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[54] NON-IMPACT, CURIE POINT PRINTER

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[52] **U.S. Cl.** .... **346/74 MT,** 346/76 L

[51] **Int. Cl.... G01d 15/12,** G02b 17/00, H01v 3/04

[58] **Field of Search** .... 346/74 MP, 74 MT, 76 L; 179/100.2 CR; 178/94; 350/7

[56] **References Cited**

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[57] **ABSTRACT**

Printing and duplicating are carried out utilizing the thermoremanent magnetization of a magnetic thin film. Information is stored by heating the film above its Curie temperature and allowing it to cool in a small magnetic field. A copy of the latent image is made by coating the magnetized areas of the film with a magnetic ink and transferring the ink to paper. The film is locally heated by selective heating with a light source, preferably a laser.

13 Claims, 4 Drawing Figures

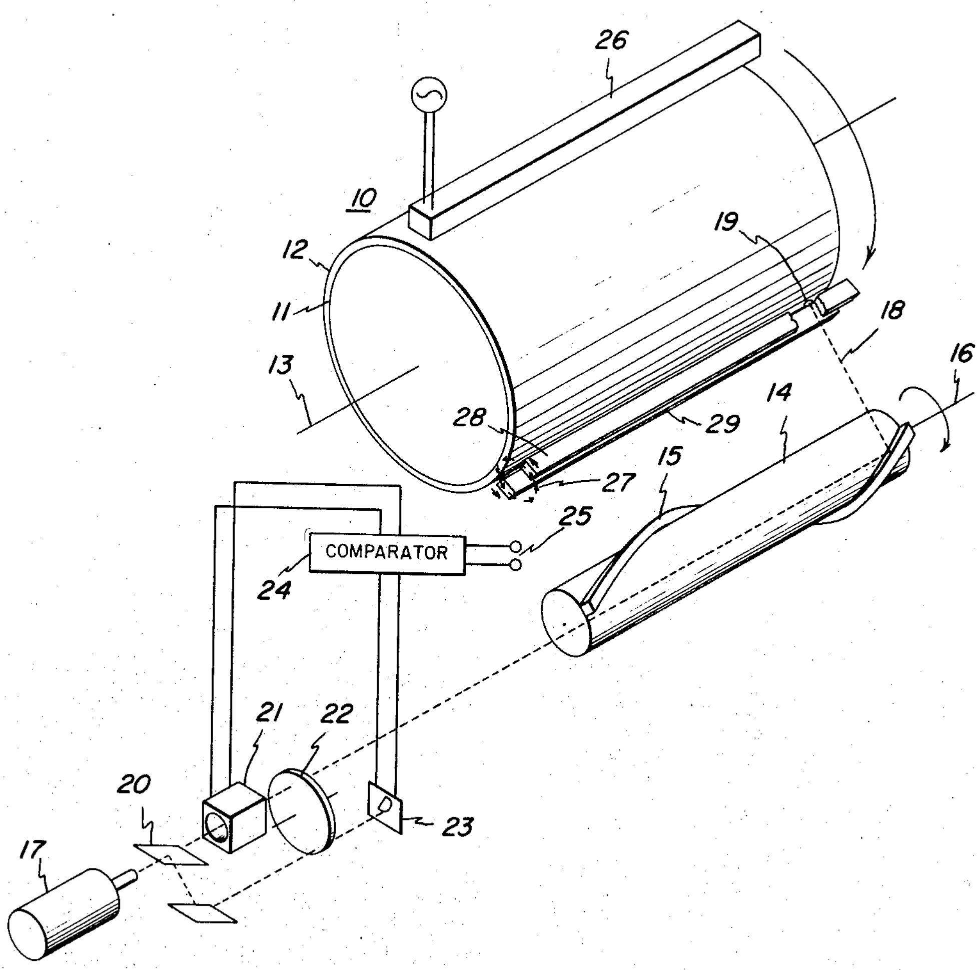


FIG. 1

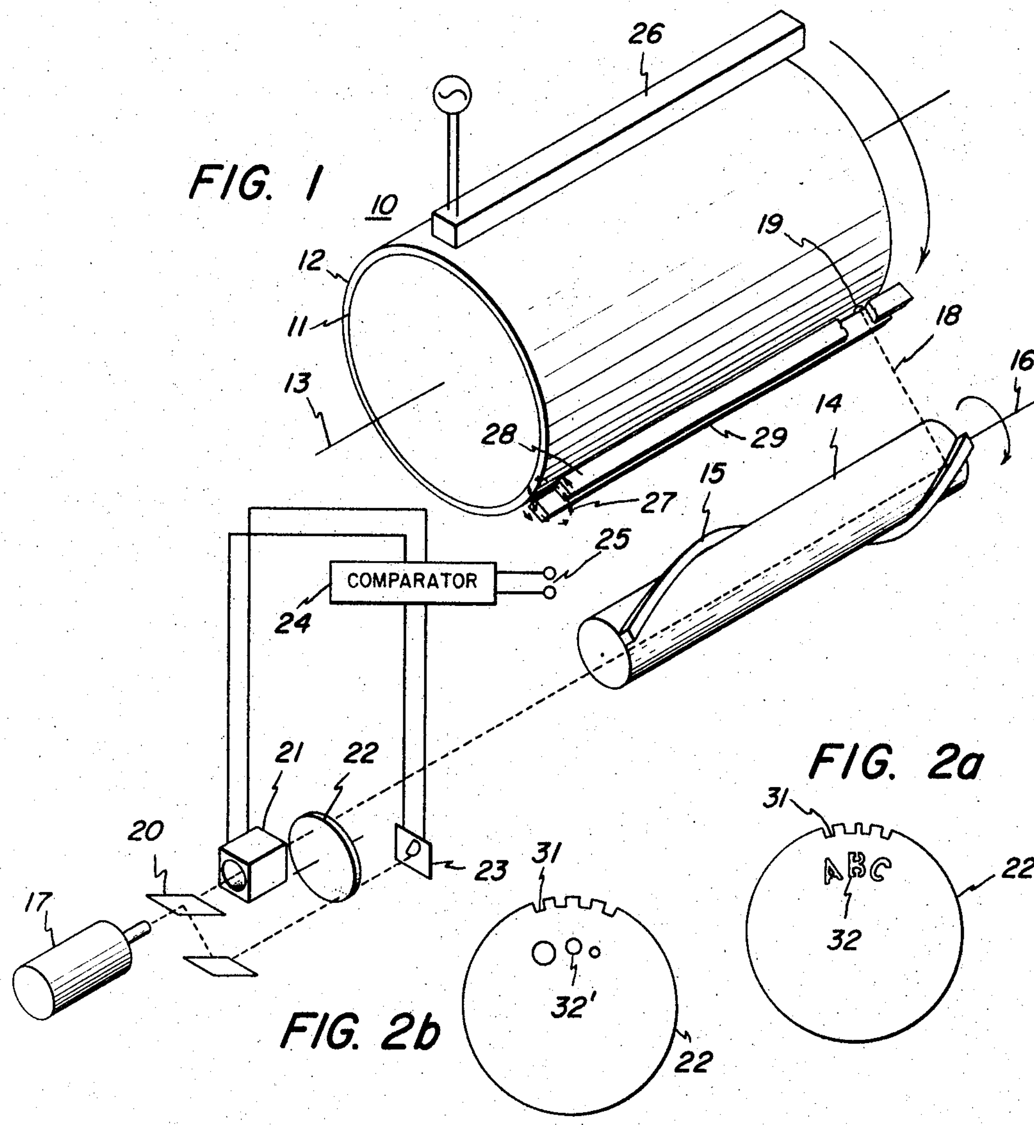
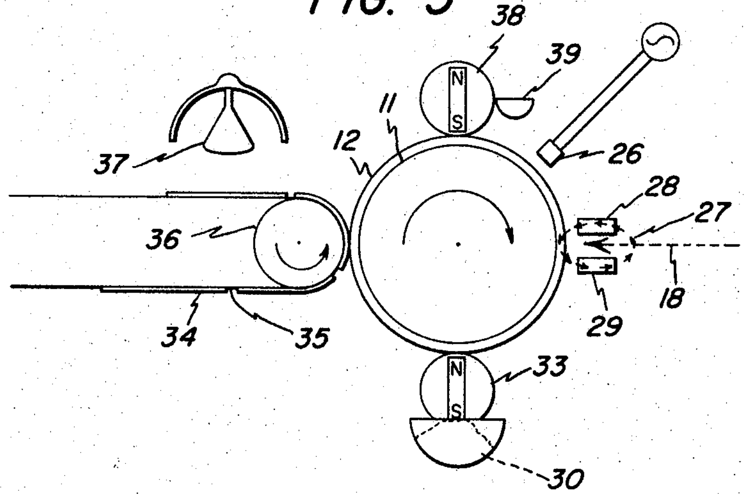


FIG. 2a

FIG. 2b

FIG. 3



NON-IMPACT, CURIE POINT PRINTER

This invention relates to printing and duplicating systems, and in particular to non-impact printing and duplicating utilizing magnetic effects, such as Curie point recording.

Encompassing a number of arts, that may be generically described as a machine interfacing with a human operator, there is the need for a printing and copying mechanism that combines relatively high speed, good quality image and low cost. Further, it is frequently desirable that the mechanism be capable of producing an image transmitted from a remote source. (Throughout this specification, image is used as generic to both typewriter characters and non-typewriter characters, e.g., photographs).

For example, in the computer art, there is a need for a low cost, high speed printer capable of printing the output from on-line (as generated) computers or terminals.

For hard copy duplication, it is desirable that the copier be capable of reproducing a gray scale, reproduce large dark areas, and have good resolution. In addition, it is desirable that the copier be insensitive to ambient conditions, e.g., humidity, and that the copier work equally well with remote image sources. Prior art copiers, while quite good in some of these respects, do not fulfill all of them to the same degree.

In view of the foregoing, it is therefore an object of the present invention to provide an improved magnetic printer.

Another object of the present invention is to provide an improved non-impact printer for alphanumerical characters and facsimile.

A further object of the present invention is to provide a high speed printer utilizing Curie point writing.

Another object of the present invention is to provide an on-line printer for computers and terminals.

The foregoing objects are achieved in the present invention wherein a drum covered with thermomagnetic material is imaged with the information to be printed. The imaging selectively heats the material above its Curie temperature. When allowed to cool in a small magnetic field, the information is recorded. The drum is then inked with a suitable magnetic ink that adheres only to the magnetized areas. Printing then transfers the magnetic ink to the paper. Imaging is carried out by selective heating with a laser utilizing an aperture disc and a scanning mirror.

A more complete understanding of the present invention can be obtained by considering the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates a preferred embodiment of the present invention.

FIG. 2*a* illustrates one form of aperture disc suitable for use in the present invention.

FIG. 2*b* illustrates another form of aperture disc suitable for use in the present invention.

FIG. 3 illustrates the printing operation in accordance with the present invention.

FIG. 1 illustrates a preferred embodiment of the recording portion of the present invention in which the characters to be printed are recorded on a drum coated with thermomagnetic material. The recording portion of the preferred embodiment generally comprises the recording drum, suitable optics for recording on the

drum, and electronics for controlling the pattern of the beam incident upon the drum.

Specifically, recorder **10** comprises drum **11** having a thermomagnetic coating **12** thereon. Drum **11** rotates on axis **13** and is driven by any suitable driving mechanism. Adjacent drum **11** is a second drum **14** having thereon a single turn helical mirror **15**. Helical mirror **15** is rotated about its axis **16** by any suitable driving mechanism and is preferably mechanically coupled to drum **11** to provide synchronization. A continuously running laser **17** provides a beam **18** that is reflected by helical mirror **15** onto a selected spot **19** on the thermomagnetic coating of drum **11.** The laser beam passes through beam splitting mirror **20,** optical gate **21,** and mask wheel **22** on its way to spot **19.** Beam splitting mirror **20** provides a small secondary beam which also passes through mask wheel **22** and is detected by detector **23.** The output from detector **23** is applied as one input to comparator **24.** The other input, input **25,** is provided by a remote source and comprises a coded signal to be compared with the signal from detector **23.** Upon the matching of the information at each input, comparator **24** produces an output signal which is applied to gate **21** to enable optical gate **21** to transmit beam **18.**

The overall operation of the recording portion of a preferred embodiment of the present invention may best be understood by also considering FIG. 2 in which mask wheel **22** is illustrated showing its full diameter.

Assuming that the recording apparatus is to be used as a printer for a computer, then mask wheel **22** would preferably comprise at least one pair of tracks wherein one track comprises a plurality of translucent areas **31,** illustrated in FIG. 2 and 2*a* as a plurality of openings forming teeth about the periphery of mask wheel **22,** and a second track **32** comprising alphanumerical characters, wherein a code, for example, binary code, corresponding to each letter is carried on the periphery of mask wheel **22** in a position corresponding to the appropriate alphanumerical character.

In operation, an input signal from the computer would be received at input **25** and applied to comparator **24.** This coded signal is compared with the output signal from detector **23,** which preferably comprises a photocell detector. When there is a match between the output from the computer and the coded signal on mask wheel **22,** comparator **24** produces an output signal to gate **21** thereby opening gate **21** and allowing laser beam **18** to pass therethrough and through the alphanumerical portion of mask wheel **22.** The particular alphanumerical character through which the laser beam passes effectively shapes the pattern of the beam by shaping the beam in the form of the particular alphanumerical character. This beam is then reflected by helical mirror **15** to a predetermined point **19** on drum **11.** The laser beam serves to heat portion **19** above the Curie temperature of the thermomagnetic coating. By allowing the portion to cool in the presence of a small magnetic field, the information is thus magnetically recorded on recording **12.**

The small magnetic field can be provided a number of ways. For example, as illustrated, magnetic field **27** is provided by permanent magnets **28** and **29,** the spacing of which provides a slit through which beam **18** passes. Magnets **28** and **29** are preferably magnetized in the direction illustrated, but may also be magnetized in the perpendicular directions which would produce a fringe field intersecting the surface of drum **11**. Alternatively, D.C. electromagnets may be used.

Helical mirror **15** is rotated faster than drum **11** so that one complete turn of helical mirror **15** scans one line on drum **11**. If desired, so that the printed line is parallel to the axis of the drum, axes **13** and **16** can be made slightly skew to one another so that as drum **11** rotates slowly a straight line is scanned thereacross. Alternatively, drum **11** can be started and stopped.

The thermomagnetic coating on drum **11** may comprise any suitable material having a Curie temperature between 30° and 150° C. One example of a suitable material is disclosed in copending application Ser. No. 278,535, filed Aug. 7, 1972, and assigned to the assignee of the present invention. This material, substituted cobalt ferrite, has a Curie temperature that can be varied within these limits. An example of a suitable ferrite is $CoGa_{.82}Fe_{1.18}O_4$ having a Curie temperature of 150° C.

The particular Curie temperature chosen is determined in part by the beam power available from laser **17** and the length of time the laser beam is permitted to irradiate a particular location. Thus, the thermomagnetic material used in a particular application is chosen consistent with the thermal energy available. In general, the remanent magnetization at the ambient temperature decreases with decreasing Curie temperature. Conversely, the speed with which the magnetic latent image can be produced depends on the power required to reach the Curie temperature. An easily accessable value for Curie temperature is between 75°and 150° C. In this range, flash tubes and incandescent sources can be used as well as the laser as illustrated in FIG. **1**.

The use of a beam splitting mirror **20** and a translucent track on mask wheel **22** is but one form of mechanism for reading out the coded information contained on mask wheel **22**. Detector **23** could also, for example, comprise a magnetic detector sensitive to a magnetized code in one track of mask wheel **22**. Alternatively, reflection from light and dark areas in a track on mask wheel **22** could be used as the coding element. Detector **23** would then be positioned to detect reflections from the surface of mask wheel **22** rather than transmission through translucent areas.

Gate **21** may comprise any suitable mechanism for controlling the beam of laser **17**. One suitable gate is produced by the Isomet Corporation of New Jersey. Laser **17** may comprise any suitable laser, for example, a helium-neon laser.

FIG. **3** illustrates the printing of the recorded information in accordance with the present invention. In order to print the characters formed by laser beam **18**, a magnetic brush **33** is used to transfer magnetic ink **30** to the surface of the drum where it adheres only to the areas magnetized during the recording operation. Magnetic brush **33** preferably comprises a magnet within a rotating drum for attracting a magnetic core particle of the magnetic ink and transferring the ink to drum **11**. The magnetic ink may comprise either magnetically soft or hard particles coated with a low melting point resin. As a specific example, 10 micron diameter ferrite particles having a resin coating comprising 25 percent polyvinylbutyral, 70 percent rosin-modified phenolformaldehide and 5 percent carbon black are suitable as a magnetic ink.

The magnetic ink adheres to the imaged portions of the drum and is transferred to paper **34** on conveyor **35** by the pressure of roller **36** against drum **11**. After the impression is made, heater element **37** heats the ink sufficiently to melt the resin thereby permanently bonding the ink to the paper. Any residual ink on drum **11** is removed by magnetic brush **38** and deposited in receptacle **39**. Demagnetizer **26** then demagnetizes the drum and the drum is ready for additional information to be recorded by laser beam **18**.

There are actually two ways in which alphanumerical characters can be recorded on drum **11**. One, as described above, is where mask wheel **22** contains the whole alphanumerical character in a first track and a coded second track. The second is where the character is built up by a plurality of dots in a matrix. In order to do this, as illustrated in FIG. **2***b*, the alphanumerical characters in track **32** are replaced with holes of varying size, as in track **32'**. The digital code in track **31** is used to select the proper diameter hole and hence the density of the dot being formed.

While requiring from six to twelve scans per printed line of characters, the use of different sized holes in mask wheel **22** enables the system to print any image including photographs. With the variable density dot, a full gray scale is obtained and even large dark areas in an image are accurately reproduced.

An alternative embodiment of the present invention, when used for facsimile, does not utilize mask wheel **22**, detector **23** or comparator **24**. In this instance, the input signal to input terminals **25** is a coded signal indicating the reflectance of the document (gray scale) being transmitted from a remote source. Comparator **24** is replaced with a decoding circuit which decodes the input signal and opens gate **21** for a time inversely proportional to the reflectance of the document. The longer time allows a greater spread of the heat on the thermomagnetic material and thus produces a darker image.

There is thus provided by the present invention an improved non-impact magnetic printer which can be used for both non-impact printing and hard copy duplications. The use of continuously rotating drums obviates the need for any reciprocal motion and enables high speed operation. For example, utilizing the present invention, a printer of 132 characters per line, 13,600 lines per minute is attainable. Further, the use of magnetic rather than electrostatic effects enables the printer to be less sensitive to ambient conditions.

In view of the foregoing it will be apparent to those of skill in the art that various modifications can be made within the spirit and scope of the present invention. For example, helical mirror **15** could be replaced, with some increase in non-linearity, by a tautband mounted, magnetically deflected, plane mirror.

What we claim as new and desire to secure by letters patent of the United States is:

1. A non-impact magnetic printer comprising:
   a first rotatable cylinder coated with thermomagnetic material;
   light source means producing a light beam for locally heating portions of said material;
   magnetic means adjacent said cylinder for producing a local magnetic field in said heated portions;
   mirror means for deflecting the light beam to selected portions of said material;

mask wheel means, interposed in the beam path between said light source means and said mirror means, for shaping the pattern of the beam incident upon said material; and

inking means for transferring magnetic ink to the surface of said thermomagnetic material.

2. A non-impact magnetic printer as set forth in claim 1 wherein said mirror means comprises:

a second rotatable cylinder having a single turn, helical mirror wound thereon, the axes of said first and second rotatable cylinders being approximately parallel.

3. A non-impact magnetic printer as set forth in claim 1 wherein said mask wheel means contains a first track, containing a plurality of patterns to be projected onto said material, and a second track, containing a coded designation for each of said patterns.

4. A non-impact magnetic printer as set forth in claim 3 and further comprising:

detecting means for detecting the code designation in said second track and producing an output signal indicative thereof;

comparator means for comparing input information indicative of a particular pattern with the output signal from said detecting means and producing a control output signal;

gate means, interposed in said beam path between said light source means and said mask wheel means, for permitting the light beam to pass therethrough in response to said control signal.

5. A non-impact magnetic printer as set forth in claim 4 wherein said second track comprises a plurality of translucent areas on said mask wheel for providing said coded designation and said detecting means comprises:

beam splitting means for deflecting a portion of said light beam through said second track; and

photocell means on the opposite side of said mask wheel means for sensing the passage of said portion of the light beam through said translucent areas.

6. A non-impact magnetic printer as set forth in claim 5 wherein said patterns comprise alphanumerical characters.

7. A non-impact printer as set forth in claim 5 wherein said patterns comprise a plurality of holes of differing diameters.

8. A non-impact magnetic printer as set forth in claim 1 wherein said magnetic means comprises:

a pair of parallel, spaced magnetic elements defining a slit therebetween through which said light beam passes.

9. A non-impact magnetic printer as set forth in claim 8 wherein said magnetic elements comprise permanent magnets.

10. A non-impact magnetic printer as set forth in claim 8 wherein said magnetic elements comprise electromagnets.

11. A non-impact magnetic printer as set forth in claim 3 wherein said patterns comprise alphanumerical characters.

12. A non-impact magnetic printer as set forth in claim 3 wherein said pattern comprises holes of varying size for varying the diameter of said beam incident upon said material.

13. A facsimile printer comprising:

a first rotatable cylinder coated with thermomagnetic material;

light source means producing a light beam for locally heating portions of said material;

magnetic means adjacent said cylinder for producing a local magnetic field in said heated portions;

mirror means for deflecting the light beam to selected portions of said material;

optical gate means interposed in the beam path between said light source means and said mirror means;

decoder means receiving a coded input signal indicative of the reflectance of a spot being scanned, said decoder means producing a time control output signal for controlling the length of time said gate means transmits said light beam;

inking means for coating the magnetized portions of said material with a magnetic ink; and

paper press means for guiding paper against said cylinder to transfer the magnetically stored image to said paper.

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