United States Patent

[11] 3,615,993

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[54] **MAGNETIC BALL PRODUCTION METHOD**
7 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **156/155,** 35/61, 35/66, 335/303, 335/306
[51] **Int. Cl.** **B431 1/12**
[50] **Field of Search** 335/303, 306; 35/66, 61; 156/155

[56] **References Cited**

UNITED STATES PATENTS

Re.25,822	7/1965	Tate	35/66
3,024,392	3/1962	Baermann	335/303
3,406,363	10/1968	Tate	335/303
3,426,453	2/1969	Dingwall et al.	335/306
3,432,941	3/1969	Minchom	335/306

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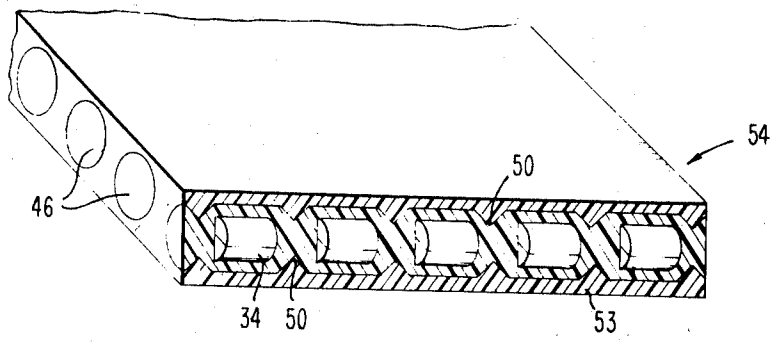
ABSTRACT: Method of making a sheeting material which is capable of having graphic subject matter produced thereon and erased therefrom by a magnetic stylus and wherein one sheet of the material can have reproduced thereon graphic subject matter present on another sheet.



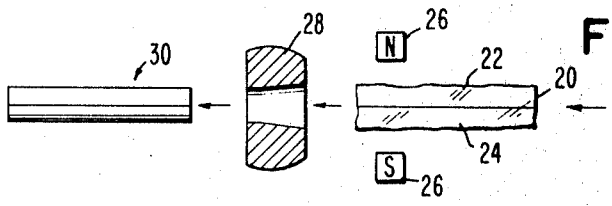


FIG. 1

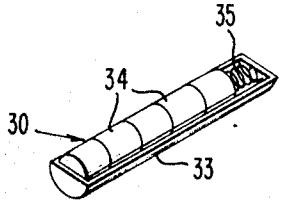


FIG. 2B

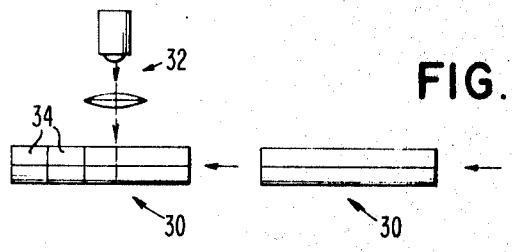


FIG. 2A

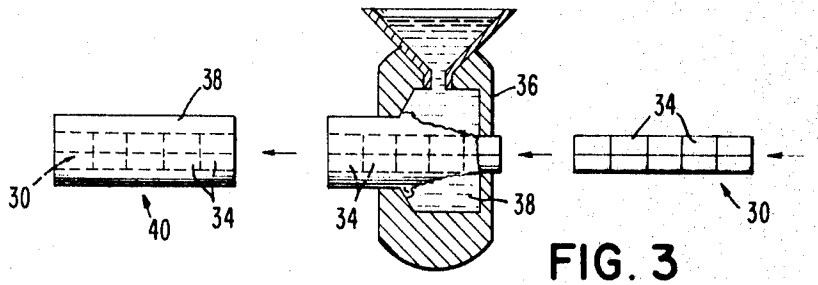


FIG. 3

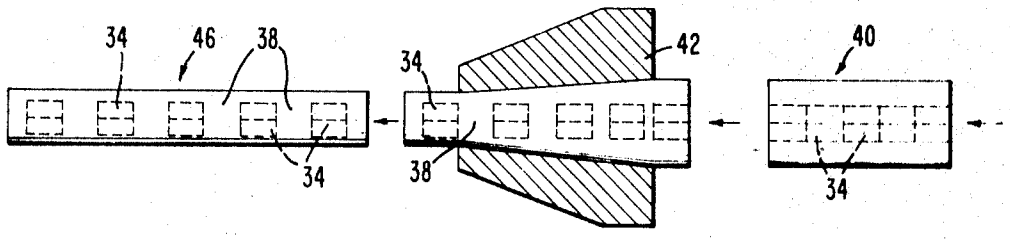


FIG. 4

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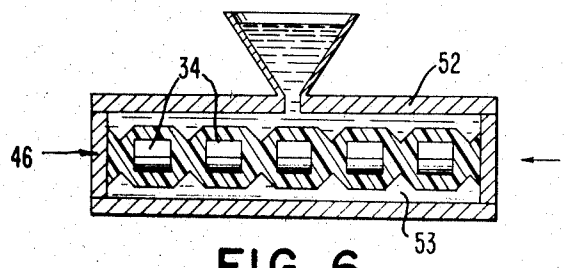


FIG. 6

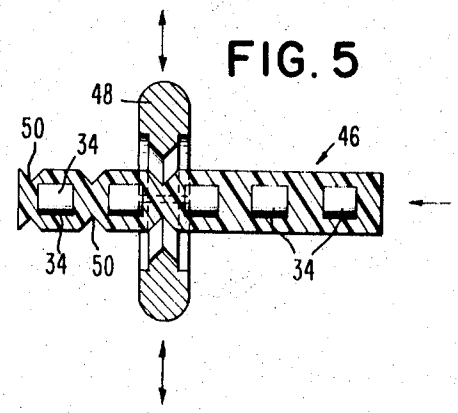


FIG. 5

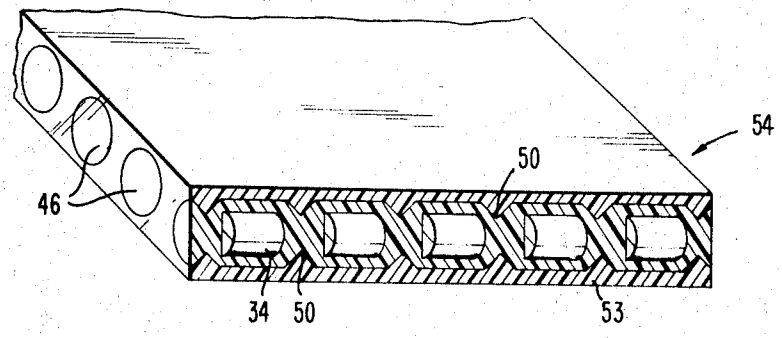


FIG. 7

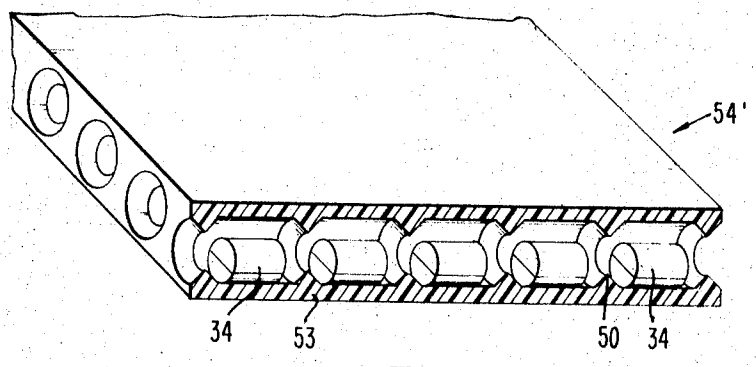
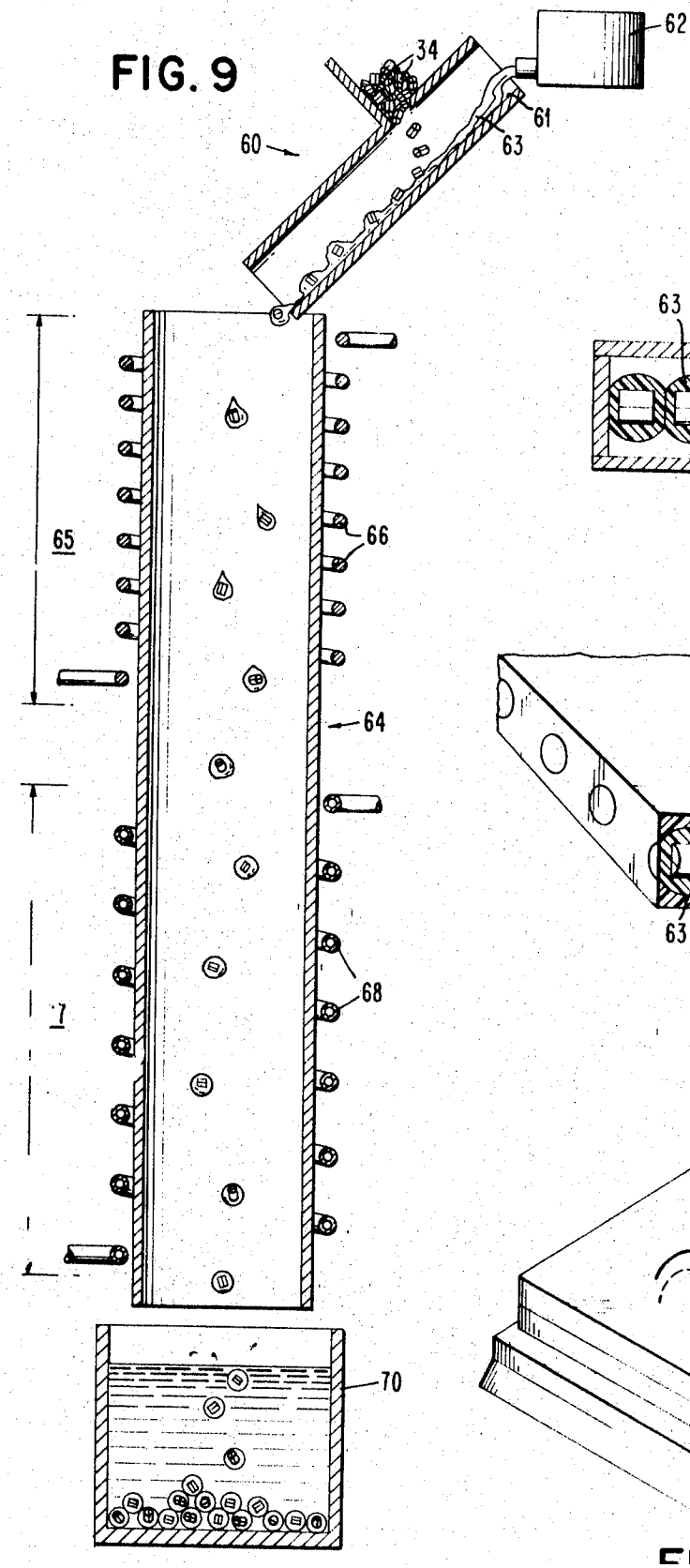


FIG. 8

FIG. 9



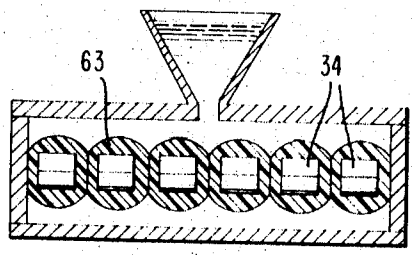


FIG. 10

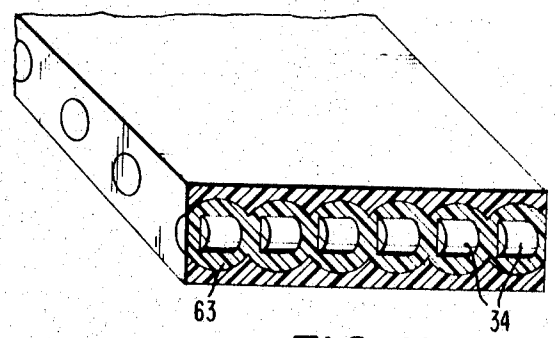


FIG. 11

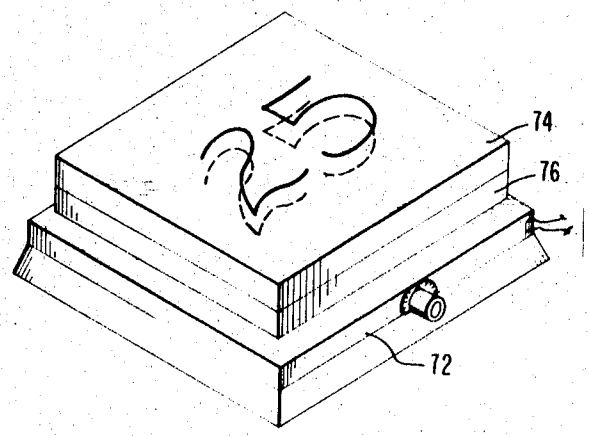


FIG. 12

MAGNETIC BALL PRODUCTION METHOD

BACKGROUND OF THE INVENTION

This invention relates to materials capable of having graphic subject matter produced thereon by magnetic means More particularly, it relates to a novel sheet and a method of making thereof which can be used both for having graphic subject matter inscribed thereon by a magnetic instrument and for reproducing such graphic subject matter on one sheet on another sheet.

Magnetic slates and chalkless blackboards are well known. Examples of such devices are those wherein a magnetic stylus coalesces magnetic particles to produce graphic subject matter, those wherein a magnetic stylus pulls into view magnetic particles which are contained in respective chambers, and those wherein a magnetic stylus rotates individual magnetic material spheres having contrastingly colored hemispheres contained within individual pockets.

It is an object of this invention to provide a method of making a thin sheet material capable of having graphic subject matter inscribed thereon and erased therefrom by magnetic means.

It is another object to provide a method of making a thin sheet material capable of having graphic subject matter inscribed thereon and erased therefrom by magnetic means and of having inscribed graphic subject matter thereon reproducible therefrom.

It is a further object to provide the thin sheet material produced in accordance with the method of the preceding objects objects.

It is a still further object to provide a method for reproducing graphic subject matter utilizing sheets of the material provided in accordance with the preceding objects.

SUMMARY OF THE INVENTION

In accordance with the invention there is provided a method of making a sheet containing a multiplicity of magnetic bodies which are capable of being freely rotated under the influence of a magnetic field applied to the sheet. The method comprises coating the bodies with a thermoplastic material, arranging the coated bodies in a planar array and enveloping the array in a sheeting material to produce the sheet.

Also in accordance with the invention there is provided a sheet capable of being written on by a magnetic stylus comprising a thin planar structure which comprises a transparent plastic material and a multiplicity of adjacently disposed chambers contained within the structure. Each of the chambers contains a magnetically polarized magnetic material body which is free to rotate within its chamber, each of the magnetic bodies comprising a first portion of one magnetic polarity and of a relatively light color and a second portion of the opposite polarity and of a relatively dark color.

This is further provided a method of reproducing graphic subject matter which comprises a first step of producing graphic subject matter by writing with a magnetic stylus on a first heated sheet, the latter first heated sheet comprising a thin planar structure which comprises a transparent plastic material containing a multiplicity of adjacently disposed chambers. Each of the chambers contains a thermoplastic material and a magnetically polarized magnetic material body which is free to rotate within its chamber when the thermoplastic material is softened by heating. Each of the magnetic bodies comprises a first portion of one magnetic polarity and of a relatively light color and a second portion of the opposite magnetic polarity and of a relatively dark color. The method further comprises a second step of cooling the first sheet after the graphic subject matter has been written thereon to harden the heat softened thermoplastic material and thereby fix the disposition of the magnetic material bodies within their respective chambers. The method also comprises a third step of placing a second sheet having the same structure as the first sheet and sufficiently heated to soften the thermoplastic material contained therein in intimate contact with the first sheet whereby the magnetic material bodies contained in the second sheet are caused to be rotated to magnetically conform to the disposition of the magnetic material bodies contained in the first sheet whereby the graphic subject matter on the first sheet is reproduced on the second sheet.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a depiction of the stage in accordance with the method of the invention wherein an elongated cylinder of magnetic material is produced;

FIG. 2A shows the stage of the method according to the invention wherein the elongated cylinder is sliced up into short cylinders;

FIG. 2B shows a suitable support arrangement suitable for use in the stage depicted in FIG. 2A;

FIG. 3 depicts the step wherein the cut elongated cylinder is coated with a "release agent" such as a thermoplastic material;

FIG. 4 shows the step in which the coated elongated cylinder is contracted in diameter to cause the thermoplastic material to space the short cylinders from each other;

FIG. 5 depicts in cross section the step in which the contracted diameter coated cylinder is circumferentially notched at points between adjacent short cylinders;

FIG. 6 is a view, partly in section, which shows the step according to the method of the invention wherein the notched coated cylinders are encapsulated to form a sheet;

FIG. 7 is a view, partly in section, of the sheet resulting from the step depicted in FIG. 6;

FIG. 8 is a view, partly in section, which shows the sheet of FIG. 7 with the release agent removed therefrom;

FIG. 9 is an elevational view, partly in section, of apparatus for providing another embodiment of release agent coated magnetic material bodies, in accordance with the invention;

FIG. 10 is a cross-sectional view illustrating the encapsulating into a sheet of the bodies produced in the apparatus shown in FIG. 9;

FIG. 11 is a view, partly in section, of a sheet formed, according to the invention, of the magnetic bodies produced in the apparatus of FIG. 9; and

FIG. 12 is a three-dimensional view of a graphic subject matter copier utilizing the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to FIGS. 1–8 wherein there are respectively depicted various stages in the method according to the invention.

In FIG. 1 there is shown a rectangular rodlike structure 20 which suitably consists of a magnetic rubber or a magnetic plastic material. If desired structure 20 may consist of two magnetic material laminates 22 and 24 suitably welded or otherwise attached together, each of the laminates being of different colors. Thus, one magnetic laminate 22 may be white and the other magnetic laminate 24 may be black.

A magnet 26 which may be of the fixed or electromagnetic type may be provided to magnetize structure 20. As shown for convenience of explanation, the upper portion or laminate 22 of structure 20 is given a north pole magnetic orientation and the lower portion or laminate 26 is given a south pole magnetic orientation in accordance with the magnetic poling shown for magnet 26. It is readily appreciated that structure 20 may be provided in very thin slices from a sheet or laminated sheet of magnetic rubber or magnetic plastic.

After structure 20 has been polarizedly magnetized, it may be passed through an extrusion die 28 or other suitable device to produce a rod of substantially right circular cylindrical configuration. Alternatively, structure 20 may be sliced into cubes or parallelepipeds.

FIG. 2A schematically depicts the cutting step in the processing of rod 30. Since there are being handled structures of extremely small dimensions (for example, rod 30 may have a diameter in the order of about 3–100 microns, and cut lengths of rod 30 of about the same order, it is necessary to provide a very thin cutting mechanism). A suitable mechanism for effecting such cutting may be an extremely thin blade, an ultrasonic wave source, or a mechanism such as a laser 32 as shown in FIG. 2A. Thus, as rod 30 is passed by a cutting station, cutting mechanism 32 is operative to cut rod 30 into equal length cylindrical sections 34.

FIG. 2B shows an example of an arrangement for maintaining cut sections 34 in alignment and in abutting relationship and suitably comprises a trough 33 and a tensioning spring 35.

FIG. 3 schematically depicts the step of coating of cut rod 30 with a "release agent," the latter term being intended to signify a paraffin, wax or other quan-lubricant or thermoplastic material which softens or flows at relatively slightly elevated temperatures and which in its softened or fluid state will insinuate itself between adjacent abutting cylinders 34. A suitable example of a liquid release agent is glycerine. Wax is a suitable example of a thermoplastic release agent. In this connection, it is to be noted that in FIGS. 2A, 2B and 3, cylinders 34 are shown as remaining in abutting contact and in alignment to together retain the configuration of rod 30. Cylinders 34, as has been explained hereinabove, may be extremely small. However, to insure that they may remain in contact when desired, well-known mechanical expedients can be employed such as spring loaded plungers, a trough along which they are moved and the like, as hereinabove described in connection with FIG. 2A.

In the release agent coating step shown In FIG. 3, cut rod 30 is passed through a vessel 36 containing the release agent 38 therein to have the release agent applied thereto whereby there is produced a rod 40 having as its inner core rod 30 comprising cut cylinders 34 and an outer coating 38 of release agent. Vessel 36 may be a vibratory coater or like suitable coating device.

In FIG. 4, there is schematically depicted the releasing step. In this step, rod 40 is passed through a die 42 whose diameter tapers from right to left whereby the diameter of rod 40 is contracted and the release agent 38 is forced between adjacent cylinders 34. The resulting rod 46 emerging from die 42 contains aligned cylinders 34 substantially equispaced from each other by release agent.

In FIG. 5, there is schematically depicted a crimping step. In this step, rod 46 is passed by a crimping tool 48 which provides spaced circumferential notches 50 around rod 46 intermediate respective adjacent cylinders 34.

In FIG. 6, there is shown the encapsulating or casting step. In this step, a plurality of equal length crimped rods are placed side by side to form a rectangular suitably spaced array thereof and are then potted or cast in a suitable transparent plastic 53 or other encapsulating material in a shaped container 52 whereby there is produced in container 52 as shown in FIG. 7, a clear plastic sheet 54 containing a plurality of equispaced substantially parallel disposed rods 46.

In FIG. 8, there is shown the construction of sheet 54 after release agent 38 has been removed therefrom. Such removal is suitably effected by heating sheet 54 whereby release agent 38 becomes molten and readily flows out. Such flowing out can readily be effected through the ends of columns 46 as shown in FIG. 8. It is, of course, to be realized that plastic 53 and release agent 38 have to be so chosen whereby plastic 53 has a melting point sufficiently higher than release agent 38 to insure that sheet 54 does not buckle when it is heated to remove release agent 38 therefrom.

At this point, finished sheet 54' as shown in FIG. 8 can again be subjected to a strong polarizing magnetic field across its surfaces. There, thereby results from the process, according to the invention, a sheet comprising a plurality of individually freely turnable compartmentalized magnetic cylinders 34. With cylinders 34 having a diameter in the few to 100 micron range, sheet 54 need only have the thickness of paper. Sheet 54 or 54' can be written upon and erased with a bar magnet and may be written on automatically with a moving electromagnet which is moving in synchronization with a communication channel or tape recorder.

In a variation of the embodiment shown in FIGS. 1 to 8, the release agent need not be removed from sheet 54 but may be one which softens at a relatively slightly elevated temperature. For example, it may be a wax which softens sufficiently at a temperature of 150° F.–180° F. In this case, the heating of sheet 54 to the latter temperature would be required to permit magnetic writing thereon. With this variation, there can be effected a simple copying device as is further explained hereinbelow. Thus, if it is assumed that one sheet has been written on and has black graphic subject matter thereon, i.e., one portion of all of the magnetic material bodies are black, such written on sheet is permitted to cool until the release agent therein has hardened. A second sheet 54 is heated until the release agent softens to permit the magnetic cylinders 34 therein to rotate freely. The two sheets are then placed in intimate contact whereupon the heated sheet will take on the image of the graphic subject matter on the other sheet and retain it up on its cooling. Thus, with a simple hot plate or like device, a copier may be provided.

Referring now to FIG. 9, there is depicted therein an apparatus suitable for use in producing another embodiment of the invention.

In FIG. 9, cylindrical or parallelepiped magnetic material bodies 34 such as are produced by the slicing of cylinder 30 or rod 20 (FIG. 1) are fed into an inclined hopper whereby they slide down the inner surface 61 of hopper 60 into a tower 64. The structure 62 represents a source of a release agent 63 such as a wax or glycerine which is poured along surface 60 whereby magnetic material bodies 34 are coated, at least in part, by the release agent as they slide down surface 61.

Tower 64 may be of the type in which shot is manufactured and comprises a hot zone 65 and a cold zone 67. Hot zone 65 may suitably be heated by a coil 66, a hot air source or other well-known means used for such purpose. Cold zone 67 may be cooled by cooling coils 68, a fan or other suitable device. As the coated magnetic material bodies 34 fall through hot zone 65 of tower 64, their outer surfaces, i.e., of the release agent, melt, whereby the bodies fall assume a substantially spherical configuration and such configuration is hardened into place as the coated bodies fall through cold zone 67. The hardened little spheres terminate their movements in an arresting device 70, shown in FIG. 9 as a liquid containing tank. However, device 70 may be a ramp or other suitable stop. It is to be realized that magnetic material bodies 34 themselves could be rendered substantially spherical by their dropping through tower 64.

The spheres produced in the apparatus shown in FIG. 9 are laid out in a rectangular array and in tangential contact with each other and are then encapsulated, the encapsulating step being shown in FIG. 10, FIG. 10 illustrating substantially the same step as that shown in FIG. 6.

FIG. 11 is a view similar to that of FIG. 7 and shows the finished sheet with the magnetic material bodies embedded in their release agent. The chambers are substantially spherical.

FIG. 12 shows an office copier device which can be made utilizing the sheet made in accordance with the invention. In the device of FIG. 12, the structure 72 illustrates a hot plate for heating a sheet. Sheet 74 has had graphic subject matter entered thereinto by the writing thereon with a magnetic stylus. Such writing was effected by using a sheet 74 (such as sheet 54) in which the release agent of the thermoplastic type had not been removed therefrom but wherein the sheet had been heated so as to enable the magnetic material bodies in the sheet to be rotated freely within their embedding release agent. After the sheet 74 had been written upon, it had been permitted to cool to freeze the magnetic material bodies into place within their hardened release agent. Now, in the copying step, a blank sheet 76, identical in construction to that of sheet 74 is heated on hot plate 72 to free its magnetic material

bodies within their embedding release agent and cool sheet 74 is placed thereon. In this situation, since only the magnetic material bodies of sheet 76 are free to move, the latter align themselves in accordance with the pattern of the magnetic material bodies in sheet 74 and the graphic subject matter on sheet 74 is reproduced on sheet 76.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of making sheet containing a multiplicity of magnetic bodies which are capable of being freely rotated under the influence of a magnetic field applied to the sheet comprising the steps of:

coating said bodies with a thermoplastic material;

disposing said coated bodies in a planar array;

encapsulating said array with a plastic material to produce said sheet, said plastic material being chosen to have a melting point higher than the melting point of said thermoplastic material; and

heating said sheet to at least render said thermoplastic material molten, said heating being carried out at a temperature which is below the melting point of said plastic material whereby said magnetic bodies are caused to be freely rotatable under the influence of a magnetic field applied to said sheet.

2. A method of making a sheet containing a multiplicity of magnetically polarized bodies which are thereby capable of being freely rotated under the influence of a magnetic field applied to the sheet, said bodies respectively comprising a first portion of a first color of one magnetic polarity and a second portion of a second contrasting color and of opposite magnetic polarity comprising the steps of:

coating said bodies with a thermoplastic material;

disposing said coated bodies in a planar array;

encapsulating said array within a sheet of plastic material, said encapsulating material being chosen to have a melting point higher than the melting point of said thermoplastic material; and

heating said sheet to at least render said thermoplastic material molten, said heating being carried out at a temperature which is below the melting point of said encapsulating material whereby said magnetic bodies are caused to be freely rotatable under the influence of a magnetic field applied to said sheet.

3. A method of making a sheet containing a multiplicity of magnetically polarized bodies which are capable of being freely rotated under the influence of a magnetic field applied to said sheet, said bodies respectively comprising a first portion of a first and light color of one magnetic polarity and a second portion of a second and dark color and of the opposite magnetic polarity comprising the steps of:

coating said bodies with a thermoplastic material;

disposing said coated bodies in a planar array;

encapsulating said array within a sheet of transparent plastic material, said plastic material being chosen to have a melting point higher than the melting point of said thermoplastic material; and

heating said sheeting to at least render said thermoplastic material molten, said heating being carried out at a temperature which is below the melting point of said plastic material whereby said magnetic bodies are caused to be freely rotatable under the influence of a magnetic field applied to said sheet.

4. A method of making a sheet containing a multiplicity of magnetically polarized bodies which are capable of being fully rotated under the influence of a magnetic stylus applied to said sheet, said bodies respectively comprising a first portion of a first and light color of one magnetic polarity and a second portion of a second and dark color and of the opposite magnetic polarity comprising the steps of:

slicing a plurality of relatively long cylinders of magnetic material into respective groups of substantially equal length relatively short cylinders, said magnetic material which is utilized comprising semicylinders of light and dark colored magnetic materials respectively attached to each other along their diametric surfaces;

maintaining the respective groups of sliced relatively short cylinders in abutting relationship and coating said groups with a thermoplastic material;

contracting uniformly under pressure, the diameters of said coated elongated cylinders to force said thermoplastic material between said short cylinders to longitudinally space said short cylinders from each other within said thermoplastic material;

circumferentially notching said coated elongated cylinders at points between the abutting ends of adjacent short cylinders;

arranging said notched elongated cylinders in substantially parallel relationship in a planar array;

encapsulating said array in a transparent encapsulating material in a thin parallelepiped configuration to produce said sheet, said encapsulating material being chosen to have a melting point higher than the melting point of said thermoplastic material; and

heating said sheet to expel said thermoplastic material therefrom to thereby produce a multiplicity of hollow chambers, each of said chambers containing one of said short cylinders, said heating being carried out at a temperature which is at least the melting point of said encapsulating material whereby said thermoplastic material can be flowed out of said chambers through openings in said encapsulating material.

5. A method as defined in claim 4 and further including the step of first producing said relatively long cylinders, said producing comprising:

welding a sheet of light colored magnetic material to a sheet of dark colored magnetic material;

cutting said welded sheet into rectangular strips whereby each of said strips comprises a dark colored material portion and a light colored material portion;

magnetizing said strips whereby said portions are of opposite magnetic polarities; and

passing said rectangular strips through a cylindrical extruding die to convert said strips to cylindrical form to produce said elongated cylinders.

6. A method as defined in claim 5 wherein said sheets of magnetic material are selected from the group consisting of a magnetic rubber and a magnetic plastic.

7. A method of making a sheet containing a multiplicity of spaced, magnetically polarized bodies which are capable of being fully rotated under the influence of a magnetic stylus applied to said sheet, said bodies respectively comprising a first portion of a first and light color and of one magnetic polarity and a second portion of a second and dark color and of the opposite magnetic polarity comprising the steps of:

slicing a plurality of relatively long cylinders of magnetic material into a plurality of relatively short cylinders, said cylinders consisting of substantially semicylindrical light and dark colored portions;

coating said short cylinders at least partly with a thermoplastic material;

permitting said coated short cylinders to fall through a zone having a temperature at least sufficiently high to cause said thermoplastic material to melt and thereby cause said thermoplastic material to become substantially uniformly distributed around said cylinders and to cause said coated cylinders to assume a substantially spherical configuration as they fall through said hot zone, and to then fall through a zone having a temperature sufficiently low to cause said thermoplastic material to harden about said short cylinders;

disposing said coated cylinders in a planar array; and

encapsulating said array in a transparent plastic material in a thin parallelepiped configuration to produce said sheet, said encapsulating material being chosen to have a melting point higher than the melting point of said thermoplastic material whereby, upon the heating of said sheet to a point at which said thermoplastic material becomes molten, said cylinders can be freely rotated under the influence of a magnetic stylus applied to said sheet.

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