FIG. 5
PNEUMATIC METHOD AND APPARATUS FOR PRODUCING FLOCK-COATED MATERIAL

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ABSTRACT OF THE DISCLOSURE

Method and apparatus for making flock coated materials by applying adhesive to a substrate sheet, adhering elongated flocked particles to the adhesive coating and passing the flock-coated substrate sheet over at least one tuned slot of a pneumatic cavity resonating at a low audio frequency, each tuned slot directing resonant frequency pneumatic waves against the substrate sheet to generate therein a standing vibrational wave extending across the width of said substrate sheet to thereby vertically orient and embed the flock fibers in the adhesive. Preferably, the pneumatic cavity is of a truncated conical shape in which the tuned slots are located in the truncating surface.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to the production of pile surfaces or coated materials and more particularly relates to apparatus for and methods of coating sheet materials with flock, tinsel or other particles using low audio frequency compression waves provided by tuned slots of a resonant pneumatic cavity to vibrate the sheet material and the particles applied thereto during the coating process. Preferentially, the resonant cavity is of a truncated conical shape in which the tuned slots are located in the truncating surface.

Description of the prior art

Flocking methods find great utility in the textile and paper industry as a means of coating webs with a velvet-like pile. Particular advantage is found in the use of flocking methods for the fabrication of automobile floor mats, draperies and upholstery.

Heretofore, flocked coating of sheeting has been accomplished by spray gun techniques, electrostatic methods and by mechanical beating. Pile surfaced, flocked or other particle-coated materials are most commonly manufactured by first coating the surface of a base material with an adhesive or by printing particle containing designs thereon and thereafter applying flock or other particles to the base material while vibrating the base material with mechanical beaters. The use of mechanical beaters is effective in embedding flock fibers or other particles in the adhesive or printed coating with a generally upstanding pattern with respect to the base material. However, the operation of the beaters to vibrate the material is accompanied by objectionable frictional contact between the beaters and the base material which causes wear and strain on the base material. The mechanical beating also requires a relatively large amount of power and is accompanied by objectionable overall vibration of the coating apparatus.

In the electrostatic method, the base web is coated in the conventional manner with an adhesive and flock particles are deposited thereon. The adhesive and flock coated sheet is passed through a constant or alternating electrostatic field oriented generally perpendicular to the web surface which causes the alignment of the flock fibers into a generally upstanding configuration. Electrostatic methods require that the fibers be coated with various chemical compounds to increase their attraction to the electrostatic field. This coating requirement limits the material and applications to which electrostatic flocking may be applied.

Spray gun techniques consist simply of spraying elongated flock particles against an adhesive coated surface. Of the three most common methods, the spraying technique produces the least desirable results.

Acoustical flocking methods have been proposed in which the substrate web is passed over a vibrating diaphragm which is set into vibration by the action of audio and super audio acoustic waves generated beneath the diaphragm. A commonly used generator source for this purpose includes electromagnetically or electrodynamic loud speakers adapted to generate high intensity sound waves at audible and super audible frequencies. For practical results, the acoustical methods heretofore proposed require the utilization of high frequency acoustic waves, i.e., frequencies in excess of 1,000 cycles per second. Acoustical techniques of the above described nature are inefficient in that an irregular pattern of standing vibrational waves are set up in the diaphragm so that the degree of vibration is non-uniform over the diaphragm surface. Consequently, the conventional acoustical methods will result in non-uniform flocking of the substrate sheet.

SUMMARY OF THE INVENTION

Broadly described, the method of the present invention includes applying an adhesive coating to a moving substrate sheet, adhering elongated flock particles to the adhesive coating so that the flock engages therein and passing the substrate sheet over an pneumatic vibrator provided with at least one tuned slot communicating with an pneumatic cavity resonating at a low frequency. Each tuned slot directs resonant compression waves against the substrate sheet to generate therein a standing vibrational wave located opposite the tuned slot and extending across the width of the substrate sheet. The extending wave vibrates in a direction generally perpendicular to the plane of the substrate sheet to implant the flock particles in the adhesive in a generally perpendicular orientation. Preferentially, the pneumatic cavity is of a truncated conical shape in which the tuned slots are located on the truncating surface. Advantageously, the frequency of the tuned cavity is a low frequency, defined for the purposes of this disclosure as including frequencies of about 10 cycles per second to about 150 cycles per second.

In a preferred embodiment of this invention, a continuous carrying sheet is coated with a heat setting adhesive, flock is applied to the adhesive coating and the flock and adhesive coated carrying sheet is passed over at least one tuned slot of a pneumatic vibrator, the tuned slot directing low frequency compression waves against the carrying sheet to generate therein a standing vibrational wave extending across the width of the carrying sheet thereby implanting the flock fibers in an orientation generally perpendicular to the sheet. After vibrating, the carrying sheet is passed through a heating zone to set the adhesive to hold the fibers in position and subsequently the flock embedded adhesive layer is separated from the carrying sheet.

The above described flocking method may be employed with equal advantage where it is desired not to separate the flocked layer from the substrate sheet, but rather to retain the flocking on the substrate as a pile, suitable substrates for flock coating include paper, plastic film, plastic foam sheet and woven textiles such as carpet backings, etc.
FIG. 1 depicts a side view of a preferred apparatus for practicing the pneumatic flocking method of the present invention. FIG. 2 is an enlarged detailed cross-sectional view of a portion of the pneumatic vibrator and flock hopper of the apparatus depicted in FIG. 1; FIG. 3 depicts in cross-section a flock and adhesive coated carrying sheet passing over a tuned slot of the pneumatic vibrator during the resonant portion of the resonant frequency standing wave generated in the pneumatic cavity; and FIG. 5 depicts a prospective view of a preferred design of pneumatic vibrator.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First preferred embodiment

Referring to FIG. 1, a carrying sheet 1 is continuously moved by means of rollers 2 and 3, driven by a suitable drive mechanism (not shown). An adhesive coating apparatus containing a supply of adhesive, generally designated as 4, applies a layer of adhesive 5 to the carrying sheet 1, by means of coating roller 6. (A base material printing mechanism may also be used to deposit equal amounts of adhesive layer.) Flock hopper 7 having suitable passageways located in its bottom portion at 8 is vibrated by means (not shown) to deposit an even and controlled quantity of elongated flock particles 9 on to the adhesive coating 5 on the sheet surface as the continuous sheet 1 passes over the acoustical vibrator 10. Although in FIG. 1 flock hopper 7 is located directly above the pneumatic vibrator 10, the flock hopper 7 may be located at a point before the adhesive coated carrying sheet 1 reaches vibrator 10.

As the flock and adhesive coated carrying sheet 1 is passed over pneumatic vibrator 10, the tuned slots 11 direct compression waves against the lower portion of the carrying sheet 1 to impart to it a generally vertical vibratory motion causing the flocked fibers to become implanted at one end in the adhesive. As the carrying sheet is vibrated, the moment of the flock particles causes them to become oriented in a generally vertical direction. With increased vibration, the orientation of the flock fibers becomes more vertical. By the time carrying sheet 1 has reached the right end of the pneumatic vibrator 10, it has a uniformly coated surface of planted flock fibers 16.

After vibration, the flock and adhesive coating carrying sheet 1 is passed through hot air dryer 11 to dry the adhesive. After drying, the adhesive layer is separated from the carrying sheet 1, for example, by tripping or by use of a knife means (not shown) and rolled up upon roller 12. The carrying sheet 1 passes over roller 3 and is returned to roller 2 to repeat the above-described cycle. Advantageously, a vacuum device (not shown) may be located between the air dryer 11 and roller 12 to remove excess flock which has not become embedded in the adhesive. In the case where the flock layer is not to be separated, the flock coated carrying sheet would be wound up on a suitable roller and no continuous carrying sheet would be required.

FIG. 2 depicts in cross section a detail of the pneumatic vibrator 10. As shown in FIG. 2, the pneumatic vibrator 10 is essentially a resonant pneumatic cavity comprising a box of truncated conical shape. One end of the box is closed by a truncating surface 13 which is provided on tuned slots 11 over which the carrying sheet is caused to pass. One or more flock hoppers 7 may be located before or directly above the truncated surface to deposit flock particles onto the adhesive coating. The pneumatic cavity 10 may be supplied with pneumatic waves at the resonant frequency of pneumatic cavity by any suitable generating means such as an electromagnetic or electrodynatonic loud speaker, a piston driving a vibrating diaphragm or compressed air flowing over an orifice. Preferentially, the resonant frequency of the pneumatic cavity 10 is a low frequency, in the range of 10 to 150 cycles per second, although practical results have been achieved at frequencies greater than 150 cycles per second.

The tuned slots 11 are located at points of maximum amplitude of the standing wave generated within the cavity at its resonant frequency. By so locating tuned slots 11, the greatest amount of vibrational effect may be achieved for a given amplitude of pneumatic waves supplied to the pneumatic cavity. Further efficiency is obtained in the present invention through the conical configuration of the acoustical cavity which has the effect of focusing the resonant frequency standing wave towards the truncated surface thereby achieving greater amplitudes of the standing wave at the tuned slots.

Various flocking effects may be achieved by changing the resonant frequency of the pneumatic cavity by changing the slot dimension and by changing the amplitude of the standing acoustical wave generated within the cavity. The exact frequency and dimensions of the resonant cavity and tuned slots depend upon the desired angle of lay of a flock, the size and density of the flock, the properties and thickness of the adhesive coating and the momentum of the carrying sheet. For example, in some instances, by increasing the vibration of the carrying sheet, the flock fibers will be forced into a more perpendicular orientation to the carrying sheet. By decreasing the vibration, the angle of the lay of the flock fibers may be decreased a desired amount.

FIG. 3 illustrates the manner in which the substrate and adhesive layer are moved downwardly on a negative portion of a standing wave generated at tuned slot 11. FIG. 4 illustrates the manner in which the carrying sheet and adhesive layer are moved upwardly during a positive portion of a standing wave. As the carrying sheet 1 is vertically vibrated in the manner shown in FIG. 3 and FIG. 4, the momentum of the flock fibers causes them to be implanted at one end in the adhesive and are oriented into a generally upstanding configuration.

Second preferred embodiment

A second preferred embodiment is depicted in FIG. 5 which illustrates the configurations and dimensions of an pneumatic vibrator for a particular application. In this preferred embodiment, a Teflon coated substrate 18 of 0.040 inch thickness is coated with an approximately 0.015 inch thick coating of adhesive, for example, a latex based adhesive, on to which was deposited nylon flock fibers having a length of about 0.190 inch. The flock coated carrying sheet (not shown) was passed over the pneumatic vibrator 18 at a speed of ten inches a second, and was set into vibration by 35 cycles per second acoustical waves directed against the carrying sheet by the tuned slots 17. The pneumatic vibrator 18 was resonated at 35 cycles per second by four low frequency electrodynamic loud speakers (not shown) located in the base of the pneumatic vibrator. After passing over the pneumatic vibrator 18, the flock coated carrying sheet was biased to dry the adhesive and the layer of flocked adhesive was stripped from the carrying sheet and rolled up on a suitable roller.

The pneumatic vibrator 18 utilized in this preferred embodiment has a fundamental resonant frequency of 35 cycles per second. For this embodiment of the invention, dimensions 4 of the square base 14 of the housing are 20 inches by 20 inches and the height of the pneumatic vibrator is also 20 inches. The dimensions 4 of the square truncating surface 15 are 7⅔ inches by 7⅔ inches. Four tuned slots 17 are located in the truncated surface having dimension d equal to 4½ inches and dimension e equal to ¾ inch. The spacing between slots, dimension j, is equal to 1½ inch. The configuration of the above-described pneumatic vibrator is such that when resonated at a frequency of 35
cycles per second, a standing pneumatic wave is generated within the pneumatic cavity having major vibrational amplitudes located substantially within the four tuned slots.

The above described apparatus may also be successfully used to embed 0.75 inch nylon flock particles onto a 0.05 inch coating of latex based adhesive employing a resonant frequency of 55 cycles per second.

Advantageously, the pneumatic vibrator is constructed so that its volume, slot dimension and slot spacing may be varied for different applications. Also it is desirable that the pneumatic wave source, e.g. the electrodynamic loud speakers utilized in the above-described preferred embodiments, be adapted to produce a variable frequency within a given range.

The above description and particularly the preferred embodiments are set forth by way of illustration only. It should be understood by those skilled in the art that many modifications and changes may be made hereon without departing from the spirit and scope of the present invention as is more particularly defined below in the appended claims.

We claim:

1. In the manufacture of flock-coated sheet material, the improved method which comprises the steps of:
   (a) applying an adhesive coating to a moving substrate sheet;
   (b) adhering elongated flock particles to the adhesive coating so that the flock engages therewith;
   (c) passing the flock and adhesive coated substrate sheet over a pneumatic vibrator comprising a box having a closed end with at least one tuned slot in said closed end resonating at a characteristic frequency, each tuned slot directing resonant low frequency compression waves against the surface of said substrate sheet opposite the flock and adhesive coating to generate a standing vibrational wave located opposite said tuned slot and extending across the width of said substrate sheet, said wave vibrating in a direction generally perpendicular to the plane of said substrate sheet,
   wherein said elongated flock fibers are implanted in the adhesive in a generally perpendicular orientation to the substrate sheet.

2. In a method for manufacturing flock-coated sheet material, the improved method comprising the steps of:
   (a) applying heat setting adhesive layer to a moving continuous carrying sheet;
   (b) adhering elongated flock particles to said adhesive layer so that the flock engages therein;
   (c) passing the flock and adhesive coated carrying sheet over a pneumatic vibrator comprising a box having a closed end with at least one tuned slot in said closed end communicating with a pneumatic cavity resonating at a characteristic frequency, each tuned slot directing resonant low frequency compression waves against the surface of said carrying sheet opposite the flock and adhesive coating to generate a standing vibrational wave located opposite each said tuned slot and extending across the width of said carrying sheet, said wave vibrating in a direction generally perpendicular to the plane of said sheet thereby implanting the flocked fibers in the adhesive in a generally perpendicular orientation to the carrying sheet,
   (d) heating the flock implanted adhesive layer to set said adhesive, and
   (e) separating the set, flock impregnated adhesive layer from said carrying sheet.

3. An apparatus for manufacturing flock-coated sheet material comprising:
   (a) a continuous carrying sheet adapted to be coated on a first surface thereof with a layer of heat setting adhesive,
   (b) a pneumatic vibrator comprising a box closed at one end to form a pneumatic cavity resonant at a characteristic frequency, said closed end provided with at least one tuned slot communicating with said pneumatic cavity,
   (c) wave generation means for supplying low frequency pressure waves to said cavity at substantially said characteristic frequency,
   (d) adhesive means to continuously coat a heat setting adhesive layer to said first surface of said carrying sheet,
   (e) flock hopper means to continuously coat elongated flock particles on said adhesive layer so that the flock adheres and engages therein, and
   (f) sheet moving means to continuously pass the flock and adhesive coated carrying sheet over each tuned slot of said pneumatic vibrator whereby each tuned slot will direct a resonant frequency compression wave against the side of said carrying sheet opposite said adhesive layer to generate a standing vibrational wave located opposite said tuned slot and extending across the width of said carrying sheet, said wave vibrating in a direction generally perpendicular to the plane of said carrying sheet.

4. An apparatus as described in claim 3 in which said pneumatic cavity is of a truncated conical shape with said tuned slots located at the truncating surface of said cavity.

5. An apparatus as described in claim 4 in which:
   (a) heating means are provided to set the flock embedded adhesive layer, and
   (b) separation means are provided for separating said layer of flock embedded adhesive from the carrying sheet.

6. An apparatus as described in claim 5 in which vacuum means for removing excess flock are located between said heating means and said separation means.

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