

Dec. 23, 1947.

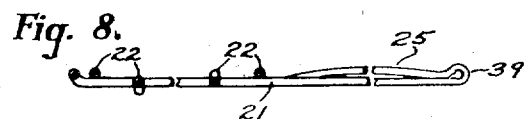
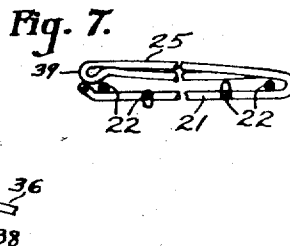
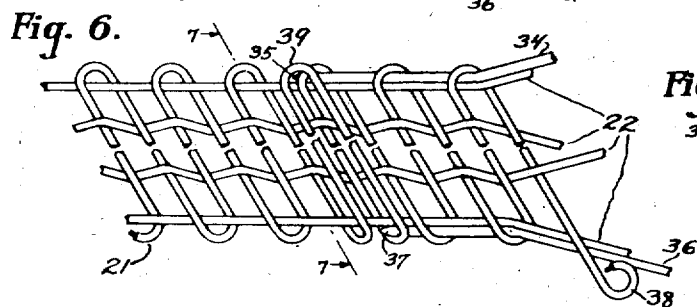
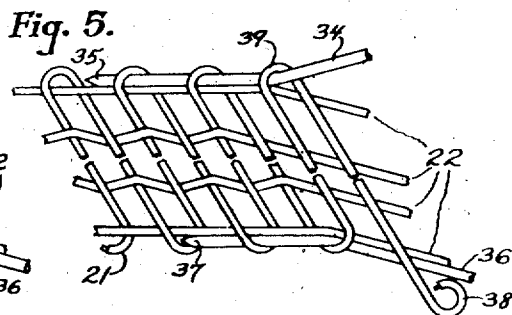
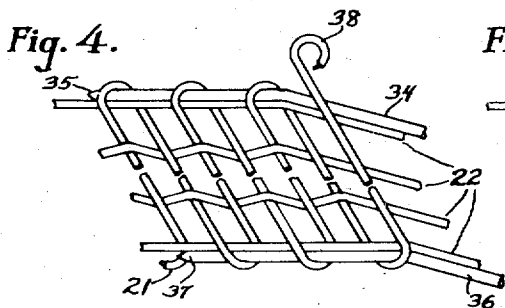
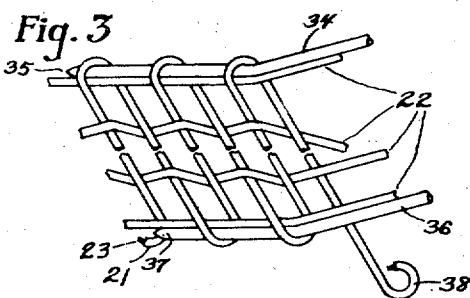
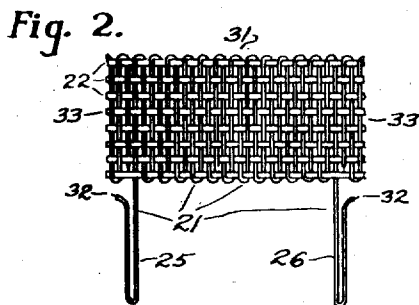
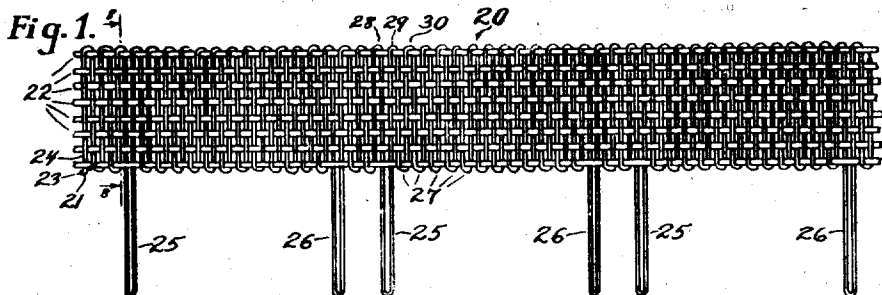
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2,433,239

ELECTROCONDUCTIVE FABRIC AND PROCESS OF MAKING THE SAME

Filed June 23, 1945

2 Sheets-Sheet 1



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ELECTROCONDUCTIVE FABRIC AND PROCESS OF MAKING THE SAME

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2 Sheets-Sheet 2

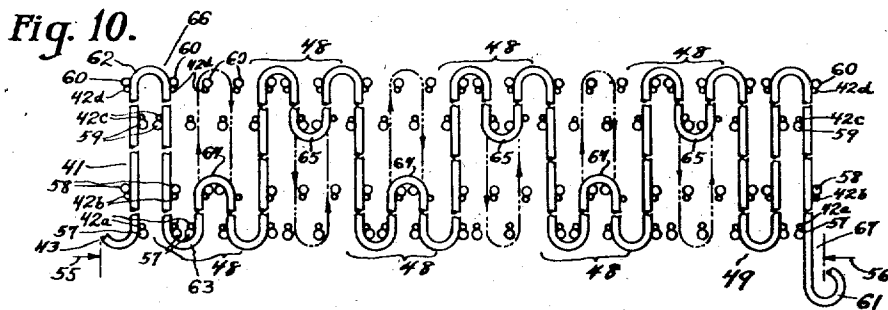
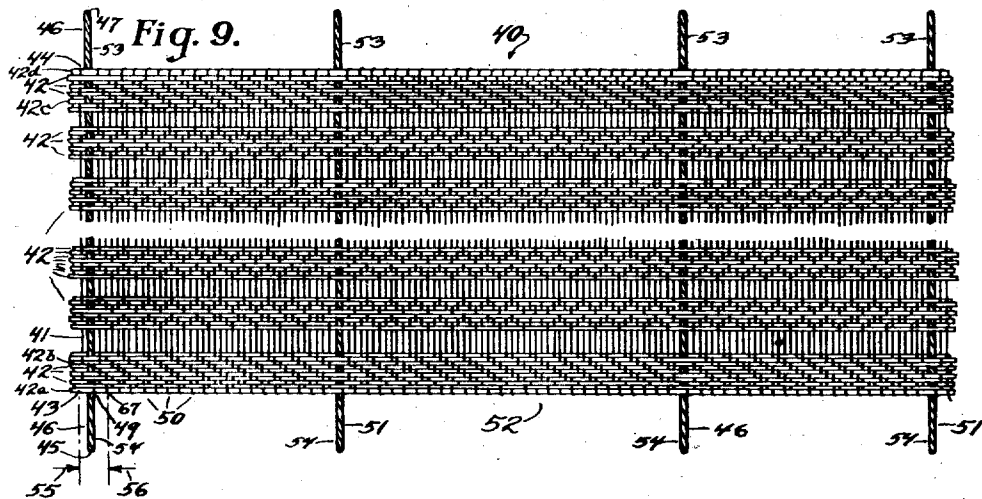
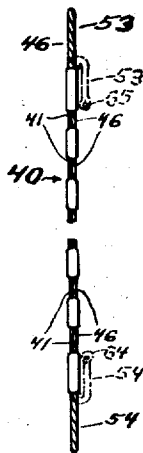


Fig. 11.



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ELECTROCONDUCTIVE FABRIC AND PROCESS OF MAKING THE SAME

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12 Claims. (Cl. 139-425)

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This invention relates to improvement in electro-conductive fabrics and process of making the same.

One object of this invention is to provide an improved electro-conductive fabric which can be manufactured in any desired length which can afterward be cut into shorter lengths for use.

Another object of this invention is to provide an improved process of making the foregoing improved electro-conductive fabric.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features in the said disclosure which are novel over the prior art.

In the description and claims, the various parts and steps are identified by specific terms for convenience, but they are intended to be as generic in their application as the prior art will permit.

In the accompanying drawings forming part of the present disclosure, in which certain ways of carrying out the invention are shown for illustrative purposes:

Fig. 1 is a face view of an electro-conductive fabric illustrating one embodiment of the present invention;

Fig. 2 is a face view of a segmental portion or unit cut from the fabric illustrated in Fig. 1, and which is in condition for one use in accordance with the present invention;

Fig. 3 is a schematic perspective view illustrating the mode of weaving the fabric illustrated in Fig. 1;

Fig. 4 is a schematic perspective view similar to Fig. 3 but illustrating a further stage of the weaving operation;

Fig. 5 is a schematic perspective view similar to Fig. 4 but illustrating a still further stage of the weaving operation;

Fig. 6 is a schematic perspective view similar to Fig. 5 but illustrating a still further advanced stage of the weaving operation;

Fig. 7 is a sectional view on line 7-7 of Fig. 6;

Fig. 8 is a view similar to Fig. 7 but with the loop swung over to an opened-out position, and is also a sectional view on line 8-8 of Fig. 1;

Fig. 9 is a face view of an electro-conductive fabric illustrating another embodiment of the present invention;

Fig. 10 is a schematic view illustrating the mode of weaving the fabric illustrated in Fig. 9; and

Fig. 11 is a left-end view of the fabric shown in Fig. 9.

In carrying out the invention in the way illustrated in Figs. 1 to 8 inclusive of the drawings, the electro-conductive fabric 20 is formed by interweaving a weft-strand or weft 21 with warp-strands or warps 22. The weft-strand 21 is an electro-conductive strand formed of an electro-conductive wire 23 which may or may not be

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provided with a covering material 24. The warp strands 22, and the covering 24 of the weft strand 21 can be formed of any suitable material or materials. Where such covering material is to have an insulating character it could, for example, be of glass fiber, asbestos, cotton or other suitable insulating material. Depending upon the use to which the fabric is to be put, the wire 23 can, for example, be of copper, Nichrome, or other suitable conductive material.

It will be noted that in Fig. 1 the weft-strand 21 is formed with pairs of loops or loop-portions 25 and 26 which are not interwoven with the warp-strands 22, and the weft-strand 21 is also formed with loops or loop-portions 27 which are interwoven with the warp-strands 22. A portion of the weft-strand 21 which extends from a location such as 28 to location 29, and includes a loop-portion such as 25 or 26 not interwoven with warp-strands 22, is a looped reach, and a portion of the weft-strand 21 which extends from a location such as 29 to a location 30, and includes a loop-portion such as 27 interwoven with warp-strands 22, is also a looped reach. Fig. 2 illustrates a single operative electro-conductive unit 31 separated from the fabric illustrated in Fig. 1 by cutting the fabric 20 of Fig. 1 between each two closely-adjacent loop-portions 26 and 25 to provide a plurality of units similar to that illustrated in Fig. 2, each unit 31 also having the weft-strand portion forming each of its loops 25 and 26 severed at 32 to provide convenient long leads for connection to an electric source of current, for example, for passing electric current through the weft-wire 21 to thereby heat substantially the entire area of the unit 31 between the pair of loops 25 and 26 substantially uniformly. The fragmental woven portions 33 at the opposite ends of the unit are not heated, and may conveniently be employed for clamping or otherwise aiding in securing the unit in position, or they may be cut off. One use of such a heating-unit, for example, is for heating the portion of a camera containing operating mechanism, in order to maintain the operating mechanism in good and uniformly easy-operating condition even at the low temperatures encountered in an airplane high in the air.

The fabric 20 illustrated in Fig. 1 can be woven on a loom of usual construction, provided there is added thereto, at least one temporary forming- or holding-member such, for example, as 34 (Figs. 3 to 6). The forming-member 34 is preferably in the form of a wire or wire-like member which may conveniently be of piano wire or other spring wire which may, for example, have a diameter of about $\frac{1}{16}$ of an inch. The forming-wire 34 has its right-hand end (not shown) attached to a suitable fixed part of the loom (not shown) and has its free left end 35 ex-

tending to the left in the general direction of feed of the fabric toward the take-up roll (not shown), as the fabric is woven on the loom. A similar forming-wire 36 is preferably also fastened to a fixed part of the loom and has its free left end 37 also extending to the left in the general direction of the feed of the fabric as it is woven.

The wire-like forming-members 34 and 36 extend from their places of attachment to the loom at the right (not shown), forwardly to the left of Fig. 3 through the eyes of heddles of harness-frames (not shown) the same as is true of the warp-strands 22, so that the various warp-strands and wire-like forming-members 34 and 36 can be properly shedded for the weaving operation, all as will be understood by those skilled in the art. The wire-forming members 34 and 36 extend along the opposite outside warp-strands 22 as will be seen in Fig. 3. The shuttle which carries the weft-strand 21 is schematically indicated at 38. Before the shuttle 38 moves from its position indicated in Fig. 3 to the position indicated in Fig. 4, the warp-strands 22 and the wire forming-members 34 and 36 will all be placed in the downshedded position shown in Fig. 4, whereupon the shuttle 38 is moved across from its position illustrated in Fig. 3 to its position illustrated in Fig. 4. Before the shuttle 38 moves back from its position in Fig. 4 to its position in Fig. 5, the wire forming-member 34 is moved from its downshedded position of Fig. 4 to its upshedded position of Fig. 5, whereupon the shuttle 38 is moved back across the fabric being woven to its position shown in Fig. 5, thus causing the weft-strand 21 to be looped at 39 about the forming-wire 34 so that from the time the shuttle 38 left its position shown in Fig. 3 to pass across the fabric to its position of Fig. 4 and then return again to its position of Fig. 3 as shown in Fig. 5, the weft-strand 21 has been engaged around only a single member, namely, the forming-wire 34. As the shuttle 38 is passed back and forth across the fabric 20 being woven, the various warp-strands and the wire forming-members 34 and 36 will be shedded in a way that will be evident from the several successive picks that are illustrated as having been formed in Fig. 6. As the fabric 20 is woven it moves to the left from the position shown in Fig. 3 to that shown in Fig. 6 in a way well known to those skilled in the art. As it moves to the left, all of the fabric moves, but it will be noted that the two forming-wires 34 and 36 do not move, but that the loops of the weft-strand slide along off of the ends 35 and 37 of the wires 34 and 36. Thus it will be seen that as illustrated in Fig. 6, the loop 25 in the weft has not been woven with any of the weft-strands as shown in Fig. 6, is entirely free of restraint by the wires 34 and 36 so that it can spring up slightly due to the inherent slight spring in the wire core of the weft 21, to some such position as shown in Fig. 7, from which position it can be swung or bent from its position shown in Figs. 6 and 7 to its position shown in Figs. 1 and 8.

The modified form of electro-conductive fabric 40 illustrated in Figs. 9 to 11 is formed by interweaving a conductive weft-strand 41, with warp-strands 42 arranged in a plurality of groups. In the particular fabric illustrated, the weft-strand 41 is a relatively fine bare wire, and the warp-strands 42 are of asbestos. The width of a sample of fabric similar to that illustrated, is about six inches, and has twelve groups of warps instead of

the six groups illustrated in Fig. 9. This particular fabric is useful in connection with radar.

In weaving the fabric 40, the weft-strand 41 is woven back and forth between the warps in any suitable way as for example that illustrated, with the weft-strand 41 extending from its extreme lower left location 43 in Fig. 9, up to the top location 44 where it is looped over the top warp-strand 42d in Figs. 9 and 10 and then extends down to the lower end 45 of, and as part of, the cable-bar or cable-length 46, and then extends up to the top 47 of the cable-length 46, and then similarly extends down and up or back and forth several additional times to completely form the cable-length 46, as will be more fully hereinafter described in connection with Fig. 10. During this weaving of the cable-length 46 portion of the fabric 40, the feed of the fabric toward the left is stopped, and the warps are preferably so shedded that the back and forth bunched-together looped reaches 48 (Fig. 10) of the cable-length 46 can be twisted together (by hand or otherwise) to form the single, unitary cable-length 46 in twisted form as illustrated in Fig. 9. After all the bunched-together looped reaches 48 have been woven-in to form the cable-length 46, the feed of the fabric is again started and the weft-strand 41 leaves the cable-length 46 at 49 and is woven back and forth to form spaced-apart looped reaches 50, and this weaving action continues until the location for the next cable-length 51 is reached, when the feed of the fabric is again stopped until the cable-length 51 is completely woven-in, whereupon the feed of the fabric is again started until the location for the next cable-length 46 toward the right is reached, which corresponds to the first cable-length 46 at the extreme left of Fig. 9.

After the fabric is woven, it can be cut across between each two nearer-together cable-lengths 46 and 51 to divide the fabric up into units similar to the way described concerning Figs. 1 and 2, so that each two farther-apart cable-lengths 51 and 46 form the electric terminals for each unit 52.

The cable-lengths 46 and 51 have been described as though they were woven in their fully-extended form shown in Fig. 9, and they could be so woven by having two forming-wires extending parallel to the warps, with each forming-wire extending at right angles to the cable-lengths and respectively extending through the opposite looped ends of the cable-lengths, in a way similar to the way the fabric 20 of Figs. 1 to 8 could be woven with the loops 25 and 26 opened out in the position shown in Fig. 8 by having a forming-wire extend through the loop 39 thereof instead of weaving it as illustrated in Figs. 3 to 6.

But it is advantageous to weave the cable-lengths 46 and 51 with their opposite end-portions 53 and 54 in the temporarily bent-in positions shown in broken-line outline in Fig. 11, and this mode of weaving will now be described.

Referring to Figs. 9 and 10, the weft-strand 41 schematically shown in Fig. 10, between the arrows 55 and 56 of Fig. 10, is schematically illustrative of the weaving of the portion of the fabric 40 in Fig. 9 between the corresponding arrows 55 and 56. In other words, most of Fig. 10 is illustrative of the weaving of the cable-length 46 at the left of Fig. 9, with the cable-length woven with its end-portions 53 and 54 temporarily bent-in or extending over, the body of the fabric 40 as illustrated in dotted lines in Fig. 11.

Referring to the schematic Fig. 10, only four warp-strands, namely, the two opposite outside,

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and two of the intermediate, warp-strands are illustrated, and beginning at the bottom of Fig. 10, these four warp-strands are numbered 42a, 42b, 42c and 42d. Also respectively adjacent each of the said four warp-strands are four forming-wires 57, 58, 59 and 60, each of which forming-wires is similar to, and extends in similar manner to, the forming-wires 34 and 36 illustrated in Figs. 3 to 6.

Owing to the several back-and-forth picks which are woven in or laid in at a single location while the fabric is not being fed toward the take-up roll (not shown) in order to form each cable-length 48 and 51, it is not possible to illustrate this weaving action by the simple pictorial schematic method employed in Figs. 3 to 6, but a more difficult method must be employed as in Fig. 10. As the weft 41 extends up and down in Fig. 10, when a warp or forming-wire is shown adjacent the left side of the weft 41, it is intended to indicate that the weft extends over the top of the warp or forming-wire, and when a warp or forming-wire is shown adjacent the right side of the weft 41, it is intended to indicate that the weft extends under the warp or forming-wire.

Starting with the weft-wire 41 at the extreme lower left location 43 in Fig. 10, as the shuttle 61 which carries the weft 41, passes horizontally across (upward in Fig. 10) through the shed formed by the warps and forming-wires, it goes under the forming-wire 57 and warp 42a, over warp 42b and forming-wire 58, under forming-wire 59 and warp 42c, and over warp 42d and forming-wire 60. Before the shuttle carrying the weft 41 makes the reverse movement (down in Fig. 10) to weave the second pick in Fig. 10, the wire 60 and warp 42d are shifted from the lower shed beneath weft 41 to the upper shed above weft 41, thus causing the loop 62 of weft 41 to loop around wire 60 and warp 42d at the start of weaving the second pick, and after the shuttle has passed beneath warp 42a and wire 57 at the bottom of Fig. 10 to complete the second pick, the warp 42a and wire 57 are shifted from the upper shed above weft 41 to the lower shed beneath weft 41, thus causing the loop 63 of weft 41 to loop around wire 57 and warp 42a. During the time that the shuttle weaves both the third and fourth picks, no warp changes its shed position and the only wire which changes its shed position is wire 58, which shifts from above weft 41 to below weft 41, thus causing the weft 41 to form a loop 64 around the wire 58 only, as part of the broken-line-indicated bent-in portion 54 (Fig. 11).

In similar manner, each of the loops 65 is looped around the forming-wire 59 as part of the broken-line-indicated bent-in portion 53 (Fig. 11), and each of the remaining loops 64 is looped around the forming-wire 58 as part of the broken-line-indicated bent-in portion 54 (Fig. 11). As hereinbefore stated in connection with Fig. 9, while the shuttle 61 is weaving the weft 41 from the location 66 at the upper left of Fig. 10 to the location 49 at the lower right of Fig. 10, there is no movement or travel of the fabric to the left toward the take-up roll (not shown), and therefore all of this portion of the weft 41 will be laid in or woven in at one location to form the cable length or cable-bar 46 at the left of Fig. 9. Extending from the location 66 to the location 49 in Fig. 10 are six bunched-together looped reaches 48.

From the time the weft 41 proceeds beyond the location 49, the fabric is fed to the left toward the

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take-up roll (not shown), thus causing the formation of spaced-apart looped reaches 50 of the weft 41 until the location of the next cable-length 51 is reached, which is woven in the same way as was previously described for the cable-length 46. Each of the spaced-apart looped reaches 50 extends a distance equal to that from the location 49 to the location 67.

The remainder of the fabric 40 to the right of Fig. 9 is woven in the same manner as has been hereinbefore described concerning correspondingly similar parts of the fabric.

As the fabric travels toward the left toward the take-up roll (not shown), and as the forming-wires 57, 58, 59 and 60 are longitudinally stationary and arranged similarly to the forming-wires 34 and 36 shown in Figs. 3 to 6, the loops 64 and 65 slide off the ends of their respective forming-wires 58 and 59 to thus completely free the loops 64 and 65, thus permitting of the end portions 54 and 53 which are respectively formed by the loops 64 and 65, being bent from their broken-line positions to their full-line positions and twisted (Fig. 11).

Any electro-conductive fabrics made in accordance with the present invention may be woven of indefinite length and of any desired width, and the warp-strands may have any desired regular or irregular arrangement, and the panels, and the panel-like portions between the panels, can be of any dimensions desired.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

I claim:

1. An electro-conductive fabric comprising: warp-strands; and an electro-conductive weft-strand extending back and forth and forming looped reaches in interwoven relation with said warp-strands, and each of said reaches being approximately equal in cross-sectional area to each of the others of said reaches; certain of said reaches being spaced-apart warpwise of the fabric, and certain others of said reaches being arranged in bunched-together relation as a bunch at each of a plurality of spaced-apart locations, at least a plurality of the reaches of each of said bunches each being of a length at least equal to the length of said spaced-apart reaches.

2. An electro-conductive fabric comprising: warp-strands; and an electro-conductive weft-strand extending back and forth and forming looped reaches in interwoven relation with said warp-strands, and each of said reaches being approximately equal in cross-sectional area to each of the others of said reaches; certain of said reaches being spaced-apart warpwise of the fabric, and certain others of said reaches being arranged in bunched-together relation as a bunch at each of a plurality of spaced-apart locations, at least a plurality of the reaches of each of said bunches each being of a length substantially greater than the length of said spaced-apart reaches.

3. An electro-conductive fabric comprising: warp-strands; and an electro-conductive weft-strand extending back and forth and forming looped reaches in interwoven relation with said warp-strands; certain of said reaches being

spaced-apart warpwise of the fabric, and certain others of said reaches being arranged in bunched-together relation in a single shed of warps at each of a plurality of spaced-apart locations, the length of said bunched-together reaches being substantially greater than the length of said spaced-apart reaches.

4. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands; certain of said reaches being relatively-short, and certain others of said reaches being relatively-long; a loop-portion of each of said relatively-long reaches extending inwardly over the fabric and being not interwoven with any of said warp-strands and being formed by said weft-strand being looped about a temporary forming-member inwardly beyond an edge of the fabric.

5. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands; certain of said reaches being spaced-apart warpwise of the fabric, and certain others of said reaches being arranged in bunched-together relation in a single shed of warps at each of a plurality of spaced-apart locations and being formed by said weft-strand being looped about a temporary forming-member.

6. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands; certain of said reaches being relatively-short and spaced-apart warpwise of the fabric, and certain others of said reaches being relatively-long and arranged in bunched-together relation in a single shed of warps at each of a plurality of spaced-apart locations and being formed by said weft-strand being looped about a temporary forming-member.

7. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands; certain of said reaches being relatively-short and spaced-apart warpwise of the fabric, and certain others of said reaches being relatively-long and arranged in bunched-together relation in a single shed of warps at each of a plurality of spaced-apart locations; a loop portion of each of said relatively-long reaches extending inwardly over the fabric and being not interwoven with any of said warp-strands and being formed by said weft-strand being looped about a temporary forming-member inwardly beyond an edge of the fabric.

8. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands, the said fabric being fed warpwise as it is woven; a loop portion of each of certain of said reaches being not interwoven with any of said warp-strands and being formed by said weft-strand being looped about a wire-like forming-member fixed against substantial longitudinal

movement and having a free end extending in the general direction of feed of the fabric.

9. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands, the said fabric being fed warpwise as it is woven; certain of said reaches being relatively-short, and certain others of said reaches being relatively-long; a loop portion of each of said relatively-long reaches being not interwoven with any of said warp-strands and being formed by said weft-strand being looped about a wire-like forming-member fixed against substantial longitudinal movement and having a free end extending in the general direction of feed of the fabric.

10. An electro-conductive fabric comprising: warp-strands; and an electro-conductive weft-strand extending back and forth and forming looped reaches in interwoven relation with said warp-strand; certain of said reaches being spaced-apart warpwise of the fabric, and certain others of said reaches being arranged in bunched-together relation in a single shed of warps at each of a plurality of spaced-apart locations.

11. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand of approximately uniform cross-sectional area with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands; certain of said reaches being spaced apart warpwise of the fabric, and certain others of said reaches being woven in bunched-together relation as a bunch at each of a plurality of spaced-apart locations, at least a plurality of the reaches of each of said bunches each being of a length at least equal to the length of said spaced-apart reaches.

12. The process of making an electro-conductive fabric comprising: interweaving an electro-conductive weft-strand of approximately uniform cross-sectional area with warp-strands by passing said weft-strand back and forth to form looped reaches in interwoven relation with said warp-strands; certain of said reaches being spaced apart warpwise of the fabric, and certain others of said reaches being woven in bunched-together relation as a bunch at each of a plurality of spaced-apart locations, at least a plurality of the reaches of each of said bunches each being of a length substantially greater than the length of said spaced-apart reaches.

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