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3,144,650

ELECTRICAL PROCESS

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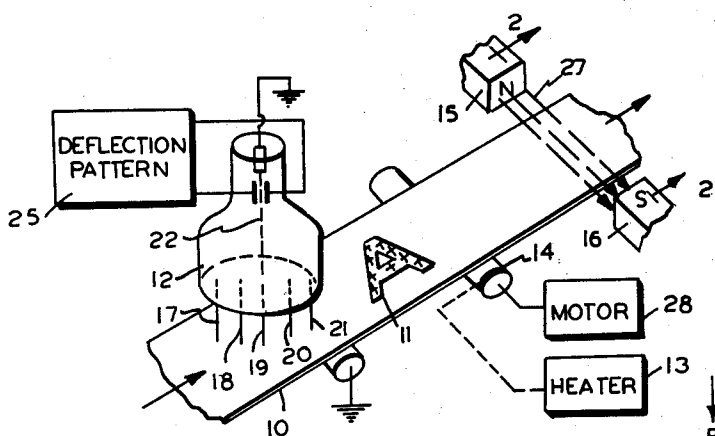


FIG. 1

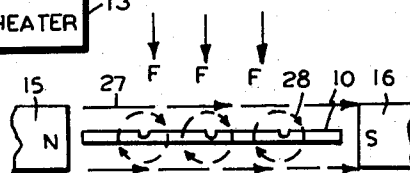


FIG. 2

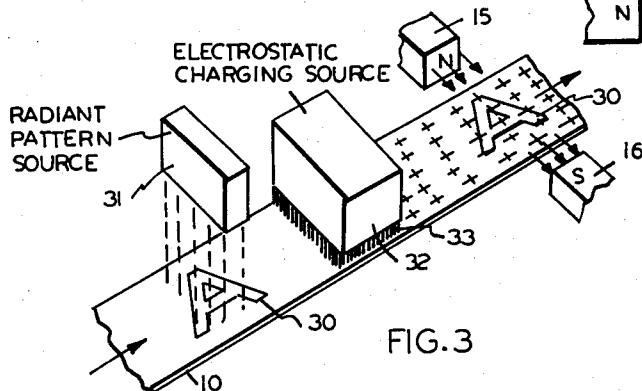


FIG. 3

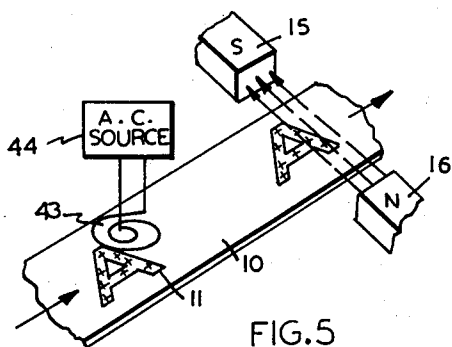


FIG. 5

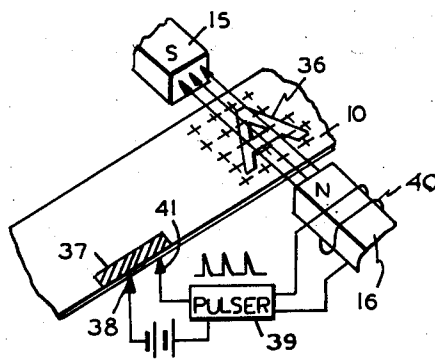


FIG. 4

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ELECTRICAL PROCESS

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This invention generally relates to improvements in the recording of images on thermoplastic materials, and more particularly to improved processes for developing a latent image on a thermoplastic material into a corresponding deformation of the material for such purposes as recording information, and ornamentation among many others.

In the art of thermoplastic recording, it is a common practice to provide an electrostatically charged latent image on the surface of a heat softenable tape or other thermoplastic material and then develop this image by first heating the tape to uniformly soften the material and then subjecting the softened tape to an electric field to exert a dielectric force on the charge image. The dielectric force selectively operating only upon the charged image deforms the softened tape in the image pattern to record the image on the tape in a detectable manner.

According to the present invention there is provided an improved manner of developing deformation images on thermoplastic materials, by the use of magnetically produced forces instead of dielectrically produced forces. According to one preferred embodiment, a thermoplastic material carrying the latent electrostatic image is subjected to a changing magnetic flux by such means as being moved relative to an external magnetic field, or alternatively by varying the flux produced by an external magnet. The changing magnetic flux interacts with the electrostatically charged image to produce magnetic forces of attraction and repulsion on the electric charges of the image. These forces react against the thermoplastic carrier to selectively deform the material in the pattern of the latent image, thereby developing the image into the desired deformation pattern on the thermoplastic as is desired.

According to another embodiment of the invention a similar result may be obtained by providing a latent image in the form of a variable heat or radiation pattern on the thermoplastic carrier to provide an image of heat softened areas thereon. This latent pattern is then developed by uniformly charging the thermoplastic carrier and then subjecting the combined image and charged surface to a changing magnetic flux, as before. In this case, the interaction between the electrostatic charges on the thermoplastic and the varying external magnet field uniformly stresses the material but only selectively deforms those portions on the material that have been softened by the latent image thereby to develop the latent image into a corresponding pattern of deformation on the material.

It is accordingly a principal object of the invention to provide an improved process for developing a latent image on a thermoplastic member into a deformation image.

A further object is to provide such a process employing magnetically produced forces.

A still further object is to provide a process for deforming a thermoplastic that employs the combination of electrostatic fields, radiant energy and magnetic fields.

Other objects and additional advantages will be more readily understood by those skilled in the art after a detailed consideration of the following specification taken with the accompanying drawing wherein:

FIG. 1 is a perspective view illustrating one manner of carrying out a process according to the present invention,

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FIG. 2 is a sectional view taken along lines 2—2 of FIG. 1,

FIG. 3 is a perspective view illustrating a different process for providing the latent image and developing this image,

FIG. 4 is a perspective view illustrating an alternative manner of developing the latent images obtained by the processes of FIGS. 1 or 2, and

FIG. 5 is a perspective view illustrating still another manner of applying and developing a latent image on a thermoplastic material.

Referring now to the drawings there is illustrated in FIGS. 1 and 2 one manner of practicing a process according to the invention to develop a deformation image on a thermoplastic tape 10 corresponding to a latent electrostatic image.

As shown, the latent electrostatic image 11 in the desired pattern may be continually applied to the surface of a moving thermoplastic tape 10 of dielectric material, such as a wax layer, by the use of a so-called pin tube 12, which is known in the art and comprises a cathode ray tube provided with a series of conducting pins 17 to 21, inclusive, being embedded in its end face and projecting exteriorly therefrom to engage the surface of the tape 10. These pins are adapted to be selectively bombarded by the electron beam 22 within the tube in a desired pattern as controlled by variously deflecting the beam according to a predetermined pattern produced by a deflection pattern source of voltage 25. The selective bombardment of the pins 17 to 21, inclusive, imparts an electrostatic charge to the upper surface of the tape 10 according to the desired latent image or pattern 11. The lower surface of the tape is continuously engaged by an electrically grounded metal roller, as shown, so that the tape 10 functions as a dielectric to receive and retain the electrostatic charge.

After producing this latent image 11, the tape 10 is next advanced over a heated roller 14 or other suitable heating means, which serves to heat and thereby uniformly soften the thermoplastic tape. Thus after leaving the heated roller 14, the tape 10 is uniformly softened by heat and carries an electrostatic latent image 11 on its upper surface corresponding to the desired intelligence pattern to be recorded.

Continued movement of the tape, then carries the latent charged image 11 between the opposite poles 15 and 16 of a stationary magnet or electromagnet that passes a strong external magnetic field 27 through the tape 10. The relative movement of the electrostatic charges in the image 11 with respect to the external magnetic field 27 produces an induction magnetic field 28 about the electrostatic charges, according to the well known Lenz's right hand rule as is shown in FIG. 2. This induction magnetic field 28 interacts with the static magnetic field 27 to produce forces of attraction and repulsion on the electrostatic charges against the heat softened thermoplastic tape 10 which thereupon is selectively deformed by these magnetic forces to produce ridges, valleys, wrinkles and the like in the plastic corresponding to the image. Although the tape 10 is uniformly softened by the heated roller 10, the magnetic forces are selectively produced only where the electrostatic charges exist on the surface of the tape. Consequently, those positions on the tape that do not carry a charge are not subjected to a deforming force whereas those portions carrying a charge receive a deforming force and there is produced a selective deforming of the tape corresponding to the latent image 11.

It is to be particularly noted that according to the invention, the development of the image occurs during movement of the tape 10 through the external magnetic field 27 whereby this development may be performed rapidly and continuously. Furthermore since the electro-

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static charges may also be applied to the tape in a continuous manner, by the use of pin tube 12 or by other known means, the complete process of applying and developing the latent image may be made continuous and rapid as may be desired for such applications as high speed printing, telegraphy, pictorial facsimile, or diverse other purposes.

FIG. 3 illustrates a different process of recording wherein the applied latent image is in the form of a radiation produced image 30 instead of an electrostatic latent image 11 as in FIG. 1.

In this process the latent image 30 is provided by irradiating the thermoplastic tape by a suitable radiation source 31, such as an infra-red radiant energy source, which selectively heats and softens the different positions of the thermoplastic tape 10 in the pattern of the information to be recorded thereby to provide selective areas of soft and more rigid positions on the tape.

After applying this heat image 30, the tape 10 is next sprayed or coated with a uniform electrostatic charge over its upper surface by such means as being passed beneath the wipers or brushes 33 of a suitable electrostatic charging source 32.

In the final step after receiving the uniform electrostatic charge over its surface, the tape 10 is then passed between the poles 15 and 16 of a suitable magnet or electromagnet where the moving electrostatic charges interact with the magnetic field to uniformly stress the thermoplastic tape 10. However, only at those positions on the tape 10 that have received the latent heat image 30 and been softened thereby, is the tape selectively deformed by the magnetic stressing forces whereas the unsoftened positions on the thermoplastic resist the magnetic forces and hence are not deformed.

FIG. 4 illustrates an alternative manner of developing the images of FIGS. 1 or 2 without the need for relative movement between the tape and the external magnetic field.

According to this embodiment, the externally produced magnetic field is unidirectionally pulsed to expose the electrostatic charges to a rapidly changing unidirectional magnetic flux, which varying flux interacts with the charges to produce a magnetic deforming force on the tape in the same manner as previously described. In this case, however, the tape 10 and electromagnet may be maintained relatively stationary with respect to each other, or alternatively may be made relatively movable as before to further increase the magnitude of the magnetic stressing force.

The position of the tape 10 is preferably synchronized with the pulsed energization of the magnets 15 and 16 whereby upon the image 36 being properly located between the magnet poles 15 and 16, a triggering source or pulser 37 is suitably actuated to apply a sharp wave front unidirectional electrical pulse, or a series of such pulses, to the magnet winding 40. Referring to FIG. 4, one manner of simply performing this function is to provide an electrically conducting strip 37 at the edge of the tape 10, together with a pair of feeler contacts 38 and 41 for sensing the presence of the conducting strip 37 when the image 36 is properly located between the magnetic poles 15 and 16. When the image 36 is properly positioned, the feelers 38 and 41 make contact through the conducting strip 37 to energize the pulser 39 for applying unidirectional energization to the magnetic winding 40. If a series of pulses are to be applied to the magnet winding 40 instead of a single pulse, each of these pulses should be characterized by possessing a steep or sharp wave front and a more slowly decaying trailing edge, or the reverse, for the purpose of providing a net unidirectional charge of flux through the magnets instead of a bidirectional change at both the leading and trailing edges. More specifically, the force being exerted on the electrostatic charges is proportional to the rate of change of the current passed through the

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winding 40 and accordingly by providing a greater change of flux at the leading edge than at the trailing edge the net stressing force applied to the tape 10 is unidirectional to deform the tape as desired.

Alternatively, if only one pulse is to be applied, the leading edge thereof is preferably synchronized to occur when the latent image 36 is properly positioned between the magnetic poles 15 and 16, and this pulse continues in duration and does not decay until the detecting feelers 38 and 41 sense that the latent image 36 has been removed from between the poles. This is easily accomplished by incorporating a bistable flipflop circuit (not shown) in the pulser mechanism 39 which is actuated when the image is properly disposed between magnetic poles and is maintained in this stable condition until the image is removed from between the poles as is detected by the feeler contacts 38 and 41 leaving the conductive strip.

FIG. 5 illustrates an alternative manner of selectively applying heat to soften the tape only at the discrete positions of the latent image rather than uniformly heating the tape 10 as in FIG. 1. In this embodiment, the electrostatic image 11 may be applied to the tape by a pin tube 12 as in FIG. 1. In the next step, instead of uniformly heating the tape 10, the tape is subjected to an alternating current magnetic field being provided by a high frequency loop or winding 43 that is energized by a high frequency alternating current source 44. The rapid alternation of the flux produced by winding 43 produces a high frequency alternating torque on the electrostatic charges to vibrate and stress the thermoplastic material at high frequency and create heat at the stressed positions, thereby to selectively soften the tape only in the regions of the applied image. In this manner, only the image regions are heat softened by the high frequency field and the remaining position of the tape are both unheated and uncharged.

In developing this latent image the tape may be again passed between the poles 45 and 46 of a stationary magnetic field, as in FIGS. 1 and 2, as shown, or the tape may be pulsed by a unidirectional changing magnetic field as is shown in FIG. 3. Alternatively, the tape 10 may be sufficiently heated by the high frequency field to change the characteristics of the tape and develop the image without the need for magnetic development.

After the steps as described above have been performed, the cooling and consequent rehardening of the softened areas on the plastic serves to freeze and permanently retain the embossed image. However, if it is desired to erase the image and restore the tape to its original condition this may be performed by uniformly heating the surface of the tape, or subjecting the tape to other softening radiation so that the plastic flows to fill in the cavities, undulations, and wrinkles formed in the embossed pattern. Alternatively a number of thermoplastic materials are known that possess a "plastic memory" and will return to their original shape upon reheating without reaching a melted or flowable condition.

The intensity of the magnetic field, electrostatic charges, the heat or radiation image and the thickness of the tape embossed member may all be varied as desired to charge the depth or other characteristics of the embossed image.

With regard to the thermoplastic materials employed, a wide variety of dielectric plastics are suitable such as the various of the many known waxes, natural and synthetic resins, and various gelatinous materials, such as those formed of silicone oil.

Although specific means have been disclosed for performing the process steps it is believed evident that these steps are not dependent upon such means for their performance and may be carried out independently of the specific means disclosed.

For example, although the production of the electrostatic image or pattern 11 in the process of FIGS. 1 and 5 has been described as being performed by the

use of a pin tube 12, it is well known, that electrostatic images may be applied by many other means such as by electrical arcing techniques, by the use of a charged capacitor templet, or even by manually rubbing together two dielectric materials to produce a charge and then tracing this charge on the tape. Similarly the step of uniformly heating the tap to soften the thermoplastic may be performed by other steps such as by irradiating the tape with infra-red rays or by other actinic radiation which will soften the thermoplastic, by the use of electrical heating coils, by microwave heating, or even by the step of exposing the tape to strong sunlight.

Similarly in the process of FIG. 3, the heat pattern or image 39 may be applied simultaneously or by sequentially scanning the tape by the use of infrared radiation traced or projected through a suitable mask or templet; by irradiating the complete image or by sequentially scanning a pencil beam of sunlight to trace the pattern; by applying a microwave radio beam; or by applying a heated templet to the tape among many others.

Many other variations in these steps may also be made without departing from the spirit and scope of the invention as is believed now evident in view of the foregoing to those skilled in the art and accordingly this invention is to be considered as being limited only by the following claims.

What is claimed is:

1. A process for applying a desired pattern of embossing on a thermoplastic member comprising: the combined steps of applying actinic radiation to the member to soften the plastic and applying an electrostatic charge to the member with one of the radiation or charge being in the pattern of embossing that is desired, and developing the pattern into the corresponding embossed pattern by subjecting the combined irradiated and charged material to a varying magnetic flux.

2. In the process of claim 1, said radiation being applied to the member as a latent image in the pattern desired to variably soften the member at the image positions and the electrostatic charge being applied to said member at both the image and nonimage positions.

3. In the process of claim 1, said electrostatic charge being applied to the member as a latent image in the pattern desired and the radiation being applied to the member to variably soften the member at both the image and nonimage positions.

4. In the process of claim 1, the electrostatic charge being applied to the member as a latent image in the desired pattern and the step of applying radiation to the member to soften the member being performed by subjecting the member having the electrostatic image to a high frequency radio beam.

5. In a process for embossing a thermoplastic material in a desired pattern, the steps of processing the material to provide a latent image of softened positions thereon in the desired pattern, and developing said softened image pattern by the combined steps of applying an electrostatic charge to the member and subjecting the member to a varying magnetic field.

6. In a process for embossing a thermoplastic material in a predetermined pattern, the combined steps of applying an electrostatic charge and applying actinic radiation to the thermoplastic, with one of the charge or radiation being in a latent pattern of the embossing desired, and developing the latent pattern by applying to the thermoplastic a substantially unidirectionally changing magnetic field.

7. In the process of claim 6, the step of applying a

substantially unidirectionally changing magnetic field being performed by repetitively pulsing an electromagnet by impulses having a more rapid variation in one direction and a more slow variation in the other.

8. In the process of claim 6, the step of applying a substantially unidirectionally changing magnetic field being performed by applying a single pulse to an electromagnet and subjecting the thermoplastic material to the unidirectionally changing field produced thereby.

9. In the process of claim 6, the step of applying a substantially unidirectional changing magnetic field being performed by providing relative movement in one direction between the thermoplastic and a magnetic field.

10. In a process for embossing a dielectric thermoplastic material in a desired pattern comprising the combined steps of radiating the plastic and applying an electrostatic charge to the plastic, with one of the radiation or electrostatic charges being applied as a latent image of the desired pattern, and developing the latent image into the desired embossing by subjecting the thermoplastic to a changing magnetic field.

11. In a process for embossing a thermoplastic material in a desired pattern, the steps of forming an electrostatically charged latent image of the desired pattern on the surface of the thermoplastic, and developing the image into the corresponding surface embossing, the step of developing the latent image including subjecting the electrostatic image to a rapidly changing magnetic field.

12. In the process of claim 11, the additional step of preheating the thermoplastic before subjecting the image to the magnetic field.

13. In the process of claim 11, the step of subjecting the electrostatic image to the magnetic field being performed by irradiating the image by a high frequency radio field.

14. In the process of claim 11, the step of subjecting the electrostatic image to a magnetic field being performed by applying a static magnetic field to the image and repetitively pulsing the field.

15. Apparatus for embossing a dielectric thermoplastic material comprising:

means for irradiating the thermoplastic with radiation energy to soften the thermoplastic,

means for applying an electrostatic charge to the thermoplastic,

one of said irradiating means or electrostatic charge applying means producing a latent image on the thermoplastic material corresponding to the desired embossing,

and means for developing the latent image into an embossed image by subjecting the thermoplastic to a changing magnetic field

whereby the interaction of the electrostatic charge with the changing magnetic field deforms the radiation softened thermoplastic to develop the image.

16. In an apparatus for embossing a dielectric thermoplastic material comprising:

means for applying an electrostatic charge to the thermoplastic material,

and means for producing a changing magnetic field and applying the field to the charged thermoplastic.

17. In the apparatus of claim 16, said means for producing a changing magnetic field comprising a high frequency generator.

References Cited in the file of this patent

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