

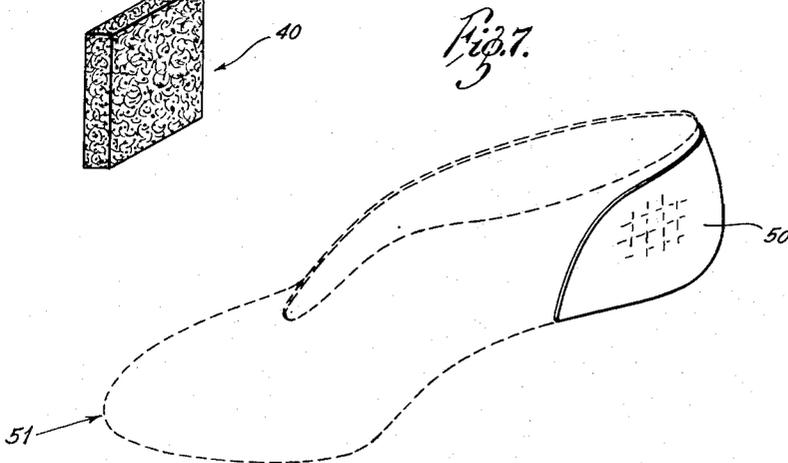
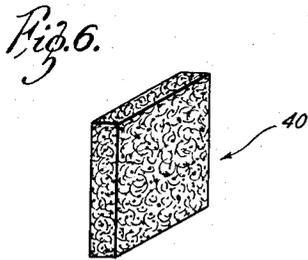
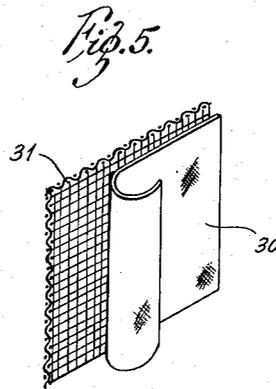
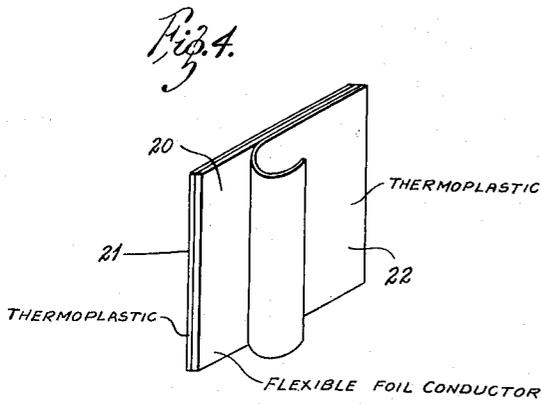
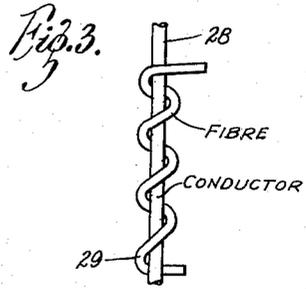
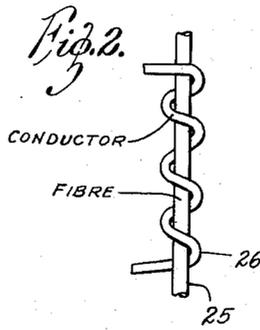
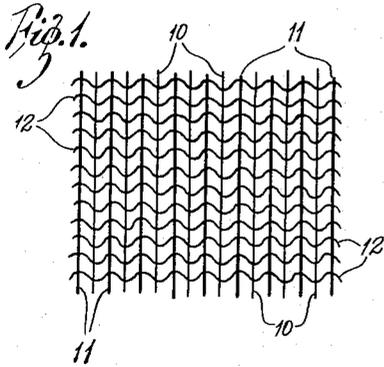
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INITIALLY SOFT STIFFENABLE MATERIAL

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INITIALLY SOFT STIFFENABLE MATERIAL

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The present invention relates to an initially soft stiffenable material. More particularly, it relates to a material that is initially flexible but that may be hardened by being subjected to inductive fields, such as high frequency inductive fields, and, as a result of being so treated, will become relatively stiff. To illustrate, this invention relates to a material that may be used for stiffeners in the manufacture of such articles as shoes where it is highly desirable to be able to apply the material in a flexible state and thereafter, following subsequent forming operations, to be able easily to cause the material to assume a stiff state by the expedient of subjecting it to a high frequency inductive field.

It is a specific object of the invention to provide material, usually in sheet form, having a plastic content that is initially flexible, together with electrical conducting means intimately associated therewith, which conducting means likewise is flexible, so that the material may be applied to the object in its flexible form, then fabricated while flexibility is necessary, as it is in the manufacture of certain types of shoes; and which material, owing to the presence of the electrical conductors and to the disposition of the plastic, is caused to stiffen as a result of being subjected to an inductive field that generates heat in the conductors.

As illustrated in the manufacture of shoes, this invention has the object to permit counters and stiffeners to be used in types of shoes wherein they have not heretofore been capable of use, and in other types of shoes wherein their use presented serious difficulties. This invention also simplifies inclusion of stiffeners in conventional shoes. For example, in a typical slip-lasted shoe it has heretofore been practically impossible to insert stiffeners and counters, owing to the fact that the upper and sole liner, or sock lining, are united prior to the lasting operation and closed so that the stiffeners cannot be inserted. Yet, even if the stiffeners could be inserted in stiff form, prior to the lasting operation, the lasting operation cannot be successfully performed. With the present invention, the material is sufficiently flexible that the lasting and stitching operations may be readily performed. After the shoe is completed, with the material embodied therein, it may be subjected to a high frequency inductive field, and very rapidly the material will be treated so that it assumes a stiff condition.

A further object of the invention is to provide a material of this kind with control of the degree of ultimate stiffness. It is a further object of the

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invention to provide for the control of the speed of the heating of the material for its change of condition from flexibility to stiffness.

It is a further object of the invention to provide various types of stiffening materials having different physical characteristics for different applications.

In the drawings:

Fig. 1 is an enlarged view of a weave of plastic yarn and flexible electrical conductors, constituting one form of the invention;

Fig. 2 is a view of another form of the invention comprising a plastic fiber surrounded by a flexible conductive coil;

Fig. 3 shows a third form of the invention, consisting of a flexible conductor surrounded by plastic yarn;

Fig. 4 shows a still different form of the invention consisting of laminations of thermoplastic sheet material with electrical conducting foil;

Fig. 5 shows another form comprising a plastic-impregnated flexible material associated with a flexible screen conductor;

Fig. 6 shows a form of material that is like a felt; and

Fig. 7 shows a typical use of these materials.

The broad objective of this invention is to provide an initially flexible material that may be stiffened at will as a result of the application of heat. In all of its forms, it will be found to consist of a plastic composition or fabrication that is initially flexible, but which becomes stiff as a result of the application of heat, together with a flexible electrical conductor associated with the plastic in the area to be stiffened, with or without certain additional material, such as filler. The heat is generated in the conductor by induction, such as by subjecting the material to the inductive field of a high frequency inductive coil of the known induction heaters.

The thermoplastic class of plastic materials is those that soften when heated. When in a finely separated shape, such as a yarn, they are flexible, as typified by garments made of thermoplastic yarns. The individual fibers or other separated constituents are, however, fusible at relatively high temperatures into a more unitary mass, which mass, upon cooling, is much stiffer and less flexible than are the constituents in separated condition. Such thermoplastic materials constitute one of the essential parts of this invention.

The other component of this invention comprises an electrical conducting means in a flexible form. It may, for example, take the form

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of a flexible wire, or a finely divided particulate material capable of dispersion, or a flexible foil.

The flexible conductor is intimately associated with the plastic material. As both are flexible in the initial state, their combination is likewise flexible, and preferably also penetrable as by needles. However, when subjected to an inductive heating field, the conducting means throughout the mass becomes hot. As it is intimately associated with the plastic, it transmits heat to the latter and causes the same to soften, whereupon the previously separated, individual, plastic elements fuse together. Upon subsequent cooling, this fused mass, by its physical change, is relatively stiff, and remains so as long as it is held below its softening temperatures.

The foregoing represents broadly the preferred form of the invention. Other ways of practising it will be disclosed hereafter.

Mechanically, the preferred way of practising the invention consists of forming a fabric of the plastic material and conductors, as shown in Fig. 1. There the plastic is in the form of yarn, and the conductors in the form of fine flexible wires. The warp in Fig. 1 is made up of strands 10 of flexible plastic yarn, alternated with iron wires 11. The woof is made of plastic yarn 12. Fig. 1 shows these elements woven together to form a flexible fabric, that is flexible and penetrable.

When it is desired to stiffen this sheet of fabric, it is subjected to an inductive heating field, which generates heating currents in the wires 11. This heat is transmitted to adjacent fabric yarn threads, causing the filaments of the threads to soften and fuse together, and causing adjacent yarn threads to fuse together to a degree determined by the time-temperature factor that may be readily controlled. When the fabric is thereafter permitted to cool, it is stiff because the fusing has changed its physical state.

The particular weave shown has the advantage of employing a minimum of wire. Each yarn thread section, either of warp or woof, is immediately adjacent a wire portion from which it may be heated.

Such fabric may, however, be made otherwise. Fig. 2 shows a yarn thread 25 of plastic material about which a strand of conducting wire or foil 26 is wrapped. Fig. 3 shows the reverse, the wire strand 28 being wrapped with a plastic yarn 29. In either case, the combination threads may be used as desired, by being woven into a fabric or otherwise.

The fabric style of embodiment of this invention is the easiest to fabricate and easiest to handle. It lends itself to excellent control of ultimate stiffness because of the flexibility it offers for variation of the factors involved in stiffness. For example, it may be made with relatively fine component threads, and applied to its use in laminations, the number of laminations determining the stiffness. Certain of its component threads may be made of filler material such as cotton or like material which is not injured at the softening temperatures, such filler giving any desired thickness or body to the ultimate product.

Also, the axis of stiffness may be regulated, as by using heavier plastic threads for either warp or woof, or by using a thermoplastic material for one that is stiffer than that used for the other.

The plastic materials that may be used are very numerous, as the thermoplastic class covers many different products. It is merely required that, in this embodiment, the plastic be one that softens

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when heated, fuses, and cools into a state in which it is stiff.

To illustrate, the methyl methacrylates, such as those going under the trade name of Plexiglas, may be used. Also, the polyamine resins such as those known by the trade name "Nylon" may be used. Likewise, the copolymers of polyvinyl chloride and polyvinyl acetate, such as those going under the trade names of Vinyon and Vynlite, may be used. In general, it may be said that the methyl methacrylates represent material that produces a relatively stiffer end product, and the polyvinyls represent material that produces a less stiff product. As noted above, two may be combined.

The cellulose acetate and cupra-ammonium compounds typified by rayon may be used. Some of the commercial rayons do not fall within the definition of an initially flexible material that is softened as a result of application of heat, and thereafter stiffened upon cooling, because for particular commercial uses they have been modified to overcome such thermoplasticity.

It is not necessary to list all of the plastics that fall under the definition as they comprise a very large list. It is only necessary to consult trade catalogues or texts to find proper ones. The detail characteristics of end products are easily predicted from the published characteristics of the plastics.

Another way of practising the invention is shown in Fig. 4. In it the electrical conductor is shown as a flexible metal foil 20. It is coated with films 21 and 22 of thermoplastic material. These films may be applied to the foil as thermoplastic material dissolved into a paste in a suitable known slow-drying evaporable solvent. For example, methyl methacrylate may be formed into a paste by dissolving it in one of the commercial cement solvents such as glacial acetic acid. As long as the solvent remains in the material, it will remain flexible and penetrable. In its flexible form it may be fabricated and shaped. When it is desired to stiffen it, it is subjected to an inductive field, which causes generation of heat in the foil. This heat drives out the solvent, leaving the remaining plastic material in its characteristic stiff condition.

It is clear that the paste may be applied to some base material or part to be stiffened, and the foil placed in intimate association therewith. Also the foil is merely a preferred form of flexible conductor for this purpose. A flexible screen illustrates another form of such conductor.

A third way of using the present invention is to form an emulsion of plastic material, by which a dispersion of plastic particles is obtained. Such emulsion may then be applied to a material to be stiffened and intimately associated with a flexible conductor.

Such practise is shown in Fig. 5. A sheet of flexible fabric 30 has been dipped into an emulsion and thereby impregnated with particles of the thermoplastic material in such wise that the particles remain separate, but are associated with each other. The flexible conductor is here shown as a flexible screen 31. The two members 30 and 31 are preferably formed together as a laminated or interwoven unit. When heat is produced by induction in the screen wire, the separate particles of the plastic material soften and fuse together, and, when cooled, produce a stiff product.

Typical plastic material may be a liquid form of polyvinyl acetate emulsified.

In certain cases, it may be desired to compound

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a plastic to obtain a particular degree of stiffness.

Most thermoplastic resins have varying characteristics of stiffness at normal temperature at different viscosities. Usually, the higher the viscosity the stiffer they are at a given temperature. Also, the viscosities can be modified by mixing two different ones in a melted state arriving at stiffness somewhere between the firmness of each. Another property of thermoplastic resins is that their solvents change with their viscosity, one solvent affecting the low but not the high, while another solvent will dissolve the high but not the low.

If these properties are realized, a heat-cold stiffenable material can be made by the following method: Dissolve a high viscosity thermoplastic resin such as Gelva #60 in acetone; dissolve a low viscosity resin of the same kind such as Gelva #10 in methyl or ethyl alcohol; mix the two together; apply the resulting mixture to a metal foil or mesh; evaporate the solvents.

Since the alcohol and the acetone will mix, while they will not affect the resin that they do not dissolve, a form of dispersion will result, producing a soft translucent film since the particles of the resin are not continuous. Upon being placed in the field of a high frequency induction furnace, the metal becomes heated, liquefying the resin particles, fusing them together assuming the properties somewhere between the two viscosities forming a relatively stiff substance upon cooling.

The same result can be obtained by a variation of this system. If a low viscosity resin is dissolved in a solvent which will not affect the higher viscosity thermoplastic, the higher viscosity can be added in a powdered form. Upon evaporation of the solvents, the high viscosity resin in a powdered state will be dispersed through the film formed by the low viscosity resin. When heated, the reaction will be the same as that described in the first case.

It will also be understood that the fabric or other material to be stiffened may be impregnated with the proper thermoplastic material in powder form, and then associated with the conducting means.

Another form of the invention is shown in Fig. 6. It consists of a nonwoven, felt-like product 40, comprising particles of thermoplastic materials such as have been described, closely mixed as a dry mixture with particles of a metal conductor. The plastic may be short fibers, and the conductor may be short wire pieces. After mixing, the combination may be pressed into a felt-like mass, with or without a filler.

When subjected to an inductive field, heat is generated in the metal particles, causing the plastic particles to fuse together. When cooled, the product is a stiff mass.

As one of the uses of this material, stiffeners for shoes present a typical situation. In Fig. 7, a counter 50 has been cut of a shape typical to a shoe, generally indicated at 51. This counter is flexible in its initial state, and, therefore, can be inserted in the shoe, which may thereafter be otherwise processed as is desired. For example, if the shoe is a slip-lasted shoe, the counter 50 may be applied thereto prior to the closing of the upper and sock lining of the shoe, and the subsequent processing proceeds because the counter is in a flexible state that does not interfere at all with either the lasting or the stitching operations.

When the shoe is completed, it may be sub-

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jected to an inductive field such as in a high frequency inductive heater, which, as is known, generates heat in conductors that come within its field. In the present case, the conductors will extend over only the area of the counter or other stiffener in the shoe, will be quickly heated, and will transmit their heat to adjacent plastic filaments, which will fuse with their adjacent filaments and produce the end result of a stiff piece of plastic material. It is of particular importance in such manufacture of shoes that the heating be localized. Localizing of the heat results in the present case from the combination of the thermoplastic or other material previously mentioned and the localized conductors. The entire shoe will not be heated, and therefore will not be subjected to heat conditions that might be damaging thereto. Furthermore, the heating operation is very quick and may be performed along a high production line.

The ultimate material may be thin or heavy, as desired. Ordinarily, it is more satisfactory to make relatively thin sheets, because then the stiffness may be controlled by employing more or fewer layers. The laminated material, such as is produced by superposing several of the fabric sheets shown in Fig. 1 together, has the advantage of reducing fraying and giving very accurate control of the flexibility.

The use of a powder or liquid applied directly to either a backing material or to the material that must be stiffened, as a shoe upper, has been described. In such case, the conductor, such as a piece of screen, may be incorporated into the shoe upper.

There are many different plastic materials that may be used singly or in combination to form this initially flexible, finally stiff product. It is necessary only to specify to one of the plastic manufacturers the need for a thermoplastic material that is initially flexible and that may be fused by the application of heat, and which, in such fused condition, is stiff, as the art well knows many such materials.

It is ordinarily more convenient to form the material as a flexible solid rather than as a liquid, and the fabric of Fig. 1 is the preferred form of the invention. The thermoplastic is properly associated in any case with the flexible conductor, by which only localized heat is generated upon subjection to an inductive heater.

For shoe counters, it has been found that a fabric woven from 200 denier, 34 filament, nylon thread, formed with a conductor of #38 gauge iron wire, is satisfactory.

In the manufacture of shoes, which is a particularly important use of this type of material, many steps in the manufacture are eliminated. It is not conventionally necessary to use the messy heavy counter or box toe cement that is required because these counters may be applied with an initial light cement that will hold them in place during the processing. When they are heated, there is an adhesion effected by the softening of the plastic material and its ultimate stiffening in place that causes the article to adhere to the adjacent parts of the shoe.

While shoes have been suggested as one of the principal uses of this material, it will be understood that it is capable of general use wherever it is desired to have a stiffener that is initially flexible; nor is it critical in most of the foregoing when the heating step is performed. For example, personalized shoes may be produced by the manufacture of shoes with the stiffeners in

flexible condition, and the hardening thereof to the ultimate purchaser's foot by the simple expedient of subjecting them to the inductive heat at the time of sale.

What is claimed is:

1. The method of making a stiffened fabric, comprising twisting together yarns of thermoplastic material of the type which is initially soft and which stiffens on being heated and allowed to cool, and metallic wires, weaving these together into a fabric, and subjecting the fabric to an alternating electromagnetic field so as to cause the wire to become hot and fuse the thermoplastic yarns into a substantially unitary mass.

2. The method of making a stiffened fabric, comprising weaving together yarns of plastic material and metallic wires, the plastic being of a type that softens when subjected to heat and stiffens when recooled, and subjecting the fabric to an alternating electromagnetic field so as to cause the wire to become hot and at least partially fuse the yarns of plastic material together.

3. A fabric, comprising yarns of thermoplastic material of the type which stiffens when heated and allowed to cool and metallic wires twisted together and interwoven into a fabric, the yarns of thermoplastic material being at least partially fused together, the thermoplastic yarns in the woof being stiffer than those in the warp, whereby the axis of stiffness is regulated.

4. A fabric comprising yarns of thermoplastic material of the type which stiffens on being heated and allowed to cool and metallic wires twisted together and interwoven into a fabric, the yarns of thermoplastic material being at least partially fused together, the thermoplastic yarns in the warp being stiffer than those in the woof, whereby the axis of stiffness is regulated.

5. An article of manufacture, comprising a shoe having an upper and a sole; and a potentially stiffenable member associated with said upper, said member including a fabric comprising strands of thermoplastic material and flexible electrical conductors woven together, the thermoplastic material being of a type which is initially flexible, which softens and flows when subjected to heat, and which stiffens on being cooled.

6. An article of manufacture, comprising a shoe having an upper and a sole; and a potentially stiffenable member associated with said upper, said member including a fabric of interwoven elements, the said elements comprising flexible electrical conductors having strands of thermoplastic material wrapped around them, the thermoplastic material being of a type which is initially flexible, which softens and flows when subjected to heat, and which stiffens on being cooled.

7. An article of manufacture, comprising a shoe having an upper and a sole; and a potentially stiffenable member associated with said upper, said member including a fabric of interwoven elements, said elements comprising strands of thermoplastic material having flexible electrical con-

ductors wrapped around them, the thermoplastic material being of a type which is initially flexible, which softens and flows when subjected to heat, and which stiffens on being cooled.

8. An article of manufacture, comprising a shoe having an upper and a sole; and a reenforcing member associated with said upper, said member including a fabric comprising strands of thermoplastic material of the type which softens when subjected to heat and which stiffens on being cooled and flexible electrical conductors woven together, the strands of thermoplastic material being at least partially fused together.

9. An article of manufacture, comprising a shoe having an upper and a sole; and a reenforcing member associated with said upper, said member including a fabric comprising strands of thermoplastic material of the type which softens when subjected to heat and which stiffens on being cooled and having flexible electrical conductors wrapped around them, the strands of thermoplastic material being at least partially fused together.

10. An article of manufacture, comprising a shoe having an upper and a sole; and a reenforcing member associated with said upper, said member including a fabric comprising flexible electrical conductors having strands of thermoplastic material of the type which softens when subjected to heat and which stiffens on being cooled wrapped around them, the strands of thermoplastic material being at least partially fused together.

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