantially constant during the weaving process.

The conductors are woven into the cable when apparatus (not shown) alternately elevates the harnesses **14** and **20** to form sheds and weft threads are passed through the shed to traverse the warp. For example, when the apparatus raises the harness **14**, the heddles **16** and **18** raise the warp conductors **32** and **36** to form a shed with the remaining conductors **34** and **38**. Once the harness forms a shed, other apparatus (not shown) propels a shuttle **42** through the shed to a receiving member (not shown). As the shuttle passes through the shed, it deposits a weft thread **44**. Next the harness **14** drops to its original position and the harness **20** rises, and then other apparatus moves the reed **26** to beat the weft thread **44** against the previously woven cable portion. Then the shuttle **42** returns through the shed in the opposite direction and deposits another weft thread. With this sequence, known as tabby weaving, a weft thread travels alternately over and under adjacent warp conductors while adjacent weft threads alternately pass over and under a given warp conductor.

Other known weaving patterns, such as twill weaves, can be obtained by warping the loom differently or by altering the harness sequence. FIG. 2 shows a section of flat electrical cable woven with a twill weave. A twill weave produces an overall surface pattern of diagonal lines, usually all running to the left or right and made by floating weft threads **46** over groups of two or more warp threads **48** and staggering the floats.

As is immediately evident, the warp consists only of the conductors **48**; so the warping and connection procedures are simplified and the attendant expenses reduced. As no textile threads are in the warp, the conductor insulation can be removed automatically. Further, if the conductors must be separated, it is merely necessary to remove a portion of the weft thread **46** from the cable.

Although flat cables can be woven successfully on shuttle looms, certain steps may be required to prevent the weft from unravelling. As will be apparent from FIG. 2, the entire weft thread can be unravelled merely by pulling on either end of the weft thread. If the cable is to be jacketed, the jacket prevents unravelling Other alternatives are also available; however, whenever weft unravelling is a problem, I prefer to weave the cable on a needle loom.

FIG. 3 schematically shows a needle loom in which a warp feeding unit **76**, which is similar to the warp feeding unit shown in FIG. **1**, carries four representative warp conductors **80**, **82**, **84** and **86**. These warp conductors enter the warp feed unit **76** from a supply unit (not shown). Of the four representative conductors, conductors **80** and **84** pass through heddles **87** and **88** mounted on a harness **89**. Conductors **82** and **86** pass through heddles **94** and **96** on harness **98**. All the conductors pass through a reed **100**, and weft threads are woven into the warp between the reed **100** and a breastbeam **101**. During the weaving process, the warp feeding unit **76** maintains the warp conductors under constant tension.

After the harnesses **89** and **98** form a shed, apparatus (not shown) moves a carrier **102** through the shed from a first selvage **103**. A typical carrier **102** includes hook portion **104**, and a weft thread **108** from a spool (not shown) passes through an aperture **106** in the hook portion **104**.

When the carrier **102** is fully extended through the warp, the weft thread **108** forms a loop **112** around a latch needle **114** at a second selvage. The latch needle **114** includes a hook **116** and a latch **118** and moves parallel to the selvage **115**. When the carrier **102** retracts, the loop **112** wraps around the needle between the hook **116** and latch **118** so the latch needle **114** holds the weft thread in position at the selvage **115**. As the carrier **102** continues retracting, additional weft thread is deposited in the shed so two weft threads are woven into the warp when the harnesses form another shed.

Before the next double weft strand is pulled through the shed, the latch needle **114** extends and the loop **112** slides away from the hook **116** and opens the latch **118**. Then another loop **120**, shown in phantom, is formed around the latch needle **114**. When the latch needle **114** retracts, it closes the latch **118** and pulls the loop **120** through the loop **112**. Then the latch **118** opens as the latch needle **114** is extended to engage the next loop formed in the weft. This sequence of operations produces a regular knitted edge which is easily unravelled from one end only.

FIG. 4 illustrates a preferred weft termination for a cable woven on a needle loom. This weft termination simplifies steps for connecting the cable to a device. As the cable is being woven, a latch needle **122** disposed parallel to a selvage **123** with an initially opened latch **124** and a hook **126**, passes through a previously formed weft loop **128** and a loop **130** formed by a cord **132**. When the hook **126** is fully extended, it engages the cord **132**. A weft carrier **134** passes through the shed to a position shown in phantom and denoted by the reference numeral **134'** and then retracts looping a weft thread **136** around the hook **126**. The latch needle **122** retracts so the loops **128** and **130** engage and close the latch **124**. As the latch needle **122** continues to retract, it pulls both the weft thread **136** and the cord **132** through the weft loops **128** and **130**. These operations repeat and knit the cord **132** into the loops.

Pulling the cord **132** and the weft thread **136** from the last cable end to be woven unravels the weft thread from the warp. Once the proper amount of weft has been removed, further unravelling is prevented by one of two procedures. In a first procedure, the weft thread is pulled generally transversely to the cable from the other selvage to move the free end of the cord **132** through the next weft loop. With the second procedure, the free end of the cord **132** is pulled back through the preceding loop. Either procedure locks the cord **132** and weft thread **136** to prevent further unravelling. At the other end of the cable, the weft termination is cut at the proper position along the warp. Then the weft between that position and the other cable end is unravelled back to the end of the cable. The succeeding coil and weft loops lock the remaining cord **130** to a weft thread **136** to prevent unravelling between the ends.

Different looms can produce various cable configurations in accordance with this invention. The single warp conductors in a cable may actually comprise two or more diverse conductors. In FIG. 4, a twisted pair of conductors constitute one warp conductor **140**; a shielded conductor **142** is another warp conductor; and single wire conductors **142** and **146** of different sizes constitute other warp conductors. Furthermore, optical and electrical conductors or hydraulic tubing can all be combined in a single cable.

The insulation on the individual conductors shown in FIG. 4 provides the primary spacing control. The weft threads may vary the spacing to a certain degree by varying the weft thread weight or by changing the weaves. Normally, the weft or weave are constant for a given cable. Therefore, the relative lateral positions for each conductor remain substantially fixed to facilitate conductor identification.

It is also possible to weave a flat cable with fastening devices to facilitate subsequent installation. For example, spaced grommets or eyelets can be woven into the cable during manufacture. Once they are woven into the cable, the grommets or eyelets can be placed on hooks or pins during installation or otherwise be affixed to supports in the final installation.

There are several methods available for identifying individual conductors with my cable because the relative conductor positions are constant. For example, the weft termination provides identification for cables woven on needle looms. Alternatively, a uniquely color coded selvage can identify all the conductors. Additional color codes may also be used. However, color coding may be confusing when a cable comprises a large number of conductors. This confusion can be overcome by printing numbers or symbols directly onto the conductor insulation.

In prior cables, a printing head stamps the identification on an individual conductor before the cable is formed. During the weaving operation, however, the conductors may twist and obscure the identification in the cable. My cables, on the other hand, can be printed after the cable is woven because the improved conductor spacing obtained with these cables substantially eliminates printing registration problems present in prior cables. An example is shown in FIG. 4 where alternate conductors are printed by transferring a woven cable past a printer. These symbols are always visible because the individual conductors do not twist after they are woven.

In summary, I form woven cables from electrical or optical conductors or hydraulic tubing which constitute the active warp. It will be obvious that various weaving methods and apparatus can implement the invention and that the specific cable construction can vary while the advantages of this invention are still realized. Therefore, it is the object of the appended claims to cover all such modifications as come within the true spirit and scope of this invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A woven cable comprising:

A. at least one warp section, each warp section consisting of warp conductors, and

B. a resilient weft thread woven into said warp conductors, said weft thread having a transverse dimension significantly less than a like dimension of a warp conductor.

2. A woven cable as recited in claim 1 wherein said conductors comprise electrical conductors.

3. A woven cable as recited in claim 1 wherein certain of said conductors include identifying marks spaced along their length.

4. A woven cable as recited in claim 1 including first and second selvages, said weft thread being woven into said warp at said first selvage, and forming weft loops at said second selvage, said cable additionally comprising means for interlocking adjacent of said weft loops.

5. A woven cable as recited in claim 1 including first and second selvages, the weft thread being woven into said warp at said first selvage and forming interlocked weft loops at said second selvage.

6. A woven cable comprising:

A. at least one warp section, each warp section consisting of warp conductors, and

B. a resilient weft thread woven into said warp sections, said weft thread having a transverse dimension significantly less than the like dimensions of a warp conductor, said woven cable having first and second selvages and said weft thread being woven into said warp at said first selvage and forming interlocked weft loops at said second selvage.

7. A woven cable as recited in claim 6 additionally including separate means for interlocking adjacent of said weft loops at said second selvages.

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