United States Patent

[11] 3,579,250

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[21] Appl. No. **607,521**
[22] Filed **Jan. 5, 1967**
[45] Patented **May 18, 1971**

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[54] **PRODUCTION OF LATENT IMAGES BY CURIE POINT RECORDING**
16 Claims, 14 Drawing Figs.

[52] **U.S. Cl.** **178/6.6,** 346/74
[51] **Int. Cl.** **H04n 5/76,** G03g 19/00
[50] **Field of Search** ..... 178/6.6 (A); 346/74 (MT), (Inquired)

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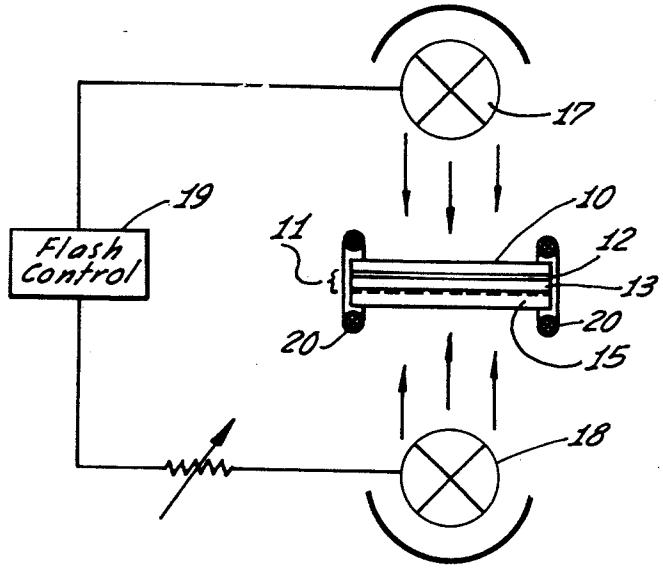
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Assistant Examiner—Joseph A. Orsino, Jr.
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ABSTRACT: A latent magnetic image, positive or negative, is provided on a low Curie point storage carrier by providing concurrently radiation for a line raster and for pictorial information. Depending on the chosen intensity of the thermal radiation energy bias and information, the image will be positive or negative. The image is represented by a series of magnetic pole lines of alternating polarity and variable spacing.



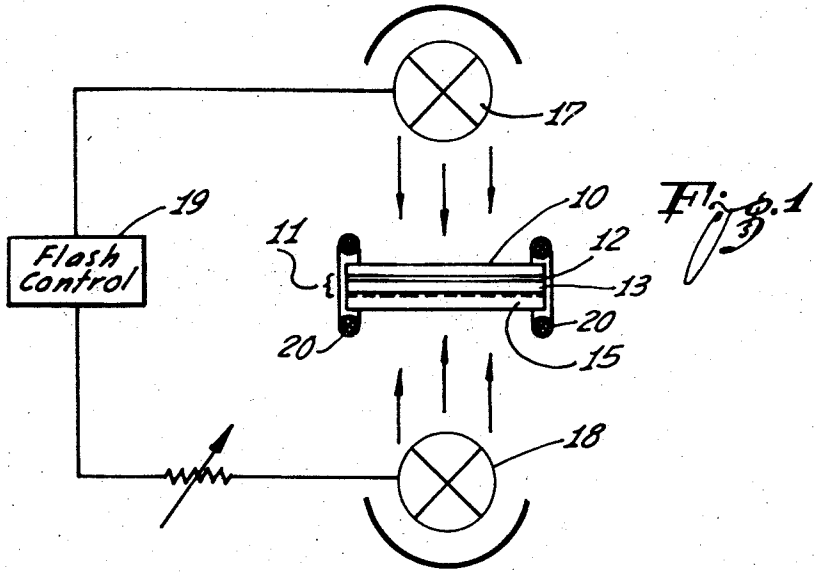
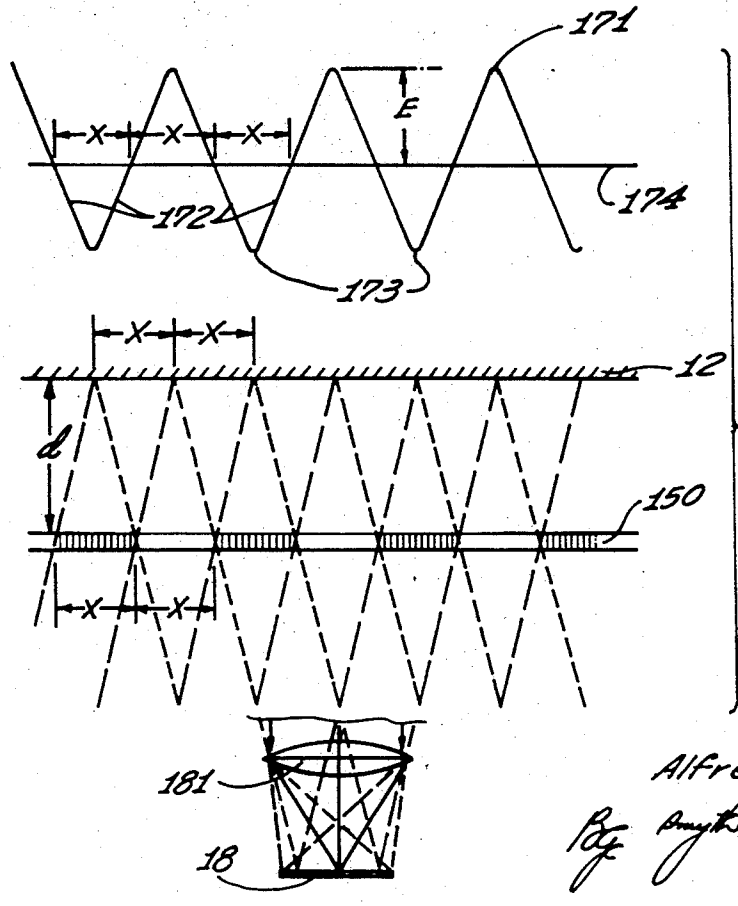


Fig. 1

Fig. 8



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Fig. 2

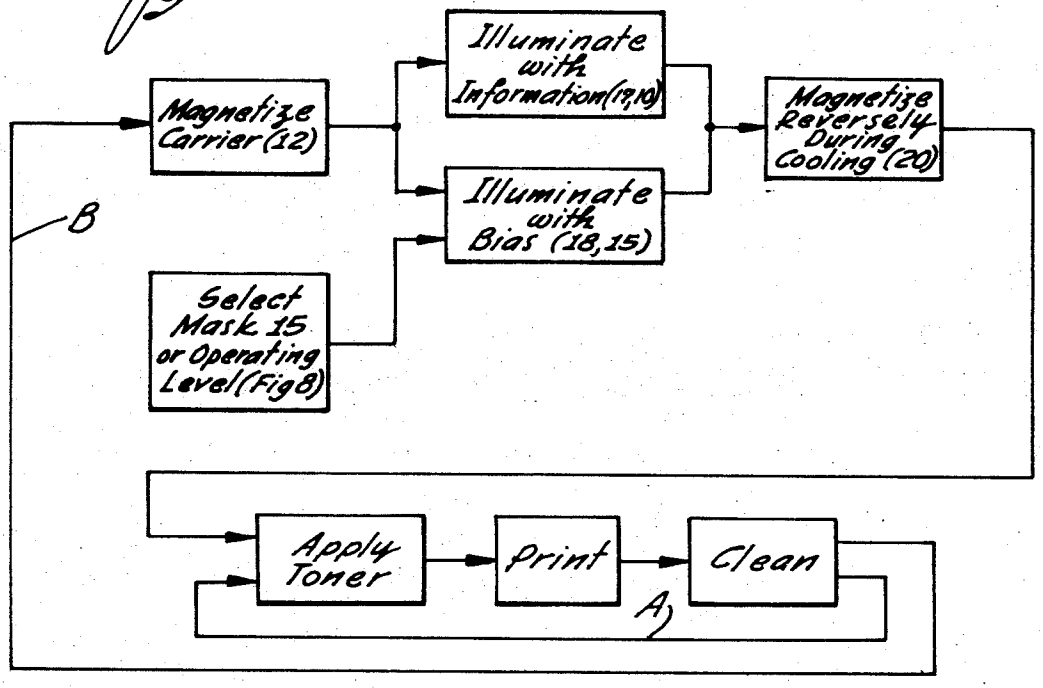


Fig. 3

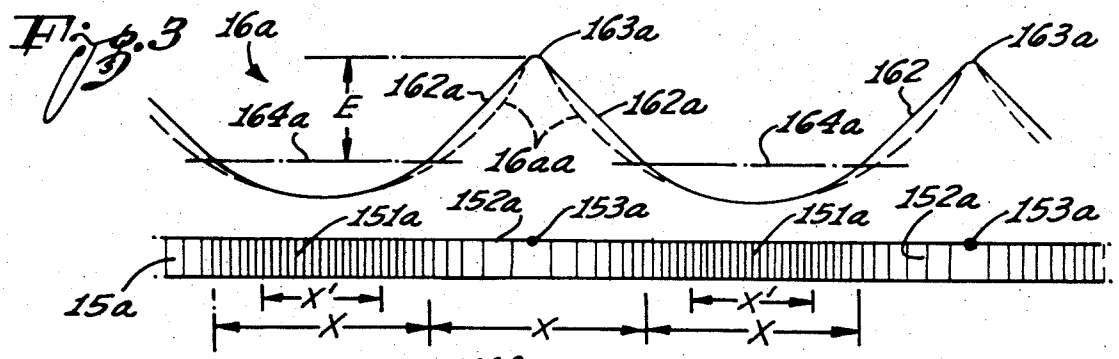
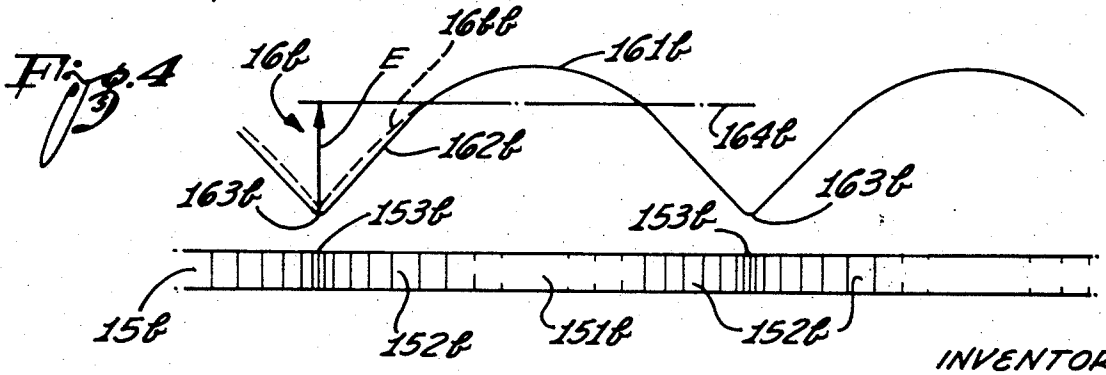


Fig. 4



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Fig. 5a

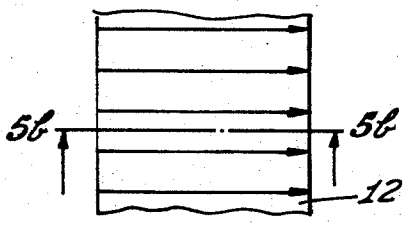


Fig. 5b

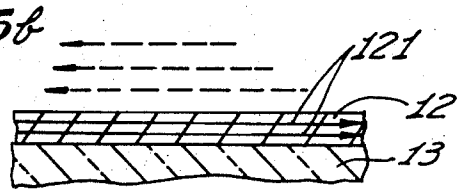


Fig. 6a

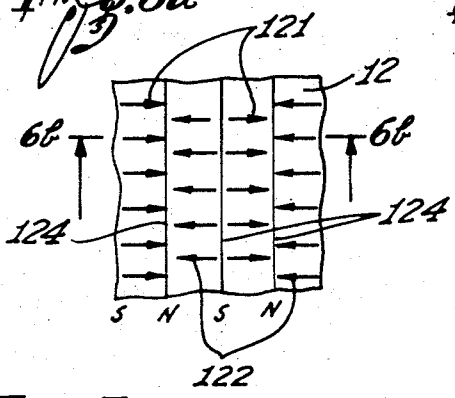


Fig. 6b

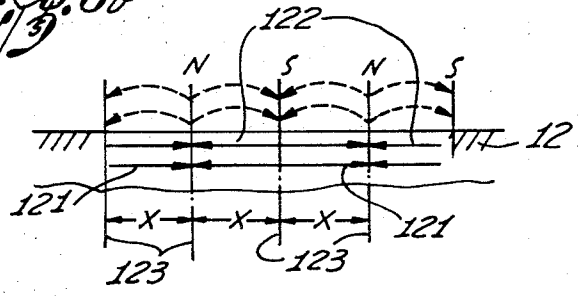


Fig. 7a

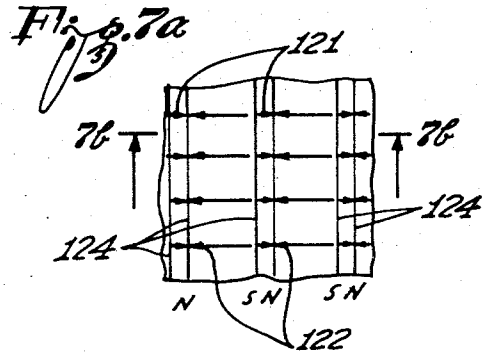


Fig. 7b

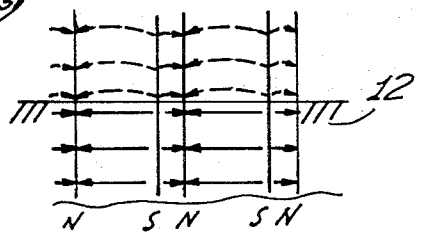
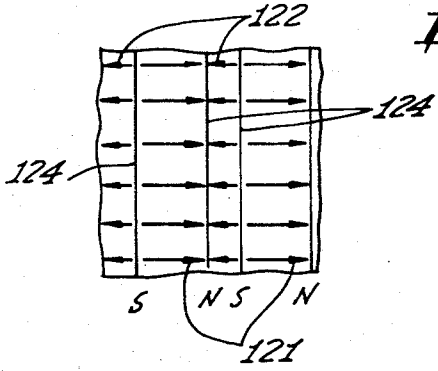


Fig. 7c



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Fig. 9

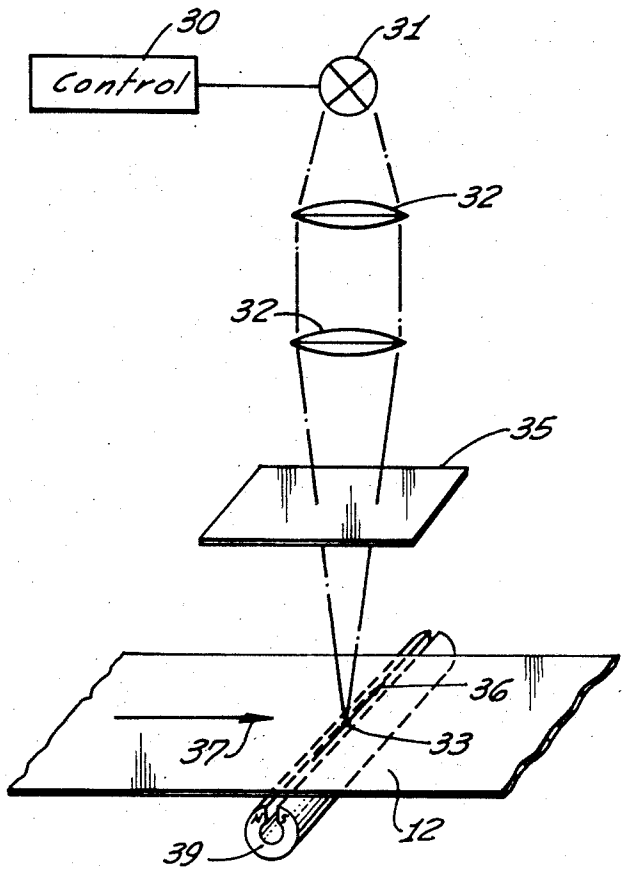
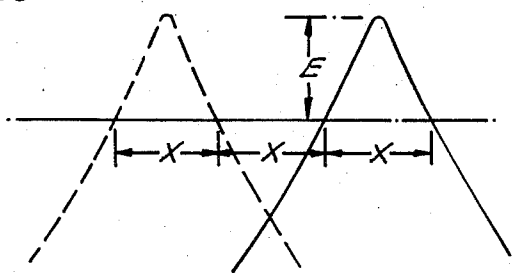


Fig. 10



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PRODUCTION OF LATENT IMAGES BY CURIE POINT RECORDING

The invention relates to a method and system to provide a negative or positive latent image on a carrier as copy from a master defined by a two-dimensional, contrast producing information field such as a picture or the like.

For practicing the invention a carrier is needed which can retain various states of energization for the production of localized regions exhibiting an attracting force upon a substance, which upon being attracted causes the latent image to be developed. Furthermore, these states of energization should be controlled by radiation, for example in a threshold-type manner, in that a particular radiation intensity (and higher intensities) reaching a particular area of the carrier can destroy such an energization therein, while permitting substitution of a different state of energization.

For example, a magnetizable storage carrier having an extended surface can retain a longitudinal magnetization when in the ferromagnetic state. If that carrier has a rather low Curie point and a temperature dependent coercivity, it is possible to destroy such magnetization and to render the carrier locally paramagnetic. If a magnetic field of below room temperature coercivity is applied to the carrier, the latter field will determine the final magnetization of all those paramagnetic areas, provided the magnetic field persists while the paramagnetic areas revert to the ferromagnetic state after decay of the radiation which caused the heating. If the substitute magnetization has an orientation different from the original magnetization retained in those areas which remained ferromagnetic, then there will appear border zones which are magnetic poles capable of attracting magnetic particles.

In a particular area these magnetic poles may be arranged along parallel, equidistantly spaced lines. For convenience, the term, pole line, will be used having the following meaning. In a magnetizable layer a first region may be magnetized longitudinally, i.e., parallel to the surface and in one particular direction. In a neighboring region the layer may be magnetized in the opposite direction. This results in a border area across the interior of the layer along which magnetic poles of similar polarity and pertaining to the two oppositely magnetized regions face each other. These poles are also substantially oriented parallel to the surface. The border area traverses the surface in a line which, as far as surface magnetization of the layer is concerned, is a magnetization discontinuity. Such a line will be called a pole line and the polarity thereof is that of the magnetic poles of the material underneath the line and facing each other in the interior of the layer. The result of such pole line is a magnetic gradient field normal to the surface in the vicinity of the pole line with maximum values at such a pole line itself. If a surface area under consideration has dimensions which are large as compared with the spacing of the pole lines, the carrier surface will appear to be rather uniformly covered with such pole lines. Each line attracts a particular amount of magnetizable particles and it thus appears that in this case there will be a uniform density of particles per unit area.

If the equidistant relationship is perturbed in that the same number of pole lines are rearranged to define pairs of more closely spaced lines, then in the space in between each two such pairs there is a relatively large strip to which particles will not be attracted. There is thus an asymmetrical line spacing relative to each individual line, in that the neighboring line on one side is closer than on the other side. Furthermore, the pole strength along each line is weakened as compared with the pole strength for an equidistant spacing between the pole lines. When the pole lines of a pair appear to merge, very little attraction is provided for magnetizable particles. Where no pole lines appear, uniform magnetization prevails providing no attraction to magnetizable particles.

In summary then, equidistantly spaced pole lines wherever so arranged, provide for maximum attraction of magnetizable particles per unit area, such "unit area" being traversed by a large number of lines and an asymmetrical relationship as defined diminishes the number of particles which can be attracted.

The production of a latent image therefore involves the setting up of such a line pattern and the localized controlling of the line spacing, because line spacing is related to the amount of developer particles a given area can attract. Thus, the line spacing must be made dependent upon the local picture brightness or darkness to be "translated" into quantities of particles to be attracted. The production of a latent image in this manner can be done as positive or negative (image reversal) process depending on the production of the lines.

Initially the carrier is longitudinally, uniformly magnetized preferably at saturation, exhibiting no or very little magnetic attraction towards the surface of the carrier. Then the carrier is illuminated by a two-dimensionally modulated radiation field, the modulation defining the picture contrasts to be imaged. Concurrently thereto the carrier is then heated in accordance with a spatially variable heating pattern as bias and to an extent which depends on the type of imaging desired, positive or negative process. This combined information-bias heating may be carried out by two concurrent radiation flashes reaching a given area of the carrier through different optical paths. One radiation flash contains all of the imaging information, the other flash provides the bias. Alternatively, a focused beam may be directed towards the carrier to write a line pattern defined by controlling the motion between carrier and beam.

For a positive process, heating is established so that without (or with "dark") pictorial information radiation the carrier is rendered paramagnetic in strips by the bias heating alone. These strips are of similar width, and are separated by strips of the same width in which the material remains ferromagnetic and thus retains its original magnetization. For information intensities above and up to full brightness, the paramagnetic strips are wider up to the point where the entire material is rendered paramagnetic over an area equal to the size of such a bright or clear image portion.

For a negative process or image reversal, heating is established in that a pattern of similar width strips of alternating paramagnetic and ferromagnetic states is established for maximum information radiation. In areas of lesser information radiation intensity, the paramagnetic strips have smaller width, and for dark information areas the material may remain ferromagnetic throughout, or become ferromagnetic in very thin strips only.

In either case, the material is subjected to a weak magnetic field below the coercivity of the regions which remain ferromagnetic to affect only the paramagnetic regions as they revert back to the ferromagnetic state. The resulting magnetization in those regions is oriented oppositely in comparison with the initial magnetization retained in the regions which remain ferromagnetic. The essential point here is that between zones having remained in the ferromagnetic state, and the zones which have become paramagnetic temporarily and are now ferromagnetic again, there are set up borders along which magnetic poles of opposite polarity face each other, resulting in normal, strong magnetic fields external to the carrier with maximum field strength gradients along the surface lines of the borders.

These magnetic pole lines have alternating polarity and their spacing varies from an equidistantly spaced relationship, through a range of asymmetrical spacing as between any pole line and its two neighboring pole lines up to the extreme case of a complete vanishing of any pole lines.

For "developing" the latent image, magnetizable powder is applied to the surface. This powder will adhere to the poles along the lines. There will be a maximum density of particles, averaged over an area larger than defined by the distance between two pole lines, adhering in areas where the pole lines are equidistantly spaced; a few or no particles will adhere where there are no pole lines; and less than maximum particle density will adhere to areas of asymmetrical line spacing as defined. It is an important aspect of the present invention that

the amount of toner particles adhering to any pole line, where the pole lines are equidistantly spaced, has maximum values for a line spacing somewhat below the resolution of the unarmed eye. The magnetic pole strengths and the resulting attraction towards each pole line is relatively weak when the lines are visibly far apart. The number of field lines linking externally the two poles of a magnet decreases with increasing distance of the two poles from each other and the strength of any pole is reduced. Conversely, when the lines are too densely spaced, the magnetic poles will be rather weak also.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention and further objects, features, and advantages thereof will be better understood from the following description taken in connection with the accompanying drawing, in which:

FIG. 1 illustrates somewhat schematically a side view of a copying station for providing a latent magnetic image on a magnetizable storage carrier;

FIG. 2 is a flow chart of the several steps for practicing the inventive method;

FIGS. 3 and 4 show cross sections through two different masks for producing radiation rasters respectively used for a negative or a positive copying process, above each of the masks is plotted the resulting heating characteristics;

FIG. 5*a* illustrates schematically a top view of the storage carrier prior to receiving imaging radiation, showing further the initial magnetization of such carrier;

FIG. 5*b* illustrates a cross section along lines 5*b* in FIG. 5*a* and showing additionally the resulting internal and external magnetic fields in the carrier;

FIGS. 6*a*, 7*a* and 7*c* show views similar to FIG. 5*a* but after production of a latent magnetic image, with FIG. 6*a* showing particularly equidistantly spaced pole lines corresponding to an area which will be upon subsequent development, and FIGS. 7*a* and 7*c* show asymmetrical line spacings corresponding to the same gray tone in the picture to be copied but respectively representing positive and negative images thereof;

FIGS. 6*b* and 7*b* are respectively cross-sectional views as indicated correspondingly in FIGS. 6*a* and 7*a*;

FIG. 8 illustrates schematically a mask, a light source and an optical path for producing negative and positive latent images depending on intensity control of the light source with a resulting thermal pattern plotted above the optical path and in alignment therewith;

FIG. 9 illustrates schematically a copy station wherein the contrasting pictorial information is represented by an one-dimensional signal used to control the intensity of a light spot which in turn is used to write a heating pattern on a magnetized carrier; and

FIG. 10 is a plot of the energy intensity distribution of the light spot shown in FIG. 9.

Proceeding now to the detailed description of the drawings, in FIG. 1 thereof there are illustrated, as stated, the essential components of a copy station for producing a latent magnetic image from a master 10, presumed to be a photographic film having a positive or negative, developed photographic picture. From a more general point of view the master is defined as a two-dimensional modulation of its transparency. The film 10 is in intimate, face-to-face contact with a magnetic carrier 11 having a magnetizable layer 12 on a transparent backing member 13.

The layer 12 is a juxtaposed to the photographic emulsion of film 10. Layer 12 has as its principle, active component a low Curie point material having also a temperature dependent coercivity and remanence. A suitable material is, for example, Chromium Dioxide, the Curie point of which is below 200°C.

In the following reference to the flow chart of FIG. 2 will be made repeatedly and in accordance with that flow chart, element 11 is the carrier for a magnetic image to be produced subsequently. The layer 12 of carrier 11 has been magnetized uniformly in one longitudinal direction and preferably up to saturation, see flux lines 121 in FIGS. 5*a* and 5*b*. The surface area of layer 12 about to receive the magnetic image does not exhibit, at this point, any substantial magnetic field component having a direction perpendicularly to the extension of surface of layer 12. Thus, magnetizable particles will not be attracted to any particular point at the surface. However, at this stage of the process no such particles are applied and, moreover, that surface is in contact with, and thus covered by, the film in the station of FIG. 1.

A masking element 15 is positioned underneath carrier 11, and this masking element 15 carries a raster. The element 15 has been selected, for example, from one of the elements shown in FIGS. 3 and 4 and respectively denoted 15*a* and 15*b*. In either case, the raster is defined by a line pattern. The mask 15 is positioned in the copy station so that the lines extend transversely to the direction of the longitudinal magnetization in carrier layer 12. During operation a light source 18 will transmit a light beam towards mask 15 for modulation in accordance with the raster of mask 15.

The line pattern of the mask 15*a* shown in FIG. 3 is formed, first, by a plurality of equidistantly spaced, strip-shaped, semitransparent or completely opaque regions 151*a*, each having a width X'. The regions 152*a* in between the regions 151*a* are of varying transparency. In particular, each one of the regions 152*a* is completely transparent along a center line 153*a*, with gradually decreasing transparency on both sides towards the respectively adjoining regions 151*a*.

A collimated beam directed towards the mask 15*a* will be modulated in a line pattern, and the modulation across the line pattern has a configuration such as is plotted above mask 15*a* in FIG. 3, the plotted curve having numeral 16*a*. For the moment we shall interpret curve 16*a*, and later on curve 16*b* in FIG. 4, as representations of the radiation energy permitted to pass through the respective mask when a collimated beam is used as light source. This is correctly true only if the layer 12 is extremely small in comparison with the dimensions of the raster modulation. The ultimate purpose of the masks is to establish temperature distributions in layer 12 having the configurations of the curves 16*a* or 16*b*. For thicker layers 12 (or smaller raster constants) the temperature distributions will be somewhat different so that the radiation distribution as resulting from the raster modulation should actually be as shown with the dotted curves 16*aa* and 16*bb*, and curves 16*a* and 16*b* will then represent only operating energy or temperature distributions deviating from the radiation distribution due to some lateral heat diffusion.

Turning back to the description of details of curve 16*a*, the resulting modulation pattern thus has line-shaped regions 161*a* of low light intensity and merging into regions 162*a* of gradually increasing intensities towards an apex or peak illumination value 163*a*.

A light energy differential E is measured between the peaks 163*a* and an energy level 164*a*. It is now helpful to think of that radiation field as being divided into portions where the light energy intensity is below level 164*a* and portions in which the intensity is higher than level 164*a*. The width of these portions is about equal and denoted with X. The radiation field is thus provided by alternatingly rising and falling intensities as between level 164*a* and 163*a*. The intensities in between these two levels appear organized in strips of width X, separated from each other by strips of equal width X in which the intensities are below level 164*a*.

The mask 15*b* shown in FIG. 4 defines a line raster by regions which can be regarded as being to some extent complementary to the regions defining the line raster of mask 16*a*. Regions 151*b* having width X' are relatively highly transparent. It shall be assumed at this point, that either one of the masks 15*a* and 15*b* will be used without change in the illumination intensity of the source 18 the radiation of which is to be modulated by the rasters. Thus, the region 151*b* is to be transparent only to the extent that the radiation permitted to pass is somewhat above the level 164*a* produced with mask 15*a* when using the same light source.

Interspaced are regions **152***b* having a gradually decreasing transparency with a minimum transparency along lines **153***b*. A beam of collimated light when directed towards mask **15***b* will be modulated by this line raster in that line-shaped regions **161***b* show maximum light intensity separated by regions **162***b* of gradually declining intensities with minimum intensities **163***b* along the lines **153***b* of the raster.

There is thus provided an illumination field, varying from sharply pronounced minima **163***b* to plateaulike maxima **161***b* at either side of a minimum. Measured from the level of the minima **163***b*, an energy differential of value E leads to a level **164***b* defined by the rule that the illumination field has a pattern in which strips of equal width having intensities below level **164***b*. These widths are again denoted with X. Moreover, it shall be assumed, that level **164***b* equals the level of **164***a* of mask **15***a* when the same lamp is used. For convenience of representation the different degrees of transparency in the masks are shown as shading which could be interpreted as graduated absorption. In actuality, however, semitransparency is better established by semireflecting layers, to keep the temperature of the mask as low as possible.

For convenience of representation similar raster constants are assumed for the two masks **15***a* and **15***b*; this, however, is by no means essential. However, selection of the proper raster type is important for the invention and the raster constant 2X is not arbitrarily selectible. Neither too large nor too small values for 2X will produce satisfactory results as will be shown more fully below. A raster or grating constant of 500 line pairs per inch, i.e., X=1 milli-inch, has produced very satisfactory results. This value, however, is not of absolute criticality and depends on the magnetic properties of layer **12** and on type of material to be used for developing the latent image once produced. The size of the magnetizable particles will determine how small a useful grating constant can be selected. It is very important however, that grating constants can be selected to be so small that they are below the resolution of the eye. Quite obviously for most applications a smaller grating constant is not necessary and a larger grating constant is not desirable.

The principle contours of the modulated illuminating fields such as **16***a* or **16***b* are important for the invention, the structure of the masking member is not. In particular, one can use alternating regions of uniformly high and low transparencies and one can use the dispersion of the light source to produce the slopes **162***a* and **162***b* which are essential for the invention. When using gray tone modulated masks such a **15***a* and **15***b*, the light source should be without substantial dispersion. It will be explained below with reference to FIG. **8** how optical dispersion can be used in lieu of gray tone modulation for a mask.

After having selected the mask **15** and after the three elements **10**, **11** and **15** have been stacked into juxtaposition in the copy station as shown, the two lamps **17** and **18** are triggered by a control **19** for concurrently providing flashes of light (see flow chart). The selection of the light intensity is very critical for satisfactory performance. First of all, the intensity of lamp **17** is selected so that the modulation the beam undergoes when passing through film chip **10** covers, approximately at least, an energy range of value E, with the value E itself being the light energy intensity (per unit square) after passing through a clear portion of the picture in film chip **10**, and the intensity of light that still may pass through a dark picture portion is presumably <<E, a db. range of 40 is useful for normal photographic films.

The thus modulated light, in the following called information beam, impinges upon the layer **12** and is substantially absorbed therein. Concurrently thereto, a light beam from lamp **18** and modulated by the raster of mask **15** reaches layer **12** through the transparent backing member **13** of carrier chip **11**, and again substantially all of the radiation thereof is absorbed in layer **12**.

The conventional thickness of a layer of magnetizable material on a tape is about 0.2 milli-inches, and this suffices to absorb substantially all of the radiation from either source. Inasmuch as this thickness is below the dimensions of the raster modulation resolution in the biasing radiation, the heating pattern imparted upon the layer **12** by the biasing beam is substantially uniform throughout the thickness of layer **21**. Therefore, if the layer **12** were heated by the biasing beam alone, a temperature distribution will be set up in the layer **12** throughout its extension corresponding to the curve **16***a* or **16***b*. It can be assumed readily that the resulting temperature increase in any point is proportional to the energy absorbed, and the energy absorbed is proportionate to the radiation received.

Due to thermal conduction in layer **12** transversely to its extension the temperature underneath any point on the surface of layer **12** can be regarded as uniform. However, it must be discussed briefly that some thermal conduction occurs also in lateral direction. As it will be developed below, the highest temperature any point in the layer **12** (averaged over the thickness thereof) obtains after this radiation treatment determines the contribution that point makes to the production of the latent image. Thus, curves **16***a* and **16***b* are actually representations of the distributions of the maximum temperature resulting in any point of layer **12** from a flashed bias, expressible in terms of maximum energy reaching any point. For an infinitely thin layer **12**, or for a layer thin in comparison with the dimension X, the radiation distribution and the temperature field can be regarded as equal.

In actuality the masks should have a somewhat lesser transparency in the sloping regions to take some lateral spreading of thermal energy into account. Thus, in the following we shall regard the curves **16***a* and **16***b* as representing temperature or energy distribution curves, showing the maximum temperature (energy) in layer **12** averaged for each surface point thereof over the entire thickness of layer **12** underneath. For not too small a thickness of layer **12**, the radiation field may thus be as shown with curves **16***aa* and **16***bb*.

To the biasing energy for any point in layer **12** there is added information energy in accordance with the degree of transparency the film **10** has at that point (it will be recalled that layer **12** and the photographic emulsion of film **10** are juxtaposed). The energy levels are now chosen, that a biasing energy level corresponding to peak levels **163***a* (mask **15***a*), plus an information energy level corresponding to a substantially dark picture portion (<<E) may just suffice to raise the temperature of the thus affected portions of layer **12** up to the Curie point, rendering that portion almost paramagnetic. Thus, the Curie point is reached nowhere, even though along lines **153***a* the temperature will be very close to the Curie point.

Using mask **15***b*, level **164***b* will coincide with the Curie temperature or energy level. Thus, for such a completely dark picture area, and when using the mask **15***b*, a line heating pattern is set up in layer **12** in which strips of a width about X remain ferromagnetic and are separated by strips of about equal width X which become paramagnetic.

Now consider a completely clear portion, adding everywhere to the respective biasing energy the information energy E. Here, first we consider mask **15***a*. Since E was also the energy differential between apeces **163***a* and the level **164***a*, strips of layer **12** having width X become paramagnetic, separated by strips of equal width X which remain ferromagnetic. Using the mask **15***b*, we find this situation: maximum information energy when added to the biasing energy raises the temperature everywhere above the Curie level to render the material paramagnetic, because again, Curie level **164***b* was chosen to be above minimum level **153***b* by that value E now added from the information beam everywhere to the layer **12**.

The above development result can be restated as follows: Using a mask **15***a*, maximum information energy produces paramagnetic strips of width X, leaving ferromagnetic strips of equal width. Minimum information energy leaves ferromagnetic strip of a width 2X. Thus, gray tones in the picture varying from clear to dark, establish paramagnetic strips having a width smaller than X, leaving interspaced ferromagnetic strips

of width larger than X. Using a mask 15*b*, information energy varying from "clear" to "dark" produce paramagnetic strips varying width from X to 2X, and leaving interspaced ferromagnetic strips having width between zero and X.

Having thus established the complementary results in terms of paramagnetic and ferromagnetic strip width produced with the same film chip picture by the two different masks we proceed with the description of the process. Still concurrently with the light flashes from lamps 17 and 18 a weak magnetic field set up by coils 20 will become effective. This field is to have strength below room temperature coercivity. Thus, it may actually be produced permanently as it will not affect layer 12 before the lamps 17 and 18 have flashed. Thereafter, the field from coils 20 will magnetize the portions of layer which became paramagnetic. The direction of the magnetizing field is now chosen to be oppositely directed to the premagnetization of layer 12, which premagnetization is not destroyed in the portions remaining ferromagnetic. The premagnetization is destroyed in the paramagnetic portions of layer 12, and the magnetic dipoles therein are realigned by the reversely directed magnetizing field set up by coils 20.

As the flashes from lamps 17 and 18 decay, the thermal energy in layer 12 will decay very quickly, but the field from coils 20 persists, so that the previously paramagnetic strips in layer 12 revert to the ferromagnetic state under the aligning influence of this magnetic field.

In FIGS. 5*a*, 5*b*, 6*a*, 6*b*, 7*a*, 7*b* and 7*c*, arrows 121 denote the original magnetization and arrows 122 denote the substitute magnetization of opposite polarity. The strip-shaped zones of like magnetization are thus bounded by strip-shaped zones of opposite magnetization. In the border areas between any two such neighboring strips magnetic poles of similar polarities face each other, and there thus results a pattern of alternating magnetic North and South poles defined by the border areas 123 in between neighboring strips. Such border areas 123 extend substantially across layer 12 and transverse or reach the surface of layer 12 in lines 124, which are the above-defined pole lines.

The carrier will thereafter bear a latent magnetic image of the film picture defined as a variable width line pattern. That line pattern differs, however, depending on the type of mask used for bias. For mask 15*a*, clear picture portions are represented by a line pattern in which neighboring strips of about equal width are magnetized at opposite orientation. The same magnetization pattern will result from a dark picture portion when using mask 15*b*; the distance from pole line to pole line being X in either case. The magnetization pattern is illustrated in FIGS. 6*a* and 6*b*.

A uniform magnetization will result from a dark image portion when using mask 15*a*, or from a clear image portion when using mask 15*b*. If mask 15*a* was used, layer 12 will actually still show the original magnetization, as it has been destroyed nowhere. If a mask 15*b* was used, a clear image portion of film 10 causes the complete destruction of the initial magnetization and a complete substitution of the uniform magnetization derived from coils 20. The final magnetization here will be as shown in FIGS. 5*a* and 5*b* except that it is oppositely directed, which is not of principal importance. Thus, the two masks produce a complementary latent magnetic image representation.

The steps involved in the development of the latent image do not require detailed elaboration. Briefly then, the carrier 11 with latent image is removed from the station after cooling and dipped into a magnetizable toner. Thereupon, carrier 11 becomes a printing platen. The toner may be a powder or a colloidal solution having basically two characteristics; it must contain contrast producing particles and it must contain magnetizable particles. Normal iron powder or the like has both characteristics. The magnetizable particles of the toner will tend to adhere to the above-defined pole lines. Then a picture is printed on paper or on any other suitable material. Any residue is cleaned off thereafter and, if multiple copying is wanted, (see flow line A) toner material is applied again to the latent image surface, etc. Alternately or subsequently the latent image on carrier 11 may be erased in that the layer 12 thereof is magnetized uniformly (see flow line B). The carrier 11 thus is magnetically biased again and can be used again as platen for receiving another image.

One can see that the carrier 11 may actually pertain to a rotating drum or endless belt passing through the copy station shown in FIG. 1, and passing sequentially through a station for applying toner particles, through a printing station, a cleaning station, a remagnetization station and back to the copy station. For repeated printing of the same copy, remagnetizing station and copy station may be temporarily deactivated.

It was explained above, that the relationship between pole line spacings and image brightness is inversed if one exchanges one of the masks 15*a*, 15*b* for the respective other one. It will now be explained why the developing, such as printing of a latent image produced with the aid of the mask 15*a*, will result in a negative copy of the film picture, so that a positive copy will result if mask 15*b* were used (or one can reason vice versa).

As shown in FIGS. 6*a* and 6*b*, equidistantly spaced pole lines are produced by clear picture portions when mask 15*a* is used and by dark picture portions when mask 15*b* is used. The spacing of the pole lines is X. When magnetizable toner particles are applied, they are attracted to the pole lines and to the vicinity thereof.

The same amount of toner particles will adhere to either side of any line. The magnetic field inhomogeneities are of a repetitive nature over the surface of layer 12 and larger than the desired resolution. As stated above, the pole lines are very densely spaced; the raster has 500 lines per inch, and for each raster line there are produced two pole lines, so that there are 1,000 lines per inch or 40 lines per millimeter which is well above the resolution of the eye. Moreover, the line density has been chosen that for such equidistant spacing of pole lines the amount of toner particles attracted to any pole line at either side extends about or almost halfway to a neighboring line. Thus, to the naked eye the surface of layer 12 will appear to be uniformly covered with adhering substance.

For an intermediate gray tone area, the pole lines appear differently arranged in the layer 12. As one can see from FIGS. 7*a* and 7*c*, the pole lines are now asymmetrically spaced with reference to each individual line. A pole line has one other pole rather close to it, while a third pole line on the other side is farther apart. To state it differently, the pole lines are arranged in pairs of more or less closely spaced lines, with each pair separated from the next pair by a distance larger than X. The space on layer 12 in between the two more closely spaced pole lines reduces the amount of toner particles that could adhere here as compared with the available space were the lines farther apart. Conversely in the area in between two pole lines farther apart there is an area wider than in case of equidistantly spaced pole lines, to which no toner particles will adhere for lack of a normal magnetic field gradient and due to lateral attraction towards the pole lines. Moreover two more closely spaced pole lines of opposite polarity will exhibit some mutual neutralization, so that the effective pole strength of either line is reduced as compared with an overall equidistant spacing (FIG. 6*a*). Thus, an intermediate gray tone will be produced.

The gray tone production is qualitively similar for both types of masks, except that two differently bright gray tones of the film picture are printed with inverted gray shades when mask 15*a* was used instead of mask 15*b* or vice versa. This is depicted in FIGS. 7*a* and 7*c*. In FIG. 7*a*, it is presumed that the mask 15*a* has been used and that the picture portion here is rather dark, resulting in a very narrow spacing of respectively two pole lines with a large spacing in between two such pairs; the resulting printout will be rather light. In FIG. 7*c*, it is presumed that the mask 15*b* has been used, but the same picture portion will produce only a slight asymmetry as between three pole lines and the final printout will thus be rather dark. Thus, mask 15*b* will indeed produce a positive picture, mask 15*a* will produce image reversal.

A completely white printing surface will result when there are no pole lines anymore in layer **12**. For negative printing this is produced out of a dark picture portion if only such minimum information energy is added to the biasing heating pattern produced with the aid of mask **15***a* and even the sum of these energies does not suffice to destroy the initial magnetization anywhere. Conversely, for making a positive printout of a very clear picture portion, the information energy when added to the biasing energy produced by mask **15***b* suffices to render the material paramagnetic everywhere, and when the weak magnetic field from coils **20** remagnetizes the layer **12** uniformly, no pole lines are set up. Wherever uniform magnetization is the end result, no toner particles will adhere.

One can understand now, that the method will not operate with just any line pattern or any material; here it has to be realized that each magnetized strip (magnetizations **121** or **122**) is a flat, elongated magnet, placed side by side with other such magnets, and with its poles oriented parallel to its flat surface. When for an equidistant line spacing the the lines are too closely spaced, these magnets are very small in the direction of the magnetic axis and thus the poles are weaker the smaller such magnets are. This holds true for equal size magnets (**121** and **122**), i.e., for an equidistant pole line spacing. The shifting of pole lines to asymmetrical positions will then have little effect on the amount of particles attracted for a large range of gray tones, and everything will be dark. The same will be true when the magnetizable toner particles are, themselves, too large. It is repeated here, however, that a line spacing very much below the resolution of the eye is not needed, and the spacing range mentioned above provides operative conditions. It is thus immaterial that the method may not work satisfactorily for closer spacings.

Conversely, if the pole lines are too far apart in case of equidistant line spacing, then the amount of toner material adhering to any pole line will not vary when the pole lines are somewhat closer to each other on one side of any pole line than on the other side thereof. In other words, an intentionally coarse and directly discernible raster pattern will not produce satisfactory results except if the magnetizable particles are of comparable coarseness.

Moreover, a wide line spacing means large magnets (large in the direction of a magnetic axis). Larger magnets, however, exhibit lower pole strength, because the external gap to be overbridged by field lines is rather large. This gap increases with the size of the magnet along the magnetic axis (pole distance) and the pole strength goes down. That effect depends, of course, also on the thickness of the magnetizable layer. It has been found, that the pole strength, and thus the attraction exhibited by the material towards any individual pole line, increases when the equidistant line space (magnet size) is chosen to be below the resolution of the eye.

It follows, from the foregoing, that the inventive method has optimum performance characteristics of operation in just that range of dimensions which are most desirable from standpoint of the final result and product, viz, a printout without discernible features of the structure elements of which the picture is composed. The main equipment variable, for a given toner, is the grating constant of the mask used and can readily be found by trial and error for any toner material.

Proceeding now to the description of FIG. **8**, there is shown how one can substitute the two masks **15***a* and **15***b* by a single mask **150**. The positive-negative selection results here from bias intensity control. In FIG. **8** it is furthermore presumed that the mask **150** has no gradated transparency modulation, but the raster is defined by regions of high and low transparency. The light source **18** here is presumed to have a definite dispersion and a collimator lens **181** thus produces axis parallel radiation as well as beams of parallel radiation inclined to the axis of lens **181**.

If D is the dispersion of the light source **18** as effective at the image side of lens **181**, if *d* is the distance of the raster from layer **12**, and Y is the distance of the layer **12** from the light source, then an illuminating field as plotted in FIG. **10** can be produced when $d/X=Y/D$, where 2X is the grating constant of the raster. Normally *d* will be the thickness of backing member **13**, but that is not mandatory, it can be made larger by interposing additional, transparent spacers. In this relationship, only X is fixed; all other values can be conveniently selected to meet the relationship.

The curve **170** of FIG. **8** shows peaks **171**, valleys **173** and slopes **172** in between. The curve can be understood as a combination of the curves **16***a* and **16***b* of FIGS. **3** and **4**, respectively. Beginning from a minimum **163***b*, the curve goes up a slope **162***b* continues with a branch **162***a* to a peak **163***a* from there down a slope **162***a* continues along **162***b* to the next minimum **163***b* etc., levels **164***a* and **164***b* merge and define the midlevel **174**.

If one selects the regions of low transparency of mask **150** high enough (for example 80 percent of or higher than the value of the high transparency region) then the energy differential 2E between peaks **171** and valleys **173** is quite small. This is actually of advantage, as one can operate lamp **17** at quite a low level (always E). Since in a film chip the "black" portions of the emulsion are black because of absorption, a low intensity level for that lamp **17** is desired.

The midlevel **174** is now selected to coincide with the Curie level for a positive process. For a negative process, the light intensity of lamp **18** is reduced so that the level of the peaks **171** is just below the Curie level. Thus, for a positive process, copying without inversion, the information is operative as shifting the Curie level relative to the bias pattern between levels **174** (for a dark image portion) and the level defined by the minima **173**.

Again, one can see here that the energy differential 2E between biasing maxima and minima must not be too large in order to prevent excessive heating of the central region of each strip which becomes paramagnetic, which central region receives always peak bias plus, possibly, peak information energy. It will be recalled that in the mask **15***b* the flattened characteristics **161***b* avoided such peaks. Such avoidance may actual necessitate the use of two masks if the thermal operating conditions are critical. The backing members and/or binders may not stand too high temperatures.

For a negative process the light intensity is reduced so that the peaks **171** are just below Curie level for minimum information energy. In this case now the information energy appears to shift the Curie level relative to the biasing level between levels **171** and **174**. Thus, with the mask **150** the selection of positive or negative process is simply to be made by varying the output energy of lamp **18**. However, the output of lamp **17** must also be reduced for the following reason.

When lamp **18** provides full output for a positive process levels **171** and **173** are apart by energy value 2E. The energy differential E between midlevel **174** and the minima **173** defines the operating range for a positive process. When for a negative process the intensity of lamp **18** is reduced by the value E so that the maxima **171** are just under the Curie level. then the range now available for the negative process still is the range between (the now reduced) midpoint level **174** and the maxima **171** but that differential is not E anymore but $E-E/\epsilon$, where ϵ is the energy needed to raise the temperature of any point from room temperature to the Curie level. It follows that the lamp **17** furnishing the information energy should be reduced by the same amount, as the information energy should vary between about zero and the biasing operating energy differential, presently $E-E/\epsilon$. One can see, that in case $E<<\epsilon$ that correction is of negligible value and may not be needed. If, however, the regions of low transparency of mask **150** are actually opaque, then $\epsilon = 2E$, and the correction is definitely needed.

With reference to FIGS. **9** and **10** it will now be explained how the inventive method can be practiced by providing a latent magnetic image through a line writer driven from an electrical, scanning type signal. The electrical signal is assumed to be provided by a controls unit **30** controlling a lamp **31**, and a lens system **32** focuses the light into a spot **33**. The intensity of the spot **33** varies in accordance with the strength

of the signal from unit 30. The focused light passes through a filter 35. Deflection means (not shown) may be provided to cause the light spot to repetitiously run in direction 36 across the surface of layer 12, moved transversely in direction 37 during the image writing process. The deflection may be produced by a rotating mirror or the like.

The light spot 33 may have a distribution curve 34 as illustrated in FIG. 10. Normal lenses or lens systems when focusing a collimated beam will produce a Gaussian distribution of the radiation intensities around the focal point. However, by using suitable filter means such as filter 35 that curve can be given any other shape, and it is presently assumed that the filter means 35 are provided to establish the distribution curves as illustrated, having in the neighborhood of its pronounced apex a conical configuration.

The writing of image lines composing a positive or negative image is now a matter of intensity control of that beam. The light spot 33 will inscribe on the magnetic record carrier 12 a plurality of parallel tracks of a given width. The light spot moves across the carrier in direction 36 and concurrently thereto the carrier moves transversely thereto. The distance from line to line, called distance 2X is equal to the ratio of the propagation speed of the carrier and the repetition range for the scanning beam.

The intensity of this beam is now controlled in the following manner: for a particular value of the signal strength the intensity of the beam is such that a circle having approximately a diameter of X is rendered paramagnetic, this situation is shown in FIG. 12 wherein the line 38 represents the Curie level. For the writing of a positive image, this will represent the information corresponding to a dark image area.

Should that signal strength persist one can see that the beam thereupon will inscribe upon the carrier a line pattern in which strips having the width X are rendered paramagnetic, and in view of the repetition rate defined above these strips now will be separated from each other by strips which remain ferromagnetic and having also the width X. If concurrently thereto a weak magnetizing field is applied in a direction, for example, parallel to the direction 37 of movement of the carrier, and if that carrier was previously magnetized in a direction opposite to its movement then the resulting magnetization will be precisely the same as was illustrated in FIG. 6a. The weak, below room temperature coercivity field may be derived from a permanent magnet 39 underneath the carrier 12.

For increasing information signal strength the intensity of the focused spot will increase, which means that there is a relative shift between the Curie level 37 and curve 34. For example, level 37 moves down relative to distribution curve 34 and the widths of the several strips which are rendered paramagnetic, increases. The distribution curve 34 must now be chosen that for maximum information signal strength corresponding to a bright image portion the widths of the strip which is rendered paramagnetic is equal to 2X in which case that particular area of the carrier will be rendered paramagnetic everywhere and remagnetized.

For the providing of a negative image the control is different. The intensity control for the beam is adjusted in such a manner that the relative distribution curve 34 has relation relative to the Curie level in that a strip of width X is rendered paramagnetic for maximum signal strength corresponding, as far as the information signal is concerned, to a clear or bright image portion but now converted into a dark image portion due to the fact that it produces the line pattern as shown in FIG. 6a. If the signal strength of the information signal is reduced over a range corresponding to an intensity change over range E of the information beam, then the widths of the strips that become paramagnetic are reduced, and for minimum signal strength the beam may not suffice anywhere in that area to render the material paramagnetic. One can see, therefore, that the production of the positive or of a negative image here is strictly a matter of initial bias for the illumination strength of this scanning beam and the information modulation then simply operates over different portions of the distribution curve for the focused spot. Alternatively, one can use a different filter 35 to change the overall level of the distribution curve for otherwise similar conditions.

The invention is not limited to the embodiments described above but all changes and modifications thereof not constituting departures from the spirit and scope of the invention are intended to be covered by the following claims.

I claim:

1. An apparatus for providing a latent image on a uniformly magnetized carrier, comprising:

means including a radiation field modulated by a line pattern, further including a magnetizing field below room temperature coercivity of the carrier, for providing to the carrier a line pattern of magnetic poles, defined by pole lines of alternating opposite polarities, having predominant directions of extension which are parallel to each other, there being local variations of the line spacing, the spacing variable between a substantial equidistant spacing of neighboring lines and at least an approximate merger of pairs of neighboring lines, through a range of asymmetrical spacing between any line and its two neighboring lines; and

means for providing for such variation in the line spacing in dependence upon a two-dimensional contrasting information field, wherein field areas of maximum darkness of the latent image to be produced causing the line spacing to be equidistant, field areas of maximum brightness of the latent image to be produced causing at least approximate merger of a pair of neighboring lines.

2. Apparatus for providing a latent image to a carrier energizable to establish localized force fields for attracting particles responding to such a force field, comprising:

means for providing to the carrier a locally variable line pattern, wherein along each line there is an attracting force normal to the surface of the carrier, the variation to occur between a substantially equidistant spacing of the lines and an at least approximate merger of pairs of neighboring lines, through a range of asymmetrical spacing between any line and its two neighboring lines; and

means for providing for said variation in dependence upon a spatially variable information field, wherein field areas of maximum darkness of the latent image to be produced causing the line spacing to be equidistant and field areas of minimum darkness of the latent image to be produced causing the lines to at least approximately merge.

3. An apparatus for providing a latent magnetic image on a low Curie point storage carrier, the Curie point separating temperature dependent ferromagnetic and paramagnetic states of the carrier, the carrier being uniformly longitudinally magnetized, comprising:

means for thermally biasing said carrier in a line pattern, where along substantially parallel lines the carrier receives a particular amount of thermal energy and neighboring regions of the carrier receive an amount of energy depending upon the distance of the neighboring region from the closest one of said lines;

means for providing information energy to the carrier, the information energy being locally variable over the surface of the carrier in dependence upon a two-dimensional, contrasting information field, the energy being locally gradually variable between first and second values representing extreme contrasts of the information, the information energy being added as thermal energy to the biasing energy, so that first regions of variable width symmetrically disposed respectively in relation to said lines are in a first one of said magnetic states, and second regions in between said first regions are in the second one of said magnetic states, said first and second regions having substantially equal width in regions of said carrier receiving said first value of information energy, said first regions having a width substantially different from the interspaced second regions, in regions of said carrier receiving approximately said second value of information energy,

the regions being in the paramagnetic state, reverting to the ferromagnetic state after decay of the informative energy; and

means for magnetizing all of said regions in the paramagnetic state while reverting to the ferromagnetic state with below-room temperature coercivity field, subsequently to the providing of the information energy, the magnetization being different from the initial uniform magnetization of the carrier.

4. An apparatus for providing a latent magnetic image on a low Curie point storage carrier, the Curie point separating temperature dependent ferromagnetic and paramagnetic states of the carrier, the carrier being uniformly longitudinally magnetized;

means for providing to the carrier a first field of radiant energy being intensity modulated in accordance with a two-dimensional information field, the intensity modulation ranging between first and second values, the difference representing maximum contrast;

means for providing to said carrier a second field of radiant energy modulated in accordance with a line pattern in which the radiation energy has a particular intensity along equidistantly spaced particular lines, and in which the intensities along lines parallel to the particular lines differ from the particular intensity by an amount related to the distance from the closest particular line and over a particular range of distance values, areas of said carrier receiving information energy having said first value causing regions of said carrier along said particular lines and for a width about half the line spacing of the particular lines to have a first one of said magnetic states, the in-between regions to have the second one of said magnetic states, the width of said regions varying in accordance with information energy values in between said first and second values; and

means for magnetizing the carrier where in the paramagnetic state with below-room temperature coercivity field so that magnetic poles are set up, after the regions in the paramagnetic state revert to the ferromagnetic state, the poles appearing along the border of the regions which were in the paramagnetic state.

5. An apparatus as set forth in claim 4 said particular lines defining line shaped regions of maximum bias intensities, areas of said carrier receiving information energy less than said second value but larger than the first value becoming paramagnetic by said first and second radiation fields in regions being wider than said half-line spacing.

6. An apparatus as set forth in claim 4 said particular lines defining line-shaped regions of minimum bias intensities, areas of said carrier receiving information energy more than said second value but less than the first value becoming paramagnetic by said first and second radiation fields in regions being smaller than said half-line spacing.

7. Apparatus for providing a latent magnetic image on a uniformly magnetized storage carrier, being in the ferromagnetic state when having a temperature below a particular temperature, and being in the paramagnetic state when having a temperature above the particular temperature, comprising:

means for providing to said carrier a heating pattern for alternating rising and falling temperatures in the carrier;

means for providing radiation to the carrier which radiation is modulated in accordance with a two-dimensional, information bearing contrast pattern, the radiation varying between first and second intensity values defining maximum contrast, the first intensity value where added to the thermal energy as provided by the first means providing a pattern of similar size areas where the temperatures are alternately above and below a particular value, neighboring areas are thereby in different ones of said magnetic states, the second intensity value where added to the thermal energy as provided by the first means providing for a temperature according to which an area receiving the second intensity value in substantially in one of the magnetic states throughout its extension; and

means for fixing the image on the carrier by providing a below room temperature coercivity magnetic field, for magnetizing all areas in the paramagnetic state while reverting to the ferromagnetic state, to obtain magnetizations differently from the original magnetization retained in areas which remained ferromagnetic.

8. Apparatus for providing a latent image on a carrier in which can be established different states of energization, comprising:

means for providing said carrier with a particular state of energization;

means for providing to progressive areas of the carrier radiant energy for a short period of time, the radiation having characteristics of destroying said energization where exceeding a particular value, the radiation having a biasing component and an information component, the spatial distribution of the two components being mutually independent, the information component having a first extreme value, which when added to the biasing component over a particular area results in an absorption pattern corresponding to progressive similar size areas separated by regularly spaced boundary zones thereby separating areas in which said initial energization is retained from areas in which said initial energization is destroyed, the information component when having a value different from the first value and covering a second particular area producing progressive, dissimilar size areas separated by irregularly spaced boundary zones and separating areas in which the initial energization is retained from those in which it is destroyed; and

means for providing to said carrier energy for fixing the relative position of said boundary zones.

9. The method of selectively providing a positive or negative image of a picture comprising the steps of:

magnetizing a carrier to establish a substantially uniform magnetization;

providing radiation to said magnetized carrier, the radiation being modulated in accordance with the contrasts of said picture maximum contrast being established by the difference between a maximum and minimum radiation level;

providing a selected thermal biasing pattern, concurrently with said last step, concurrence established with reference to any particular spot of the carrier as affected by radiation in accordance with the biasing pattern;

selecting prior to said last step the operating levels for the thermal biasing pattern among a first one for producing an alternating heating pattern varying in one direction on the carrier surface between narrow, regularly spaced radiation minima and from which radiation intensities increase about linearly to a level exceeding the Curie level of the carrier covering a strip, in between adjacent minima for a width about half the value of the spacing between the adjacent minima, and a second one for producing a line heating pattern of regularly equidistantly spaced narrow maxima at about Curie level with slopes from the maximum of approximately linearly declining temperatures in the vicinity of each maximum;

applying, concurrently with said two steps for providing, a magnetic field to said carrier for magnetizing regions where the Curie level was exceeded, the magnetic field to persist beyond the duration of the two providing steps for any area on the carrier, the magnetic field being insufficient to destroy the magnetization in the carrier in accordance with the first step and in portions of the carrier remaining below the Curie point, thereof; and

developing the image resulting from the previous steps by applying magnetizable particles to said carrier.

10. The method as set forth in claim 9, said providing steps comprising the application of a focused light beam to the carrier, causing the light beam to scan the carrier in lines having distance in accordance with said minima or maxima spacing, and controlling the intensity of the beam in two different ranges in accordance with the selecting step.

11. The method as set forth in claim 9, said selecting step including the selection of the operating level for at least one of said providing steps.

12. The method as set forth in claim 9, said selective step comprising the selection of one among two masks, the second providing step including the direction of radiation through the selected mask towards the carrier to produce one of said first and second heating patterns.

13. An apparatus for providing a latent magnetic image on a uniformly longitudinally magnetized carrier having a Curie point separating ferromagnetic and paramagnetic states, comprising:

means for providing radiation to the magnetized carrier, the radiation having intensities to selectively provide strips of substantially equal width of spacially alternating paramagnetic and ferromagnetic states, dissimilarly wide strips of alternating paramagnetic and ferromagnetic states, and a substantially uniform region of one of said states;

means for controlling the radiation providing means in accordance with a two-dimensional information pattern for the selection of the radiation intensity reaching any particular point on the carrier; and

means for magnetizing the paramagnetic portions of the carrier uniformly, longitudinally but oppositely to the magnetization as provided by the first means, the magnetization to persist while the paramagnetic portions revert to the ferromagnetic state.

14. The method of providing a negative image of a picture, comprising the steps of:

magnetizing a flat carrier to establish a substantially uniform magnetization, the carrier having Curie point separating ferromagnetic and paramagnetic states:

providing radiation to said magnetized carrier, the radiation being modulated with the contrasts of said picture, and including local areas of minimum radiation intensity corresponding to incremental picture areas to be printed at minimum toner density, and other areas of maximum radiation intensity corresponding to incremental picture areas be printed at maximum toner density;

providing, concurrently with the preceding step, a two-dimensionally modulated radiation bias to said magnetized carrier, the modulation being a line pattern, but areas of the carrier receiving said minimum radiation intensity retaining the initial magnetization essentially independent from the line pattern, the local minimum radiation failing to heat the carrier above the Curie point, areas in the carrier receiving said maximum radiation being heated in a pattern defined by equidistantly spaced strips that are being heated above the Curie point separated by strips of similar width wherein the ferromagnetic state and initial magnetization is retained, areas receiving half tone representing radiation intensities of the picture representing radiation, being heated in a line pattern, wherein the line width of heating above the Curie point is smaller than the width of the lines in between;

providing to the carrier a below room temperature coercivity magnetizing field of orientation different from the original magnetization, to persist upon decay of said radiation and during reversion of heated increments of the carrier to the ferromagnetic state; and

applying magnetizable toner particles to the carrier, for maximum adherence density to areas where there was established the equidistant line spacing, defining after reversion to the ferromagnetic state an area of equidistantly spaced magnetic pole lines, alternating in polarity in direction transverse to the direction of line extension of the radiation bias.

15. The method of providing a positive image of a picture, comprising the steps of:

magnetizing a flat carrier to establish a substantially uniform magnetization, the carrier having Curie point separating ferromagnetic and paramagnetic states;

providing radiation to said magnetized carrier, the radiation being modulated with the contrasts of said picture, and including local areas of minimum radiation intensity corresponding to incremental picture areas to be printed at maximum toner density, and other areas of maximum radiation intensity corresponding to incremental picture areas be printed at minimum toner density;

providing, concurrently with the preceding step, a two-dimensionally modulated radiation bias to said magnetized carrier, the modulation being a line pattern, but areas of the carrier receiving said maximum radiation intensity being demagnetized essentially independent from the line pattern by local radiation heating of the carrier above the Curie point, areas in the carrier receiving said minimum radiation being heated in a pattern defined by equidistantly spaced strips that are being heated above the Curie point separated by strips of similar width wherein the ferromagnetic state and initial magnetization is retained, areas receiving half tone representing radiation intensities of the picture representing radiation, being heated in a line pattern, wherein the line width of heating above the Curie point is larger than the width of the lines in between;

providing to the carrier a below room temperature coercivity magnetizing field of orientation different from the original magnetization, to persist upon decay of said radiation and during reversion of heated increments of the carrier to the ferromagnetic state; and

applying magnetizable toner particles to the carrier, for maximum adherence density to areas where there was established the equidistant line spacing, defining after reversion to the ferromagnetic state an area of equidistantly spaced magnetic pole lines, alternating in polarity in direction transverse to the direction of line extension of the radiation bias.

16. Method of printing halftone images, comprising:

providing to a magnetizable carrier a line pattern of magnetic poles defined by pole lines of alternating opposite polarities having predominant directions of extension which are parallel to each other, there being local variations in the line spacing, the spacing variable between a substantial equidistant spacing of neighboring lines and at least an approximate merger of pairs of neighboring lines, through a range of asymmetrical spacing between any line and its two neighboring lines;

providing said variation of the line spacing in dependence upon a two-dimensional contrasting information field, wherein field areas of maximum darkness of the image to be printed causing line spacing to be equidistant, and field areas of maximum brightness of the image to be printed causing at least approximate merger of a pair of neighboring lines; and

applying magnetizable toner particles to the carrier prepared in accordance with the preceding steps.