1. This invention relates to process and apparatus for the production of textile fabrics etc., and in particular to a process and apparatus for forming a pile on the adhesive coated surface of a travelling web.

2. It is well known to make pile fabrics (including suededette fabrics) by causing short fibres to adhere to a suitable backing material, for example to an adhesive-coated web. Many methods have been described for facilitating the application of the fibres to the surface by activating them in an electric field through which the adhesive-coated web is caused to travel. In British Patent No. 260,960 we have described a method of making pile fabrics wherein the adhesive-coated web travels through an electric condenser in which is maintained an alternating field of special characteristics, and the fibres are fed between the adhesive-coated surface of the fabric and one plate of the condenser, the effect of the field being to set the fibres in to-and-fro motion between said plate and said plate and produce on the adhesive-coated surface a substantially uniform distribution of fibres, the fibres being aligned with their axes substantially perpendicular to said surface and adhering thereto. An alternating voltage is applied to the condenser through a variable spark gap from a charging source (for example, a high tension magneto), the voltage of which varies periodically and, during each cycle, rises steeply to a peak, immediately falls steeply therefrom, remains substantially zero for a much longer period than that occupied by said rise and fall, falls steeply to a minimum arithmetically equal to said peak, immediately rises steeply therefrom, and continues at substantially zero for the rest of the cycle. The variable spark gap is adjusted so that, under the influence of the alternating voltage supplied, the fibres move rapidly to-and-fro as described above.

3. The continuous supply of fibre in the correct amount to provide a pile of the desired density and substantial uniformity presents some difficulty, and the present invention has as its principal object to improve the method of feeding the fibre to the adhesive-coated surface in processes of the kind described and allied processes involving activation of a fibre in an electric field.

4. In the preferred form of the process described in British Patent No. 260,960, as shown in the drawing of that specification, the adhesive-coated web travels in a substantially horizontal direction past a station at which the fibre falls on to the fabric under gravity, and the fabric and fibre then immediately pass in a downward direction into and through a condenser or condensers where the orientation and distribution of the fibres on the adhesive-coated surface occurs under the influence of the electric field. This condenser or these condensers will hereafter be referred to as the main condenser or condensers to distinguish from an auxiliary condenser to be referred to later; and the fields in the main and auxiliary condensers will be termed the main and auxiliary fields.

5. We have now found that the method of feeding the fibre described above can be much improved by causing the fibres fed to the fabric, before passing into the main field, to pass through an auxiliary field in which they are orientated and most of those fibres that do not become attached to the coated surface are supported by the attached (upstanding) fibres. The desired orientation and spacing can be done by arranging for the fibres to drop onto the fabric while it is travelling substantially horizontally through an electric field, the lines of force of which are substantially vertical. A convenient arrangement is to drop the fibres through a grid forming one electrode of an auxiliary condenser, the other electrode being a substantially horizontal plate situated below the fabric.

6. The present invention, therefore, contemplates a process for making pile-surface materials by causing loose fibres to adhere to an adhesive-coated surface of a travelling web and hardening the adhesive, wherein the web runs through two high-voltage fields in succession, its path through the first, into which the fibres are fed, being at an angle greater than 45° to the vertical, its path through the second being downwards at an angle greater than 45° to the horizontal, the field in the first causing the fibres to orientate the fibres with their long axes perpendicular to said surface and to direct them so orientated into contact with the adhesive coating, the rate of feed being such that part of said fibres become attached to said coating and part remain unattached and supported by the attached, upstanding fibres, the second field serving to orientate part of the unattached fibres and project them into contact with said coating, most of the rest of the unattached fibres falling away from the path of the web, and the web after leaving said second field being carried through a zone in which the adhesive is hardened.
clined downwards at an angle greater than 45° to the horizontal, an electric condenser having one electrode parallel to and below the first run, and the other electrode in the form of a grid parallel to and above said run, a second condenser having its electrodes parallel to, and one above and the other below, the second run, means for feeding loose fibres to the space above said grid, means for creating in the first condenser a high-voltage electric field tending to orientate the fibres with their long axes perpendicular to the surface of the web and to direct them so orientated toward said surface, and means for creating in the second condenser a high-voltage electric field for orientating unattached fibres carried into said field by the web and projecting them towards the web.

The field in the auxiliary condenser may be constant in direction and intensity; or it may fluctuate in intensity, or in both direction and intensity. Preferably an alternating voltage is applied, and especially a voltage of the character applied to the main condensers as specified in British Patent No. 650,988. As described in that specification, a field of particularly suitable characteristics can be obtained in the main condenser or condensers by applying the alternating voltage thereto through a correctly adjusted variable spark gap from a charging-source, e.g. a high-tension magneto, the voltage developed by which varies periodically and, during each cycle, rises steeply to a peak, immediately falls steeply thereafter, remains substantially zero for a much longer period than that occupied by said rise and fall, falls steeply to a minimum arithmetically equal to said peak, immediately rises steeply thereafter, and continues at substantially zero for the rest of the cycle. The desired field for the auxiliary condenser can be obtained in the same way, for example by earthing the grid of the auxiliary condenser and connecting the other electrode through an adjustable spark gap with a high tension magneto. A suitable magneto may be used to charge the auxiliary condenser as well as one or more main condensers.

The best results have been obtained when, in addition to the variable spark gap, a fixed spark gap is provided between the secondary winding of the magneto and the leads to the variable gap. This fixed gap may, for instance, be provided by feeding the current in the secondary to the distributor terminals through a rotating arm between which and the several terminals at its nearest approach to them there is a gap of several millimetres. The variable gaps will in general need to be set much wider than the fixed gap, e.g. 6 to 12 mm. It will generally be necessary in order to avoid sparking in the condenser to provide between one plate of the main condenser and the path of the fabric a sheet of dielectric material at least 3 mm preferably higher and of high dielectric strength, e.g. polyvinyl chloride, polystyrene or rubber hydrochloride. This increases the charge which the condenser can take without discharge between the charged plates and the earthed plate. The magneto should be capable of developing a voltage of the order of 10,000 volts, and preferably a considerably higher voltage, e.g. 20,000 to 50,000 volts or even up to 100,000 volts. In general the greater the distance apart of the plates the higher the voltage should be. With the condenser plates at a distance apart of 3/4 inch, useful results have been obtained when the potential drop across the spark gap is between 15,000 and 50,000 volts. A suitable range of frequency for the alternating field is 8 to 15 cycles per second. In general the greater the distance between the plates the lower should be the frequency.

In the accompanying diagrammatic drawings Figure 1 shows in part sectional elevation apparatus according to the invention for forming the pile fabric; Figure 2 is an exaggerated representation (also in part sectional elevation) of the kind of distribution of fibre on the fabric that appears to occur immediately under the grid 10 of Figure 1 when the auxiliary condenser is operated; and Figure 3 is an exaggerated representation (also in part sectional elevation) of the kind of fibre distribution that appears to occur under the grid 10 of Figure 1 when the auxiliary condenser is not operated.

Referring now to Figure 1, the fabric 1 is drawn from the supply roll 3 over the tension roll 29 and guide bars 4 under the dope casting box 5 and flexible doctor blade 6 and through a heating cabinet (not shown) having radiant heating elements 7. Dope comprising a heat-hardening adhesive in solution in a volatile solvent flows from the dope casting box 5 on to the box 6 forming a thick layer 14 which is spread by the doctor blade to form a layer 15 which may, for instance, be of thickness 0.015". Within the drying cabinet the volatile solvent is evaporated. Beyond the drying cabinet the coated fabric passes under a rotating perforated drum 8 into which the loose fibres are fed and from which they fall by gravity towards the grid 10. This is formed by conducting wires running across the direction of travel of the fabric a distance of 3/4 to 3/2 inch above its surface, the wires being spaced 29 mm apart. The wires are electrically connected to an earth wire 11. Immediately below the fabric where it passes beneath the drum 8, is a metal plate 12 forming one electrode of an electric condenser of which the other electrode is the grid 10. The upper surface of the plate 12 is covered by a sheet of insulating material, for example polyvinyl chloride or polystyrene, which is not shown. Beyond the grid 10 the fabric, now carrying a layer 13 of fibres (some attached to and upstanding, the rest supported by the attached fibres), passes over idler 25 and runs in a downward direction through three successive electric condensers having a common electrode 15 with an earth connection 16 the inner surface of which is covered by an insulating sheet 17 of polyvinyl chloride or polystyrene, and separate live electrodes 18, 19, and 20. The electrodes 12, 18, 19 and 20 are connected through leads 21, 22, 23, and 24 and spark gaps 25, 26, 27 and 28 to leads 29, 30, 31 and 32 respectively, which are in turn connected to the distributor 40 of an “American Bosch” 14-point magneto 41 having an arc of 3/4 inch between the rotor arm and the output terminals of the distributor. Lead 29 is connected to the first, fourth, seventh and tenth terminals of the distributor; lead 30 is connected to the second, third, sixth, ninth and twelfth terminals of the distributor; lead 31 is connected to the fifth, eighth, eleventh and fourth terminals of the distributor; lead 32 is connected to the second and thirteenth terminals of the distributor. An alternative arrangement using a 9-point magneto and omitting electrode 20 and its connections altogether is as follows: lead 29 connected to the first, fourth and seventh terminals of the distributor; lead 30 to the second, fifth and...
eight terminals and lead 31 to the third, sixth and ninth terminals. With this arrangement it is necessary to run the fabric through the machine more slowly than with the arrangement described above.

The electrodes of the spark gaps are discs of thin diameter. The spark gaps are encased in a casing of polystyrene out of which project thumb-screws for adjusting the size of each gap over a range from zero to about 1 inch.

Beyond the last condenser (formed by the electrode 20 and earth plate 11) the fabric is taken round a guide roll 33 whence it runs substantially horizontally into a vulcanising chamber (not shown). Loose fibre 34 that has not become attached to the fabric by the time the guide roll 33 is reached falls under gravity into the bin 35. In the course of the straight run 30 of the fabric (now provided with the pile 37) from the guide roll 33 to the vulcanising chamber, any fibres not firmly attached are removed by the beater 36, which is in the form of a rotating cage with bars 39 extending over the width of the fabric and making contact with the back, uncoated, surface thereof.

The vulcanising chamber is similar in construction to the wellknown “festoon dryer.” It provides for slow passage of the material through a heated atmosphere in which the adhesive is hardened to a flexible, non-sticky, form.

In operation, the fabric is run through the machine, for instance, at a speed ranging from 1½ to 3 yards per minute. Fibre is distributed to the space above the grid 10 in greater amount per unit time than is required to provide the fabric with a pile of the desired density. The magnet is rotated at about 1,000 revolutions per minute and the spark gaps are adjusted so that fibres falling through the grid 10 move rapidly up and down until they contact and adhere to the adhesive coating or are carried beyond the electrode 12. During passage between the grid 10 and the electrode 12 most of the fibre that does not become attached to the coated surface is supported by the attached fibres. When the fabric runs downwards over the guide roll 14 these loose fibres fall under gravity, forming a cloud between the adhesive coated surface of the fabric and the earth plate 18. During their downward course in the field between the earth plate and the electrodes 18, 19 and 20, most of these loose fibres become attached to the coating, and, as described above, those which do not become so attached fall out of path of the fabric into the bin 35. To ensure a pile of adequate and substantially even density the fibres should be fed from the drum 8 at such a rate that excess fibres accumulate in the bin 35.

A great advantage of the method and apparatus of the invention is that a dense and substantially evenly distributed pile can be simply obtained thereby. In the absence of the pre-orientation provided by the field between the grid 10 and the electrode 12, it is difficult to adjust the feed of fibre so as to obtain a substantially uniform fibre distribution. All forms of fibre distributor that have been tried without a guide have been found to deposit the fibres in greater density in some areas of the fabric than in others. When a pre-orienting field is operated this unevenness in density still obtains but in the areas of lower density the fibres are upstanding and anchored in the adhesive coating, and in the areas of higher density the fibres instead of being piled randomly upon one another are substantially all orientated parallel to the lines of force of the field those which have not become anchored in the coating are carried supported endwise by the attached fibres in this area. Figures 2 and 3 respectively are intended to represent in an exaggerated and idealised form the kind of fibre arrangements that occur with and without the pre-orienting field.

The areas of low fibre density 30 are shown alternating with smaller areas 20 of high fibre density.

When the fabric leaves the pre-orienting field and runs downwards to the main field the unattached fibres fall in a cloud through the main field where a substantial proportion of them become attached to the coating in the areas of low fibre density thereon. In the absence of a pre-orienting field the fibres as a whole are much less accessible to the action of the main field when they arrive therein; some fibres are attached lengthwise instead of endwise to the coating and it has not been found possible to obtain such evenness of distribution as can be obtained with pre-orientation, even by running the fabric much more slowly through the machine.

The path of the adhesive-coated web past the feeding station is preferably horizontal and in any case should be at an angle greater than 45° from the vertical. With regard to the downward flight of the web through the main condensers, this may be vertical but is preferably at a smaller angle than 90°, for example 70 to 85°, to the horizontal such that the pile, assuming this to project perpendicularly from the surface of the fabric, inclines downwards. Thus if the flight past the feeding station is horizontal the angle between this flight and the downward flight is preferably 70 to 85°. Preferably an arrangement is provided for removing from the fabric emerging from the condensers any excess fibre that has not fallen away during its passage through the condensers. Such an arrangement may take the form of a rotating brush as described in British Patent No. 690,938. A more effective device for the purpose is a beater in the form of a rapidly rotating cage of four or more bars held between the circular end plates and mounted transversely above the path of the fabric so that the bars just touch the fabric.

In carrying out the invention, excellent results have been obtained using as the backing-fabric a fabric of cotton or other form of cellulose, including regenerated cellulose. Fabrics of high tenacity regenerated cellulose such as is obtainable by saponifying cellulose acetate yarn that has been stretched considerably in steam or hot water are particularly suitable when a strong light-weight backing fabric is required. Becking fabrics of other materials can be used, including materials of higher dielectric constant and dielectric strength and lower moisture regain than cotton, for example silk, wool, casein, soya-bean protein and other proteinaceous fibres; cellulose acetate; fibre-forming condensation polymers such as nylon; fibre-forming addition polymers such as copolyamides of vinyl chloride with vinyl acetate, with vinylidene chloride, or with acrylonitrile, or of acrylonitrile with metha-crylonitrile; and mineral fibre-forming materials such as glass. Instead of using a fabric for the backing material, other flexible non-metallic webs can be used, e.g. webs of paper or films of regenerated cellulose or of a cellulose
ester or ether (e.g. the acetate, propionate, acetate-propionate or acetate-butyrate, or ethyl cellulose) or a combination of the synthetic polymers referred to above. Metal foils or fabrics can also be used.

The staple fibre used may be composed of any of the materials specified above with reference to the backing fabric. Excellent products have been obtained with staple fibre of length between 0.2 and 8 mm., and especially between 0.5 and 1 mm. and of denier between 2.5 and 5. The fibre should be free from oil and dry.

The adhesive used should be capable of conversion from a sticky form to a non-sticky flexible form. It may, for example, be of the kind referred to in British Patent No. 644,002. Thus, for example, a suitable adhesive comprises polyvinyl acetate plasticised with a major proportion of a volatile plasticiser such as dimethyl phthalate, glycol diacetate, triethyl phosphate or tributyl phosphate, and a minor proportion of a less volatile plasticiser such as trieryls phosphate. As described in the said application, a thin foundation-layer of plasticised polyvinyl chloride is preferably provided for such an adhesive. Another form of adhesive that is very suitable particularly for bonding cellulose acetate fibre to a cellulose acetate fabric, comprises a solution in a volatile solvent of a copolymer of butadiene and acrylonitrile, vulcanising ingredients thereof, and a mixture of two plasticisers of different volatilities, e.g. dimethyl phthalate and di-2-ethyl hexyl phthalate or di-cyclo hexyl phthalate, as described in British Patent No. 679,739. The solution is applied to the fabric, the volatile solvent evaporated leaving a sticky coating and, after formation of the pile, the coating is hardened by evaporation of more volatile plasticiser and vulcanisation of the polymer. Other kinds of adhesive capable of being hardened to give a flexible coating, so firmly anchoring the pile, can be used. Thus, for example, the adhesive may be a dispersion of a plasticised polymer, e.g. polyvinyl chloride or polyvinyl acetate, that undergoes gelling when heated. Blends of polyvinyl chloride or the like with rubber-like polymers, e.g. copolymer of butadiene with acrylonitrile, may also be used. Or the adhesive may have basis of a heat-hardening synthetic resin, e.g. a heat-hardening addition polymer such as diallyl phthalate or allyl cyclohexyl phthalate, any necessary catalyst being present in the adhesive composition. Adhesives having a basis of an aqueous dispersion which can be set by drying, such as rubber latex, or aqueous dispersions of vinyl polymers, e.g. polyvinyl acetate, can also be used. The adhesive is preferably spread on to the travelling web by a doctor blade which may with advantage be flexible to deal with any irregularities in the web.

The hardening of the adhesive coating after application of the staple-fibre may be effected, for example, by radiant heat, by dielectric heating, or by means of a current of hot air. A very convenient arrangement is to draw the coated fabric by means of pin rolls engaging only the edge of the fabric, through a fescue dryer, the kind in which the material hangs in loops while travelling through the drying chamber. In this way the pile is not damaged.

The following examples illustrate the invention.

Example I

The apparatus is as shown in Figure 1 of the drawing. The web is a plain woven fabric of continuous filament cellulose acetate yarn of weight 2 to 3 oz./sq. yd. The flock used to form the pile is of cellulose acetate fibres of length 0.3 to 1 mm. and denier 2.5 to 5. The adhesive has the following composition:

- 800 parts of "Hycar O. R. 15"
- 1600 parts of dimethyl phthalate
- 400 parts of di-2-ethyl hexyl phthalate
- 80 parts of a resin of softening point 123°C obtained by polymerisation of a petroleum cracking distillate in which none of the unsaturated constituents boils below 130°C, at least 70% of the total weight of the unsaturated constituents consists of one or both of the substances beta-methyl styrene and indene, and said total weight does not contain as much as 5% of any di-unsaturated substance.
- 90 parts of zinc oxide
- 16 parts of sulphur
- 8 parts of stearic acid
- 2 parts of tetramethyl thiranium disulphide
- 8 parts of benzthiazyl disulphide
- 24 parts of yellow ochre
- 2560 parts of a 60:40 mixture (by volume) of methyl ethyl ketone and methyl isobutyl ketone.

The fabric is run through the machine at a speed of 3 yards per minute, the variable spark gaps being adjusted (to a gap in the neighbourhood of ½ inch) until the flock is caused to move to-and-fro in the electric fields. The time of passage through the vulcanising chamber, which is kept at 85 to 95°C is 15 to 20 hours.

Example II

The process is carried out as in Example I, but using as the web a fabric of the weight and construction specified made of continuous filament regenerated cellulose yarn.

In the same way as in Examples I and II (but with a different adjustment of the variable spark gap) the process can be carried out using a staple fibre of regenerated cellulose made by the viscose process.

Other adhesives may be used, e.g. any of those specified in British Patent No. 679,739. Or an adhesive comprising an aqueous dispersion of polyvinyl acetate mixed with natural or synthetic rubber latex and vulcanising ingredients can be used.

The invention has been described with reference to a process in which the main condensers are charged through spark gaps from a magnet. This is the preferred method. Other ways of charging the condensers may however be adopted. They may, for instance, be charged from a step-up transformer fed with low voltage A.C., or from a valve-oscillator.

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

1. In a process for making pile-surface materials by causing loose fibres to adhere to an adhesive-coated surface of a travelling web and hardening the adhesive, the steps which comprise running the web through two high-voltage alternating fields in succession, its path through the first being substantially horizontal and the fibre being dropped vertically into this field, its path through the second being downwards, the horizontal path of movement of said web and
the downward path of movement of said web forming an angle of 70° to 90°, each field being perpendicular to the path of the web through that field, the first field tending to orientate the fibres with their long axes perpendicular to said surface and to direct them so orientated into contact with the adhesive coating, the rate of feed being such that part of said fibres become attached to said coating and part remain unattached and supported by the attached, upstanding fibres, the second field serving to orientate part of the unattached fibres and project them into contact with said coating, most of the rest of the unattached fibres falling away from the path of the web, and carrying the web after leaving said second field through a zone in which the adhesive is hardened.

2. In a process according to claim 1, the step of establishing each field in the space between two metallic surfaces, one on each side of the path of the web, and both parallel to said path, by applying an alternating voltage to one surface of each set of two, from a charging source the electromotive force of which varies periodically and during each cycle, rises steeply to a peak, immediately falls steeply therefrom, remains substantially zero for a much longer period than that occupied by said rise and fall, falls steeply to a minimum arithmetically equal to said peak, immediately rises steeply therefrom and continues at substantially zero for the rest of the cycle, and arranging the size of the spark gap so that the fields cause fibres of the kind used to move to-and-fro.

3. Apparatus suitable for making pile-surface material by causing loose fibres to adhere to an adhesive-coated surface of a travelling web, which comprises means for drawing a web along a path having a substantially horizontal run followed immediately by a run inclined downwards, the horizontal path of movement of said web and the downward run of said web forming an angle of 70° to 90°, an electric condenser having one electrode parallel to and below the first run, and a second electrode in the form of a grid parallel to and above said run, a second condenser having its electrodes parallel to, and on opposite sides of the second run, means for dropping loose fibres through said grid, means for creating in the first condenser a high-voltage alternating electric field tending to orientate the fibres with their long axes perpendicular to the surface of the web and to direct them so orientated towards said surface, and means for creating in the second condenser a high voltage alternating electric field for orientating unattached fibres carried into said field by the web and projecting them towards the web.

4. Apparatus according to claim 3, wherein the means for creating the fields comprise a high-tension magneto connected through a variable spark-gap to one electrode of each condenser.

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