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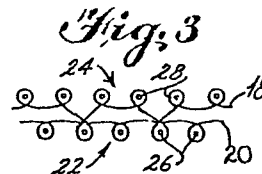
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54 **Conductive continuous filament in a stretch fabric.**

57 A fabric (10) having both electrically conductive and elastomeric properties is formed by interlacing at least one yarn into a series of interlocking loops, preferably knitted or woven. This electrically conductive yarn (20) includes an end having an electrically conductive continuous filament. It is preferred that an electrically conductive yarn (20) and an insulating yarn (18) are interlaced together to form a series of interlocking loops. The insulating yarn includes an end having an insulating fibre. Although both the electrically conductive continuous filament and the insulating fibre may have inherent stretch characteristics, an elastomeric fibre may be interlaced, knit or woven into the fabric. The electrically conductive yarn (20) and the insulating yarn (18) may be knit together on two levels forming a face (22) and a back (24) with the electrically conductive yarn forming interlocking loops on the face (22) while the insulating yarn forms interlocking loops on both the face (22) and back (24).



CONDUCTIVE CONTINUOUS FILAMENT IN
A STRETCH FABRIC

The present invention relates generally to antistatic devices and more particularly to a fabric having both conductive and elastomeric properties.

Generally, a need exists for devices to control the electrostatic charge accumulation on the body or person of an individual. Certain individuals occupy areas or handle materials in which an electrostatic discharge could either be hazardous to the individual or could damage the material being handled. Examples are individuals in the proximity of an explosive or hazardous environment and individuals who must handle static-sensitive electronic components.

Many devices have been developed to solve the problem of electrostatic charge accumulation and subsequent discharge. These include devices which have been fashioned into body straps or wrist straps to be worn by the particular individual involved. These body straps or wrist straps are then adapted to be connected to a ground potential, possibly through a predetermined resistance, in order to dissipate the electrostatic

charge accumulation on the individual and to prevent additional electrostatic charge accumulation. These devices operate by draining off any accumulated electrostatic charge from the individual.

One such device is the Model 2064 wrist strap manufactured by Minnesota Mining and Manufacturing Company (3M), Minnesota, USA. The Model 2064 wrist strap consists of a Velostat (trademark) strip held on the wrist with a band of nylon. Velostat conductive material is a carbon-loaded conductive polymer. The operation of the wrist strap relies on the conductive polymer to conduct electrostatic charge via the individual's wrist to a ground cord secured to the wrist strap with an electrically conductive snap connection. The wrist strap relies on a hook-and-loop fastener system [e.g. a Scotchmate (trademark) fastener or a Velcro (trademark) fastener] to secure the wrist strap to the wrist of the individual wearer.

A woven wrist strap manufactured by Semtronics Corporation, Georgia, USA uses a discontinuous stainless steel fibre and polyester fibre spun into a yarn which is interlaced on one side of the fabric. It is secured to the wrist with a hook-and-loop closure system.

A wrist strap manufactured by Simco, Pennsylvania,

USA also uses a similar system. The entire band of the wrist strap is made of a nylon hook-and-loop fastener system. The Simco wrist strap has a carbon-loaded conductive material secured to the inner surface of the hook-and-loop fastener. A snap connection is provided for a ground cord. The Simco wrist strap again relies on the conductive polymer for conducting the electrostatic accumulation on the individual to the snap connection and to the grounding cord. Similarly, the Simco wrist strap also relies on a hook-and-loop fastener for the closure system.

A wrist strap manufactured by Wescorp of Mountain View, California, USA consists of a carbon-loaded conductive fabric with a hook-and-loop fastener. The Wescorp wrist strap relies on the conductive fabric for the conduction of electrostatic charge from the individual instead of the conductive polymer as in the previous straps but again relies on the hook-and-loop fastener for the closure system. The Wescorp strap also utilizes the conductive fabric for a connection to ground rather than a connection point to a ground wire.

A strap manufactured by Walter G. Legge Company, New York, USA carrying the name "WRISTSTAT" uses a black nylon band with a hook-and-loop fastener. A conductive polymer is attached to the band with a metallic plate at

a relatively narrow location around the strap. The conductive polymer also has a snap connection to a ground cord. The Legge wrist strap relies on the metal plate and the conductive polymer for conductivity and relies on the nylon band with the hook-and-loop fastener for the closure system.

The straps heretofore described are all very similar in nature. Almost all rely on a carbon-loaded conductive polymer and the remainder on a carbon-loaded fabric. All of the wrist straps rely on a hook-and-loop fastener for a closure system. The use of a carbon-loaded conductive material, while electrically functional, yields a structure black in colour which is aesthetically not appealing, although the Simco wrist strap limits the black colour to the interior surface of the nylon band, which otherwise can be coloured as desired. Most importantly, however, all of the wrist straps rely on the firmly intimate contact of a conductive member to the body or person of the individual. A detachable and adjustable closure system must be adjusted individually by the wearer each time the strap is put on. Proper adjustment is required for proper functioning of the strap. This adjustability necessarily means that it can also be adjusted improperly. Proper functioning then demands that the wearer be trained and skilled in the proper adjustment

and have the incentive to adjust the strap properly every time it is worn. In any event, the wearer's supervisors can never be sure of proper installation and proper performance consistently. Particularly in an area where sensitive electronic components are being handled, the result may be a degradation of component reliability since the improper adjustment and loss of function of the strap may result in damage to the sensitive electronic components which may not become apparent until installed and used by the ultimate customer of those components.

Wescorp also has a strap consisting of a metallic bead chain to which an electrical ground cord is slideably attached. The strap relies on the metallic beads for conductivity. Since it is worn loosely around the wrist, it can be made large enough to slip over the hand onto the wrist and thus no detachable closure is required. This strap, however, does suffer from the same improper adjustment problems of previous straps since its electrical connection is not ensured since the strap does not intimately contact the body (wrist) of the individual wearer.

Controlled Static Company, Santa Fe, California, USA manufactures a wrist strap known in the trade as a "Fred strap". The strap is a metallic expansion band having a

snap connection for an electrical ground cord. The band is reminiscent of a metallic expansion watchband. The band relies on the conductivity of the metal for the drainage of the accumulated electrostatic charges and will expand to slip on the wrist over the hand and then fit relatively snugly. However, the wrist strap suffers the disadvantage of a relatively low expansion ratio. The strap must be large enough to slip over the hand, yet small enough to fit snugly on the wrist.

The two previous metallic straps also suffer another significant disadvantage. Since the highly conductive metallic surface is available at the outside surface of the wrist strap, there is a danger of accidental contact with a high voltage source and the resultant "welding" of the strap to that source preventing disengagement of the wearer from the high voltage source. It is for this reason that some electricians do not wear metallic rings, bracelets and other jewelry.

Another wrist strap manufactured by 3M is the subject of U.S. Patent No. 4,398,277. This wrist strap is made of a fabric having at least an electrically conductive yarn, and preferably an insulating yarn interlaced together. The strap is made by knitting the yarns together. One or both of the yarns is also preferably plaited with an end having an elastomeric

fibre. The electrically conductive yarn consists of a yarn containing polyester fibres and a multiplicity of staple stainless steel fibres. The strap is made by forming the fabric into a closed loop by means of a mechanical connection.

This wrist strap suffers from several significant disadvantages. The electrically conductive fibre contains small, separate, discontinuous metal fibres, that is, stainless steel staple. These metal fibres have no ability to stretch or recover and, when subjected to stretching and flexing during use, break and fall out of the fabric. This causes the wrist strap to lose its effectiveness as an electrostatic charge dissipator. Also, any metal fibres which fall out of the fabric and onto sensitive electrical equipment can cause that equipment to short circuit or discharge, resulting in damage to the equipment. Further, because of the lack of elasticity of the electrically conductive fibre, the wrist strap can eventually stretch out of shape and no longer fit snugly on the wrist.

The present invention solves the problems with the prior conductive fabrics and straps. An electrically conductive, elastomeric fabric comprises at least one interlaced yarn, said yarn including an end having an electrically conductive, coated, crimped, continuous

filament, whereby said fabric has both elasticity and electrical conductivity. It is contemplated that the interlacing of the yarn includes an interlacing to form a series of interlocking loops and preferably that the interlacing is by knitting or weaving.

In a preferred embodiment, the fabric includes an electrically conductive yarn, an insulating yarn, and an elastomeric fibre interlaced together to form a series of interlocking loops. The electrically conductive yarn includes an end having an electrically conductive continuous filament and the insulating yarn includes an end having an insulating fibre. The result is a fabric which has both electrical conductivity and excellent elasticity. In a preferred embodiment, the electrically conductive yarn, the insulating yarn, and the elastomeric fibre are knitted together to form a face and back. The insulating yarn then forms interlocking loops on both the face and the back while the electrically conductive yarn forms interlocking loops on said face and the elastomeric fibre is knitted through the interlocking loops of the insulating yarn so that it is between said face and back.

The fabric may then be constructed into a conductive body strap by means of a mechanical connection coupled to the fabric and forming the fabric into a closed loop

with an inside electrically conductive surface adapted to contact the body. An electrical connection is then coupled to the fabric for contacting the electrically conductive fibre and providing a connection point for an electrical cable capable of electrically connecting the body strap to ground.

A fabric or body strap so constructed has superior performance over those illustrated in the prior art. The electrically conductive continuous filament does not contain separate pieces of metal which can fall out. Instead, it is composed of a crimped, thermoplastic continuous filament which is plated with a conductive metal coating. This coating does not rub or wear off thereby avoiding the problems caused by the 3M fabric disclosed in U.S. Patent No. 4,398,277. Further, if silver-coated filament is used, this filament has a much lower resistance than the 3M stainless steel/polyester yarn. Also, the electrically conductive continuous filament as well as the insulating fibre have inherent stretch and recovery properties, because they are crimped or texturized thermoplastic fibres, which eliminates the need for plaiting with elastomeric fibre. The thermoplastic fibres have memory and, by texturizing or crimping, stretch characteristics are imparted to those fibres. Further, the fabric provides a strap which does not need a detachable and adjustable

closure system. The strap constructed of the fabric has sufficient elasticity to slip over the hand and fit snugly on the wrist without individual adjustment each time a new wearer is fitted with a new strap. The fabric can be constructed into a strap which needs no adjustment by the individual, and hence, the individual cannot put it on wrong with the resulting improper function. This gives assurance to the supervisor of the proper function of the strap and assures that product quality is not downgraded due to the lack of functionality of the strap. The strap is lightweight, flexible, comfortable, and the knitted fabric breathes, preventing unacceptable heat and moisture buildup. When the fabric is knitted into two layers, the fabric also provides an exterior surface which is relatively insulating and which will not "weld" upon an accidental contact with a high voltage potential.

The invention is further illustrated with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of the completed fabric;

Fig. 2 is a perspective view of the fabric completed into a strap with an electrical ground cord connected;

Fig. 3 is an end cross-sectional view of the fabric showing a preferred interlacing; and

Fig. 4 is an exploded view of the mechanical and

electrical connector.

Fig. 1 shows a perspective view of the conductive and elastic fabric 10. The fabric 10 has at least one interlaced yarn preferably interlaced together to form a series of interlocking loops and more preferably knitted or woven together. The one yarn has an end of an electrically conductive fibre. The fabric 10 can also have two yarns and this construction is generally preferred. With two yarns, one yarn can be an electrically conductive yarn and the second yarn can be an insulating yarn. Again, the electrically conductive yarn and the insulating yarn are interlaced together to form a series of interlocking loops and preferably knitted together. The insulating yarn includes an end having an insulating fibre and the electrically conductive yarn has an end having an electrically conductive continuous filament. Another preferred embodiment has two yarns and an elastomeric fibre. The electrically conductive yarn, the insulating yarn, and the elastomeric fibre are interlaced together to form a series of interlocking loops and preferably knitted together. The insulating yarn includes an end having an insulating fibre and the electrically conductive yarn has an end having an electrically conductive continuous filament.

In a preferred embodiment, the fabric is knit together utilizing an electrically conductive yarn and an insulating yarn, and an elastomeric fibre. The insulating yarn contains an end having an insulating fibre. The electrically conductive yarn contains an end having an electrically conductive continuous filament. In particular, the insulating yarn consists of 2 ply, 100 denier texturized nylon. Any continuous filament, texturized polyester or polyamide fibre would be useful, however. The electrically conductive yarn more particularly consists of 27 denier, 7 filament, X-STATIC (X-STATIC is a trademark of and manufactured by Sauquoit Industries, Inc.) yarn plaited over 150 denier texturized polyester. It consists of a yarn comprising a plurality of metal-coated crimped filaments. X-STATIC yarn is described generally in U.S. Patents Nos. 3,792,520, 3,877,965, and 4,042,737. The elastomeric fiber is 184 denier bare spandex or 38 gauge rubber. Spandex (as defined in Whittington's Dictionary of Plastics, First Edition, 1968, sponsored by the Society of Plastics Engineers, Incorporated, and published by the Technomic Publishing Company, Incorporated, 750 Summer Street, Stanford, Conn, USA) is a generic name for a manufactured fibre in which the fibre-forming substance is a long chain synthetic polymer comprising at least 85% of a segmented polyurethane.

Fig. 2 shows a perspective view of the fabric 10 formed into a closed loop by a connector 12. The connector 12 provides both the mechanical connection closing the fabric 10 into the closed loop and also provides the electrical connection from the ground cord 14 to the electrically conductive fibres of the fabric 10. The body strap 16 consists of both the fabric 10 and the connector 12. Although not required, it is preferred that the body strap 16 not be coupled to ground directly with ground cord 14, but be coupled in series through a predetermined resistance, preferably approximately 1 megohm. In the case of accidental contact of the ground cord 14 with a voltage source or in the case of accidental contact of the wearer with a line voltage, the presence of such a resistance would help prevent electrical shock injury to the wearer of the body strap 16.

Fig. 3 represents an end view of a cross-section of the fabric 10 showing the preferred knit structure of the fabric 10. Fig. 3 shows insulating yarn 18 and electrically conductive yarn 20. Insulating yarn 18 and electrically conductive yarn 20 are being knit together on two levels to form a face 22 and a back 24. The insulating yarn 18 forms a series of interlocking loops on both the face 22 and the back 24. Electrically conductive yarn 20 forms a series of loops on face 22.

Insulating yarn 18, in a preferred embodiment, is the same yarn as described in relation to Fig. 1 as 2 ply, 100 denier texturized nylon. Similarly, electrically conductive yarn 20 in Fig. 3 is the same yarn as was described in relation to Fig. 1 for fabric 10, being 27 denier, 7 filament X-STATIC yarn plaited over 150 denier texturized polyester. Fig. 3 shows a series of needles 26 on a first level forming a series of interlocking loops on the face 22 and another set of needles 28 on a second level performing a series of interlocking loops on the back 24. Thus, Fig. 3 represents the needle set-up required to knit the preferred structure of the fabric 10. It is contemplated that a 10-cut border machine with at least two colour vertical stripe capability be utilized. It is also preferred that the fabric 10 be knitted with approximately 29 needles 26 and 29 needles 28. Approximately this number of needles will provide a fabric of a suitable width so that the fabric can be fashioned into a wrist strap. It is preferred that the tensions be adjusted to obtain a relaxed width of one inch (2.54 cm) with 16-18 stitches per inch (6-7 per cm). Utilizing the yarns and the fibres suggested, the preferred embodiment results in a fabric 10 with approximately 77% by weight texturized nylon, approximately 5% electrically conductive yarn and approximately 18% rubber. Another embodiment has been made, utilizing the yarns and fibres suggested, which

results in a fabric 10 with approximately 67% by weight texturized nylon, approximately 6% electrically conductive yarn and approximately 27% spandex. The needle set-out illustrated in Fig. 3 illustrates insulating fibre 18 being looped around two of the needles 28 on the back 24 surface then being looped around one of the needles 26 on the face 22 surface before again being wrapped around two of the needles 28 on the back 24 surface. The needle set-out illustrated in Fig. 3 is, of course, only a preferred embodiment. There, of course, will exist many other needle set-outs which will result in a fabric 10 having the desired electrically conductive and elastic characteristics. It is not necessary, for example, that two levels of the needles be utilized nor that the exact spacing of the loops around the needles be maintained. It is also contemplated that, while 29 face needles 26 and 29 back needles 28 are contemplated for the fabric 10, in a preferred embodiment an edge may be constructed on each side by having a further number of both face needles 26 and back needles 28 around which are looped only the insulating fibre 18.

Fig. 4 illustrates an exploded view of the connector 12 connecting two ends of the fabric 10. The connector 12 is illustrated having a body 30 which receives the two ends of the fabric 10 and which has a plurality of

projections 32 to grip the fabric 10 and hold it in place once the cover 34 is attached. The cover 34 is mated to the body 30 and held with a snap connector consisting of elements 36 and 38. These components then result in a connector 12 which provides both the mechanical and electrical connection required to the fabric 10 to form it into a closed loop and to conduct the electrostatic charge accumulation from the body of the individual wearer. Of course, many other mechanical and electrical connectors are envisioned and could be utilized. Specifically, it is envisioned that separated mechanical and electrical connectors could be utilized on a single body strap.

Fabric 10 in a length generally suitable for encompassing the wrist utilizing the electrically conductive fabric 10 will have an electrical surface resistivity of not more than 40-50 ohms per inch (15.7-19.7 ohms per cm) or not more than 10^4 ohms per square.

A body strap 16 constructed in the foregoing manner from the fabric 10 will result in a superior body strap which is sufficiently conductive, fits snug around the body and maintains a good electrical contact with the skin of the wearer, is readily expansible to easily fit into place, e.g. easily slips over the hand, maintains

its elasticity over repeated usage, and is comfortable to the individual wearer, i.e. breathable. The fabric is superior to the prior art because there are no metal pieces which can fall out of the fabric. Also, the rows of electrically conductive yarns are interconnected and, since the X-STATIC filaments making up the yarn have a continuous metal coating, there is greater electrical contact with the skin over the entire surface of the fabric.

It is contemplated that the fabric 10 can also be utilized for applications other than body straps. It is contemplated that the fabric 10 could be used for fabrics where electrical conductivity and elasticity are desired. Examples of contemplated uses include clothing, draperies, surgical gowns and other medical applications.

CLAIMS:

1. An electrically conductive, elastomeric fabric, comprising at least one interlaced yarn, said yarn including an end having an electrically conductive, coated, crimped, continuous filament, whereby said fabric has both elasticity and electrical conductivity.
2. A fabric according to claim 1, wherein said at least one yarn is interlaced to form a series of interlocking loops.
3. A fabric according to claim 2, wherein said at least one yarn is knitted.
4. A fabric according to any one of the preceding claims, wherein said electrically conductive, continuous filament is metal-coated.
5. A fabric according to claim 4, wherein said electrically conductive filament is silver-coated crimped nylon.
6. A fabric according to claim 5, wherein said electrically conductive yarn comprises multifilament, silver-coated crimped nylon plaited with texturized polyester.

7. A fabric according to any one of the preceding claims additionally comprising an insulating yarn and an elastomeric fibre, said electrically conductive yarn, said insulating yarn, and said elastomeric fibre being interlaced together to form a series of interlocking loops, and said insulating yarn including an end having an insulating fibre.

8. A fabric according to claim 7, wherein said electrically conductive yarn, said insulating yarn, and said elastomeric fibre are knitted together.

9. A fabric according to claim 7 or claim 8, wherein said insulating fibre is nylon, polyester or polyamide.

10. A fabric according to any one of claims 7 to 9, wherein said elastomeric fibre is rubber or spandex.

11. A fabric according to any one of claims 7 to 10, wherein said electrically conductive yarn, said insulating yarn and said elastomeric fibre are knitted together on a face and a back, said insulating yarn forming interlocking loops on both said face and said back, said electrically conductive yarn forming interlocking loops only on said face, and said elastomeric fibre is knitted through said interlocking loops of said insulating yarn so that it is between said face and said back.

Fig. 1

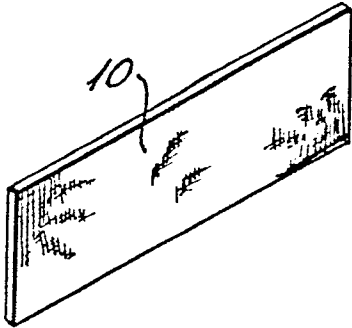


Fig. 2

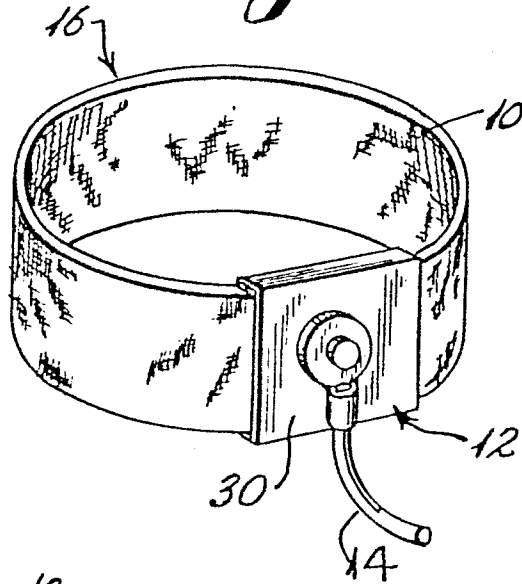


Fig. 3

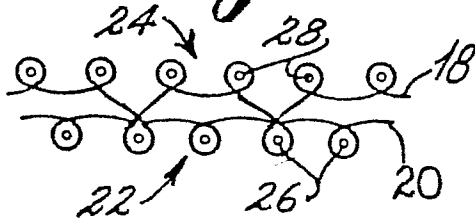
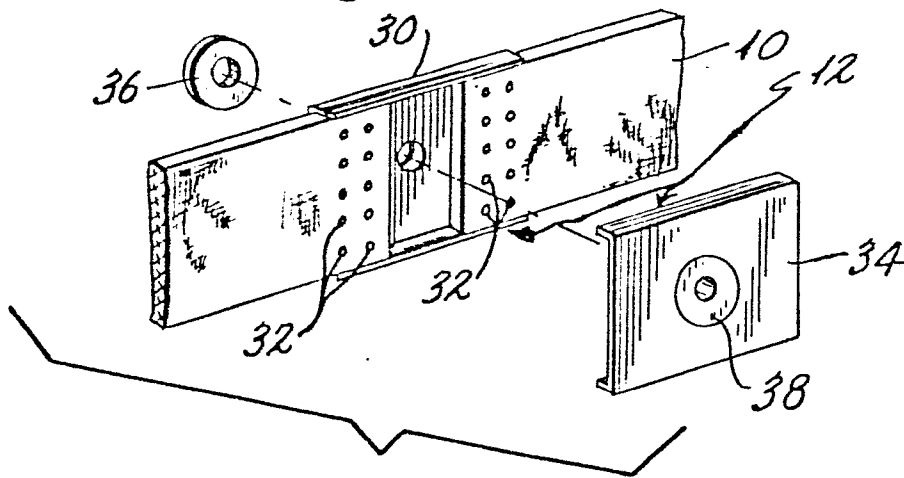


Fig. 4





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
Y	CH-A- 557 438 (TEIJIN LTD.) * Column 12, lines 35-55; column 6, line 57 - column 7, line 2 *	1	D 04 B 1/14 H 05 F 3/02
A	---	4,5	
Y,D	EP-A-0 071 342 (MINNESOTA MINING AND MANUFACTURING CO.) * Page 8, line 23 - page 10, line 5; figures 1-4 *	1	
A	---	2,3,7-11	
A	US-A-4 475 141 (ANTONEVICH) ---		
A	US-A-3 699 590 (WEBBER) ---		
A	GB-A-1 474 300 (KURARAY) ---		
A	DE-A-2 000 195 (WISSENSCHAFTLICH-TECHNISCHES ZENTRUM) -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12-03-1986	Examiner VAN GELDER P. A.
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			