

[54] THERMOMAGNETIC IMAGING APPARATUS

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[58] Field of Search 250/316, 317, 318, 319; 346/74 MT

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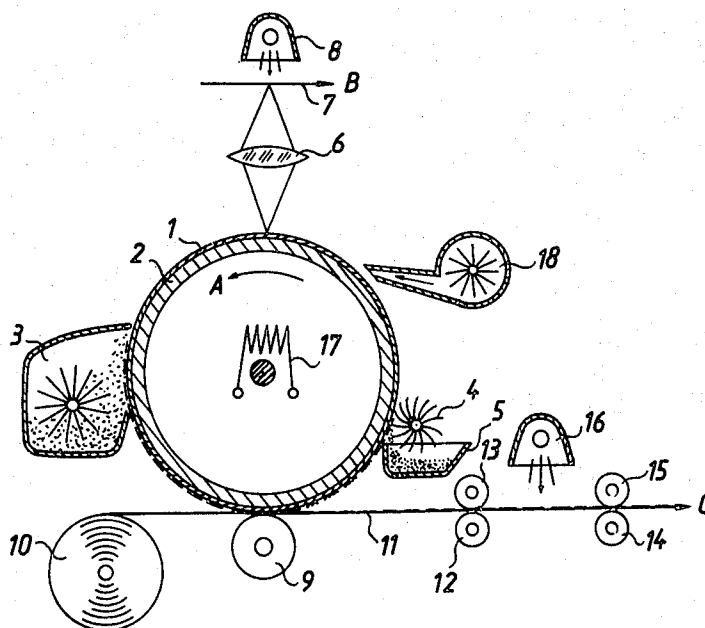
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[57] ABSTRACT

The magnetic image receiving surface of a thermomagnetic imaging apparatus is provided with a layer of FeRh or an analogous ingredient which is antiferromagnetic above and below its Neel temperature but exhibits a pronounced coercive force at the Neel temperature. The image receiving surface is moved past an exposure station to receive a thermal image of an original. The exposing step may involve heating selected areas of the image receiving surface to Neel temperature in accordance with the image pattern of the original or heating selected areas of the image receiving surface to above the Neel temperature while the remaining areas remain at Neel temperature. The resulting thermal image is converted with magnetic toner into a powder image, either on the image receiving surface or upon transfer onto an auxiliary surface, and the powder image is transferred onto and fused to paper or another transfer material.

12 Claims, 4 Drawing Figures



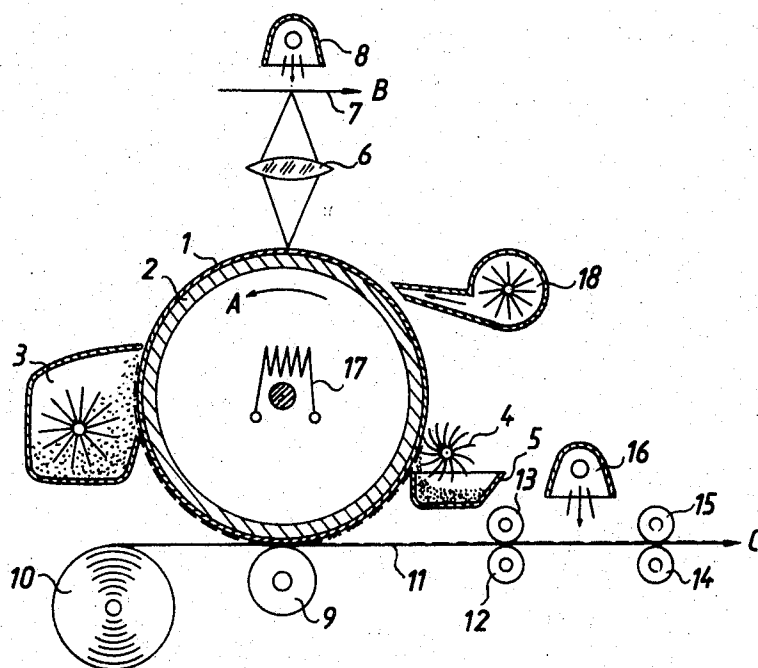
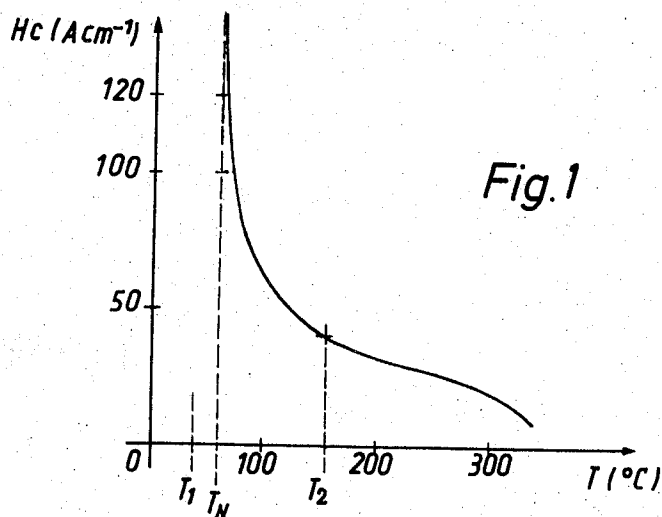
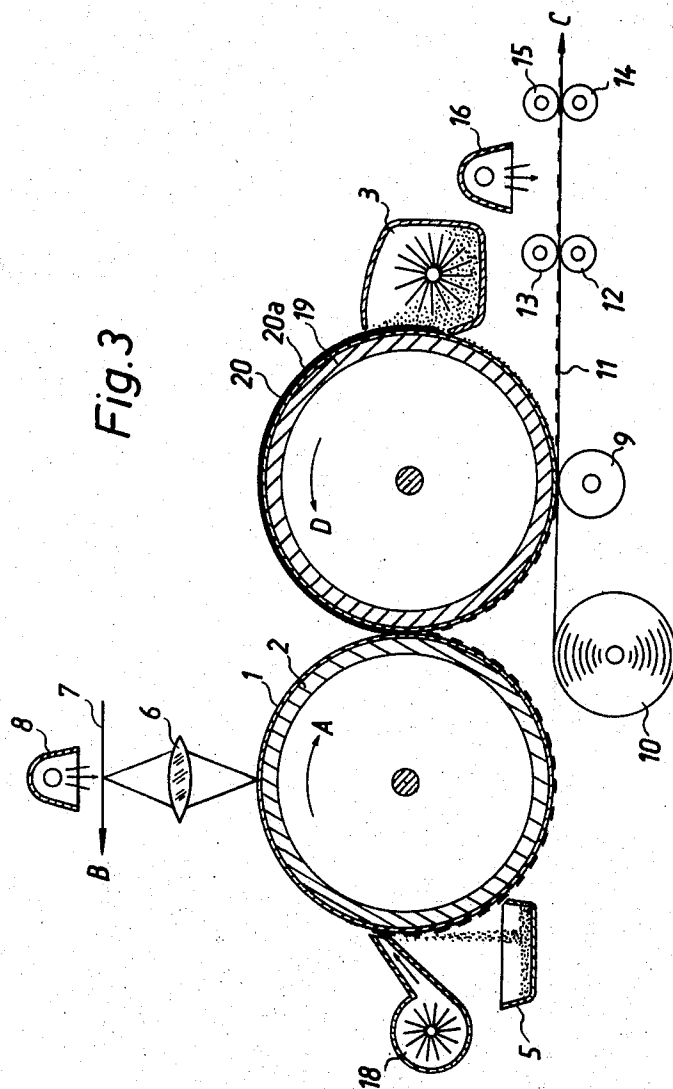
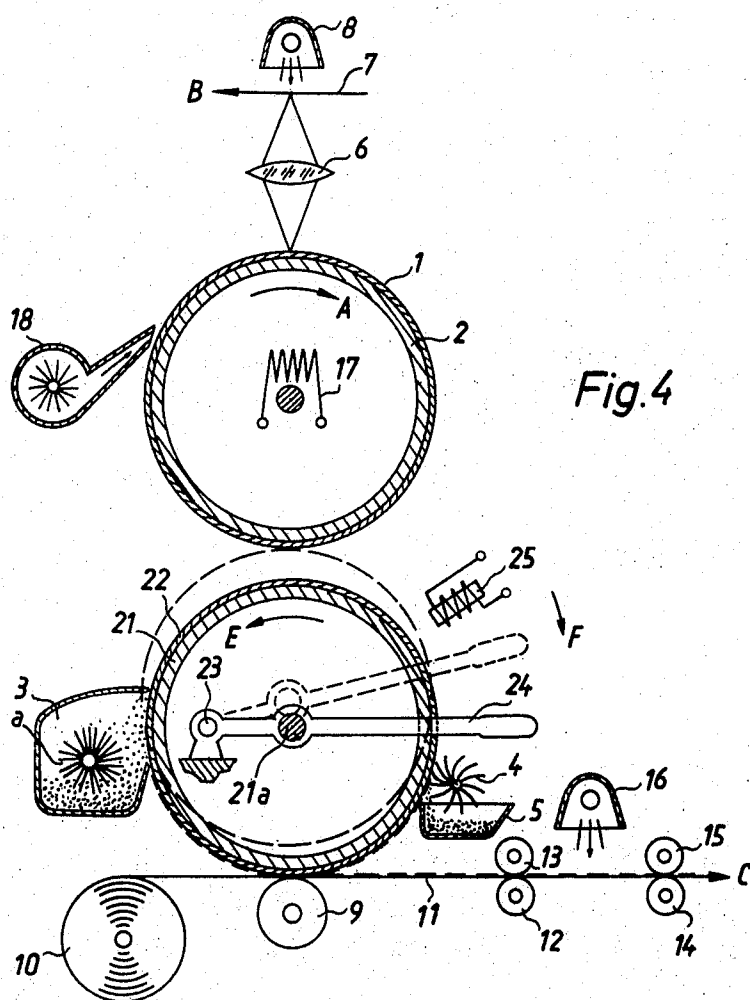


Fig. 2





THERMOMAGNETIC IMAGING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This is a division of my commonly owned copending application Ser. No. 195,338 filed Nov. 3, 1971 now U.S. Pat. No. 3,791,843 and entitled "Thermomagnetic Imaging Method."

BACKGROUND OF THE INVENTION

The present invention relates to apparatus for making copies of images of originals by the thermomagnetic imaging process, and more particularly to improvements in apparatus for converting thermal images of originals into powder images prior to transfer and fixing of such powder images to paper or other transfer material.

It is already known to produce a magnetic image of an original by applying to a uniformly premagnetized surface a thermal image wherein the temperature of certain portions exceeds the Curie point. Such magnetic images can be converted into powder images by utilizing a magnetic toner. It is further known to subject a layer of magnetizable toner to the action of an external magnetic field and to simultaneously expose onto the magnetizable toner a thermal image wherein the temperature of certain portions exceeds the Curie point. This brings about a selective removal or transfer of pulverulent toner so that the residual toner or the removed toner forms a powder image. It was also proposed to bring a magnetic layer in contact with a control layer wherein certain portions are heated above the Curie point to thus provide on the magnetic layer a permanent magnetic image of the original. A drawback of all such conventional proposals is that the image receiving layer must be subjected to the action of an external magnetic field either prior to or during the application of thermal images.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved apparatus for making thermal images of originals on magnetic image receiving surfaces and for converting such thermal images into powder images.

Another object of the invention is to provide a thermomagnetic imaging apparatus which employs a magnetic developer and wherein the image receiving surface need not be subjected to the action of external magnetic fields, either prior to or during the formation of thermal images.

A further object of the invention is to provide a novel and improved image receiving surface for reception and retention of thermal images in apparatus wherein the images are developed by resorting to magnetic toner particles.

An additional object of the invention is to provide an apparatus wherein a thermal image can be converted into a powder image as often as desired or necessary.

One feature of the present invention resides in the provision of a thermomagnetic imaging apparatus for reproducing images of originals on paper or other suitable transfer material. The apparatus comprises means for exposing a thermal image of an original on an image receiving surface containing an ingredient (e.g., FeRh, MnAs, MnTe or Cr_2O_3) which is antiferromagnetic at

temperatures above and below its Neel temperature (T_N) and which exhibits a pronounced coercive force (H_c) at the Neel temperature. The exposing means comprises means for changing the temperature of the surface in accordance with the image pattern of the original so that the surface exhibits first areas which are maintained at Neel temperature and second areas which are maintained at other than Neel temperature (i.e., above or below T_N), and the apparatus further comprises means for converting the thermal image into a powder image, either on the image receiving surface or subsequent to transfer of the thermal image onto an auxiliary surface.

If the ingredient of the image receiving surface is maintained at less than Neel temperature prior to exposing, the first areas of the surface are heated to Neel temperature; the other temperature is then preferably substantially below Neel temperature, e.g., at room temperature.

If the ingredient of the image receiving surface is maintained at Neel temperature prior to exposing, the second areas of the surface are heated to above Neel temperature so that the other temperature substantially exceeds T_N .

It is often desirable to maintain the temperature of the image receiving surface prior to exposing at a temperature which closely approximates the temperature of one of the first and second areas upon completed temperature change.

The powder image can be transferred onto and fixed or stabilized on paper or other suitable transfer material.

In accordance with a more specific feature of my apparatus, the converting means may comprise means for contacting the exposed image receiving surface with a coat of pulverulent magnetic toner from which the surface removes toner so that the thus removed toner adheres to the first areas of the surface.

Alternatively, the thermal image can be transferred onto a magnetic layer whose coercive force is less than the coercive force of the ingredient of the image receiving surface at T_N ; the converting means then comprises means for placing the transferred thermal image, at least, once into contact with a pulverulent magnetic toner to thereby convert the transferred thermal image into a powder image which can be transferred onto paper or the like.

The toner may consist of magnetizable carriers for a pigmentized thermoplastic material which can be fused to the transfer material in response to the application of heat. Such thermoplastic materials and magnetizable carriers therefor are well known in the art.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved apparatus itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagram showing the dependency of coercive force of FeRh on changes in temperature;

FIG. 2 is a partly elevational and partly vertical sectional view of apparatus which embodies one form of the invention and wherein the image receiving surface

serves for the formation of thermal and powder images as well as for the transfer of powder images onto a sheet-like carrier;

FIG. 3 is a partly elevational and partly vertical sectional view of a second apparatus wherein the formation of thermal and powder images takes place on two separate surfaces; and

FIG. 4 is a partly elevational and partly vertical sectional view of an apparatus which constitutes a modification of the apparatus shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The diagram of FIG. 1 illustrates the dependency of coercive force (magnetic field) H_c of FeRh on the temperature. Reference may be had to an article by Stoffel appearing on page 1239 of Vol. 40, No. 3 of "Journal of Applied Physics." The diagram indicates that the antiferromagnetic FeRh compound exhibits no coercive force at a temperature T_1 which corresponds to or approaches the ambient temperature. When the compound is heated to 60°C (this is the Neel temperature T_N of FeRh), the coercive force H_c increases abruptly to a value well in excess of 120 Acm⁻¹. In response to further heating to a temperature which exceeds T_N , the coercive force H_c decreases steeply and, at a temperature T_2 slightly in excess of 100°C, decreases to a value at which a magnetic toner having an appropriate particle size, coercive force or permeability cannot adhere to an image receiving surface containing FeRh.

The copying apparatus of FIG. 2 comprises a drum-shaped image receiving surface 2 whose exterior is provided with a layer 1 of FeRh. Successive increments of the layer 1 travel along a development station containing a dispenser 3 for a magnetic toner, e.g., finely divided ferrite powder of the type sold under the trade name "Keraperm 417," having a coercive force of 0.16 Acm⁻¹ and an initial permeability of 2,400. The particles of such toner are coated with a suitable synthetic thermoplastic material containing a desired type of pigment. The development station is located ahead of a drum cleaning station which includes a rotary brush 4 and a receptacle 5 serving to collect surplus toner which is removed from the layer 1 by the brush 4. An exposure station which is located upstream of the development station (see the arrow A which indicates the direction of rotation of the drum 2) includes an objective 6 which focusses the images of successive increments of a moving original 7 onto successive increments of the layer 1 so that the latter is provided with a thermal image of the original. A radiation heater 8 behind the path of the original 7 emits radiant energy which passes through the original and impinges on the layer 1. The direction in which the original 7 is being moved at the exact peripheral speed of the drum 2 is indicated by the arrow B. It is clear that the illustrated exposure station constitutes but one of several available means for producing a thermal image on the layer 1. For example, the original can be brought in direct contact with the layer 1 or the latter can receive a thermal image by resorting to an episcopic procedure.

Those increments of the layer 1 which advance beyond the development station (dispenser 3) are caused to pass along a transfer roller 9 which presses against the layer 1 successive increments of a sheet- or strip- or web-like transfer material 11 (e.g., normal writing paper). Such material 11 is stored on a roll 10 and is

being withdrawn from the roll by pairs of advancing rollers 12, 13 and 14, 15. The transfer material 11 receives from the layer 1 a powder image which is formed at the development station, and such powder image is thereupon stabilized by a fuser 16 which heats the toner so that the thermoplastic material on the particles of toner is caused to melt and penetrates into the material of the strip 11. The direction in which the rollers 12-15 advance the strip 11 is indicated by the arrow C.

The drum 2 is hollow and its interior accommodates a thermostatically controlled heater 17 which maintains the layer 1 at the temperature T_N . As stated above, the Neel temperature of FeRh is 60°C.

The operation:

The drive means (including a shaft 2a for rotating the drum 2 in the direction indicated by the arrow A) rotates the layer 1 at a speed which equals the speed of the original 7 (arrow B). The heater 17 is on and maintains those increments of the layer 1 which approach the exposure station (objective 6) at a temperature of 60°C, so that the coercive force H_c of the layer 1 greatly exceeds 120 Acm⁻¹. Those portions of the layer 1 which register with the image-free brighter portions of the original 7 are heated by the heater 8 to a temperature corresponding substantially to the temperature T_2 of FIG. 1. Consequently, such portions of the layer 1 exhibit a greatly reduced coercive force which is so weak that they cannot retain toner during travel past the development station (dispenser 3). The layer portions exhibiting a greater coercive force accept and retain toner so that the thermal image formed at the station including the objective 6 is converted into a positive powder image of the original 7. Such powder image is transferred onto the strip 11 by the roller 9 and is thereupon stabilized by the fuser 16. The surplus of toner is removed from the layer 1 by the revolving cleaning brush 4 to accumulate in the receptacle 5. A blower 18 or an analogous cooling device is located downstream of the brush 4 to cool successive increments of the layer 1 before such increments reach the exposure station. The heater 17 insures that the temperature of successive increments of the layer 1 which reach the exposure station (objective 6) equals T_N . At this temperature, the layer 1 exhibits uniform magnetic properties.

It will be noted that the apparatus of FIG. 2 forms a positive powder image because selected portions of the layer 1 are heated above T_N during travel past the exposure station whereby the thus heated portions cannot retain toner during travel past the development station.

The remaining portions of the layer 1 can accept and retain toner because their temperature equals or closely approximates T_N due to the provision of heater 17. The formation of a positive powder image is due to the fact that the magnetic properties of FeRh change abruptly in response to heating above T_N .

The cooling device 18 insures that the thermal image is erased even if the shaft 2a is caused to rotate the drum 2 at a substantial speed so that the formation of successive thermal images can be carried out at frequent intervals. Thus, the cooling action of the device 18 must be sufficient to insure, in combination with the heater 17, that each increment of the layer 1 which reaches the exposure station is maintained at or close to T_N .

FIG. 3 illustrates a second apparatus wherein the drum-shaped image-receiving surface 2 is again provided with a layer 1 of FeRh. The layer 1 is contacted by a uniform premagnetized coat 20 of toner which is applied to the periphery of an auxiliary drum 19 rotating in the direction indicated by the arrow D. The coercive force H_c of toner which forms the coat 20 exceeds the coercive force of the layer 1. The exposure station including the parts 6, 8 and a transporting mechanism for the original 7 is identical with or similar to the exposure station of the apparatus shown in FIG. 2. The thermal image which is exposed onto the layer 1 in the region of the exposure station is thereupon converted into a negative powder image during travel of successive increments of the layer 1 past the line of contact with the coat 20 on the auxiliary drum 19. The toner which forms the negative powder image on the layer 1 is caused to descend into a receptacle 5 at a cooling station which accommodates a suitable blower 18. This insures that all portions of the layer 1 which return into register with the objective 6 are free of toner.

The development station is located in the region of contact of the layer 1 with the coat 20. Such coat of toner is applied by a dispenser 3 which includes a magazine or hopper for toner and a rotating brush which sprinkles the toner onto the surface of the auxiliary drum 19 to form thereon the coat 20. The transfer roller 9 presses successive increments of strip-shaped transfer material 11 against successive increments of the positive powder image on the drum 19 downstream of the development station. The transfer material 11 is being withdrawn from a roll 10 and is being transported in the direction indicated by arrow C by two pairs of advancing rollers 12, 13 and 14, 15. The reference character 16 denotes a fuser which heats the powder image on the transfer material 11 before the material leaves the copying apparatus. It will be noted that the heater 17 of FIG. 2 is omitted in the apparatus of FIG. 3.

Due to absence of the heater 17, the layer 1 is maintained at a temperature (T_1) which corresponds to the temperature of surrounding air. Therefore, the material of the layer 1 does not exhibit any outwardly effective magnetic moments. The intensity of the source 8 of radiation energy is selected in such a way that all portions of the layer 1 which register with image-free portions of the moving original 7 are heated to the Neel-temperature T_N . Thus, the thermal image which is produced on the layer 1 at the exposure station is a negative image of the original.

As the drum 2 continues to rotate in the direction indicated by the arrow A, the layer 1 rolls in contact with successive increments of the coat 20 on the periphery of the auxiliary drum 19 whereby the negative thermal image is converted into a negative powder image. In other words, those portions of the layer 1 which are heated to the temperature T_N attract the toner of the coat 20 whereby the remainder of such coat constitutes a positive powder image of the original 7. The periphery of the auxiliary drum 19 is magnetized with a high degree of uniformity and receives toner during travel past the dispenser 3. The magnetized layer of the drum 19 is indicated at 20a.

The positive powder image which remains on the layer 19a downstream of the point of contact between the layer 1 and the coat 20 is thereupon transferred onto the strip 11 by the roller 9, and such image is fixed

by heat which is furnished by the fuser 16. As mentioned before, the negative powder image on the layer 1 of the drum 2 is destroyed during travel past the nozzle of the cooling device 18 so that the toner descends into the receptacle 5. Such destruction of the negative powder image is due to the fact that air or another coolant issuing from the cooling device 18 reduces the temperature of all portions of the layer 1 to less than T_N , i.e., the coercive force H_c of the layer 1 decreases so that the latter cannot retain the toner which forms the negative powder image.

The copying apparatus of FIG. 4 includes a hollow drum-shaped image receiving surface 2 provided with a layer 1 of FeRh and containing a heater 17 which heats successive increments of the layer to a temperature T_N not later than when such increments reach the exposure station including an objective 6, a radiation heater 8 and a mechanism for transporting the original 7 in the direction indicated by the arrow B. A cooling device 18 is adjacent to the layer 1 upstream of the exposure station. The speed of lengthwise movement of the original 7 equals or closely approximates the speed at which the drum 2 rotates the layer 1 in the direction indicated by the arrow A.

The drum 2 cooperates with an auxiliary drum 21 which is rotatable in the direction indicated by arrow E about the axis of a shaft 21a mounted on a lever 24 which is fulcrumed at 23 and can be pivoted between the solid-line and broken-line positions of FIG. 4 to respectively move a magnetic layer 22 on the periphery of the auxiliary drum 21 into contact with the transfer material 11 or with the layer 1. The coercive force H_c of the magnetic layer 22 on the auxiliary drum 21 is less than the coercive force of the layer 1 at the temperature T_N . For example, the layer 22 may consist of black iron oxide of the type known as SM and produced by Bayer-Werke, Western Germany. The coercive force of such layer may be in the range of 70 Acm^{-1} . A dispenser 3 for toner contains a revolving brush 3a which sprinkles particles of toner onto the layer 22 of the auxiliary drum 21. A cleaning station downstream of the transfer roller 9 includes a driven brush 4 and a receptacle 5 for surplus toner. The apparatus further comprises a demagnetizing device 25 for the layer 22. The parts 12-16 of the apparatus shown in FIG. 4 correspond to similarly referenced parts of the apparatus shown in FIG. 2 or 3.

The operation:

The heater 17 insures that the temperature of successive increments of the layer 1 which reach the exposure station (objective 6) at least approximates 60°C , i.e., the Neel-temperature of FeRh. Thus, those portions of the layer 1 which are in register with image-free portions of the original 7 are heated to above the temperature T_N whereby the coercive force of such layer portions decreases well below 120 Acm^{-1} . The layer 1 carries a positive thermal or magnetic image of the original 7 toward the point of contact with the layer 22 which is assumed to be maintained by lever 24 and auxiliary drum 21 in the broken-line position of FIG. 4. The magnetic image of the layer 1 is transferred onto the layer 22. Such transfer of the magnetic image from the layer 1 onto the layer 22 is due to magnetization of selected portions of the layer 22 by those portions of the layer 1 which are maintained at the temperature T_N . The lever 24 is thereupon pivoted in the direction indicated by the arrow F so as to disengage the layer 22

from the layer 1 and to cause successive increments of the magnetic image to travel past the development station where the magnetic image is converted into a positive powder image by toner which is sprinkled by the brush 3a. Such powder image is transferred onto the material 11 by the roller 9 and the surplus toner is removed by the cleaning brush 4 to enter the receptacle 5. The powder image is stabilized on the transfer material 11 during travel past the fuser 16 under the action of the advancing rollers 12-15 (see the arrow C). The development and transfer of magnetic image on the layer 22 of the auxiliary drum 21 can be repeated as often as desired, i.e., the apparatus can make any desired number of copies simply by maintaining the drum 21 in the solid-line position of FIG. 4 and causing its shaft 21a to rotate in the direction indicated by the arrow E.

When the desired number of copies is completed, the demagnetizing device 25 is activated to destroy the magnetic image on the layer 22 and the lever 24 is pivoted to the broken-line position so as to return the layer 22 into contact with the layer 1. The layer 22 is then ready to receive the positive magnetic image of a further original.

The method which can be carried out with the apparatus of the present invention is based on the recognition that a thermal image of an original can be obtained by employing a magnetic image receiving surface which contains an anti-ferromagnetic compound or ingredient and by heating selected portions of the image receiving surface to a temperature which exceeds the Neel temperature of the antiferromagnetic compound. Such compound may but need not be FeRh.

The magnetic moments of FeRh and analogous antiferromagnetic compounds are such that they do not exhibit an outwardly acting permanent magnetic moment. Thus, as a result of their antiparallel positions, the magnetic moments of antiferromagnetic compounds cancel or neutralize each other. The relatively small positive susceptibility of antiferromagnetic compounds rises to a maximum value at a temperature at which the exchange forces become incapable of maintaining the magnetic moments in positions of alignment against the thermal movements. At such temperatures, i.e., at the Neel-temperature (T_N), the antiferromagnetic compound becomes ferromagnetic or paramagnetic. These characteristics are exhibited by almost all inorganic compositions containing transition metals, rare earths, actinium, chromium, manganese, platinum, palladium and other rare metals. The method of the present invention preferably employs such antiferromagnetic compounds whose Neel-temperature is only slightly above room temperature. These materials include MnTe ($T_N = +34^\circ\text{C.}$), MnAs ($T_N = +43^\circ\text{C.}$), Cr_2O_3 ($T_N = +47^\circ\text{C.}$) and FeRh ($T_N = +60^\circ\text{C.}$).

An advantage of such antiferromagnetic compounds is that, when used in a magnetic image receiving surface, the latter can receive a thermal image without resorting to an external magnetic field. Such compounds are non-magnetic at a temperature which is below the Neel-temperature but their coercive force rises abruptly at T_N to reach a considerable value and decreases rapidly to a negligible value if the temperature rises above T_N . Consequently, an image receiving surface employing such compounds exhibits a steep gradation to allow the exposure of thermal images which are rich in contrasts.

The conversion of antiferromagnetic properties of such compounds into ferromagnetic or paramagnetic properties is accompanied by abnormal changes in specific heat. Thus, when the temperature approaches T_N , the specific heat rises approximately by one order of magnitude and drops rapidly when the Neel-temperature is exceeded to reassume its original low value. In other words, the compound tends to remain, not only during heating but also during cooling, at the temperature in the range of T_N longer than at other temperatures. The temperature T_N , at which the compound exhibits a maximum coercive force, can be established in a relatively simple and inexpensive way.

Due to the just discussed properties of FeRh and analogous antiferromagnetic compounds, the exposure of a thermal image onto the image receiving surface can be achieved by heating the magnetic layer which contains an antiferromagnetic compound from relatively low temperature to T_N of the antiferromagnetic compound (FIG. 3) or from T_N to a higher temperature (FIGS. 2 and 4). In each instance, it is advisable to maintain the starting temperature of the magnetic layer close to but slightly below the working temperature of the antiferromagnetic compound. This can be readily achieved by employing a thermostatically controlled heating or cooling device. Thus, in the apparatus of FIG. 2 or 4, the working temperature is higher than T_N , and in the apparatus of FIG. 3 the working temperature is T_N .

In the apparatus of FIG. 3, those portions of the layer 1 which approach the exposure station are maintained below the Neel-temperature, i.e., at a temperature which equals room temperature or at a temperature which exceeds room temperature but is less than T_N . Therefore, such portions of the layer 1 are non-magnetic and exhibit a low specific heat. The exposure of such layer portions to slightly elevated temperature during travel past the objective 6, i.e., the admission of relatively small amounts of heat energy, suffices to heat selected areas of the layer to T_N and to thus produce in such areas a pronounced coercive force H_c . The exact metering of maximum heat supply is not critical because the specific heat of the areas which are heated to or close to T_N increases substantially and, due to the aforesaid anomaly of specific heat changes (the compound tends to remain at or close to T_N longer than at another temperature) the image receiving surface receives a highly satisfactory thermal image of the original. The thermal image remains intact for a reasonably long interval of time because the specific heat changes in the region of T_N are slow.

The situation is analogous in the apparatus of FIGS. 2 and 4. In these apparatus, the layer 1 is maintained at T_N before it reaches the exposure station. This can be achieved without a highly accurate temperature control because the specific heat changes of the layer 1 at T_N are slow. Thus, those portions of the layer 1 which approach the exposure station exhibit a pronounced coercive force H_c . The coercive force of areas which are heated above T_N to such an extent that their specific heat decreases immediately exhibit a much weaker coercive force with the result that the thermal image is an accurate reproduction of the image of the original 7.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for var-

ious applications without pmitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In an apparatus for reproducing images of originals on transfer material, such as paper, a combination comprising a mobile image receiving surface containing an ingredient which is antiferromagnetic at temperatures above and below the Neel temperature thereof, whose Neel temperature exceeds room temperature, and which exhibits a pronounced coercive force at said Neel temperature; and means for exposing thermal images of originals onto said surface, including means for changing the temperature of said surface in accordance with the image pattern of an original so that said surface exhibits first areas which are maintained at said Neel temperature and second areas which are maintained at other than said Neel temperature.

2. A combination as defined in claim 1, further comprising means for normally maintaining said surface at a predetermined starting temperature.

3. A combination as defined in claim 2, further comprising means for moving said surface in a predetermined direction, said means for maintaining said surface at said starting temperature comprising means for cooling said surface upstream of said exposing means, as considered in said direction, and said temperature changing means comprising means for heating said first areas to said Neel temperature.

4. A combination as defined in claim 1, further comprising means for moving said surface in a predetermined direction, developing means located downstream of said exposing means as considered in said direction and including means for applying to said surface a pulverulent magnetic toner whereby said toner adheres to said first areas to convert said thermal image into a powder image.

5. A combination as defined in claim 4, further comprising means for transferring said powder image onto a transfer material downstream of said developing means, as considered in said direction.

6. A combination as defined in claim 5, further comprising cleaning means for removing remnants of toner from said surface intermediate said transferring and said exposing means.

7. A combination as defined in claim 1, further comprising means for moving said surface in a predeter-

mined direction, an auxiliary surface including a layer of permanently magnetized material in contact with successive increments of said image or receiving surface, and means for applying to said auxiliary surface a coat of pulverulent magnetic toner upstream of the region of contact between said surfaces, the coercive force of said permanently magnetized material being less than the coercive force of said first areas of said image receiving surface so that the latter removes from said coat a first powder image and the residue of said coat constitutes a second powder image of an original, one of said powder images being a positive image and the other of said powder images being a negative image of the respective original.

8. A combination as defined in claim 7, further comprising means for transferring one of said powder images from the respective surface onto a transfer material and means for fixing the transferred powder image to the transfer material.

9. A combination as defined in claim 1, further comprising means defining a path for moving transfer material, an auxiliary surface disposed between said path and said image receiving surface and having a layer of magnetic material with a coercive force which is less than the coercive force of said ingredient at said Neel temperature, means for moving said auxiliary surface between a first position of contact with said image receiving surface so as to effect the transfer of a thermal image onto said auxiliary surface and a second position of contact with the transfer material in said path, and developing means including a source of pulverulent magnetic toner and means for applying such toner to the thermal image on said auxiliary surface upstream of the region of contact between said auxiliary surface and transfer material in the second position of said auxiliary surface so that the transferred thermal image is converted into a powder image which is thereupon accepted by said transfer material.

10. A combination as defined in claim 9, further comprising means for cleaning said auxiliary surface between said region and said developing means in the second position of said auxiliary surface.

11. A combination as defined in claim 9, further comprising means for demagnetizing said layer on said auxiliary surface prior to movement of said auxiliary surface to said first position.

12. A combination as defined in claim 9, further comprising means for stabilizing the powder image on said transfer material.

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