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METHOD OF WEAVING ELECTRICAL RESISTANCE DEVICES

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FIG. 1.

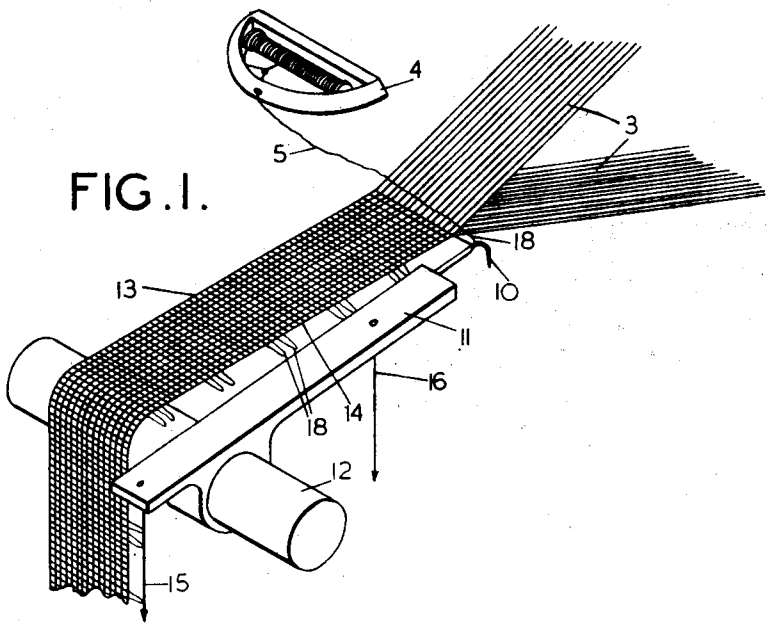
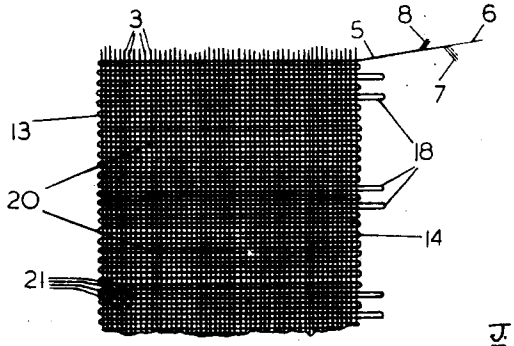


FIG. 2.



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METHOD OF WEAVING ELECTRICAL RESISTANCE DEVICES

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2 Claims. (Cl. 139—118)

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This invention relates to new or improved electrical devices and more particularly to novel electrical resistances and their manufacture, and is a continuation-in-part of our application S. No. 752,188, filed June 3, 1947.

The novel electrical resistances in accordance with the invention comprise a ribbon in the form of a plurality of sections of predetermined length woven from a warp of electrically insulating yarn and a weft comprising a resistance wire that is continuous throughout the length of the ribbon and of substantially uniform cross-section, said weft, at each end of each section, projecting beyond the edge of the ribbon in the form of a loop. When the ribbon is cut into lengths by severing it transversely between adjacent sections, the loops of weft wire so provided serve as connecting leads at each end of the cut length, by means of which the resistance constituted by the length of ribbon can be electrically connected into the circuit in which it is to be used. The number of picks of wire in each section of such a ribbon determines the resistance of that section and, in practice, it is most convenient to weave the ribbon so that the sections contain identical numbers of picks and hence are of identical resistance; resistances of various values can then be made simply by severing from a piece of such ribbon lengths containing different numbers of sections.

While the successive sections of the ribbon can be made contiguous, and can share a loop of weft-wire of which each limb serves as a connecting lead to a different section, it is preferred to provide the weft loops in pairs along one edge of the ribbon, so that the connecting lead at each end of a cut length of ribbon consists of a complete loop. Of the pair of picks of weft-wire which extend beyond the ribbon to form a loop constituting a connecting lead, one pick is included in the resistance while the other is not. In cutting the ribbon therefore, it is immaterial if this pick is damaged, a fact which facilitates cutting by allowing a margin for error. To facilitate still further the cutting of the ribbon between sections, the loops themselves, and the picks of which they form a continuation, may be separated by two further picks, or more if desired, of the weft-wire employed. When the ribbon is cut, whether into separate sections or into lengths containing more than one section, the two loops at the ends of the cut portions are cleaned, and spot welded or soldered to leads, preferably of flat wire, for connecting the resistance in circuit.

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Another feature of the present invention in addition to the novel resistances themselves, is the method of making such resistances which comprises weaving a ribbon from a warp of electrically insulating yarn and a weft comprising a continuous wire of substantially uniform section, and at intervals during weaving passing the weft, between successive picks, round a member spaced from the edge of the ribbon so as to retain a loop of the weft extending beyond the edge of the ribbon. By momentarily inserting a weft-retaining member at alternately long and short intervals, the loops can be formed in pairs, the long intervals between the pairs being the periods during which the sections of the ribbon are woven.

The invention is of particular importance in connection with the use of very fine wire of high specific resistance, for example, wire of less than 0.003" diameter and especially wire of about 0.001" diameter. The composition of the wire may be the usual nickel-chromium and copper-nickel alloys used for the manufacture of resistance wires. While the warp yarns space the weft wires apart and the ribbon could in fact be used as such, even if the resistance wire were provided with no other form of insulation, it is preferred to employ wire provided with an insulating sheath, for instance a coating of enamel, or, better still, one or more lappings of insulating yarn. The yarn used may be silk or an organic ester of cellulose, such as cellulose acetate, or regenerated cellulose, whether made from viscose or by the saponification of a cellulose acetate yarn. A particularly satisfactory product is obtained with a wire having two layers of lapping, the first being of cellulose acetate and the second of silk, the lappings being wound on in opposite directions. Where extremely fine resistance wire is used, however, e. g. of less than 0.001", it is generally more convenient to use wire having a single lapping, for example, of silk.

The warp with which the ribbon is woven can be of the same or different texture as that with which the wire is lapped. In general, there should be used a warp of less than, for example, 50 denier, and, in order to achieve the necessary fineness, it is generally desirable to use a continuous filament yarn. Especially satisfactory for the purpose is a yarn of artificial continuous filaments that have been stretched to a high degree, e. g. to 5 or 10 times their original length, in the presence of an agent adapted to facilitate stretching. The stretching operation has the effect of greatly increasing the tensile

strength of the filaments in terms of gms. per denier and also of increasing their fineness in accordance with the degree of stretch imparted. Thus, continuous filament yarns of cellulose acetate having a filament denier of 2 to 5 may be stretched in the presence of moist steam under pressure to 5, 10 or more times their original length, and the resulting fine filaments of 1 to 0.2 filament denier or less can be further reduced in weight without a corresponding diminution in their tensile strength by saponifying the substance of the filaments. Stretched and saponified fine filament yarns of this kind may also be used instead of silk as a lapping for the wire. For this purpose, however, it is preferable that, between the operation of stretching the filaments and saponifying them, they should be subjected to a shrinking treatment which, while slightly reducing their tenacity, increases their extensibility and facilitates the lapping operation.

The ribbon may be woven in any width which is suitable according to the purpose for which the resistances are required, but in general a width of about 1" has been found to have wide application. With such a width, and using 100 picks per inch of resistance wire of about 0.001" diameter, ribbons having a resistance of from 1,500 to 5,000 ohms per inch, according to the wire used, can be woven without any difficulty. Using heavier wire and/or fewer picks per inch, ribbon having a lower resistance per inch may be woven, while, with even finer wires, resistances of more than 5,000 ohms per inch can be made, e. g. with 120 picks per inch of a nickel-chrome wire of 0.0006" diameter, 1" wide ribbon having a resistance of about 15,000 ohms per inch can be made.

By way of example, one such ribbon, and the method of weaving it will now be described in greater detail with reference to the accompanying drawings in which:

Figure 1 is a perspective view of the essential elements of a ribbon loom engaged in weaving the ribbon and,

Figure 2 is a diagrammatic face view of the ribbon itself.

Example

The ribbon is woven on the loom shown in Figure 1, in which the warps are indicated at **3**, and the weft, carried by the shuttle **4**, at **5**. The warp **3** and weft **5** have the following characteristics:

Warp.—240 ends of 30 denier, 0.4 filament denier 10 turns per inch, stretched and saponified cellulose acetate yarn drawn 4 ends per dent in a 60s reed. 2 ends as one—plain weave. 2 catch threads of 2/30 denier stretched and saponified cellulose acetate yarn each side.

Weft.—100 picks per inch of 0.001" diameter "Brightray" nickel-chrome wire (indicated at **6** in Fig. 2) covered with 45 wraps per inch of 50 denier 42 filament cellulose acetate lapping yarn (indicated at **7** in Fig. 2) laid on in one direction and 67 wraps per inch of 26 denier silk (indicated at **8** in Fig. 2) laid on in the other direction.

In weaving, the weft **5** is woven normally for sixteen picks after which, by a simple adaptation of the boxing motion of the loom, a hook **10** carried by a bar **11** pivoted on the breast-beam **12** of the loom is made to drop down on one side of the ribbon **13** and close to the edge **14** thereof, to engage with the tail of the weft **5** extending from the shuttle **4** to the edge **14** of the ribbon. The bar **11** is controlled by a spring (not shown)

connected to a link **15** at one end of the bar, and by the dobby mechanism (not shown) commonly provided in such looms, which is connected to a link **16** on the other end of the bar **11**. As the shuttle **4** makes its next pick, as shown in Fig. 1, the yarn is held by the hook **10** and a loop **18** is formed outside the edge **14** of the ribbon, about ¼ inch in length.

Three more picks are then woven normally and then the hook **10** is again brought down to form another loop **18** as the next pick is made. The cycle is then repeated, the pick just made being the first of the next group of sixteen picks to be woven in the normal manner.

The resulting ribbon is diagrammatically shown in Fig. 2, and consists of sections **20** about 0.2 inches in length each having a resistance of about 400 ohms between the connecting loops **18**. The loops **18** appear in pairs, one of each pair belonging to one section and the other to the adjacent section. If the ribbon is cut into lengths each comprising a plurality of sections **20**, the resistance of each length is about 2,500 ohms per inch, i. e. about 500 ohms per section, this resistance including four picks per section (indicated at **21**), which do not enter into the resistance when the sections are used separately.

The invention provides a simple and speedy method of manufacturing wire resistances of any desired value, which are not only of a high degree of accuracy but are robust in character, and simple to use and to connect in circuit without disturbing their accuracy. Thus in particular, individual sections cut from a length of the ribbon made up of equal sections may be used as strain gauges. The resistances may also be used for other purposes where high accuracy is of importance, e. g. in electrical measuring instruments, radio, radiolocation and similar purposes. The ribbon may be woven in sections having a resistance of the particular value required for the purpose to which it is to be put and the sections subsequently separated from each other. Alternatively, ribbons may be woven with suitable standard sections, resistances of the desired value being made up by dividing the ribbon into lengths containing the required number of sections. Again, a selection of ribbons may be woven with sections having different resistances, e. g. one ribbon with sections of 10,000 ohms and another with sections of 1,000 ohms, and complete resistances made up with sections taken from any of the ribbons. In making up the resistances it must, however, be borne in mind that allowances must be made for the resistance of the picks provided between each pair of weft-wire loops to facilitate cutting.

The ribbon may, if desired, have applied to it a coating of a suitable film-forming substance to strengthen, stiffen or otherwise modify the properties of the ribbon. Compositions having a basis of cellulose esters, e. g. cellulose nitrate, acetate or aceto-stearate, or cellulose ethers, e. g. ethyl cellulose may be used for this purpose and, especially where the ribbon sections are to be used as strain gauges, the coating may be one which, as described in U. S. Patent No. 2,499,513, leaves unfilled interstices or voids extending through the ribbon.

While the resistances can be used as flat portions of ribbon, it is often more convenient in practice, especially with resistances of large ohmic value, to roll or fold the ribbon into a compact unit. Where it is important that the resistance should have a very low inductance, it is preferred

to fold the ribbon at the mid point along its length and to roll up the doubled ribbon, as by this means the lowest inductance is ensured. In any such rolled up resistance an intermediate layer of insulating material, for example, oiled silk or an insulating film, may be employed to separate the turns in the roll. The roll may be made on a core or may be wound on a mandrel subsequently withdrawn to leave a hollow tubular resistance. Strength may be given to the roll by impregnating and coating it with a solution of a suitable film-forming substance, for example, cellulose acetate, nitro-cellulose or cellulose acetate-stearate, together with suitable plasticisers. Where the resistance wire is provided with two lappings, one of which consists of a yarn made from a film-forming substance, such as cellulose acetate, impregnation of the roll with a solvent for the film-forming substance, e. g. acetone, has the effect of coalescing the yarn to form a protective film round the warp and weft, so that, when the solvent has evaporated, a firm, compact package is obtained. Further protection may then be provided by coating the resistance with a layer of film-forming substance, nitro-cellulose, ethyl cellulose or cellulose acetate-stearate being preferable, owing to their high resistance to the effect of moisture. Labels printed with suitable identifying matter, or coloured marking may be applied to the resistance, preferably before such a final coating is applied.

Having described our invention, what we desire to secure by Letters Patent is:

1. A method of making an electrical resistance, said method comprising weaving a ribbon from a warp of electrically insulating yarn and a weft comprising a continuous wire of substantially uniform cross section, and, at intervals during weaving, passing the weft between successive picks, around a member spaced apart from and out of contact with the edge of the fabric so as to retain a loop of the weft extending beyond the edge of the ribbon.

2. A method according to claim 1 comprising inserting the weft-retaining member at alternately long and short intervals so as to form pairs of loops along the edge of the ribbon.

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