

"MAGNETIC INK MEDIUM AND METHOD FOR PRINTING WITH
SAID MEDIUM"

The present invention relates to a magnetic ink medium such, for example, as may be used in a non-impact printing apparatus, in which a heat-fusible magnetic ink is transferred to a transfer medium by the aid of heat and magnetism. It also relates to a method of printing with said magnetic ink medium.

Several methods of non-impact printing with a magnetic ink have been proposed for use in small, low-priced printers. For example, Japanese Patent Laid-open Specification No. 96541/1977 discloses a method for fusion thermal transfer in which ink transfer is assisted by magnetism, because this method employs a magnetic ink as the transfer ink. In other words, ink transfer is accomplished by a heat supply means and an additional magnetic means to attract the magnetic ink in accordance with thermal images.

A disadvantage of the above-mentioned method is that the ink transfer is liable to be incomplete because a portion of the ink which should be transferred is not so transferred.

Another disadvantage of the above-mentioned method is that recording dots of normal shape are not obtained if the transfer medium has a rough surface.

The magnetic ink medium suggested for the above-mentioned method has, moreover, the disadvantages of poor ink transfer

efficiency, poor dot reproducibility, and irregular transferred dots, which lead to poor printing quality.

According, therefore, to the present invention, there is provided a magnetic ink medium comprising a heat-resistant support which carries a heat-fusible layer of magnetic ink containing ferromagnetic particles, the magnetic ink, when in its molten state at 120°C, having a surface tension of not more than 20 dyn/cm.

Preferably, the magnetic ink contains a surface active agent to control the surface tension of the magnetic ink in its said molten state.

For example, the surface active agent may be polyfluorowax; polymethyl siloxane-polyoxyalkylene copolymer; or polyoxyethylene-polyoxypropylene block copolymer.

The magnetic ink, when in its said molten state, may have a surface tension lying in the range of 5.0 to 16.8 dyn/cm and preferably in the range of 13.9 to 16.8 dyn/cm.

The ferromagnetic particles may have a particle diameter in the range of 10 to 20,000 Å and preferably in the range of 500 to 15,000 Å.

The magnetic ink may contain a heat-fusible wax binder for binding together the ferromagnetic particles.

The heat-resistant support may be of synthetic resin material, e.g. polyethylene terephthalate.

The heat-resistant support may have a thickness of 1 to 30 μm and preferably of 1-10 μm .

5 The invention also comprises a method of printing by applying heat and magnetic force to a magnetic ink medium, as set forth above, so as to cause the magnetic ink to be transferred to a transfer medium.

10 Preferably, the magnetic ink medium is not in contact with transfer medium when the magnetic ink is transferred thereto.

The magnetic ink is preferably transferred to the transfer medium in the form of at least 12 dots/mm.

15 The magnetic force used is preferably substantially 1 dyne.

The present invention enables dots of normal shape to be printed on a transfer medium having a rough surface and also on a film having a rather low affinity for the ink, and it is also possible to transfer the ink without
20 heat loss and without smudging.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figure 1 is a schematic diagram showing a magnetic head which may be used in an apparatus employing a
25 magnetic ink medium of the present invention,

Figure 2 is a schematic diagram of the said apparatus,

Figure 3 is a schematic diagram illustrating a previous transfer method,

5 Figure 4 is a schematic diagram illustrating the problems involved in the previous transfer method,

Figure 5 is a schematic diagram illustrating the problems involved in printing on a rough transfer medium by the previous transfer method, and

10 Figure 6 is a schematic diagram showing a dot printed on a rough transfer medium by the previous transfer method.

Figure 3 illustrates a previous method of non-impact printing for small, low-priced printers, in which a magnetic ink is employed. In this method, ink transfer is enhanced
15 by magnetism because a magnetic ink is employed as the transfer ink. In other words, ink transfer is accomplished by a heat supply means and by an additional magnetic means to attract the magnetic ink in accordance with thermal images. Thus, referring to Figure 3, the apparatus employed
20 in this method may comprise a thermal head 31, an ink medium 32, a transfer medium 35, and a magnet 36. Heat-fusible magnetic ink 34 on the ink medium 32 comes into contact with the transfer medium 35 (directly under the thermal head 31) when it is heated through a base film 33

by the thermal head 31. After the molten ink 34 has been transferred to the transfer medium 35, the ink medium 32 is peeled off from the transfer medium 35. The magnet 36 exerts a magnetic force of attraction which brings the molten ink 34 into close contact with the transfer medium 35 so that the transferred ink 34 is retained on the transfer medium 35 when the ink medium 32 is peeled off. Thus, this method permits high-quality printing of characters and images on a transfer medium 35 having a rough surface.

A disadvantage of the above-mentioned method is that the ink transfer is liable to be incomplete because, when the ink medium 32 is peeled off, a portion of the recording ink 34 which should be transferred is still in contact with both the base film 33 and with the non-recording ink which is not to be transferred. In other words, there is a possibility that the transferred ink is peeled off from the transfer medium 35 by the base film 33. In an ordinary heat transfer printing process, complete ink transfer is possible only when the following relationship is established:-

$$FA + FB \gg FC + FD$$

where FA is the adhesive force between the ink 34 and the transfer medium 35 and FB is the cohesive force of the ink 34 (both of which promote the transfer of the recording ink 34 onto the transfer medium 35); and FC is the adhesive

force between the ink 34 and the base film 33, and FD is the cohesive force between the recording ink 34 and the non-recording ink 34 (both of which hamper the transfer). This is illustrated in Figure 4, in which there are shown a base film 41, recording ink 42, non-recording ink 43, and a transfer medium 44.

In the case of the method, illustrated in Figures 3 and 4, the molten recording ink is pressed against the transfer medium by the magnetic force of attraction when the ink is melted. This ensures the contact of the ink with the transfer medium. In other words, the transfer efficiency is somewhat improved by increasing FA. However, FC and FD as shown in Figure 4 still exist because the base film, ink, and transfer medium are in contact with one another when the ink medium is peeled off. This brings about a situation in which $FA < FC$ or $FA < FD$ if the transfer medium has a very rough surface. This leads to incomplete ink transfer.

Another disadvantage of the method illustrated in Figures 3 and 4 is that recording dots 51 of normal shape are not obtained if a transfer medium 52 is used which has a rough surface, as shown in Figure 5. Note that the transfer medium 52 has recesses 54 which do not come into contact with a magnetic ink layer 53 when recording dots 51 are printed. In the case of printing on an extremely rough

transfer medium (having a Bekk smoothness of 1 to 2 seconds), the magnetic force used in the method illustrated in Figures 3 and 4 is not so effective, because the magnetic ink adheres only to projecting parts 61 of surface fibres of the transfer medium, thus forming recording dots 62 of irregular shape as shown in Figure 6.

The magnetic ink medium 32 of the method illustrated in Figures 3 and 4 is composed of a binder and an inorganic magnetic fine powder dispersed therein. The binder includes waxes, thermoplastic resins, dispersing agents, oils and fats, and low-molecular-weight organic substances. It has the disadvantages of poor ink transfer efficiency, poor dot reproducibility, and irregular transferred dots, which lead to poor printing quality. In other words, the method illustrated in Figures 3 and 4 involves problems not only in the printing apparatus but also in the ink composition.

The above-mentioned disadvantages are particularly serious in the case where small recording dots are densely printed.

Another disadvantage of the method illustrated in Figures 3 and 4 is that the heat-fusible magnetic ink 34 is in contact with the transfer medium 35, as shown in Figure 3. This arrangement causes a large portion of the heat generated by the thermal head 31 to be absorbed by the transfer medium 35 through the heat-fusible magnetic ink 34. (This phenomenon is referred to below as "heat loss"). This arrangement

also produces friction and heat conduction between the heat-fusible magnetic ink 34 and the transfer medium 35. This causes the ink 34 to be transferred to the non-recording part on the transfer medium. (This phenomenon is referred to below as "smudging").

The present invention is based upon the discovery that the above-mentioned disadvantages can be avoided if the magnetic ink, when in its molten state at 120°C, has a surface tension of not more than 20 dyn/cm.

The support may be a film made of a synthetic resin such as polyethylene, polypropylene, polystyrene, polyimide, polyethersulfone, and polyethylene terephthalate. It may be 1 to 30μm thick, and preferably 1 to 10μm thick.

The ferromagnetic particles may be of magnetite, manganese-zinc ferrite, nickel-zinc ferrite, garnet, metals, and alloys. The particles should desirably have a particle diameter of 10 to 20,000 Å, preferably 500 to 15,000 Å.

A heat-fusible substance may be used as a binder for the ferromagnetic particles. Suitable binders include paraffin wax, microcrystalline wax, carnauba wax, oxidized wax, polyethylene wax, α-olefin-maleic anhydride copolymer, a fatty acid amide, a fatty acid ester, and distearylketone. They may be used individually or in combination with one another.

The surface tension of the magnetic ink may be controlled by the addition of a surface active agent. Such surface active agents include ionic surface active agents such as alkyl sulfate, polyoxyethylene-alkylether sulfate, sodium dialkyl-sulfosuccinate, mono-long chain-alkyltrimethyl ammonium chloride, an amine salt of a fatty acid, benzenesulfonate, and alkyldimethylammonium betaine; and nonionic surface active agents such as polytetrafluoroethylene, polyvinylidene fluoride, hexa-fluoropropylene, dimethyl polysiloxane, methylhydrogen polysiloxane, polyoxyethylene alkylether, polyoxyethylene-polyoxypropylene block copolymer, and polyoxyethylene dodecylphenylether.

The surface tension of the molten magnetic ink varies depending on the temperature. The higher the temperature, the lower the surface tension. Therefore, the surface tension specified in the case of the present invention is one which is measured at 120°C. With a surface tension higher than 20 dyn/cm, the magnetic ink gives transferred dots of irregular size, which leads to poor dot reproducibility and poor printing quality. In addition, a magnetic ink having a high surface tension is not easily transferred. Thus the surface tension should preferably be 5.0 to 16.8 dyn/cm, and, to obtain the best results, should preferably be 13.9 to 16.8 dyn/cm.

The resolving power (i.e. the ability to print fine detail) of the transferred dots depends on the resolving power of the heating element of the thermal head. The highest resolving power available is 480 dpi (dots per inch, i.e. 19 dots/mm). The ordinary resolving power is 400 dpi (16 dots/mm), 360 dpi (14 dots/mm) or 300 dpi (12 dots/mm). The transfer of the magnetic ink may be assisted by a magnetic force of attraction of 1.0 dyn.

For printing, the magnetic ink medium may be heated so that the magnetic ink has a surface tension of not more than 20 dyn/cm, the molten ink being transferred to a transfer medium. It is better if the magnetic ink medium is not in contact with the transfer medium when the ink is so transferred. In other words, the ink flies to the transfer medium, so producing printing of good quality.

The invention will be described in more detail with reference to the following examples.

Printing was carried out using a transfer apparatus made up of a magnetic head 24 and a thermal head 21 as shown in Figure 2. The magnetic head 24, which is employed to exert a magnetic force of attraction on the magnetic ink, comprises an electromagnet 14 best shown in Figure 1. The latter has a core of Permendure (Co 50) which produces a magnetomotive force (NI) of 3000. It also has a gap (A)

which is 400 μ m wide. The thermal head 21 is that of a thin film type head (0.8 mJ/dot) having a resolving power of 180 dpi.

5 A magnetic ink medium 22 which is used for printing is composed of a 4- μ m thick PET (polyethylene terephthalate) film 25 as a support and a 6- μ m thick layer 26 of magnetic ink formed on the support 25 by hot melt coating. The composition of the magnetic ink is shown in Table 1.

10 Printing with the above-mentioned magnetic ink medium was carried out as illustrated in Figure 2, in which there are shown the thermal head 21, the magnetic ink medium 22, the transfer medium 23 (having a Bekk smoothness of 2 seconds), and the magnetic head 24. The magnetic ink medium 22 is composed of the heat-resistant support (PET film) 25 and the layer 26 of heat-resistant and heat-fusible magnetic ink which is formed on the support 25.

15 Table 1 shows a number of examples of the composition of the ink layer 26 and Table 2 shows the results of a transfer test. As will be noted, Tables 1 and 2 also refer to
20 Examples (1-1), (2-1) and (3-1) which are outside the scope of the present invention and are given for comparative purposes only.

Table 1

	Fe ₂ O ₃ fine particles		Dispersing agent	Surface tension depressant	Binder
Example No.	0.2 μ m in diameter (wt%)	0.5 μ m in diameter (wt%)	Diethyl succinate Sodium α -sulfonate (wt%)	Polyfluorowax* (wt%)	Paraffin wax (wt%)
1-1	30	20	0.9	0.1	49
1-2	30	20	0.9	0.3	48.8
1-3	30	20	0.9	0.4	48.7
1-4	30	20	0.9	0.5	48.6
1-5	30	20	0.9	0.7	48.4
1-6	30	20	0.9	0.8	48.3
1-7	30	20	0.9	1.0	48.1
(1-1)	30	20	0.9	0	49.1
			Diethyl succinate Sodium α -sulfonate	Polymethyl siloxane- polyoxyalkylene copolymer	Paraffin wax
2-1	30	30	0.7	0.5	38.8
2-2	30	30	0.7	0.7	38.6
2-3	30	30	0.7	1.0	38.3
(2-1)	30	30	0.7	0.01	39.99
			Diethyl succinate Sodium α -sulfonate	Polyoxyethylene-polyoxypropylene block copolymer	Micro-crystalline wax
3-1	10	40	0.5	0.1	49.4
3-2	10	40	0.5	0.8	48.7
3-3	10	40	0.5	1.0	48.5
(3-1)	10	40	0.5	0.05	49.95

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*Trade name: polyFluoro-150 (made by Micropowder Co. Ltd)

Parenthesized numbers indicate Comparative Examples.

The above-mentioned examples may be modified so that a portion of the wax (corresponding to 2 to 4% of the ink) is replaced by a leuco dye (Mitsui Toatsu Chemical Co. Ltd) to adjust the ink color.

5 The magnetic ink medium of the present invention, which is composed of a heat-resistant support and a heat-fusible magnetic ink layer formed thereon, as mentioned above, substantially eliminates the defective ink transfer which has occurred previously. Therefore clear transferred
10 images can be formed on a transfer medium having a rough surface and on a film having poor affinity for the ink.



C L A I M S

- 5 1. A magnetic ink medium comprising a heat-resistant support which carries a heat-fusible layer of magnetic ink containing ferromagnetic particles, the magnetic ink, when in its molten state at 120°C, having a surface tension of not more than 20 dyn/cm.
2. A magnetic ink medium as claimed in claim 1 in which the magnetic ink contains a surface active agent to control the surface tension of the magnetic ink in its said molten state.
- 10 3. A magnetic ink medium as claimed in claim 2 in which the surface active agent is polyfluorowax; polymethyl siloxane-polyoxyalkylene copolymer; or polyoxyethylene-polyoxypropylene block copolymer.
4. A magnetic ink medium as claimed in any preceding claim in which the magnetic ink, when in its said molten state, has a surface tension lying in the range of 5.0 to 16.8 dyn/cm.
- 15 5. A magnetic ink medium as claimed in claim 4 in which the said surface tension is in the range of 13.9 to 16.8 dyn/cm.
- 20 6. A magnetic ink medium as claimed in any preceding claim in which the ferromagnetic particles have a particle diameter in the range of 10 to 20,000 Å.



7. A magnetic ink medium as claimed in claim 6 in which the particle diameter is in the range of 500 to 15,000Å.

8. A magnetic ink medium as claimed in any preceding claim in which the magnetic ink contains a heat-fusible wax binder for binding together the ferromagnetic particles.

9. A magnetic ink medium as claimed in any preceding claim in which the heat-resistant support is of synthetic resin material.

10. A magnetic ink medium as claimed in claim 9 in which the synthetic resin material is polyethylene terephthalate.

11. A magnetic ink medium as claimed in any preceding claim in which the heat-resistant support has a thickness of 1 to 30 μm .

12. A magnetic ink medium as claimed in claim 11 in which the said thickness is 1 to 10 μm .

13. A method of printing by applying heat and magnetic force to a magnetic ink medium as claimed in any preceding claim so as to cause the magnetic ink to be transferred to a transfer medium.

14. A method of printing as claimed in claim 13 in which the magnetic ink medium is not in contact with the transfer medium when the magnetic ink is transferred thereto.



15. A method as claimed in claim 13 or 14 in which the magnetic ink is transferred to the transfer medium in the form of at least 12 dots/mm.

5 16. A method as claimed in any of claims 13 to 15 in which the magnetic force used is substantially 1.0 dyne.

17. A magnetic ink medium substantially as hereinbefore described.

10 18. A method of printing substantially as hereinbefore described with reference to Figures 1 and 2.
