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(72) Nakanishi, Masayuki, JP

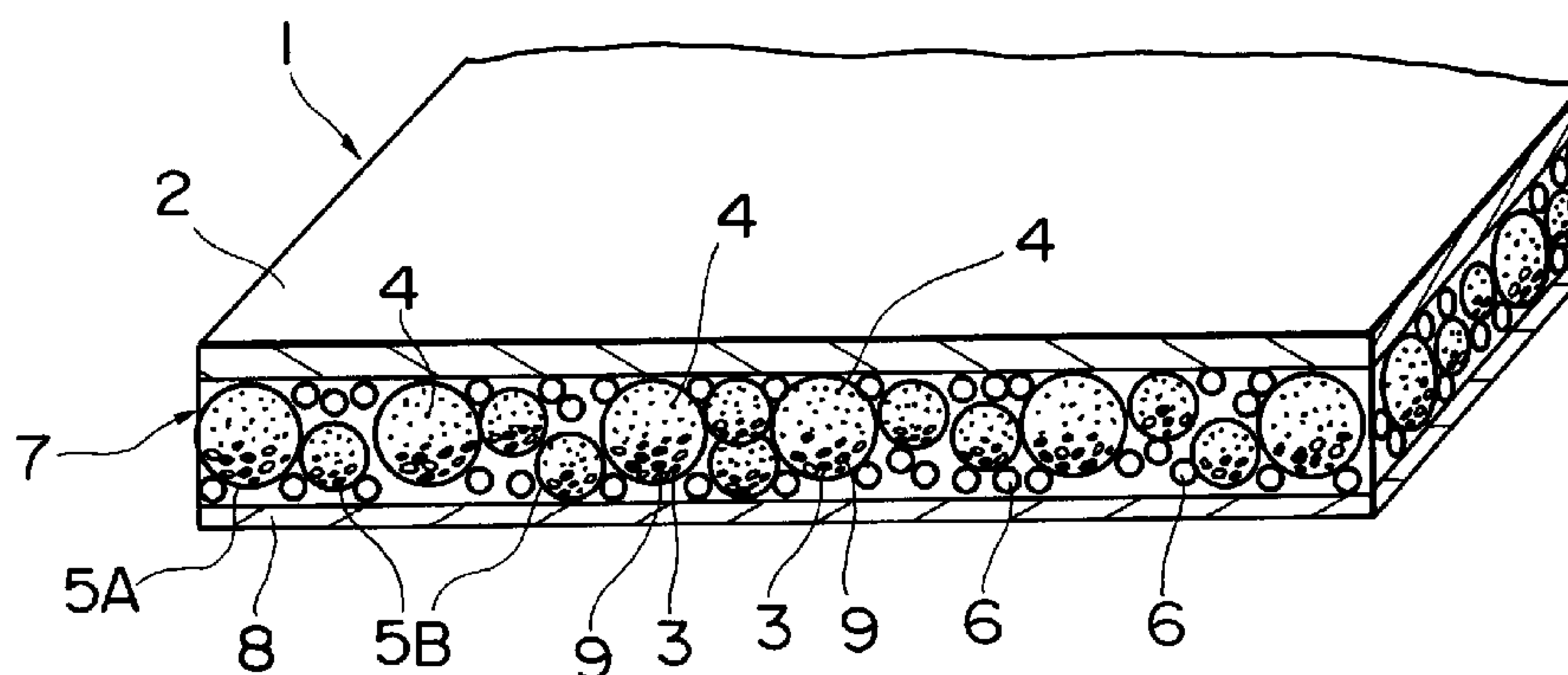
(72) Kanno, Yasuyuki, JP

(73) Japan Capsular Products Inc., JP

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(54) **SYSTEME D’AFFICHAGE MAGNETIQUE**

(54) **MAGNETIC DISPLAY SYSTEM**



(57) The invention of the present application relates to a magnetic display system using a display, wherein a non-magnetic substrate is applied thereonto with a microcapsule coating layer having sealed light-absorptive magnetic particles and light-reflective non-magnetic particles which are dispersed in an oily liquid, and a permanent magnet for causing a shift of the light-absorptive magnetic particles in one direction and, as a result, causing a shift of the light-reflective non-magnetic particles in the other direction. Objects of the invention reside in that the movability of the light-absorptive magnetic particles and the light-reflective non-magnetic particles are intensified when these particles are shifted in the microcapsules to invert the position, the agglomeration property of the light-absorptive magnetic particles after the position is inverted is strengthened, and the combination between the size of the particle diameters of the microcapsules and the size of the particle diameters of the light-absorptive magnetic particles and the light-reflective non-magnetic particles is optimized, whereby the contrast of brightness and darkness of characters and images formed on the display is improved and the side edge portions of the characters and images are made sharper. For this, in the microcapsule coating layer, the microcapsules having a plurality of particle diameters within a range from 100 microns to 1,000 microns are combined together. Furthermore, as the light-absorptive magnetic particles sealed in the microcapsules, the light-absorptive magnetic particles having a plurality of particle diameters ranging from 0.2 micron to several microns are used. Furthermore, a suitable amount of magnetic particles having characteristics capable of becoming the permanent magnet when magnetized after the microcapsule coating layer is coated is added. Furthermore, the mean particle diameter of the light-reflective non-magnetic particles sealed in the microcapsules ranges from 0.01 micron to several microns. Furthermore, a suitable amount of the microcapsules having a particle diameter far more minute than the mean particle diameter of the microcapsules and having sealed only the transparent oily liquid is added to the microcapsule coating layer.

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MAGNETIC DISPLAY SYSTEM

ABSTRACT OF THE DISCLOSURE

The invention of the present application relates to a magnetic display system using a display, wherein a non-magnetic substrate is applied thereonto with a microcapsule coating layer having sealed light-absorptive magnetic particles and light-reflective non-magnetic particles which are dispersed in an oily liquid, and a permanent magnet for causing a shift of the light-absorptive magnetic particles in one direction and, as a result, causing a shift of the light-reflective non-magnetic particles in the other direction. Objects of the invention reside in that the movability of the light-absorptive magnetic particles and the light-reflective non-magnetic particles are intensified when these particles are shifted in the microcapsules to invert the position, the agglomeration property of the light-absorptive magnetic particles after the position is inverted is strengthened, and the combination between the size of the particle diameters of the microcapsules and the size of the particle diameters of the light-absorptive magnetic particles and the light-reflective non-magnetic particles is optimized, whereby the contrast of brightness and darkness of characters and images formed on the display is improved and the side edge portions of the characters and images are made sharper.

For this, in the microcapsule coating layer, the microcapsules having a plurality of particle diameters within a range from 100 microns to 1,000 microns are combined together. Furthermore, as the light-absorptive magnetic particles sealed in

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the microcapsules, the light-absorptive magnetic particles having a plurality of particle diameters ranging from 0.2 micron to several microns are used. Furthermore, a suitable amount of magnetic particles having characteristics capable of becoming the permanent magnet when magnetized after the microcapsule coating layer is coated is added. Furthermore, the mean particle diameter of the light-reflective non-magnetic particles sealed in the microcapsules ranges from 0.01 micron to several microns. Furthermore, a suitable amount of the microcapsules having a particle diameter far more minute than the mean particle diameter of the microcapsules and having sealed only the transparent oily liquid is added to the microcapsule coating layer.

TITLE OF THE INVENTION

MAGNETIC DISPLAY SYSTEM

BACKGROUND OF THE INVENTIONField of the Invention

This invention relates to a magnetic display system wherein the vertical position of light -absorptive magnetic particles and light-reflective non-magnetic particles is reversed in microcapsules to absorb or reflect incident light, thereby forming a contrast image of brightness and darkness therebetween.

Description of the Prior Art

As a first prior art of the conventional techniques concerning magnetic display systems, there is one magnetic display system in which a transparent plastic sheet is formed over the entire surface thereof with honeycomb-like cavities, each with a dimension of about 2 mm as one side and depth. Each cavity is filled with a white pigment liquid and magnetic particles and is sealed with a transparent sheet to prevent leakage of the filling matter. In this case, a rod-like permanent magnet is shifted over the entire display surface from one end of the back surface of the magnetic display to the other, thus bringing the magnetic particles in each honeycomb-like cavity toward the back side of the display plate and leaving a white color of the white pigment on the front surface. By moving a rod-like magnetic pen with its writing end in contact with the white surface of the display, the magnetic particles in the scribed area are brought to the front surface, thus forming an image.

As a second prior art concerning the magnetic display systems, there is known a magnetic display system which utilizes a display in which microcapsules having sealed magnetic particles having anisotropy of shape are coated onto a non-magnetic substrate

and a permanent magnet as a means to change polarity orientation of the magnetic particles partially or totally and thereby forming and erasing images.

Furthermore, as a third prior art concerning the magnetic display systems, there is known a magnetic display system which utilizes a display in which microcapsules having sealed magnetic particles and non-magnetic particles are coated and arranged on a substrate, and a permanent magnet as a means for forming and erasing images by reversing the position of the magnetic particles and the non-magnetic particles in the microcapsules.

However, out of the above-described conventional magnetic display systems, in the first prior art, an image is formed by a shift of magnetic particles in honeycomb-like cavities from the back surface to the front surface. Thus, it is impossible to obtain an image resolution sharper than the size of the honeycomb-like cavity, and it is technically difficult to provide of a mold for forming the dimensions (lengths of respective sides of the periphery and depth) of the honeycomb-like cavity to be less than the current order of a few mm. Further, it is not easy to perform the processes of molding for providing honeycomb-like cavities and of sealing the white pigment liquid and the magnetic particles, and, it is almost technically impossible to make a display board providing honeycomb-like cavities have a size as large as a black-board. Even if it is technically possible, high costs cannot be avoided. Further, such disadvantages are presented that it is technically extremely difficult to pour and seal the white pigment liquid and the magnetic particles into the honeycomb-like cavities provided over the entire surface having the above-described dimensions, on the contrary, it is not easy to make the display have a size as small as a pocket size due to the construction noted above, and, even if the display

is made small in size, because the honeycomb construction has a thickness of several millimeters, an excessive weight for the portable use cannot be avoided.

Furthermore, as compared with the display system in which the magnetic particles and the white pigment are sealed into the honeycomb-like cavities provided by plastic molding in the first prior art, the second prior art is greatly advanced in the respects that the quality of characters and images that can be formed is very superior, the polarity orientation of magnetic particles can be changed with a very slight magnetic flux, and further, a display having a desired size can be readily obtained and so forth. However, this system requires magnetic particles of nickel, or alloys thereof, capable of providing a surface gloss, having anisotropy of shape and having a flakier shape (i.e., a flat and elongated shape) than those of ferrite or iron oxide obtainable by mass production, as well as readily capable of polarization, because it is necessary to provide a strong contrast between light absorption when the particles are orientated vertically and light reflection when the particles are orientated horizontally. Disadvantageously, this leads to increased costs.

Next, according to the third prior art, the display is characterized by a construction in which the light-absorptive magnetic particles and the light-reflective non-magnetic particles are dispersed in an oily liquid, sealed into the microcapsules and coated on a substrate, and can offer the following many advantages as compared with the above-described first and second prior arts. In other words, as compared with the prior art in which the magnetic particles and the white pigment liquid are sealed into the honeycomb-like cavities provided on the substrate, the microcapsules having by far minute particle diameters are utilized, so that such advantages

can be enumerated that: side edge portions of characters and images that can be formed can be made sharper; amounts of the magnetic particles, non-magnetic particles and oily liquid for dispersion, which are required for a given area of the display, can be greatly decreased for source saving; great cost reduction is possible as compared with the processes of molding the honeycomb-like cavities and of filling-sealing of the filling matter; possibilities in selection of a rigid sheet, a soft and flexible film or the like for the substrate coated thereon with the microcapsules allow selections of various shapes of displays such as a board type, a sheet type and a roll-scroll type; and selection of the display having a desirable size can be made from the sheets of mass production through cutting.

Furthermore, as compared with the prior arts of the display systems in which the polarity orientation of the magnetic particles is inverted in the microcapsules, in the third prior art, such advantages can be listed that the magnetic particles used can be obtained at overwhelmingly low costs and the means for forming and erasing the characters and images can be greatly simplified.

As described above, as compared with the display systems cited as the first prior art and the second prior art, the third prior art has many advantages. Accordingly to the present invention, this third prior art is further improved, so that mainly the improvements in quality of characters and images can be achieved.

SUMMARY OF THE INVENTION

To achieve the above-described objects according to the present invention,

in a magnetic display system comprising:

a display having a construction of that a microcapsule coating layer is applied onto a non-magnetic substrate, said microcapsules having sealed magnetic particles having an excellent

light-absorptive surface characteristic and also sealed non-magnetic particles having an excellent light-reflective characteristic and said both particles being dispersed in an oily liquid, respectively; and

a magnetic device including a permanent magnet and serving as a means for causing a shift by attraction of the light-absorptive magnetic particles toward the back surface of the display over the entire surface of the microcapsule coating layer and, as a result, causing a shift of light-reflective non-magnetic particles toward the front surface of the display, and

as a means for causing a local shift by attraction of the light-absorptive magnetic particles having been shifted by attraction from the back surface of the display to the front side thereof to thereby invert the position of the light-reflective non-magnetic particles in corresponding areas, thereby forming characters and images;

microcapsules having sealed an oily liquid dispersed therein with the light-absorptive magnetic particles and the light-reflective non-magnetic particles are of such an arrangement that a wall film thereof is formed of a polymer film being substantially transparent and having a strength capable of semipermanently holding the filling matter, and microcapsules having a plurality of particle diameters ranging from the maximum particle diameter of 1,000 microns to the minimum particle diameter of 100 microns are compounded at a suitable ratio.

As for the magnetic particles dispersed in the oily liquid in the microcapsules, the microcapsules of one type or several types of particles diameters within a range from the minimum particle diameter 0.2 microns to the maximum particle diameter of several microns are combined together.

Furthermore, a suitable amount of magnetic particles like hard ferrite capable of becoming a permanent magnet is added to the magnetic particles dispersed in the oily liquid in the microcapsules, and, after the microcapsules are coated onto the substrate, the magnetic particles are magnetized to become the permanent magnet.

Furthermore, to obtain the movability in the oily liquid of the magnetic particles dispersed in the oily liquid in the microcapsules, lipophilic treatment is applied to the surfaces thereof.

Furthermore, the mean particle diameter of the light-reflective non-magnetic particles dispersed together with the light-absorptive magnetic particles in the oily liquid in the microcapsules ranges from 0.01 micron to several microns, whereby, to obtain the dispersion property and movability in the oily liquid, lipophilic treatment is applied to the surfaces thereof.

Furthermore, the ratio of compounding between the light-absorptive magnetic particles and the light-reflective non-magnetic particles which are dispersed in the oily liquid in the microcapsules are made to be included within a range from 1 : 8 to 1 : 1.

Furthermore,

in a magnetic display system comprising:

a display having a construction of that a microcapsule coating layer is applied onto a non-magnetic substrate, said microcapsules having sealed magnetic particles having an excellent light-absorptive surface characteristic and also sealed non-magnetic particles having an excellent light-reflective characteristic and said both particles being dispersed and dissolved in an oily liquid, respectively; and

a magnetic device including a permanent magnet and serving as a means for causing a shift by attraction of the light-absorptive magnetic particles toward the back surface of the display over the entire surface of the microcapsule coating layer and, as a result, causing a shift of the light-reflective non-magnetic particles toward the front surface of the display, and

as a means for causing a local shift by attraction of the light-absorptive magnetic particles having been shifted by attraction from the back surface of the display to the front surface thereof to thereby invert the position of the light-reflective non-magnetic particles in corresponding areas, thereby forming characters and images;

a suitable amount of oil-containing microcapsules having a more minute particle diameter than the mean particle diameter of the microcapsules and having sealed only a substantially transparent oily liquid is added to and coated onto the microcapsule coating layer having sealed the light-absorptive magnetic particles and the light-reflective non-magnetic particles which are dispersed in an oily liquid to be coated onto the non-magnetic substrate.

Furthermore, the distribution of the particle diameters of the microcapsules having sealed the light-absorptive magnetic particles and the light-reflective non-magnetic particles which are dispersed in the oily liquid is optimized, so that the side edge portions of the characters and images can be made sharper.

Furthermore, the light-absorptive magnetic particles are minimized for the purpose of increasing the outer surface areas of the light-absorptive magnetic particles dispersed in the oily liquid in the microcapsules, and a plurality of light-absorptive magnetic particles which are different in particle diameter are combined together, so that the contrast of brightness and darkness can be

improved by the agglomeration effect of the minute light-absorptive magnetic particles at the time of forming the characters and images.

Furthermore, a suitable amount of the magnetic particles which becomes a permanent magnet by magnetizing it after the microcapsule coating layer is coated is added to the light-absorptive magnetic particles dispersed in the oily liquid in the microcapsules, so that the movability and agglomeration property of the light-absorptive magnetic particles in the microcapsules are intensified, thereby improving the responsiveness in forming and erasing of the characters and images and the contrast of brightness and darkness.

Furthermore, the surfaces of the light-absorptive magnetic particles and the light-reflective non-magnetic particles which are dispersed in the oily liquid in the microcapsules are lubricatingly and lipophilically treated, so that the movability during the inverting of the position therebetween.

Furthermore, the ratio of compounding between the light-absorptive magnetic particles and the light-reflective non-magnetic particles which are dispersed in the oily liquid in the microcapsules is optimized, so that the contrast of brightness and darkness can be improved.

Furthermore, a suitable amount of the microcapsules having a minute particle diameter which contains only the oily liquid is embedded in the microcapsule coating layer, so that the surface smoothness of the microcapsule coating layer can be improved, and further, a light refractive index of the oily liquid in the microcapsules is utilized to reinforce the light absorption property of the light-absorptive magnetic particles and light reflection property of the light-reflective non-magnetic particles.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanatory view showing an example of construction of the display according to the present invention;

Fig. 2 is an explanatory view showing a state where there is mounted the magnetic device for causing a shift by attraction of the light-absorptive magnetic particles in the microcapsules toward the bottom portion of the microcapsules, i. e., the back surface of the display over the entire surface of the display;

Fig. 3 is an explanatory view showing the magnetic device shown in Fig. 2;

Fig. 4 is an explanatory view showing a state where the light-absorptive magnetic particles in the microcapsules are shifted by attraction toward the bottom portion of the microcapsules, i. e., the back surface of the display over the entire surface of the display ;

Fig. 5 is an explanatory view enlargedly showing the microcapsules shown in Fig. 4;

Fig. 6 is an explanatory view showing the magnetic device for forming the characters and images on the display surface;

Fig. 7 is an explanatory view showing the inversion of the position of the light-absorptive magnetic particles and the light-reflective non-magnetic particles in the microcapsules when the characters and images are formed on the display surface; and

Fig. 8 is an explanatory view enlargedly showing the absorption and reflection of light when the light falls into the microcapsules shown in Fig. 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will hereunder be described in detail with reference to the embodiments shown in the drawings.

Referring to the drawings, designated at 1 is a display. This display 1 has such a construction that microcapsules 5

containing therein light-absorptive magnetic particles 3 and light-reflective non-magnetic particles 4 and further oil-containing microcapsules 6 containing neither magnetic particles nor non-magnetic particles and each having a minute particle diameter are coated onto the entire back surface of a non-magnetic substrate 2 to form a microcapsule coating layer 7, and further, a protective layer 8 for preventing the microcapsules 5 (5A and 5B) and the oil-containing microcapsules 6 from being ruptured due to the frictional pressure is provided.

As the non-magnetic substrate 2, there are used ones in the forms of rigid sheets or soft and flexible films made of plastics, glass fibers, glass, paper and the like which have strengths capable of satisfactorily holding the microcapsule coating layer 7.

Description will hereunder be given for the microcapsule coating layer which consists of microcapsules 5 (5A and 5B) containing the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4, and the oil containing microcapsules 6.

Now, the important characteristics of the magnetic display according to the present invention reside in that, by giving the magnetic field, the light-absorptive magnetic particles 3 is shifted in the microcapsules 5 (5A and 5B), as a result, the light-reflective non-magnetic particles 4 change the positions passibly. Therefore, the image quality is determined by the intensity of contrast of brightness and darkness caused by the light absorption of the light-absorptive magnetic particles 3 and the light reflection of the light-reflective non-magnetic particles 4, the degree of sharpness of the side edge portions of the characters and images caused by the contrast and the fact that the inversion of the position of the light-absorptive magnetic particles 3 and the light-

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reflective non-magnetic particles 4 has been performed for a short period of time and the possibility of maintainig the characters and images produced by the inversion of the position. The improvements in the above-described image quality is achieved by the optimal combination of the antinomic factors exemplified in the following.

Table 1

	Contrast of brightness and darkness	Sharpness of side edge portions	Degree of freedom in selecting fine or bold writing	Responsiveness in writing in and erasing	Stability of images
microcapsule size large small	◎ ×	× ◎	× ◎	◎ ◎	◎ ◎
magnetic particles size large small	◎ △	× ◎	× ◎	◎ ×	× ◎
non-magnetic particles size large small	◎ ×	× △	× ◎	× ◎	△ ◎
lipophilicity of dispersed particles size large small	△ △	△ △	△ △	◎ ×	◎ ◎
viscosity of particle dispersion medium high low	△ △	△ △	△ △	× ◎	◎ ×

Note: ◎ Excellent ○ Good △ No influence × No good

According to the present invention, to optimize the combination of the above-described factors, the microcapsules 5 (5A and 5B) having a plurality of particle diameters, the light-absorptive magnetic particles having a plurality of particle diameters and the light-reflective non-magnetic particles having a plurality of particle diameters are combined together, the ratio of compounding between the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4 is adjusted, the light-absorptive magnetic particles 3 and the light reflective non-magnetic particles 4 are subjected to lubricating treatment, magnetic particles 9 capable of becoming a permanent magnet by being magnetized after the microcapsule coating layer 7 is coated, is added to the light-absorptive magnetic particles 3, and the oil-containing microcapsules 6 containing neither light-absorptive magnetic particles 3 nor light-reflective non-magnetic particles 4 are suitably arranged on the microcapsule coating layer 7.

First, regarding the microcapsules 5 (5A and 5B) containing therein the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4, in this embodiment, as the light-absorptive magnetic particles 3, particles of F_3O_4 containing therein 10 % of manganese dioxide applied onto the surfaces thereof with silicone treatment and having a particle diameter of 0.5 micron and other particles similar to the above, but, having a particle diameter of 0.3 micron are mixed together at a ratio of 3 ; 1 for use. Furthermore, as the light-reflective non-magnetic particles 4, white particles of titanium oxide applied onto the surfaces thereof with lipophilic treatment and having the mean particle diameter of 0.3 micron are used. The light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4 are dispersed in dibutyl phthalate by 4 % and 14 % by weight,

respectively.

Next, an aqueous solution containing 11 % of Gum Arabic was added to an aqueous solution containing a concentration of 11 % of gelatin and adjusted to pH6 to thereby obtain an aqueous solution system for polymer films of the microcapsules. The system was elevated in temperature to about 50°C to adjust the pH of the system to 4. Then, the previously prepared dispersion liquid containing the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4 was added to the aqueous solution system of the polymer and the resultant system was agitated until dispersion liquid drops of about 400 microns were produced. After the desired dispersion liquid drops were obtained, water four times the amount of the aqueous solution of gelatin was added thereto, and, after annealing, the system was lowered in temperature to 10°C, whereby the polymer films of gelatin/Gum Arabic separated out on the interface of the dispersion liquid drops were gelatinized, and an aqueous solution of a concentration of 25 % of glutaric aldehyde was added thereto harden the polymer films, so that microcapsules 5A were obtained. Operations similar to the above are performed to produce microcapsules 5B having a particle diameter of about 200 microns.

The oil-containing microcapsules 6 will hereunder be described. First, an aqueous solution of gelatin and an aqueous solution of Gum Arabic, both of which are adjusted at 11 % concentration with to pH6, were prepared. Added into the aqueous solution of gelatin was dibutyl phthalate corresponding to about 80 % in weight of the aqueous solution of gelatin. The resultant system was agitated to produce an O/W type emulsion, from which oil drops of 40 microns were obtainable, the aqueous solution of Gum Arabic equal in amount to the aqueous solution of gelatin was added to the

emulsion and elevated in temperature to 50°C, thereafter, the pH of the system was lowered to 4.5, water four times the amount of the aqueous solution of gelatin was added thereto and the gelatin polymer films were hardened, so that minute oil-containing microcapsules 6 were obtained.

The microcapsules 5A, 5B and the oil-containing microcapsules 6, which were obtained according to the above-described method, were obtained as slurry containing about 20 % microcapsules. The respective ones of the slurry were compounded at a ratio of 10 : 5 : 3, and the water content of the slurry was reduced to one half, and an aqueous solution of 10 % polyvinyl alcohol equal in amount thereto was added, thus obtaining a coating liquid, in which the microcapsules 5A, 5B and oil-containing microcapsules 6 were mixed together.

This coating liquid was coated on the back surface of the surface-prepared non-magnetic substrate 2 formed of 100 micron thick polyethylene telephthalate sheet by use of a curtain coater with a blade to a wet thickness of about 500 microns and a layer thus coated is dried by hot air, thus obtaining a sheet of the display 1.

Other embodiments will hereunder be described. As the light-absorptive magnetic particles 3, there are three components including particles of Fe_3O_4 containing therein 10 % of manganese dioxide applied on the surfaces thereof with silicone treatment and having a particle diameter of 0.5 micron, other particles similar to the above, but, having a particle diameter of 0.3 micron and anisotropic samarium cobalt magnetic particles 9 applied on the surfaces thereof with silicone treatment and having a particle diameter of 1.0 micron (composition: Sm 25.5 %, Co 50 %, Cu 8 %, Fe 15 % and Zr 1.4 %), all of which are mixed together by 60 %, 30 % and 10 % by weight for use.

Furthermore, as the light-reflective non-magnetic particles 4, white fine particles of titanium oxide applied on the surfaces thereof with lipophilic treatment and having the mean particle diameter of 0.3 micron and the mixed magnetic particles described above were dispersed in dibutyl phthalate by 5 % and 14 % by weight, respectively.

This system of dispersion is sealed in the microcapsules 5 by the same method as in the above embodiment, whereby the microcapsules 5A and 5B having the mean particle diameters of two types were obtained. The microcapsules 5A, 5B and the oil-containing microcapsules 6 having the particle diameter of 40 microns which was obtained by the same method as the above embodiment were compounded at a ratio of 10 : 5 : 3, a mixed coating liquid obtained by adding an aqueous solution of 10 % polyvinyl alcohol was coated on the back surface of a surface-prepared polyethylene terephthalate sheet having a thickness of 100 microns and dried, and thereafter, anisotropic samarium cobalt magnetic particles 9 specially added to the microcapsules 5 as a component of the magnetic particles were magnetized to form a permanent magnet. As compared with the display in the above embodiment, the sheet of the display 1 thus obtained was superior in the responsiveness of writing-in and erasing and the sharpness of the images.

Fig. 2 shows a state where there is mounted onto a support member 11 the magnetic device 10 for causing a shift by attraction of the light-absorptive magnetic particles 3 and the magnetic particles 9 as being the permanent magnet in the microcapsules 5 (5A and 5B) toward the back surface of the display 1, in which the microcapsules 5 (5A and 5B) and the oil-containing microcapsules 6 are coated on the back surface of the non-magnetic substrate 2 to form the microcapsule coating layer 7, over the entire surface of

the display 1. As this magnetic device 10, a strip-like elongated permanent magnet is used. This magnetic device 10 is used as a slider and slidably moved from one end to the other end of the back surface of the display 1, so that the light-absorptive magnetic particles 3 and the magnetic particles 9 as being the permanent magnet in the microcapsules 5 (5A and 5B) can be shifted by attraction toward the back surface of the display 1.

Fig. 4 shows a state where, when the magnetic device 10 is moved from one end to the other end of the back surface of the display 1, the light-absorptive magnetic particles 3 and the magnetic particles 9 as being the permanent magnet in the microcapsules 5 (5A and 5B) are attracted by the magnetic device 10 to move downwardly and the light-reflective non-magnetic particles to be shifted upwardly.

Fig. 5 is an enlarged view showing the microcapsules 5 (5A and 5B) shown in Fig. 4. When the display 1, which is in the state where the light-absorptive magnetic particles 3 in the microcapsules 5 are shifted downwardly and the light-reflective non-magnetic particles 4 in the microcapsules 5 are shifted upwardly as described above, is seen from the outer surface, an incident light is reflected by the light-reflective non-magnetic particles 4, whereby the entire surface of the display 1 assumes a white color.

Fig. 6 shows the magnetic device for forming the characters and images on the display 1 showing the characters and images, having a construction in which a rod-like permanent magnet 14 magnetized at two poles is installed on a holder 13.

Fig. 7 shows a state in which a forward end of the rod-like permanent magnet 14 which is magnetized at two poles and mounted onto the holder 13 is moved in contact with the surface of the non-magnetic substrate 2 of the display 1 whose entire surface assumes

the white color by reflection, whereby the characters and like images are drawn, so that the light-absorptive magnetic particles 3 in the microcapsules 5 (5A and 5B) in the corresponding areas are shifted upwardly and the light-reflective non-magnetic particles 4 are shifted downwardly.

Fig. 8 is an enlarged view showing the reflection and absorption of light when the light falls into the microcapsules 5 shown in Fig. 7.

When the portion, in which the light-absorptive magnetic particles 3 in the microcapsules 5A and 5B have been shifted upwardly as described above, is seen from the outer surface of the display 1, a incident light is absorbed by the light-absorptive magnetic particles 3 and the portion assumes a black color. That is, white color reflection caused by the light-reflective non-magnetic particles 4 is given to the surface of the display 1 through the operation shown in Fig. 4, and thereafter, the same surface is partially turned into a black absorption color caused by the light-absorptive magnetic particles 3 through the operation shown in Fig. 6, so that the characters and images can be displayed.

As described above, according to the present invention, first, combination of antinomic factors is optimized, thus improving the image quality of the display. That is, in order to intensify the contrast of brightness and darkness of the images on the display, which is caused by the positional relationship between the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4, the particle diameter of the microcapsules 5 is made as large as possible, whereby, when the light-absorptive magnetic particles 3 are positioned at the bottom portion of the microcapsules 5 (5A and 5B), a layer of the light-reflective non-magnetic particles 4 disposed thereabove should be thickened.

Whereas, when the light-reflective non-magnetic particles 4 are positioned in the bottom portion of the microcapsules 5, a layer of the light-absorptive magnetic particles 3 should be thickened, whereby the mutually shielding forces for a powder color disposed at the bottom portions should be intensified. However, in this case, the images become rough, whereby the side edge portions of the complicated characters and the images small in widths become unclear.

On the contrary, if the particle diameter of the microcapsules 5 is reduced, then the images become dense and the side edge portions of the images come to be sharpened. However, the layers of the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4 are made thinner, whereby the mutually shielding forces of the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4 for the powder color become unsatisfactory and the contrast of brightness and darkness is weakened. According to the present invention, for the purpose of making the above-described antinomic factors consistent, the microcapsules 5A, 5B containing the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4, which have the particle diameters of two types, and the oil-containing microcapsules 6 having the minute particle diameter are compounded to thereby form the microcapsule coating layer 7 of the display.

In order to compensate the unsatisfactory shielding force of the microcapsules 5B having the smaller particle diameter out of the compounded microcapsules 5A and 5B, the oil-containing microcapsules 6 having the minute particle diameter is added to and compounded with the microcapsules 5A, 5B containing therein both the light-absorptive magnetic particles 3 and the light-reflective non-magnetic particles 4. When the images formed by the light-absorptive

magnetic particles 3 in the microcapsules 5A and 5B are present on the surface of the display 1, due to the presence of the oil-containing microcapsules 6 having the minute particle diameter, a light which has fallen into the surface consisting of lines of the image through the oil-containing microcapsules 6 being present at the top surfaces or the adjoining portions of the microcapsules 5A and 5B is transmitted and absorbed by the layer of the light-absorptive magnetic particles 3 because a difference between a refractive index 1.49 of dibutyl phthalate and a refractive index 1.65 of the light-absorptive magnetic particles 3 is small. While, a light which has fallen into a portion other than the surface consisting of lines of the image is intensified in reflection by the layer of titanium dioxide because a difference between a refractive index of dibutyl phthalate in the oil-containing microcapsules 6 and a refractive index 2.71 of titanium dioxide is large.

With this arrangement, the unsatisfactory contrast of brightness and darkness during forming of the images by the microcapsules 5B having the smaller particle diameter can be advantageously compensated.

Furthermore, the particle diameters of the light-absorptive magnetic particles 3 dispersed in the oily liquid in the microcapsules 5A and 5B are minimized to be formed to provide the particle diameters of two types, whereby dense agglomeration and absorption can be obtained in the portions for forming the characters and images, and, since the surface areas increased by minimizing can be utilized, the ratio of compounding of the light-absorptive magnetic particles 3 to titanium dioxide is reduced, when the portion other than the portion for the characters and images, i. e., the light-absorptive magnetic particles 3 is positioned at the bottom portions of the microcapsules 5A and 5B, the portion of the

layer of titanium dioxide positioned thereabove is thickened to increase the light reflection property, thereby resulting in improved contrast of brightness and darkness of the display.

Then, when the minute particle diameters of two types are used for the light-absorptive magnetic particles 3 and the magnetic field is given, particles having a relatively small particle diameter agglomerate around particles having a relatively large particle diameter, whereby the movability for inverting the position in the microcapsules 5A and 5B becomes satisfactory and the density of agglomeration of the particles of the light-absorptive magnetic particles 3 sealed in the microcapsules 5A and 5B for forming the characters and images are enhanced. Further, adding a small quantity of anisotropic samarium cobalt magnetic particles 9 to the light-absorptive magnetic particles 3 dispersed in the oily liquid in the microcapsules 5A and 5B makes it possible that, after the anisotropic samarium cobalt magnetic particles 9 is magnetized, the magnetic particles 9 attract other light-absorptive magnetic particles 3 to form cores thereof, whereby the above-described mobility becomes more satisfactory and the above-described density of agglomeration is enhanced.

As has been described hereinabove, according to the present invention, first, the combination of the antinomic factors is optimized for improving the image quality of the display, which depends on the size of the particle diameter of the microcapsules and the sizes of the particle diameters of the light-absorptive magnetic particles and the light-reflective non-magnetic particles. The distribution of particle diameters of the microcapsules having sealed the oily liquid dispersed therein with the light-absorptive magnetic particles and the light-reflective non-magnetic particle is optimized, so that the side edge portions of the characters and

images can be made sharper, and the light-absorptive magnetic particles dispersed in the oily liquid in the microcapsules are minimized in size to thereby increase the surface areas thereof and the combination between a plurality of light-absorptive magnetic particles different in particle diameter makes it possible to improve the contrast of brightness and darkness through the agglomeration of the minute magnetic particles during forming of the characters and images.

Furthermore, as the light-absorptive magnetic particles dispersed in the oily liquid in the microcapsules, when a suitable amount of the anisotropic samarium cobalt magnetic particles, which can be the permanent magnet if magnetized, is added in addition to Fe O particles, the movability and agglomeration property of the magnetic particles in the microcapsules are improved, thereby improving the responsiveness in forming and erasing of the characters and the contrast of brightness and darkness.

Furthermore, the surfaces of the light-absorptive magnetic particles the light-reflective non-magnetic particles, which are dispersed in the oily liquid in the microcapsules are subjected to lubricating and lipophilic treatments, thereby improving the movability during the inversion of the position therebetween.

Furthermore, the ratio of compounding between the light-absorptive magnetic particles and the light-reflective non-magnetic particles which are dispersed in the oily liquid in the microcapsules is optimized, thereby improving the contrast of brightness and darkness.

Further, a suitable amount of the oil-containing microcapsules having a minute particle diameter, which contains only the oily liquid is embedded in the microcapsule coating layer, it becomes possible that the light absorption property of the magnetic

particles in the microcapsules having a relatively small particle diameter, which is present in the vicinity of an embedded portion, and the light reflection property of the non-magnetic particles are reinforced through the action of the light refractive index of the oily liquid in this oil-containing microcapsules, thereby compensating the unsatisfactory degree of the contrast of brightness and darkness during forming of the images.

WHAT IS CLAIMED IS:

1. A magnetic display system comprising:
 - a display having a construction of that a microcapsule coating layer is applied onto a non-magnetic substrate, said microcapsules having sealed magnetic particles having an excellent light-absorptive surface characteristic and also sealed non-magnetic particles having an excellent light-reflective characteristic, said both particles being dispersed in an oily liquid, respectively; and
 - a magnetic device including a permanent magnet and serving as a means for causing a shift by attraction of the light-absorptive magnetic particles toward the back surface of the display over the entire surface of the microcapsule coating layer and, as a result, causing a shift of light-reflective non-magnetic particles toward the front surface of the display, and
 - as a means for causing a local shift by attraction of the light-absorptive magnetic particles having been shifted by attraction from the back surface of the display to the front surface thereof to thereby invert the position of the light-reflective non-magnetic particles in corresponding areas, thereby forming characters and images;characterized in that
 - microcapsules having sealed an oily liquid dispersed therein with the light-absorptive magnetic particles and the light-reflective non-magnetic particles are of such an arrangement that a wall film thereof is formed of a polymer film being substantially transparent and having a strength capable of semipermanently holding the filling matter, and microcapsules having a plurality of particle diameters ranging from the maximum particle diameter of 1,000 microns to the minimum particle diameter of 100 microns are

compounded at a suitable ratio.

2. The magnetic display system as set forth in claim 1, wherein, for the magnetic particles dispersed in the oily liquid in the microcapsules, one type is used or several types of particle diameters ranging from the minimum particle diameter of 0.2 micron to the maximum particle diameter of several microns are combined for use.

3. The magnetic display system as set forth in claim 1, wherein a suitable amount of magnetic particles concerning hard ferrite capable of becoming a permanent magnet is added to the magnetic particles dispersed in the oily liquid in the microcapsules, whereby the magnetic particles concerning hard ferrite, which can be magnetized to form a permanent magnet after the microcapsules are coated onto the surface of the substrate, are made to be one component of the light-absorptive magnetic particles.

4. The magnetic display system as set forth in claim 1, wherein, to obtain the movability in the oily liquid of the magnetic particles dispersed in the oily liquid in the microcapsules, lipophilic treatment is applied to the surfaces of the magnetic particles.

5. The magnetic display system as set forth in claim 1, wherein the mean particle diameter of the light-reflective non-magnetic particles dispersed together with the light-absorptive magnetic particles in the oily liquid in the microcapsules ranges from 0.01 micron to several microns, and lipophilic treatment is applied to the surfaces of the light-reflective non-magnetic particles in order to obtain the dispersion and movability of the light-reflective non-magnetic particles in the oily liquid.

6. The magnetic display system as set forth in claim 1, wherein the ratio of compounding between the light-absorptive magnetic

particles and the light-reflective non-magnetic particles which are dispersed in the oily liquid in the microcapsules is included within a range from 1 : 8 to 1 : 1.

7. A magnetic display system comprising:

a display having a construction of that a microcapsule coating layer is applied onto a non-magnetic substrate, said microcapsules having sealed magnetic particles having an excellent light-absorptive surface characteristic and also sealed non-magnetic particles having an excellent light-reflective characteristic and said both particles being dispersed and dissolved in an oily liquid, respectively; and

a magnetic device including a permanent magnet and serving

as a means for causing a shift by attraction of the light-absorptive magnetic particles toward the back surface of the display over the entire surface of the microcapsule coating layer and, as a result, causing a shift of the light-reflective non-magnetic particles toward the front surface of the display, and

as a means for causing a local shift by attraction of the light-absorptive magnetic particles having been shifted by attraction from the back surface of the display to the front surface thereof to thereby invert the position of the light-reflective non-magnetic particles in corresponding areas, thereby forming characters and images;

a suitable amount of oil-containing microcapsules having a more minute particle diameter than the mean diameter of the microcapsules and having sealed only a substantially transparent oily liquid is added to and coated onto the microcapsule coating layer having sealed the light-absorptive magnetic particles and the light-reflective non-magnetic particles which are dispersed in an oily liquid to be coated onto the non-magnetic substrate.

FIG.1

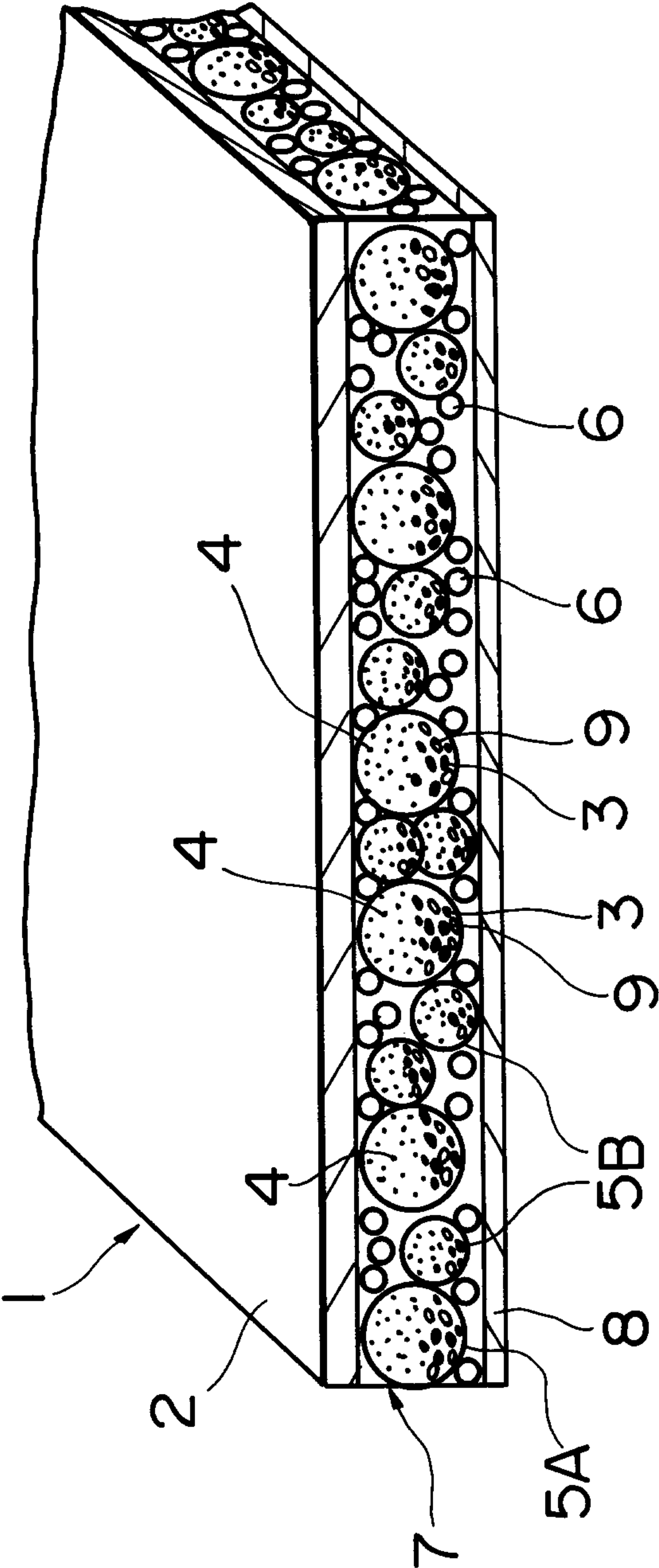


FIG.2

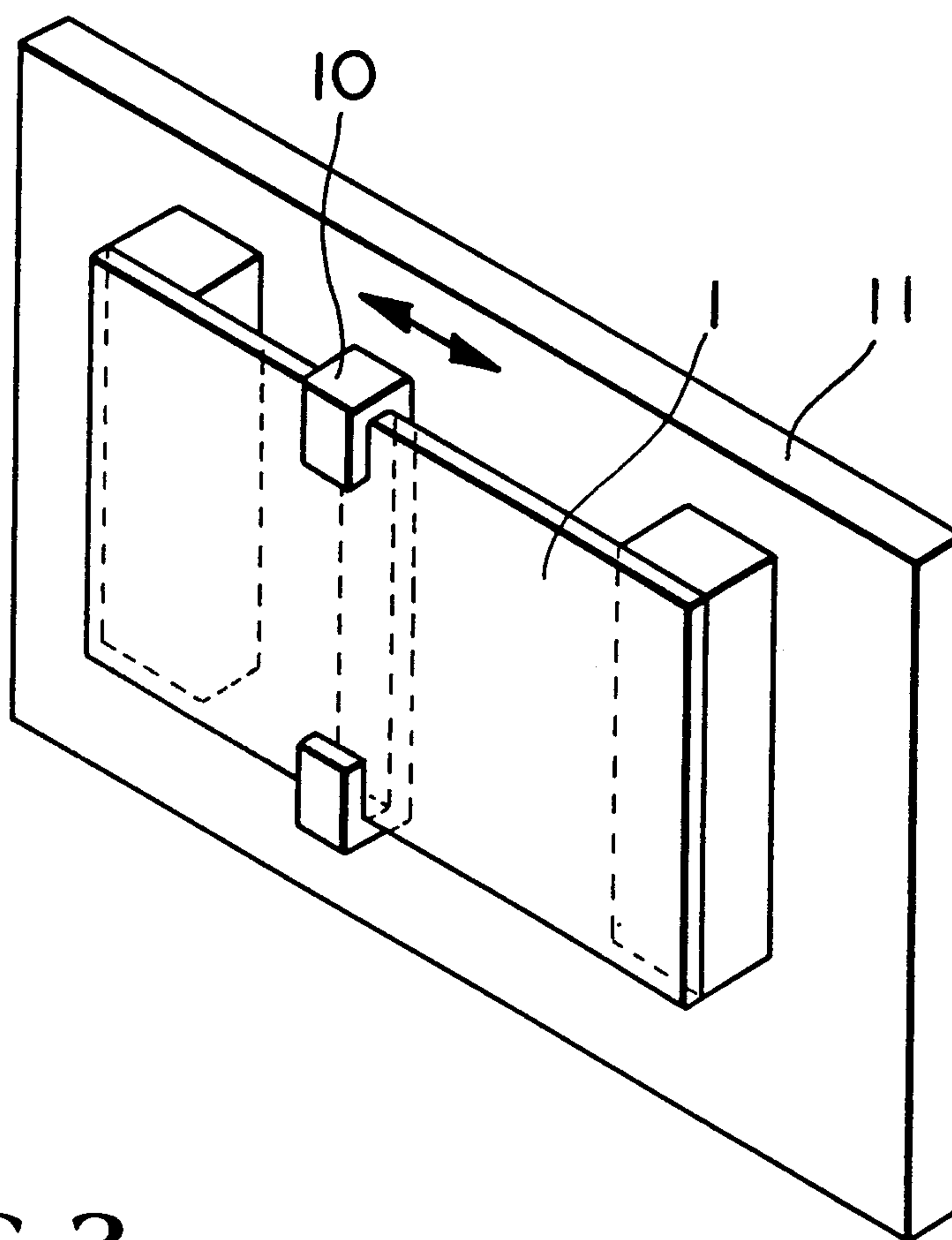


FIG.3

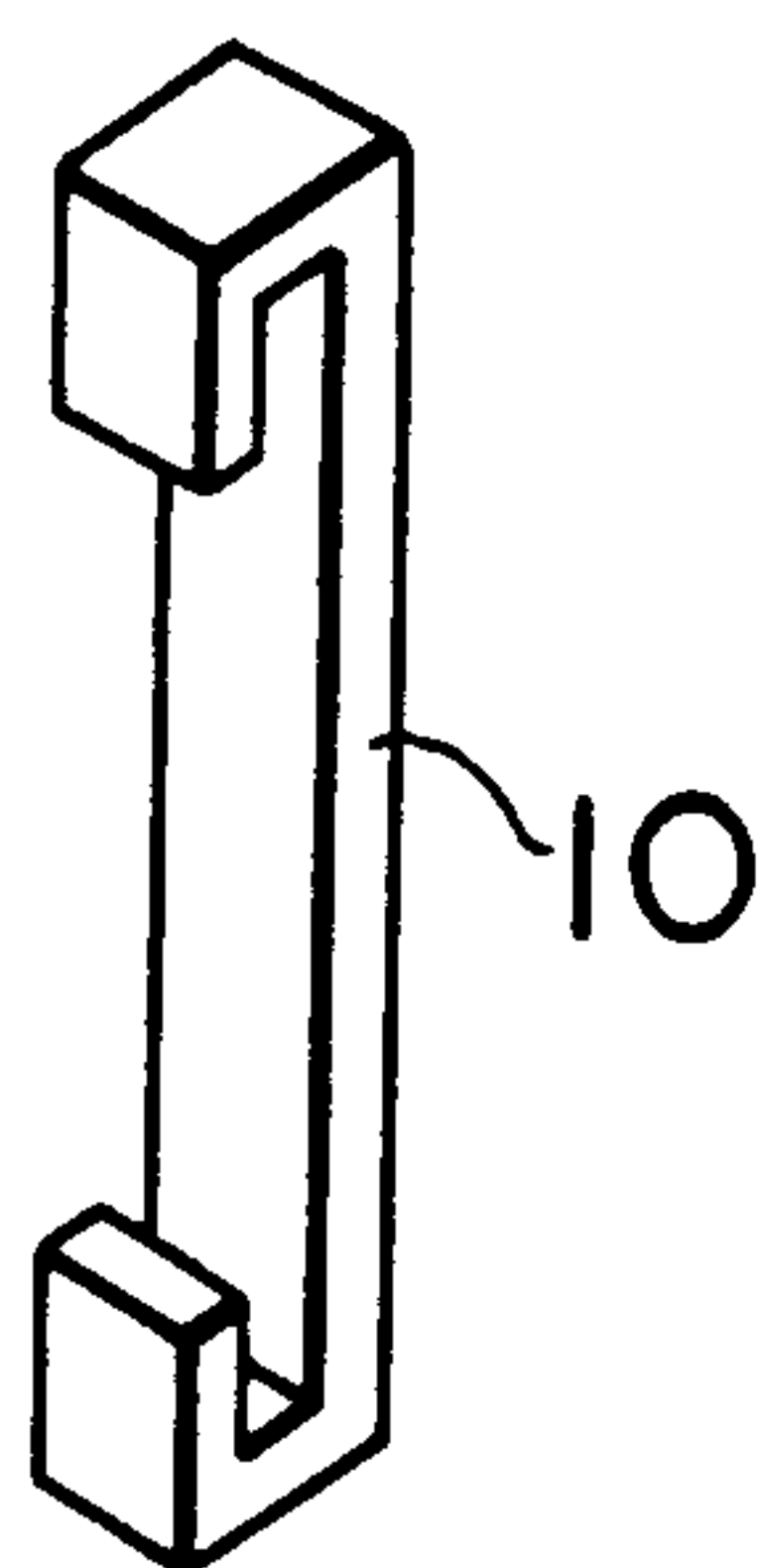


FIG.4

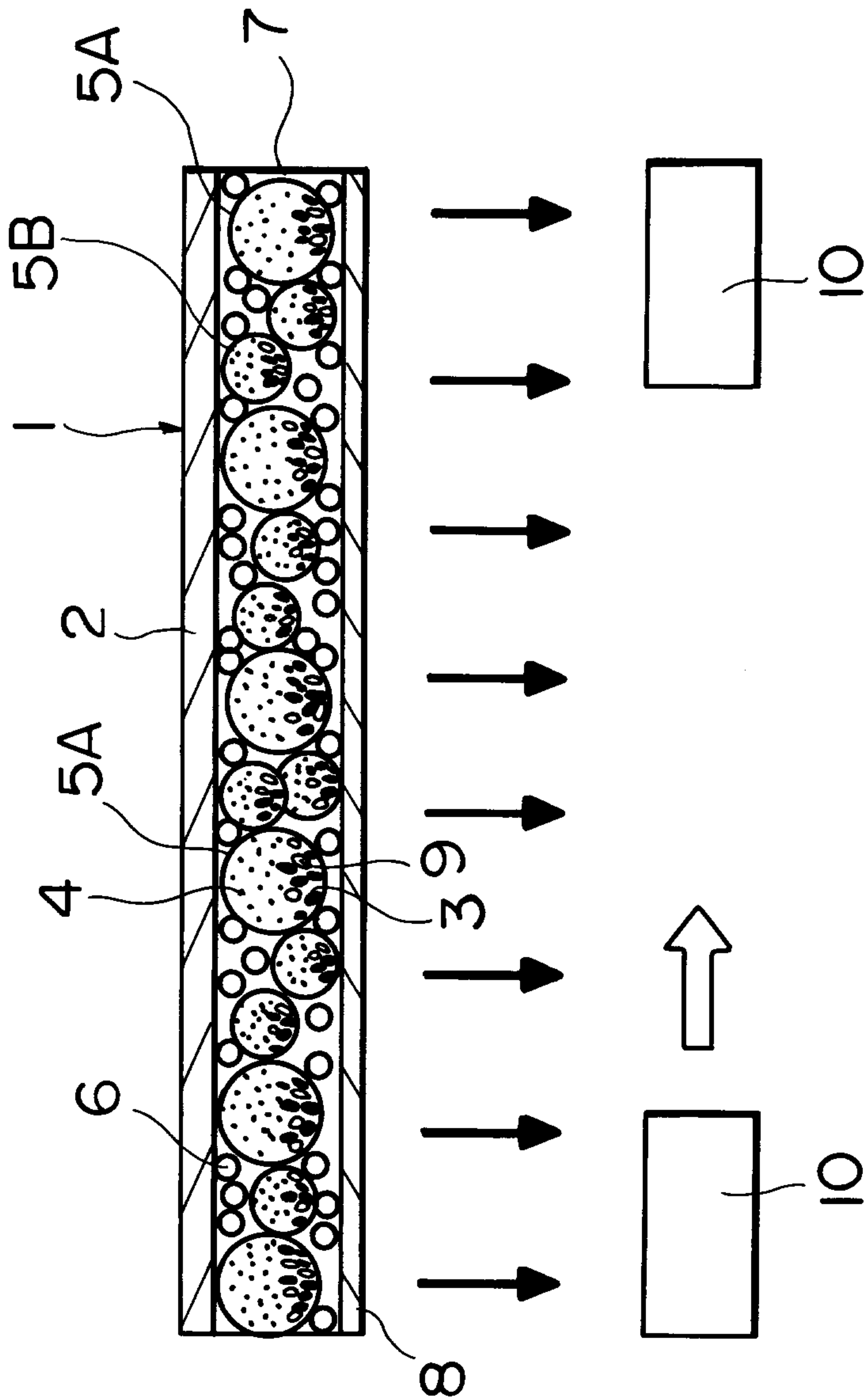


FIG.5

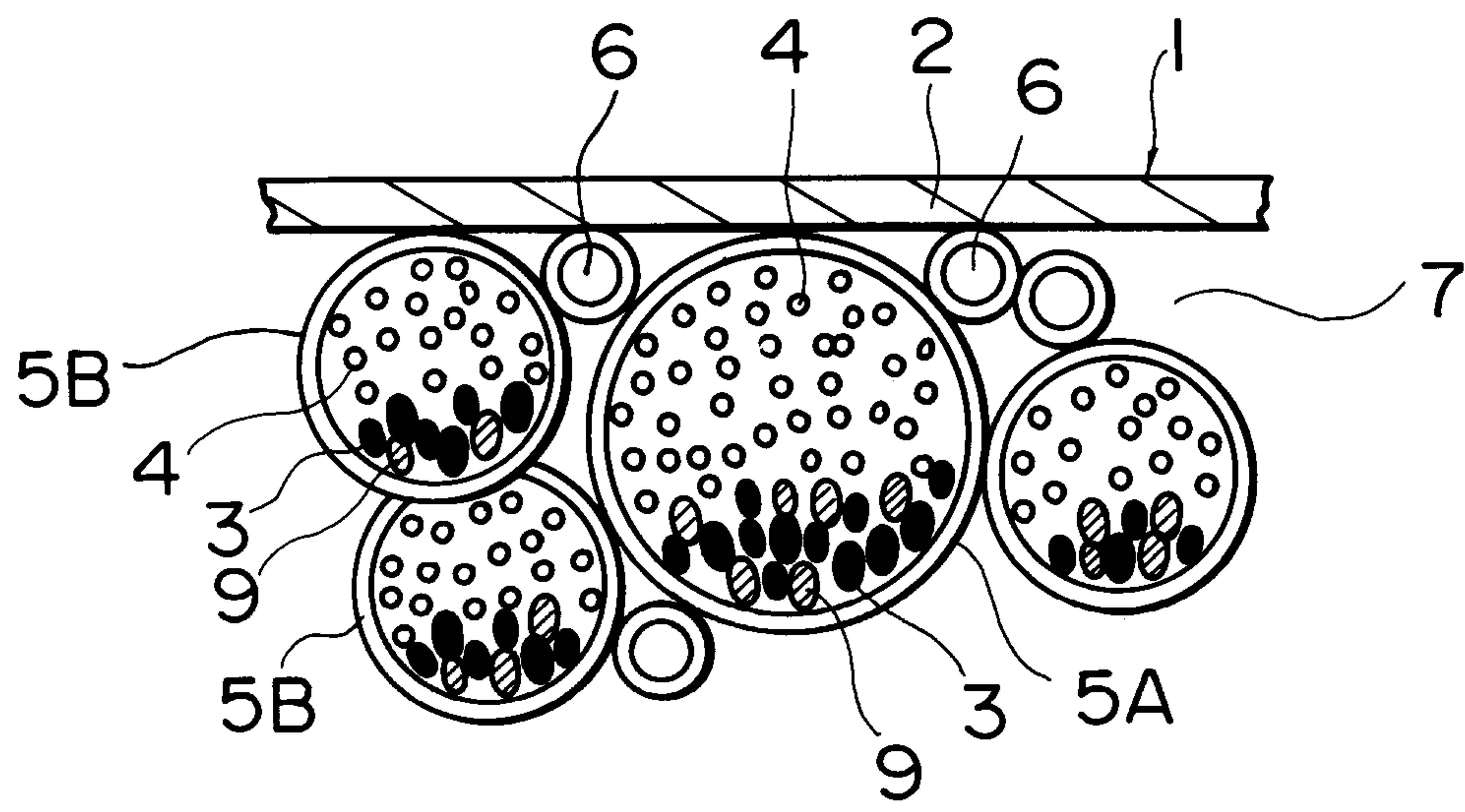


FIG.6

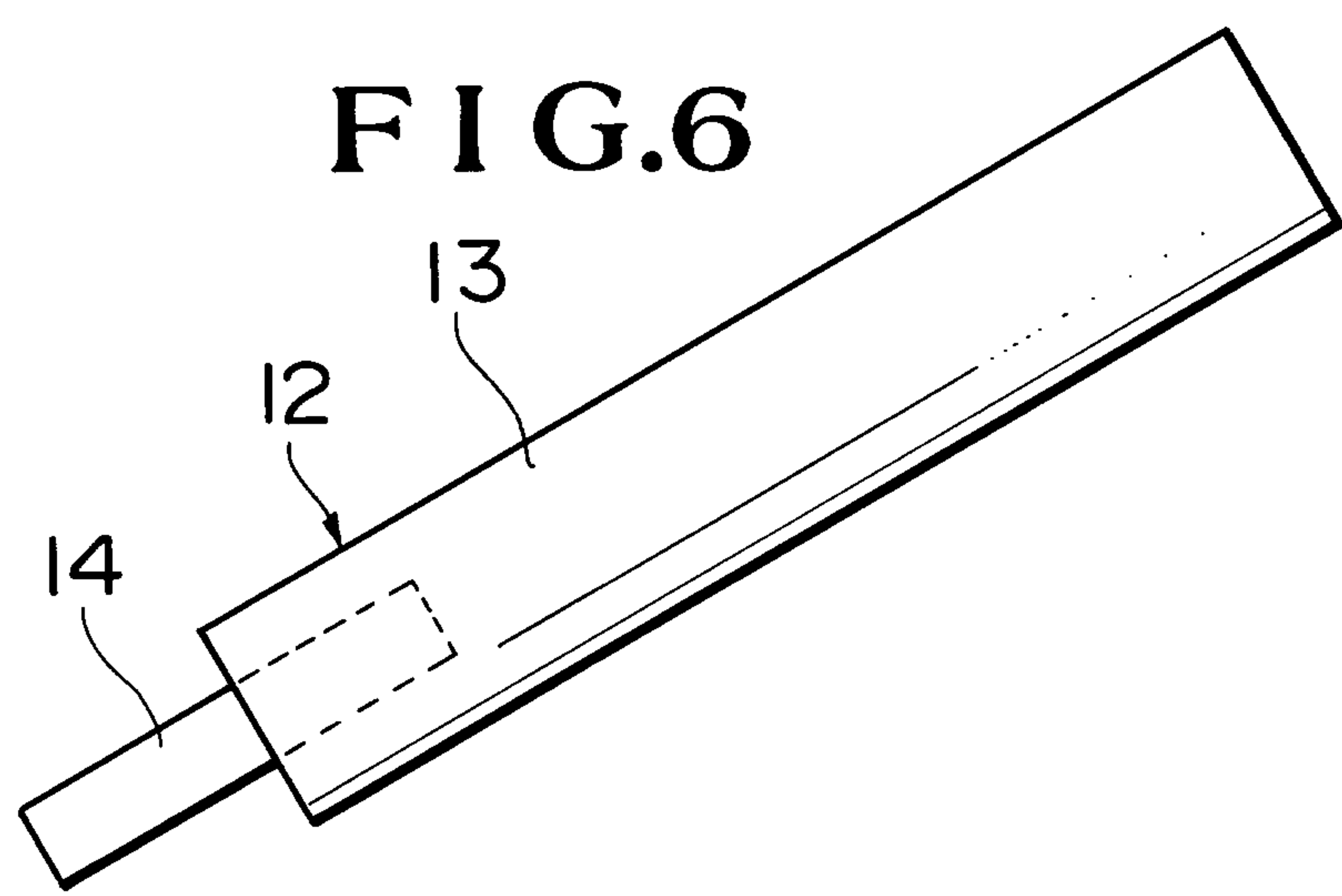


FIG.7

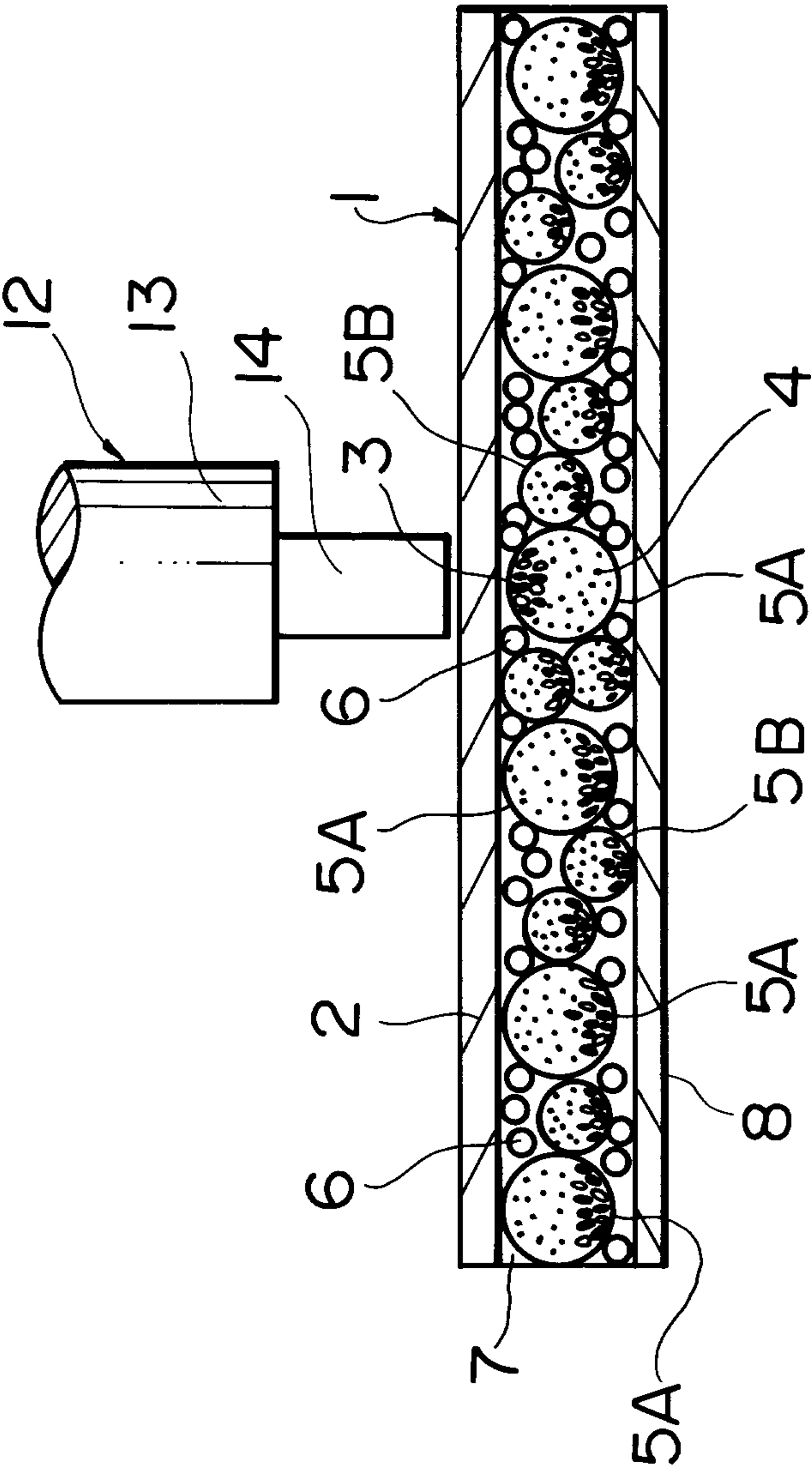


FIG. 8

