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Duck et al.

[11] **3,717,460**

[45] **Feb. 20, 1973**

[54] **METHOD OF IMAGING USING INTERDIGITATED ELECTRODES, A PHOTOCONDUCTIVE LAYER AND A MAGNETIC IMAGING LAYER**

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[52] **U.S. Cl.** ....**96/1 R,** 96/1.5, 96/1 E, 346/74 M, 346/74 MT, 117/211, 117/212, 117/215, 117/217, 117/218

[51] **Int. Cl.** **G03g 13/14,** G03g 13/22

[58] **Field of Search** ....96/11.5, 1, 1 E; 346/74 MT

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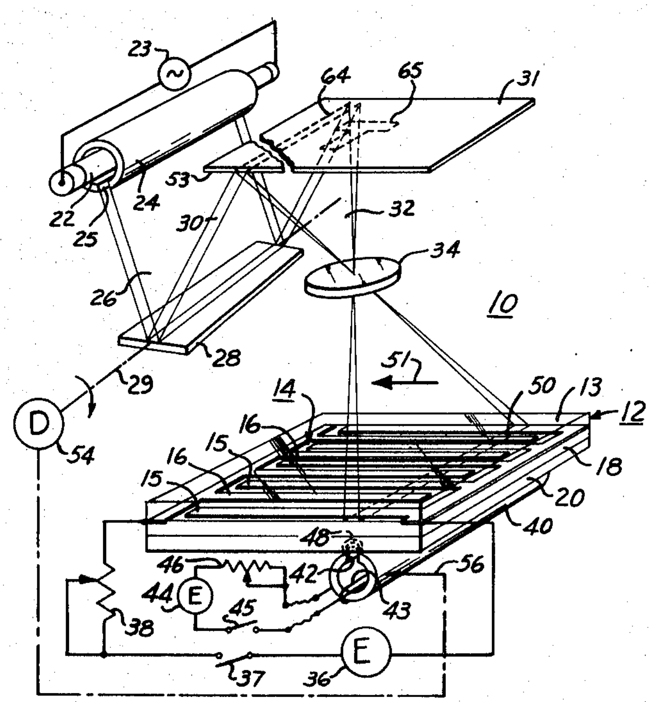
[57] **ABSTRACT**

A composite recording medium comprises a photoconductive layer, a plurality of interdigitated first and second electrodes in electrical contact with and contiguous to the photoconductive layer, and a magnetic recording layer in heat-transfer relationship with and contiguous to the photoconductive layer. Methods and apparatus for magnetically recording an image with the assistance of this composite recording medium are also disclosed.

15 Claims, 3 Drawing Figures



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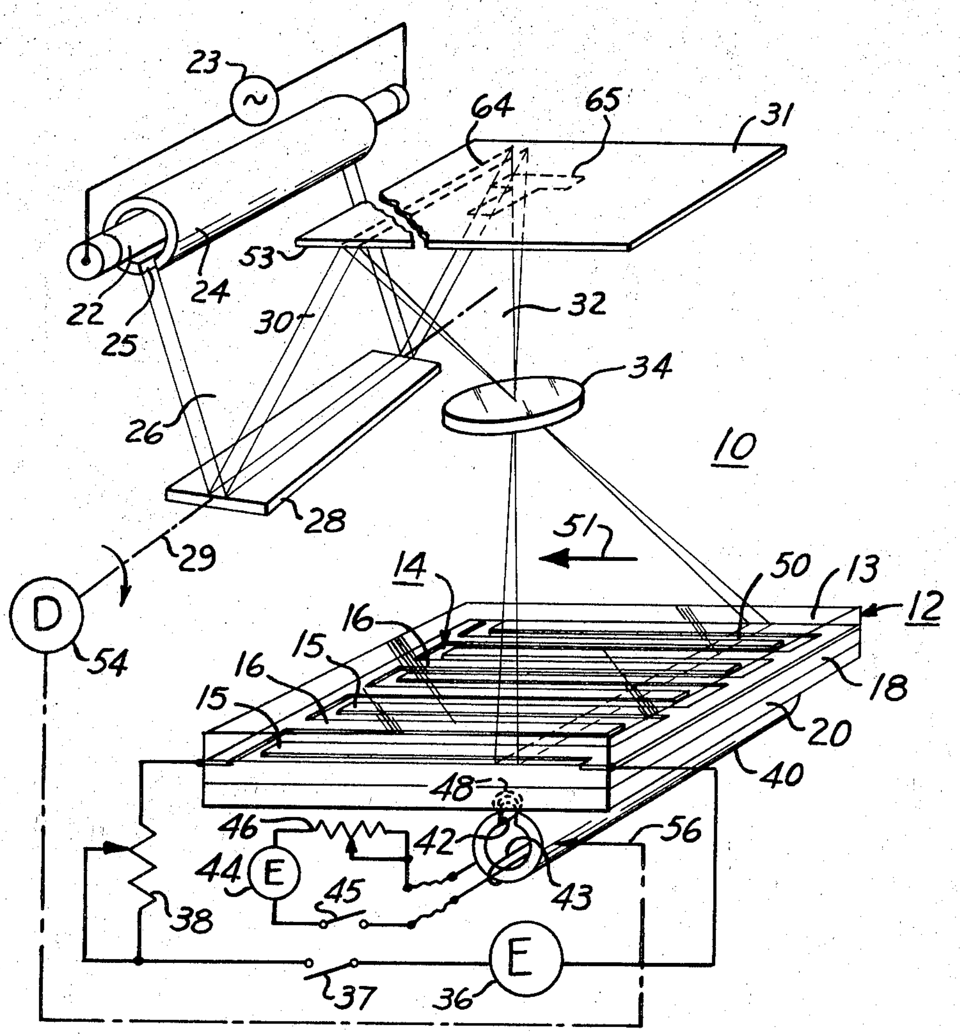

FIG. 1

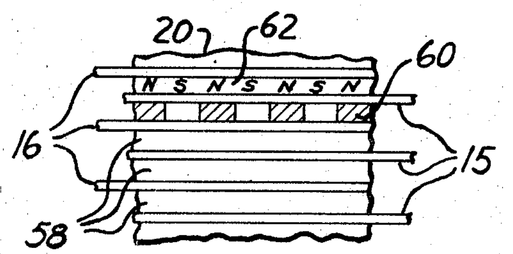

FIG. 2

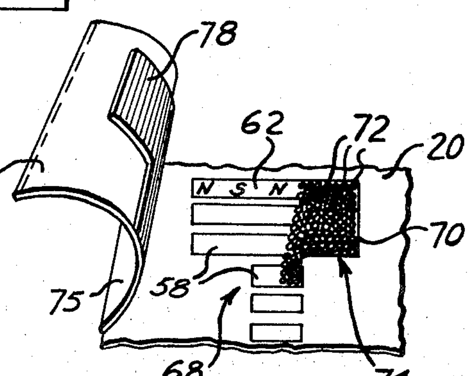

FIG. 3

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METHOD OF IMAGING USING INTERDIGITATED ELECTRODES, A PHOTOCONDUCTIVE LAYER AND A MAGNETIC IMAGING LAYER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject invention relates to magnetic recording and, more particularly, to the magnetic recording of images with the assistance of thermal gradients.

2. Description of the Prior Art

Magnetic imaging has been the subject of serious investigation in recent years, since it has several advantages over more conventional imaging techniques.

For instance, magnetic imaging offers the prospect of an avoidance of time-consuming and delicate chemical processing steps now required in customary photography. Magnetic imaging also offers the prospect of an avoidance of expensive and potentially dangerous high-voltage equipment now required in electrostatic xerography and related techniques.

Unfortunately, magnetic imaging techniques which have become publically known to date cannot compete in terms of light sensitivity and exposure speed with photographic methods or even with electrostatic xerography.

SUMMARY OF THE INVENTION

The subject invention overcomes or materially alleviates the above mentioned disadvantages and, from one aspect thereof, resides in a method of magnetically recording an image, comprising in combination the steps of providing a plurality of interdigitated first and second electrodes, providing a photoconductive layer in electrical contact with and contiguous to the interdigitated first and second electrodes, and providing in heat-transfer relationship with and contiguous to said photoconductive layer a magnetic image recording layer susceptible to an image-wise change of magnetization in response to a thermal image pattern. This method further includes the steps of connecting said interdigitated first and second electrodes to opposite terminals, respectively, of a source of electric energy and applying electrical energy from said source to the interdigitated first and second electrodes by way of said opposite terminals and exposing the photoconductive layer to the image to provide a thermal pattern corresponding to the image and constituting the thermal image pattern, and magnetically recording the image by changing the state of magnetization of the recording layer in response to the thermal pattern.

By way of example, the interdigitated first and second electrodes may be located between the photoconductive layer and the magnetic recording layer. This arrangement has the advantage that the electrode structure does not obscure the image-exposed top surface of the photoconductive layer, and that heat imparted to the electrodes is readily transferred to the magnetic recording layer.

Alternatively, at least part of the photoconductive layer may be located between the interdigitated first and second electrodes and the magnetic recording layer. A preferred embodiment of the invention in accordance with this alternative solution has the photoconductive layer provided with a first side located at the plurality of interdigitated first and second electrodes, and with a second side opposite such first side. The magnetic recording layer is then provided in heat-transfer relationship with the photoconductive layer through the latter second side of the photoconductive layer.

The latter alternative solution is presently preferred because available techniques favor the provision of an electrode structure on a substrate over the provision of an electrode structure on a photoconductive layer, and because problems of light absorption by the photoconductive layer are alleviated if the electrodes are at the image-exposed side of the photo-conductive layer.

From another aspect thereof, the subject invention resides in a method of magnetically recording an image on a composite recording medium, which medium includes a photoconductive layer, a plurality of interdigitated first and second electrodes in electrical contact with and contiguous to the photoconductive layer, and, contiguous to the photoconductive layer a magnetic image recording layer susceptible to an image-wise change of magnetization in response to a thermal image pattern. This method comprises in combination the steps of applying electrical energy from said source to the interdigitated first and second electrodes by way of said opposite terminals and progressively exposing the photoconductive layer to the image in a direction progressing parallel to the interdigitated electrodes to produce a thermal pattern corresponding to the image and constituting said thermal image pattern, and magnetically recording said image by changing the state of magnetization of the recording layer in response to the thermal pattern.

The subject invention also resides in apparatus for magnetically recording an image, comprising in combination a plurality of interdigitated first and second electrodes, a photoconductive layer in electrical contact with the interdigitated first and second electrodes, and a magnetic recording layer in heat-transfer relationship with the photoconductive layer. This apparatus further includes means connected to the first and second electrodes for electrically energizing the photoconductive layer, means for exposing the electrically energized photoconductive layer to the image to produce a thermal pattern corresponding to the image, and means operatively associated with said magnetic recording layer for changing the state of magnetization of the recording layer in response to the thermal pattern whereby a magnetic record of the image is established.

As already indicated above in connection with a method aspect of the subject invention, the interdigitated first and second electrodes may, for example, be located between the photoconductive layer and the magnetic recording layer or, alternatively, at least part of the photoconductive layer may be located between the interdigitated first and second electrodes and the magnetic recording layer. In accordance with a preferred embodiment pursuant to the latter alternative version, the photoconductive layer mentioned in the preceding paragraph of this summary has a first side located at the named plurality of interdigitated first and second electrodes, and has a second side opposite such first side. The magnetic recording layer in this preferred embodiment is in heat-transfer relationship with the photoconductive layer through the latter second side of the photoconductive layer.

The subject invention further resides in a composite recording medium operable with a source of electric energy having opposite terminals, comprising in combination a plurality of interdigitated first and second electrodes means for connecting said interdigitated first and second electrodes to opposite terminals, respectively, of said source of electric energy, a photoconductive layer in electrical contact with and contiguous to the interdigitated first and second electrodes, and a thermally responsive magnetic image recording layer in heat-transfer relationship with and contiguous to the photoconductive layer.

In accordance with a presently preferred embodiment of the subject invention, the photoconductive layer mentioned in the preceding paragraph has a first side located at the named plurality of interdigitated first and second electrodes, and has a second side opposite such first side. The magnetic recording layer is in this embodiment in heat-transfer relationship with the photoconductive layer through the latter second side of the photoconductive layer.

The above mentioned combination of photoconductive layer, interdigitated electrodes, and magnetic recording medium constitutes an important feature of the subject invention, either by itself or in combination with other features.

To be sure, the use of interdigitated electrodes on photoconductors is old in the art of photoelectric devices. In the field of electrophotography, however, to a subgroup of which the subject invention belongs, the use of interdigitated electrodes on one side of the photoconductive layer has so far been generally rejected, and emphasis has been placed on the use of sandwich configurations in which the photoconductive layer is located between a pair of sheet-like electrodes.

In the course of intensive investigations into magnetic imaging we have, however, been able to reach the conclusion that the prior-art bias is unfounded and that an interdigitated electrode approach presents, indeed, the best overall solution as far as the particular field of magnetic imaging is concerned.

In particular, we have found that the interdigitated electrode structure acts in the manner of a halftone plate which materially improves image resolution and quality. We have also found that the interdigitated electrode structure greatly facilitates the premagnetization of the magnetic recording layer, which is important where information is recorded by a selective demagnetization of premagnetized material.

We have also found in the course of extensive tests that composite magnetic recording media of the type herein disclosed with interdigitated electrode structures display less sensitivity to pin holes and lumps in the photoconductor. In sandwich-type photoconductive media, these irregularities lead to very annoying effects in the printed-out image.

We have further come to the conclusion that the heavy electric currents required for the thermomagnetic imaging effect require that the transparent top electrode in sandwich-type arrangements has to have a considerable thickness, which can lead to severe transmission losses in the incoming image. In contrast thereto, our interdigitated electrode structure does not impair light transmission in the areas between the conductors. This feature alone permits an increase in sensitivity by a factor of two or more, despite the fact that the conductors themselves obscure part of the incoming light.

An interdigitated electrode structure also permits a significantly improved management of the requisite current supply coupled with a very considerable reduction of instantaneous current flow, which has always been a problem in sandwich-type configurations. By way of example, if the photoconductor is exposed to the image within a narrow exposure band that extends across the interdigitated electrodes and that progresses during the exposure in a direction parallel to the electrodes, a very significant reduction of the current intensity required for the operation of the recording medium is accomplished, and a superior rheology is still preserved, since every light-exposed point is serviced by two adjacent electrodes.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will become more readily apparent from the following detailed description of preferred embodiments thereof, illustrated by way of example in the accompanying drawings, in which:

FIG. 1 is a perspective view of an imaging apparatus in accordance with a preferred embodiment of the subject invention;

FIG. 2 illustrates a first phase in the operation of the apparatus of FIG. 1; and

FIG. 3 illustrates further phases in the operation of the apparatus of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

The apparatus **10** of FIG. **1** includes a composite photoelectromagnetic recording medium **12** which embodies key features of the subject invention. The composite recording medium **12** includes a transparent substrate **13** which may be a sheet of glass or an organic equivalent thereof, such as a transparent high-temperature polyimide or polybenzamidazole.

An interdigitated electrode structure **14** including interdigitated first and second electrodes **15** and **16** is preferably located on the transparent substrate **13**, although the electrodes may alternatively be located on the photoconductive layer presently to be described. The deposition of electrode structures on a transparent substrate is a well-established art and does not as such form part of the subject invention. Suffice to say therefore, that the electrode structure **14** may be deposited on the substrate **13** by evaporation, painting or sputtering, and that preferred electrode materials include gold, indium, chromium, and aluminum.

A photoconductive layer **18** is deposited on the substrate **13** and electrode structure **14**. Suitable photoconductive materials include cadmium sulfide, cadmium selenide, alloys of cadmium sulfide or cadmium selenide, and sensitized zinc sulfide. High-gain photoconductor materials are presently preferred, since they provide for the large currents needed for heating of the magnetic material but require only moderate input light levels. The thickness of the layer **18** is not generally critical, but a layer thickness of about 3 to 10 microns is presently preferred for resolutions of more than about ten line pairs per millimeter.

The composite recording medium **12** further includes a magnetic recording layer **20** which is pressed against, coated on, or deposited on the photoconductive layer **18**, to be in heat-transfer relationship therewith. Several materials and types of materials are suitable as a magnetic recording medium in the layer **20**. Presently preferred materials for the magnetic recording layer **20** include low-Curie point media of the type described in U.S. Pat. No. 3,176,278, by L.J. Mayer, issued Mar. 30, 1965, U.S. Pat. No. 3,250,636, by R.A. Wilferth, issued May 10, 1966, U.S. Pat. No. 3,368,209, by McGlauchlin et al., issued Feb. 6, 1968, U.S. Pat. No. 3,364,496, by Greiner et al., issued Jan. 16, 1968, and British Pat. Specification No. 1,139,232, filed Apr. 27, 1966 by E.I. du Pont de Nemours and Company. Presently preferred media include MnAs films and ferromagnetic chromium dioxide.

In the composite recording medium **12** we prefer the use of a magnetic recording medium **20** that has an acute temperature-dependent transition between the ferromagnetic and paramagnetic states at the Curie point. Where this is not inherent in the material, the preferred acuity may, according to the allowed U.S. Pat. application, Ser. No. 649,540, Magnetic Information Recording, filed June 28, 1967, by James U. Lemke, and assigned to the subject assignee, now U.S. Pat. No. 3,541,577, be realized by providing the low-Curie point magnetic particles with a shape anisotropy that dominates their crystal anisotropy.

Two preferred magnetic recording techniques include information-selective thermal demagnetization and information-selective thermoremanent magnetization. In selective demagnetization the recording medium **20** is typically premagnetized and is thereupon demagnetized by above-Curie point heating until the remaining magnetized areas present a record of the input image. In thermoremanent magnetization a thermal pattern which represents the input image is imposed upon the typically unmagnetized recording medium **20** so that selected portions of that medium are heated above Curie point. These portions are thereupon cooled in the presence of a magnetic field whereby a thermoremanent magnetization of the type described by C.D. Mee, The Physics of Magnetic Recording (North-Holland Publishing Company, 1964), pp. 80–84, and in the above mentioned Greiner et al. U.S. Patent and British du Pont Patent Specification takes place. If desired, strong positive magnetic records may be produced in the manner disclosed in Patent application, Ser. Nos. 821,232 and 821,432, filed by Luc P. Benoit on May 2, 1969, and assigned to the subject assignee, now U.S. Pat. Nos. 3,611,420 and 3,582,877 respectively. As will become apparent in the further course of this disclosure, either of these magnetic recording techniques, or a combination of these techniques to be more fully described below may be employed for recording the magnetic image.

The apparatus **10** further includes a source of light **22**, such as an incandescent lamp or a fluorescent tube, which is energized from an electric power source **23** and which is combined with a reflector and shade **24** that defines a narrow longitudinal slit **25** for the emission of a sheet of light **26**. The light sheet is reflected by a mirror **28** which is tiltable about a longitudinal axis **29** and which reflects the impinging light in the form of a light sheet **30** onto a master record **31** that may, for instance, be supported on a sheet of glass (not shown).

The light **32** reflected by the master record **31** is imaged by a lens **34** onto the interdigitated electrode structure **14** and photoconductive layer **18**.

The first and second electrodes **15** and **16** of the interdigitated electrode structure **14** are connected to opposite terminals of a source of electric energy **36**. A switch **37** and a variable resistor **38** are connected in this circuit to control timing and intensity of the current flow to the electrode structure **14** and through the photoconductor layer **18**.

If the magnetic record is to be established by thermoremanent magnetization, then the apparatus **10** requires means for magnetizing portions of the magnetic recording layer **20** that, after an image-wise thermal exposure, cool down through the Curie point of the magnetic recording medium. If the magnetic record is to be established by selective demagnetization, then the apparatus **10** requires means for premagnetizing the magnetic recording layer **20** prior to its image-wise thermal exposure. The same elongated magnetizing head **40** may be employed for both methods with the difference that the magnetic field provided by the head **40** is applied to the magnetic recording layer **20** prior to image exposure if the record is to be established by selective demagnetization, and is applied after thermal exposure during the subsequent cooling step if the record is to be established by thermoremanent magnetization.

By way of example, it is assumed that the illustrated apparatus **10** operates with a combination of the two methods by imposing a premagnetization through the agency of thermoremanent magnetization and by establishing the magnetic record by an image-wise selective demagnetization.

The magnetizing head **40** has an air gap **42**, as well as an energizing winding **43** which is connected to a source of electric energy **44** through a switch **45** and a variable resistor **46** which serve to control the timing and intensity of the magnetic field **48** provided at the air gap **42**.

To provide for a premagnetization, the photoconductive layer **18** and interdigitated electrode structure **14** are subjected to a uniform exposure. A flood lamp (not shown) which uniformly irradiates the electrode structure **14** and photoconductive layer **18** may be provided for this purpose. A light exposure which operates within a narrow exposure band **50** that extends across the alternating electrodes **15** and **16** and that progresses in the direction of an arrow **51** parallel to the electrode **15** and **16** is, however, preferred for two reasons. First, if the exposure is at any instant limited to a narrow exposure band, then the intensity of electric current flow is very substantially reduced relative to intensities that would occur if the entire composite medium were exposed at that instant. Secondly, it is easier to impose a premagnetization that has the requisite uniformity over the recording layer if such premagnetization takes place successively along a progressing band, rather than over the entire recording layer at once. Also, the total electric current flow is distributed over the electrodes if the exposure band extends across the electrodes rather than parallel thereto.

Accordingly, a light-reflecting element **53**, only part of which has been shown, is initially substituted for the master record **31**. The reflecting element **53**, may, for instance, include a white sheet of paper or a mirror. The exposure band **50** is then swept across the composite recording medium **20** in the direction of the arrow **51** by a tilting of the mirror **28** about its axis **29**. This tilting motion is effected by a drive **54** which is coupled to the mirror **28** and also to the magnetizing head **40** so as to move this head in the direction of an arrow **56** and in proportion to the tilting motion of the mirror **28**, in such mutual synchronism that the magnetic field **48**, which extends across the magnetic recording layer **20**, follows the exposure band **50** in the direction of the arrow **51**.

The switch **37** is closed and the variable resistor **38** is adjusted to supply sufficient electrical energy to the interdigitated electrode structure **14** so that successive portions of the magnetic recording layer are heated above the Curie point of the magnetic recording medium, and do thereupon cool through the Curie point as the exposure band **50** travels along the arrow **51**. The position of the traveling magnetizing head **40** relative to the moving exposure band **50** is selected such that the magnetic field **48**, which extends in parallel to the exposure band **50**, trails this exposure band at such a distance that the magnetic field **48** is successively present at all the magnetic layer portions that cool back through their Curie point.

In preparation of this thermoremanent magnetization, the switch **45** is closed and the variable resistor **46** is adjusted so that the magnetic field **48** has an intensity which is insufficient to magnetize the layer **20** while the same remains at a temperature below its Curie point, but which is sufficient to magnetize portions of the layer **20** that cool through their Curie point. As is known in magnetics, thermoremanent magnetization has the highest efficiency and linearity for all forms of magnetization.

The source **44** which energizes the magnetizing head **40** may be a source of direct current, in which case the thermoremanent premagnetization produces in the layer **20** a pattern of magnetized lines that extend in parallel to the electrodes **15** and **16** and occupy regions that correspond to areas located between the interdigitated first and second electrodes. This magnetic line pattern effect is brought about by the fact that light exposure of the photoconductive layer **18** takes place between the interdigitated electrodes **15** and **16** whereby areas below these electrodes remain colder than adjacent areas between these electrodes. To be sure, areas below the electrodes can be heated by thermal diffusion from adjacent regions, but a diffusion effect can easily be overcome by decreasing the light intensity of the source **22** or by increasing the traveling speed of the exposure region **50**, or by a combination of these measures.

In contrast to a uniform premagnetization, a line-pattern premagnetization provides a multitude of sharp magnetic gradients which promote large-area fill-in, increased contrast and increased resolution.

If a point-pattern, rather than a line-pattern, is desired, then the reflecting element **53** may be provided with a pattern of alternating light-reflecting and light-absorbing areas, or the source **44** may be a source of current pulses, whereby every line **58** is only magnetized along spaced points, as shown at **60**. Point-patterns are sometimes preferred to line-patterns as is well known in the book and newspaper printing arts.

If the source **44** is a source of alternating current, each of the premagnetization lines **58** possesses a pattern of alternating magnetizations as shown in FIG. 2 at **62**. In practice, this corresponds to a point-pattern magnetization, since no magnetizing effect takes place at and adjacent the zero crossovers of the alternating current. A strong toner attraction may result in this type of pattern from the alternating polarity of the magnetized points.

After the premagnetization step has been completed the reflecting element **53** is replaced by an information master record **31** that may, for instance, be a drawing, a writing or a printed text. By way of example, it is assumed in FIG. 1, that the master record **31** is a white sheet of paper on which a black character **65** has been printed.

For imaging according to the embodiment shown in FIG. 1, the switch **45** is opened and the magnetizing head **40** is decoupled from the drive **54** so that no magnetic field **48** follows the exposure band **50**. The mirror **28** is, however, coupled to the drive **54** so that the light sheet **30** is moved across the master record **31** whereby successive portions of the master record are illuminated within a traveling narrow band **64**. As before, the lens **34** images the band **64** onto the composite recording medium **12** whereby the latter is exposed within an exposure band **50** that travels in the direction of the arrow **51**. The switch **37** is again closed and the variable resistor **38** adjusted so that electric currents in the photoconductive layer **18** heat the magnetic recording layer **20** above its Curie point at locations at which light reflected by the white background of the master record **31** impinges on the photoconductive layer **18**. This above-Curie point heating causes a demagnetization of the recording layer **20** or of its premagnetized line or point pattern. An application of magnetic fields to the recording layer **20** is avoided at this stage to preclude an undesired remagnetization of demagnetized areas through the agency of thermoremanent magnetization.

No significant light is reflected by the black character **65**, whereby portions of the photoconductive layer that correspond to that character remain dark. Since no electric currents are caused to flow at those corresponding portions, the temperature of the magnetic recording layer **20** remains below its Curie point within an outline occupied by an image of the character **65**. The resulting lack of demagnetization of the premagnetized line or point-pattern leads to a magnetic record **68** of the character **65** as shown in FIG. 3.

A further substantial advantage of the apparatus, methods and media of the subject invention may be considered at this juncture. Information recording methods that rely on a selective demagnetization of a premagnetized medium are frequently hampered by the fact that areas which have been demagnetized are remagnetized by the magnetic information record itself when the recording medium cools back through its Curie point. Since this undesired remagnetization takes place through the agency of thermoremanent magnetization, it is strong and interferes with the resolution of the magnetic record.

With the composite recording medium of the subject invention it is easy to provide a super focusing effect since portions of the magnetic recording medium **20** corresponding to points of the photoconductive layer

18 located midway between adjacent electrodes 15 and 16 tend to acquire a higher temperature than areas corresponding to points located more closely to the electrodes. The reason for this resides in the fact that the photoconductive layer portions below the electrodes 16 remain dark and do thus not produce heat-generating electric currents, and that the electrodes themselves provide a heat-sink effect. Accordingly, the premagnetization lines 58, 60 or 62 can easily be made narrow and spaced from each other whereby a thermoremanent remagnetization effect brought about by the information record during cooling will limit itself to a broadening of the premagnetization lines or points until the same have dimensions desired for a printout of the magnetic image. This broadening is very beneficial since the thermoremanent magnetization effect under discussion typically provides magnetized fringes that have a polarity opposite to the magnetic polarity of the adjacent regions whereby strong magnetic gradients provide a sharp outline of the details of the magnetic image.

The magnetic image 68 may be stored in the magnetic recording medium 20 and printed out as often as desired. A magnetic toner 70 may be applied to the magnetic image 68 to render the same visible or printable. Magnetic toners typically comprise magnetically attractable particles 72 in powdered form or liquid suspension. Suitable materials for the toner particles 72 include iron, nickel, cobalt or ferromagnetic alloys. By way of example and not by way of limitation, preferred materials for the toner particles 72 include submicron particles of iron, carbonyl iron, and magnetite (Fe_3O_4). Magnetic toners, toning techniques, and toning apparatus are disclosed in U.S. Pat. No. 2,932,278, by J.C. Sims, issued Apr. 12, 1960; U.S. Pat. No. 3,052,564, by F.W. Kulesza, issued Sept. 4, 1962; and U.S. Pat. No. 3,250,636, by R.A. Wilferth, issued May 10, 1966.

The toner image 74 resulting from a toning of the magnetic image 68 may be printed out on a sheet of paper, on a film, or on another material having similar surface qualities. If desired, a sheet of paper 75 may be provided with an adhesive coating 76 to assure a transfer and retention of the toner image 74 in the form of a copy 78 of the original character 65. To effect such a transfer, the adhesive paper 75 is pressed onto the magnetic recording layer 20 and is thereupon removed whereby the toner image 74 adheres to and is pulled off together with the paper 75. As is known in the art of magnetic printing, the toner 70 may be present in the form of a magnetic ink that is absorbed by the paper 75, or the toner particles may be provided with shells of a thermoplastic or other fusible material that may be fused to the paper 75 by a combination of pressure and heat. No adhesive coating 76 is provided if a magnetic ink or a fusible material is employed.

If no further printout or storage is desired, the magnetic image 68 may be erased by such conventional methods as an exposure of the magnetic recording layer 20 to anhysteretic magnetic erasing fields, or to above-Curie point heating. The latter may be effected by a sweeping of the light sheet 32 across the interdigitated electrode structure 14 and photoconductive layer 18, while the electrodes are connected to the electric energy source 36 and the reflective element 53 is substituted for the information record 31.

The magnetic recording layer 20 may be permanently deposited on the photoconductive layer 18. Since the magnetic recording layer 20 is typically much cheaper than the combined interdigitated electrode structure 14 and photoconductive layer 18, it may be advantageous to provide the magnetic recording layer 20 on a substrate that is selectively movable into contact with, and removable from, the photoconductive layer 18.

Reverting to the interdigitated electrode structure 14 it should be noted that the same affords a much better management of current supply than systems in which the photoconductive layer is sandwiched between sheet electrodes. In the interdigitated structure shown in FIG. 1, any exposed point of the photoconductive layer is serviced by two current supply electrodes. If a light exposure shifts in the direction of the arrow 51, then an increase in electrical resistance along an electrode 15 is automatically compensated by a corresponding decrease in electrical resistance along an adjacent electrode 16. Electrode sheets, on the other hand, do not provide a similar favorable rheology so that contrast, resolution and quality of image points tend to be dependent on the location of the particular point relative to the edges of the recording medium.

We claim:

1. A method of magnetically recording an image, comprising in combination the steps of:
providing a plurality of interdigitated first and second electrodes;
providing a photoconductive layer in electrical contact with and contiguous to said interdigitated first and second electrodes;
providing in heat-transfer relationship with and contiguous to said photoconductive layer a magnetic image recording layer susceptible to an image-wise change of magnetization in response to a thermal image pattern;
connecting said interdigitated first and second electrodes to opposite terminals, respectively, of a source of electric energy;
applying electrical energy from said source to said interdigitated first and second electrodes by way of said opposite terminals and exposing said photoconductive layer to said image to produce a thermal pattern corresponding to said image and constituting said thermal image pattern; and
magnetically recording said image by changing the state of magnetization of said recording layer in response to said thermal pattern.

2. A method as claimed in claim 1, wherein:
said photoconductive layer is provided with a first side located at said plurality of interdigitated first and second electrodes, and with a second side opposite said first side; and
said magnetic recording layer is provided in heat-transfer relationship with said photoconductive layer through said second side of said photoconductive layer.

3. A method as claimed in claim 1, wherein:
the state of magnetization of said recording layer is changed by premagnetizing said recording layer and heating with said thermal pattern portions of said premagnetized recording layer corresponding to said pattern so as to demagnetize said portions of said recording layer.

4. A method as claimed in claim 3, wherein:

said recording layer is premagnetized by cooling said recording layer through its Curie temperature in the presence of a magnetic field.

5. A method as claimed in claim 3, wherein:

said recording layer is premagnetized by thermoremanent magnetization including a heating of said recording layer with the assistance of an electrical energization and a progressive exposure of said photoconductive layer in a direction progressing in parallel to said electrodes, and a subsequent cooling of said recording layer in the presence of a magnetic field.

6. A method as claimed in claim 1, wherein:

said photoconductive layer is progressively exposed to said image in a direction progressing in parallel to said interdigitated electrodes.

7. A method as claimed in claim 1, wherein:

said photoconductive layer is exposed to said image within a band of exposure extending substantially across said interdigitated first and second electrodes and progressing in a direction parallel to said interdigitated electrodes.

8. A method of magnetically recording an image on a composite recording medium, which medium includes a photoconductive layer, a plurality of interdigitated first and second electrodes in electrical contact with and contiguous to said photoconductive layer, and, in heat-transfer relationship with and contiguous to said photoconductive layer, a magnetic image recording layer susceptible to an image-wise change of magnetization in response to a thermal image pattern, comprising in combination the steps of:

connecting said interdigitated first and second electrodes to opposite terminals, respectively, of a source of electric energy;

applying electrical energy from said source to said interdigitated first and second electrodes by way of said opposite terminals and progressively exposing said photoconductive layer to said image in a direction progressing parallel to said interdigitated electrodes to produce a thermal pattern corresponding to said image and constituting said thermal image pattern; and

magnetically recording said image by changing the state of magnetization of said recording layer in response to said thermal pattern.

9. A method as claimed in claim 8, wherein:

said photoconductive layer is exposed to said image within a band of exposure extending substantially across said interdigitated first and second electrodes and progressing in a direction parallel to said interdigitated electrodes.

10. A method as claimed in claim 8, wherein:

the state of magnetization of said recording layer is changed by premagnetizing said recording layer and heating with said thermal pattern portions of said premagnetized recording layer corresponding to said pattern so as to demagnetize said portions of said recording layer.

11. A method as claimed in claim 10, wherein:

said recording layer is premagnetized by cooling said recording layer through its Curie temperature in the presence of a magnetic field.

12. A method as claimed in claim 10, wherein:

said recording layer is premagnetized by thermoremanent magnetization including a heating of said recording layer with the assistance of an electrical energization and a progressive exposure of said photoconductive layer in a direction progressing in parallel to said electrodes, and a subsequent cooling of said recording layer in the presence of a magnetic field.

13. A composite photoelectric recording medium operable with a source of electric energy having opposite terminals, comprising in combination:

a plurality of interdigitated first and second electrodes;

said interdigitated first and second electrodes connected to opposite terminals, respectively, of said source of electric energy;

a photoconductive layer in electrical contact with and contiguous to said interdigitated first and second electrodes; and

a thermally responsive magnetic image recording layer contiguous to said photoconductive layer.

14. A composite recording medium as claimed in claim 13, including:

a transparent substrate carrying said interdigitated first and second electrodes and said photoconductive layer.

15. A composite recording medium as claimed in claim 13, wherein:

said photoconductive layer has a first side located at said plurality of interdigitated first and second electrodes, and a second side opposite said first side; and

said magnetic recording layer is in heat-transfer relationship with said photoconductive layer through said second side of said photoconductive layer.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,717,460 Dated Feb.20,1973

Inventor(s) Sherman W.Duck, Frederick J.Jeffers, James U.Lemke

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 19, -- in heat-transfer relationship with and -- should be inserted after "and".
Column 3, line 5, insert comma after "electrodes"

Signed and sealed this 26th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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