# United States Patent [19]

**Doi et al.**

[11] E **Re. 28,693**

[45] **Reissued Jan. 20, 1976**


[54] **IMAGE TRANSFER RECORDING APPARATUS WITH RESIN COATED DRUM**


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[73] Assignee: **Hiatchi, Ltd.,** Japan



[22] Filed: **May 9, 1974**

[21] Appl. No.: **468,600**

**Related U.S. Patent Documents**

Reissue of:

[64] Patent No.: **3,662,395**
Issued: **May 9, 1972**
Appl. No.: **9,176**
Filed: **Feb. 6, 1970**

[30] **Foreign Application Priority Data**

Feb. 7, 1969 Japan ..... 44-8738
Nov. 7, 1969 Japan ..... 44-88757

[52] **U.S. Cl.** ..... **346/74 ES;** 117/37 LE; 260/78 TF
[51] **Int. Cl.²** ..... **G01D 15/06;** G03G 15/16
[58] **Field of Search** ..... 346/74 ES, 74 S, 74 SB, 346/74 P, 74 EX, 74 EK; 117/17.5, 37 LE; 118/637; 355/4; 260/78 TF, 77.5 R



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[57] **ABSTRACT**

An image transfer recording apparatus in which a recording drum on which an information signal is recorded by electrostatic recording means is provided with a surface layer of electrically insulating resin so that a powdery developer attaching to the electrostatic latent image formed on the surface of the recording drum can be completely transferred onto a recording sheet thereby to obtain a recorded image of good resolution.


**9 Claims, 17 Drawing Figures**

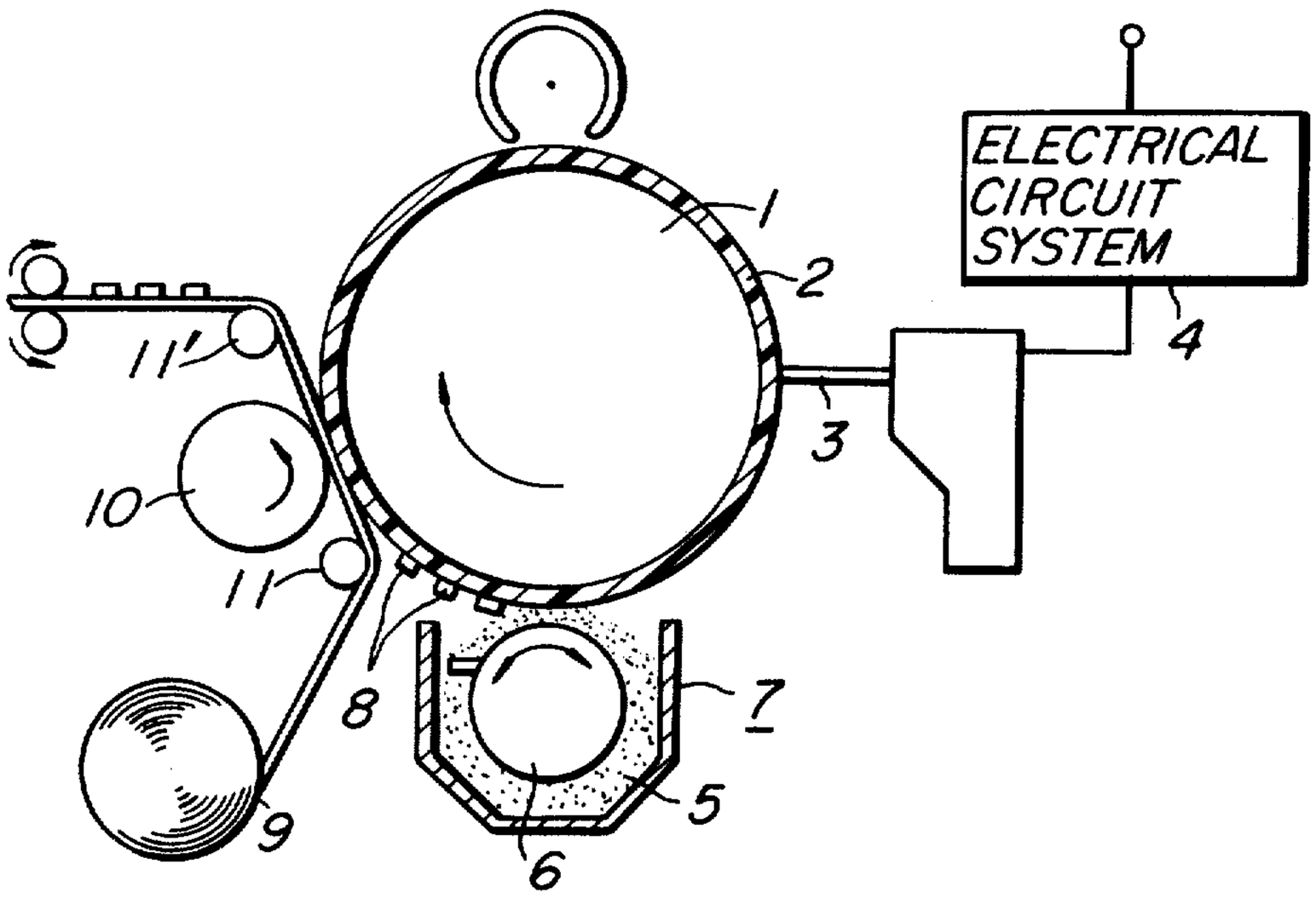


FIG. 1

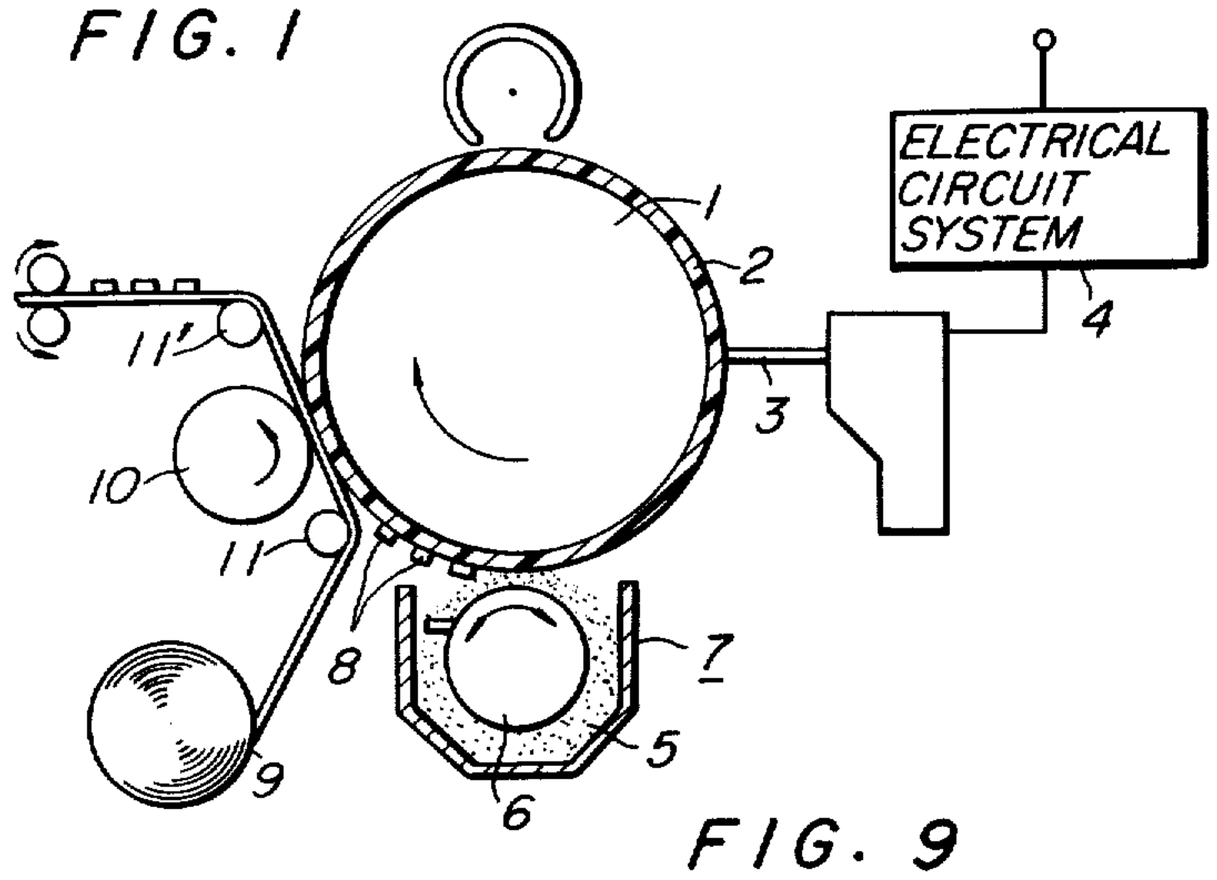



FIG. 2

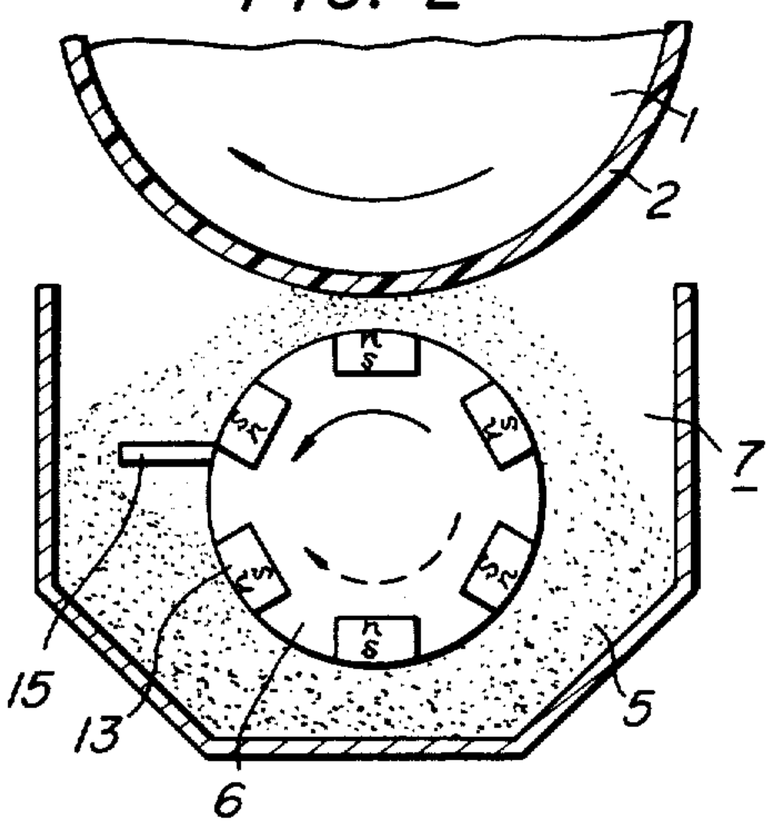



FIG. 9

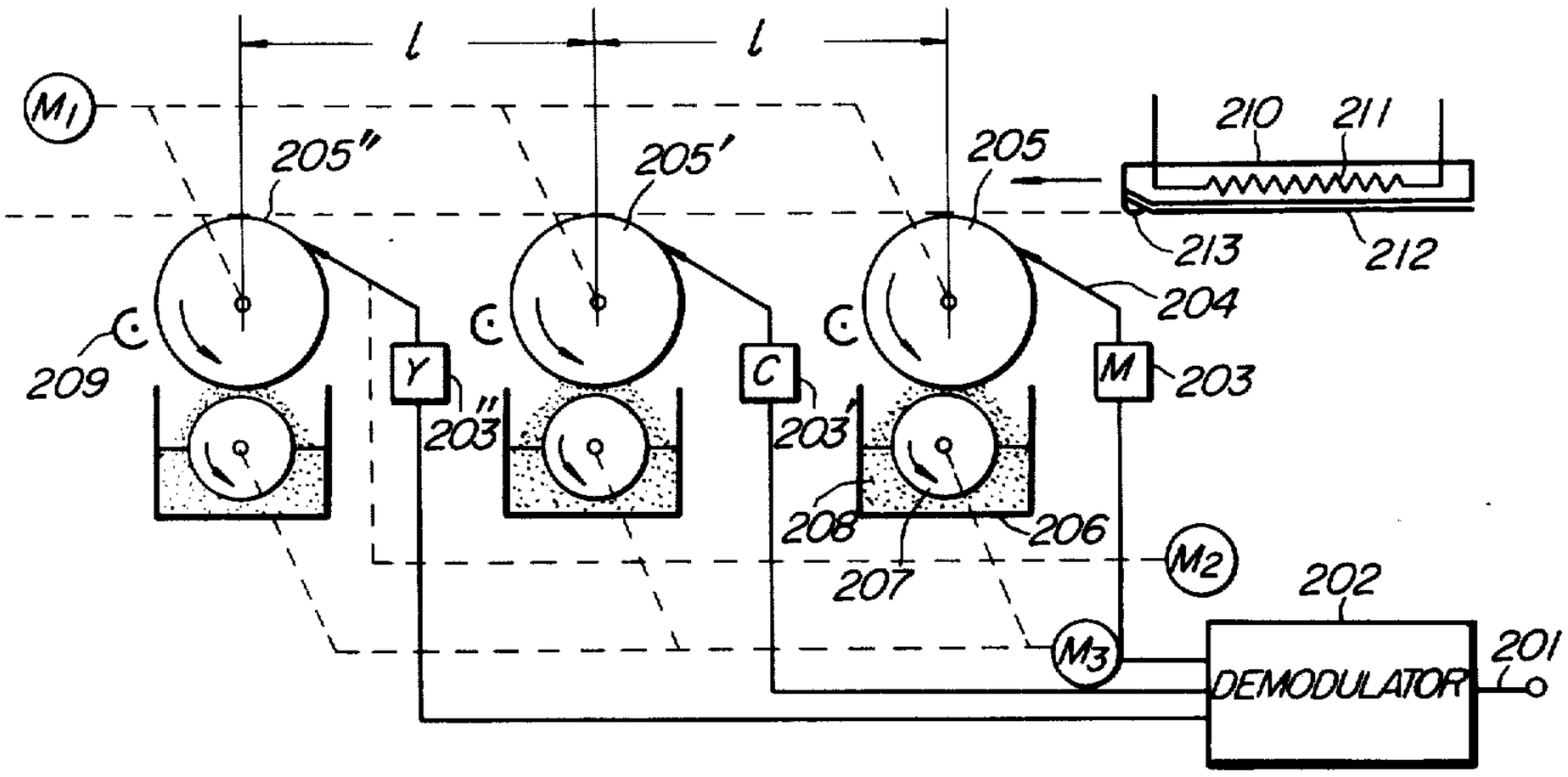
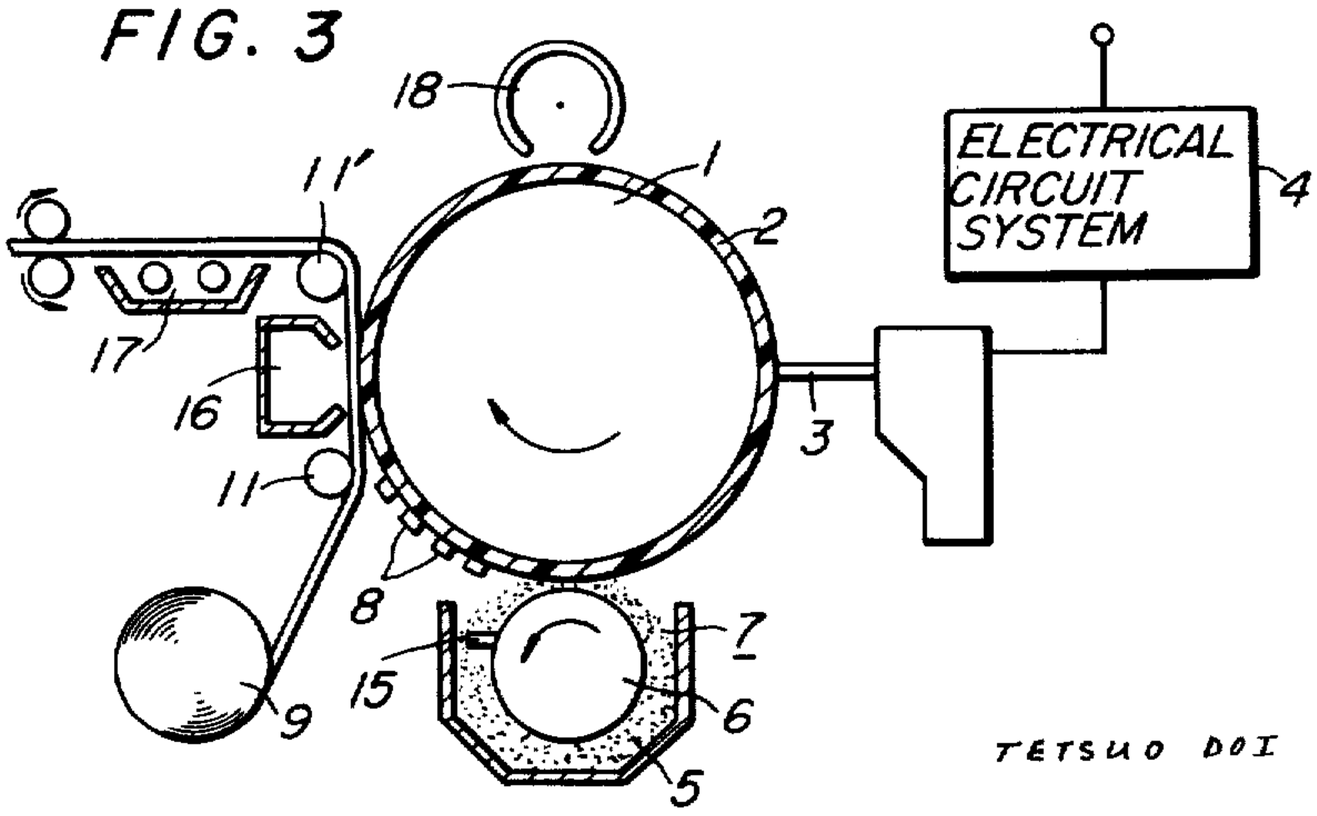



FIG. 3

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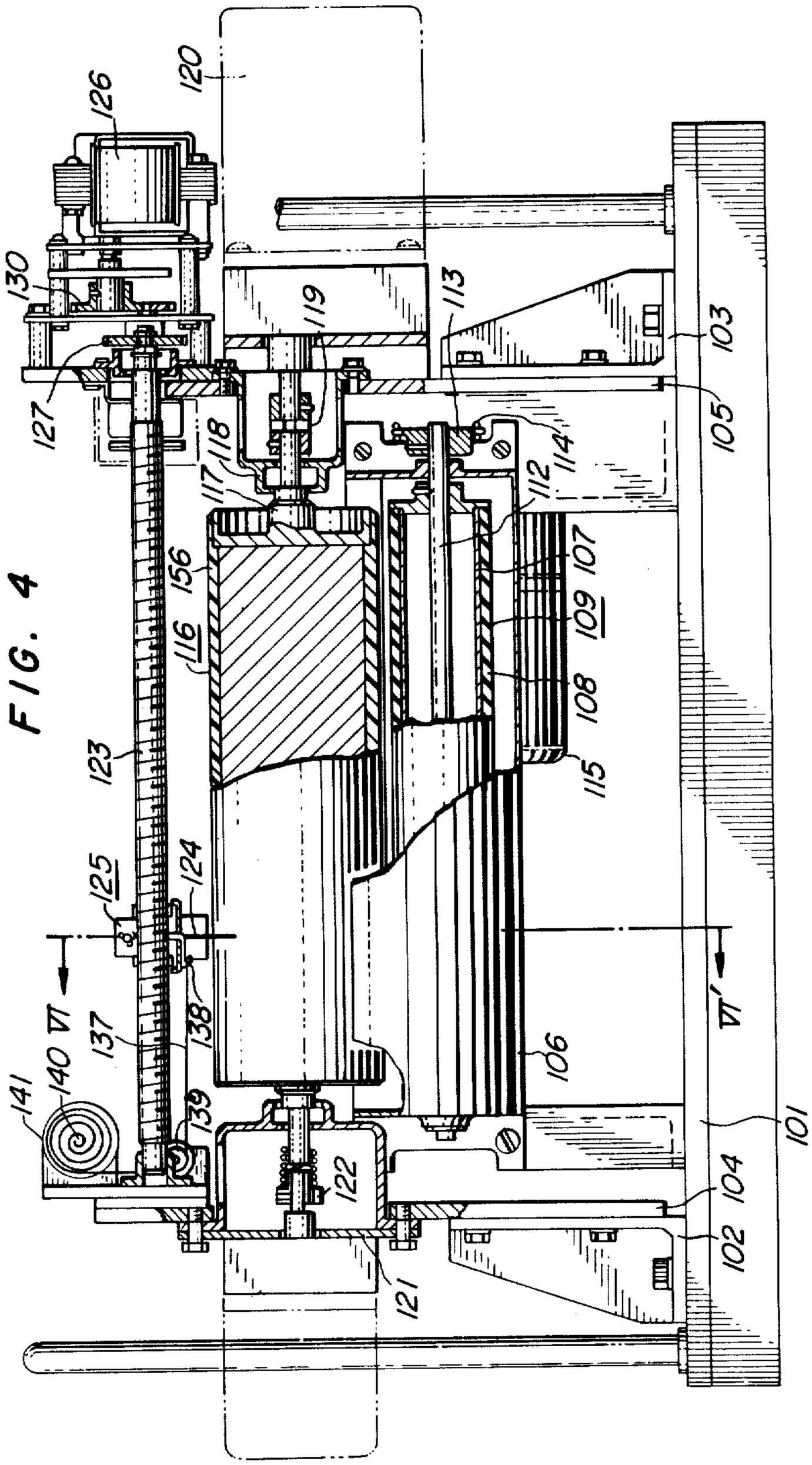


FIG. 4

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FIG. 5

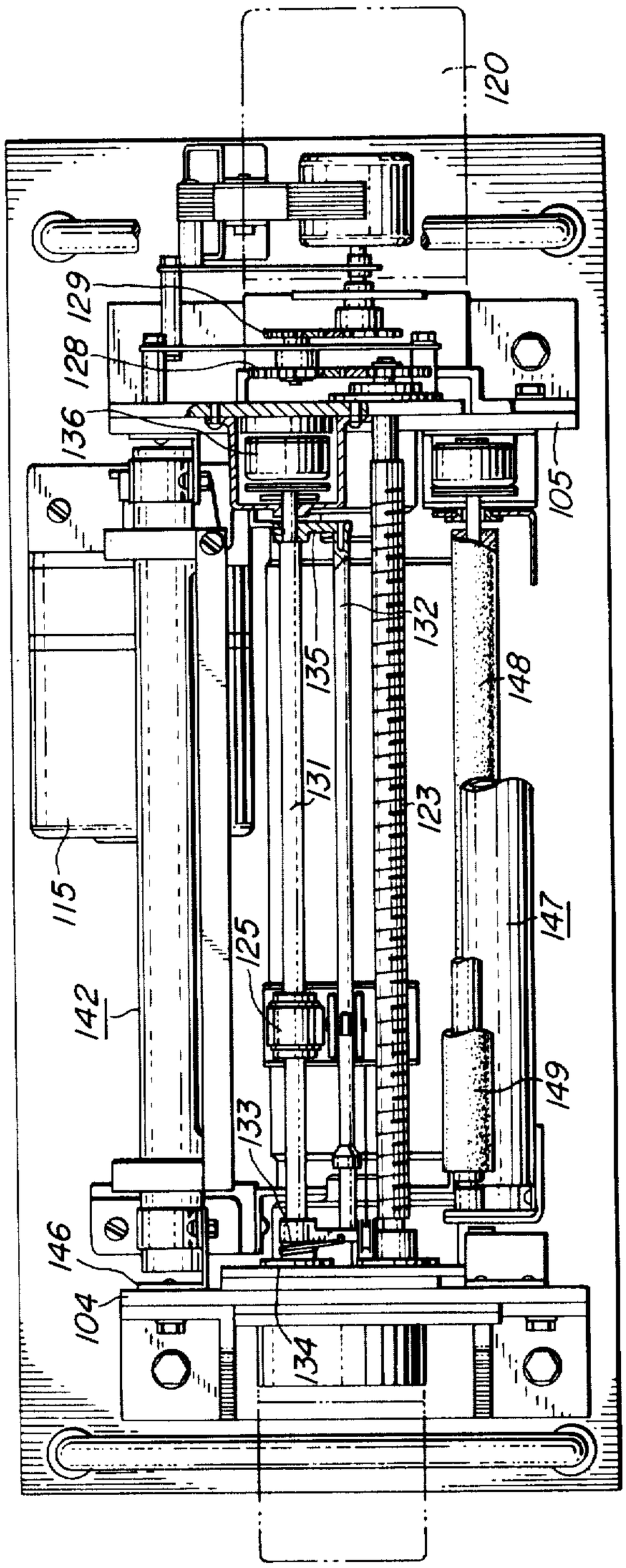


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FIG. 6

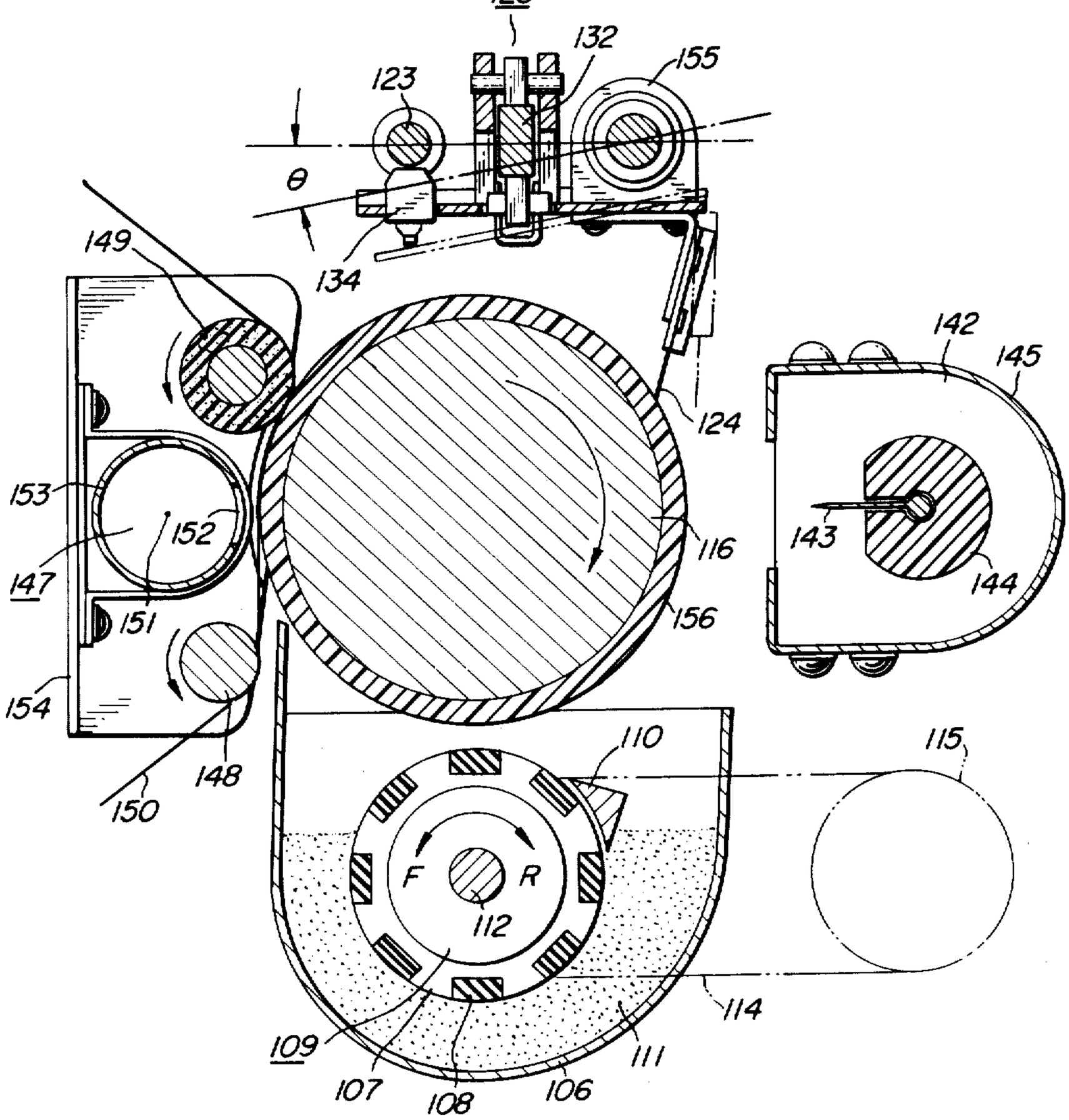


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FIG. 7a

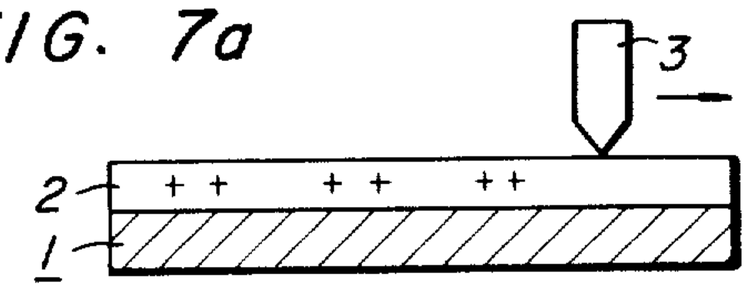



FIG. 7b

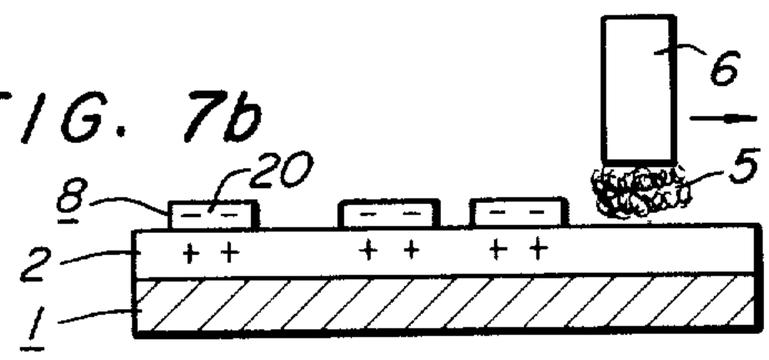



FIG. 7c

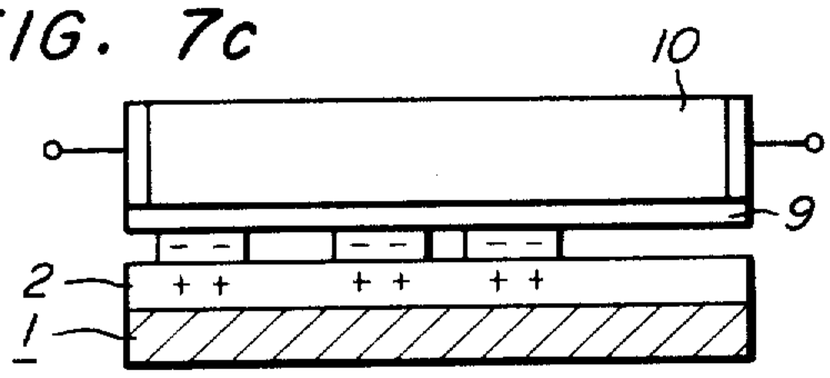



FIG. 7d

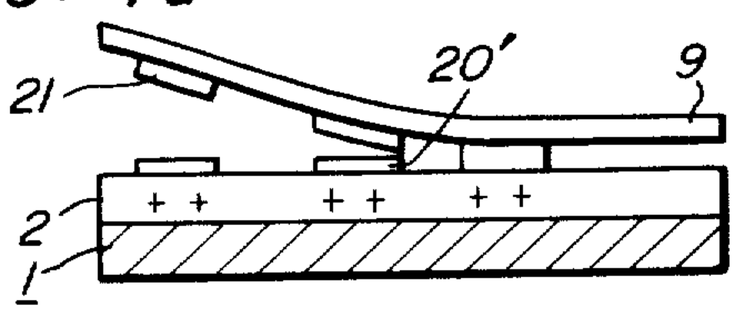



FIG. 7e

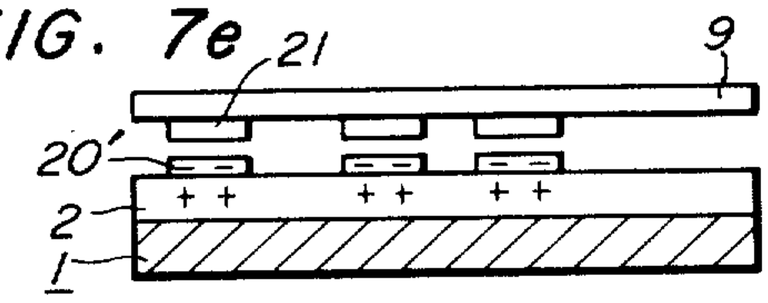



FIG. 8a

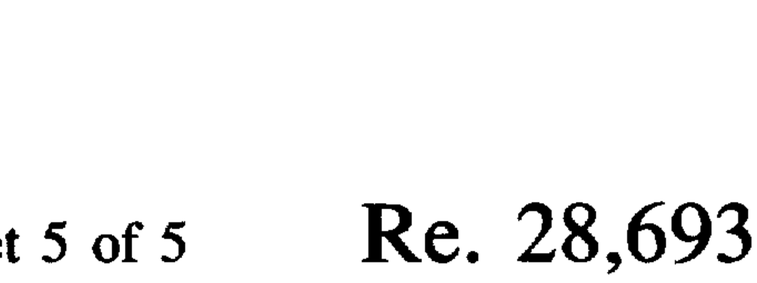



FIG. 8b

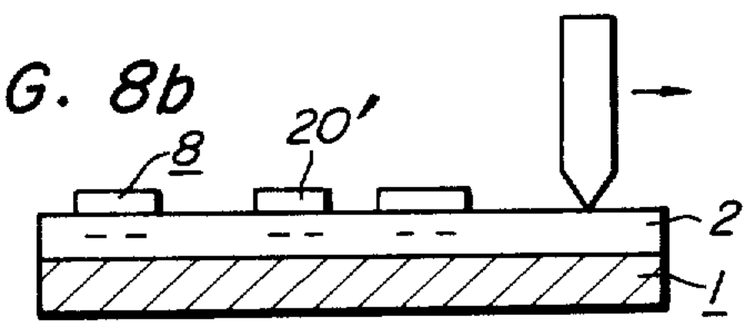



FIG. 8c

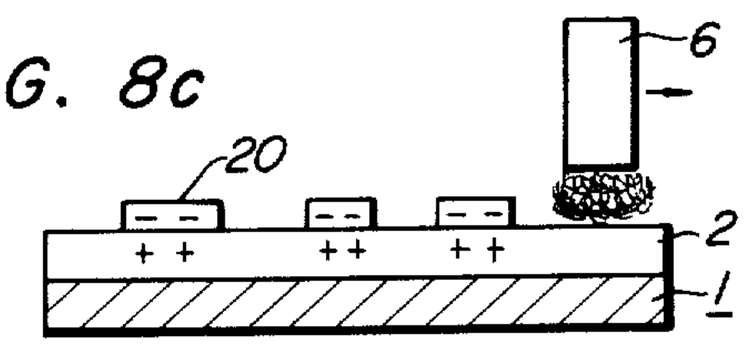



FIG. 8d

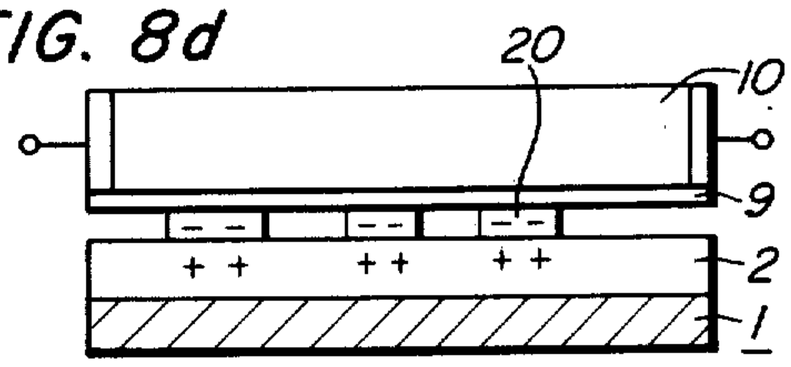
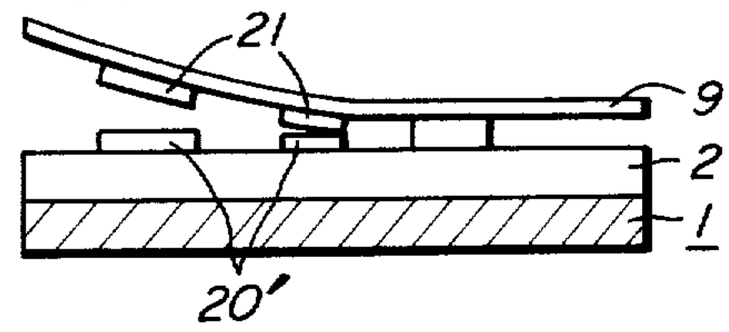



FIG. 8e

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# IMAGE TRANSFER RECORDING APPARATUS WITH RESIN COATED DRUM

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.**

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to recording apparatus such as copying apparatus and facsimiles, and more particularly to an inexpensive and simple recording and apparatus capabale of recording an image on a sheet of plain paper without using a special recording sheet such as, for example, a copying sheet treated with a photoconductive material such as zinc oxide.

2. Description of the Prior Art

Prior art recording apparatus of this kind employed a wide variety of methods which had their respective merits and demerits.

In one type of such facsimile apparatus, a recording method of this kind utilizing the breakdown due to an electric discharge has been in use for quite a long time, which method includes providing a white surface coating on a carbon black layer and electrically destroying the white surface layer to obtain a record. This electric discharge recording method has been defective in that it requires a special recording sheet which is quite expensive, gives off fumes that are accompanied by bad odors which are produced from the recording sheet during recording and products of the breakdown due to the discharge tend to become attached to the recording stylus.

Another type of facsimile apparatus employs a method of the kind in which a color is produced by electrolysis. According to this electrolytic recording method, a material which develops a color when subjected to electrolysis is coated on a recording sheet and a signal voltage is applied to the recording sheet through a recording stylus so that a colored record can be obtained by the electrolytic reaction which takes place at the portions applied with the voltage. The electrolytic recording method has been defective in that a special expensive material must be coated on a recording sheet and, since it includes a wet process, a record of high density and resolution cannot be obtained owing to the blurring of the recorded image. The electrolytic recording method has further been defective in that a special expensive material must be coated on a recording sheet and, since it includes a wet process, a record of high density and resolution cannot be obtained owing to the blurring of the recorded image. The electrolytic recording method has further been defective in that the record obtained tends to undergo a change due to aging since the color is produced by a chemical change, and the recording sheet tends to be chemically affected by other sheets during the storage thereof with the result that the recorded image is also subject to a change.

An electrostatic recording method has been advantageous over these methods in that a record can be reproduced on a recording sheet by relatively simple means and an improvement in the picture quality can be expected. However, the electrostatic recording method



has been disadvantageous in that not only a special expensive recording sheet called an electrostatic recording sheet is required, but also an extra process of developing and fixing after making the recording is required compared with the above-mentioned recording method which utilizes the breakdown of an electric discharge, or color production by electrolysis, and the requirement for these extra process leads to complex apparatuses.

Other methods employed heretofore include converting a signal into mechanical vibrations and striking a recording sheet through carbon paper by means actuated by mechanical vibrations thereby to obtain a record, or using a special recording sheet (a pressure-sensitive sheet) which produces a color in response to pressure. These methods have however been defective in their poor frequency response and in the trouble of requiring such a special sheet.

Silver salt photography is another recording method employed heretofore in the art. This method has however been unfit for practical use except for applications to very special purposes where a high recording performance is required, because the recording material itself is very expensive. Materials employed in copying apparatus and the like will now be discussed. Electrofax is an optical recording method which employs a recording sheet prepared by coating a mixture of a photoconductor such as zinc oxide and a special resin binder on a sheet of paper. Thus, this method also requires a specially processed recording sheet. Further, there is a recording method employing a heat-sensitive recording sheet which is expensive and specially processed. Thus, the problem of expensiveness of the recording sheet is still left unsolved in these methods.

Diazo-type copying apparatus is one typical example of copying apparatus of simple construction using a relatively inexpensive recording sheet. In spite of the fact that this apparatus is very favorable for the reproduction of an original in sheet form by exposure to transmitted light, it has been defective in that its application is limited due to the inability to carry out the reflection copying of articles, such as books and the reproduced record cannot be preserved for an extended period of time due to discoloration or disappearance of the image since a chemical material is used.

Xerography is an inexpensive and favored method in the point that a highly accurately reproduced record can be obtained in spite of the use of a sheet of plain paper. However, this method has had the disadvantge that the plate or drum of photoconductive selenium used therein is quite costly and mechanically brittle and therefore extreme care must be taken in the handling thereof. Further, for the successful electrostatic transfer printing of a toner image onto a sheet of plain paper, very complex handling and expensive means have been required since the remaining toner image must be swept off by means such as a soft brush or a vacuum sweeper to prepare for the next copying cycle.

## SUMMARY OF THE INVENTION

With the above defects in mind, it is an object of the present invention to provide a novel and simple recording apparatus.

Another object of the present invention is to provide an apparatus including electrostatic recording means responsive to an information signal for forming a latent image in the form of an electrical charge on a recording

drum having on the surface thereof a layer of electrically insulating resin of a highly non-wetting and non-adhesive nature, developing means for transforming the latent image into a toner image, and means for transfer printing the toner powder image formed on the recording drum onto a heated recording sheet and, at the same time, heating the toner to fix the image.

A further object of the present invention is to provide an apparatus including developing means for transforming a latent image formed on a recording drum into a toner image, and means for applying an electrostatic force which is greater than the electrostatic force existing between the toner image and the recording drum to the back face of a recording sheet engaging the surface of the recording drum so as thereby to facilitate and improve the transfer printing of the toner image onto the recording sheet.

A still further object of the present invention is to provide an apparatus including developing means for transforming a latent image formed on a resin layer on the surface of a recording drum into a toner image, means for transfer printing of the toner image formed on the surface of the recording drum onto a recording sheet to obtain a recorded image, and means for sweeping off the electrical charge of the latent image on the recording drum and of the toner remaining on the surface of the recording drum without being transferred after the step of transfer printing so as to thereby prevent any undesirable disturbance to a succeeding record and to ensure a good picture quality for an extended period of time.

A yet further object of the present invention is to provide an apparatus including a magnet drum disposed within a developing unit for supplying a toner to a recording drum, a sweeping plate disposed to engage the magnet drum with a portion thereof for controlling the amount of the toner supplied to the recording drum, and means for rotating the magnet drum in normal and reverse directions for selectively supplying the toner to the recording drum.

Another object of the present invention is to provide an apparatus including a plurality of sets of means for electrostatically recording an image on a recording drum and means for developing the image, said sets being arranged side by side by the number corresponding to the number of required primary colors so as thereby to obtain a multi-color print by a single operation.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a schematic view of a system for transfer printing of an image using heat.

FIG. **2** is an enlarged sectional view of parts of the developing unit in the system shown in FIG. **1.**



FIG. **3** is a schematic view of an electrostatic transfer printing system.

FIG. **4** is a partly vertical sectional front elevational view of an electrostatic recording apparatus embodying the present invention.

FIG. **5** is a partly cross-sectional plan view of the apparatus.

FIG. **6** is an enlarged sectional view taken on the line VI—VI' in FIG. **4.**

FIGS. **7a–7e** and **8a–8e** are explanatory views showing the successive steps of a cleaning-less method according to the present invention.

FIG. **9** is a schematic view of a color copying apparatus utilizing the principle of image transfer recording according to the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1** showing the basic principle of a system for the transfer printing of an image under heat, a recording drum **1** is arranged to be rotated by an external drive source. The recording drum **1** is a drum member of a conductive metal and is provided on its surface with a layer **2** of electrically insulating resin of a heat-resistive nature having a low adhesion. Information in the form of a recording signal such as a facsimile signal is supplied to an electrical circuit system **4**, and a recording stylus **3** disposed in close proximity to or engaging the surface of the recording drum **1** is actuated in response to an output from the electrical circuit system **4** to form a latent image of an electrical charge on the insulating resin layer **2** depending on the information. A powdery developer **5** attracted onto a magnetic drum **6** in a developing unit **7** is transferred to the recording drum **1** to develop the charge image (latent image) thereby to provide an image (visible image) **8** formed of powders. The powder image **8** is transfer printed onto a recording sheet **9** which is moved in contact with the recording drum **1** by another driving mechanism. The recording sheet **9** is moved in one direction in rolling contact with the recording drum **1** while being pressed against a heating drum **10** and guided by guide rollers **11** and **11'**. Since the resin layer **2** covering the recording drum **1** carrying the powder image **8** is formed from an electrical insulator having a low adhesion, the toner forming the powder image **8** is easily transferred onto the recording sheet **9** and the transferred image is fused by the heat of the heating drum **10** to be permanently fixed on the recording sheet **9.**

The specifications required for the recording drum **1** are shown in Table **1** and the properties of preferred materials for forming the resin layer **2** coated on the recording drum **1** are shown in Table **2.**

Table 1

| Classification | Items | Specifications | Remarks |
|---|---|---|---|
| Electrical properties | Breakdown voltage | Not less than 1KV | Recording voltage: 500–600 V. |
| | Volume resistivity | More than $10^{14}\Omega$cm | Static recording sheet: $7–9\times10^{14}\Omega$cm |
| | Surface resistivity | More than $10^{14}\Omega$ | Static recording sheet: $6–10\times10^{14}\Omega$ |
| | Dielectric constant | The higher, the better | Commonly 2–3 in plastics |
| Properties of film | Pinhole | No pinholes are allowed | Static recording sheet:about 6$\mu$. |
| | Thickness | 15–20 ±10% | |
| | Surface smoothness | Mirror surface | |
| | Coatability | Coatable on metallic drum | Present drum material:stainless steel. |
| Physical properties | Non-adhesiveness | The greater the better | Fused toner must not become attached to the resin layer. |
| | Resistance to heat | Toner's melting point + 50–80° C | Toner's melting point:about 100° C. |
| | Resistance to wear | Tungsten wire 0.2$\phi$, stylus pressure 2–3 g | Should endure 100,000 frictional contacts. |
| Chemical properties | Resistance to toner | Should not be corroded by thermoplastic resin in toner. | |
| | Resistance to corona | Should endure 500,000-second (140-hour) continuous tests under eraser electrode (about 100,000 recordings). | |

TABLE 2

| Items | Tetra-fluoro-ethylene | Fluoro-ethylene propylene | Taflum (Alumite surface impreg-nated with Teflon) | Vinyl-idene fluoride | Poly-amide imide | Poly-ethylene tereph-thalate | Remarks |
|---|---|---|---|---|---|---|---|
| Breakdown voltage | O | O | X | O | O | O | Electrical properties |
| Insulation resistance | O | O | X | X | O | O | |
| Pinhole | X | O | X | O | O | O | Properties of film |
| Uniform film thickness | O | X | O | Δ | O | O | |
| Surface smoothness | O | X | O | X | O | O | |
| Coatability | O | O | O | O | O | X | |
| Nonadhesiveness | O | O | O | Δ | Δ | Δ | Physical properties |
| Resistance to heat | O | O | O | Δ | O | Δ | |

In Table **2**, the symbols employed are defined as follows: O - sufficiently satisfactory for achieving the object of this invention. Δ - somewhat satisfactory for achieving the objects of the present invention. X - quite unsatisfactory for achieving the objects of the present invention.

It will be known from the above tables that, in spite of the fact that fluorocarbon resins are ideal materials in respect of the requirements for the resistance to heat and non-adhesiveness, tetrafluoroethylene and fluoro-ethylene propylene are not safisfactory for properties of the film, while taflum (cf. Table **2**) is not satisfactory in its electrical properties as well as the other physical properties of the film. It is therefore desirable to solve these faults of the fluorocarbon resin materials.

On the other hand, polyamide imide is slightly inferior to the fluorocarbon resins in the non-adhesiveness regarding physical properties, but is substantially satisfies the specifications in regard to other requirements. Thus, polyamide imide can be freely used in practical applications provided that the attachment of the fused toner can be effectively prevented.

There is a very great possibility that resin materials satisfying the above requirements can be developed in the near future and the problems incountered in respect of the material will soon be solved.

Referring to FIG. **2** schematically showing the structure of the developing unit **7** for supplying the powdery toner developer **5** to the resin layer **2** covering the recording drum **1**, the developing unit **7** comprises a casing within which the magnet drum **6** and a mass of the powdery developer **5** are contained. The magnet drum **6** is adapted for normal and reverse rotation by being driven by another drive source (not shown) and is composed of a support **14** and a plurality of rubber magnets **13** having the same axial length as the support **14** and embedded radially in the outer peripheral portion of the support **14**. The powdery developer **5** consists of a toner and a carrier for the toner. A sweeping plate **15** is disposed in such a fashion that one end thereof engages the surface of the magnet drum **6**.

With a structure as described above, it is desirable that the powdery developer **5** in the developing unit **7** is restrained from contact with the recording drum **1** until the recording of a latent image on the recording drum **1** is completed. Thus, during the normal or counterclockwise rotation, for example, of the magnet drum **6**, the powdery developer **5** including the carrier attaches to the magnet drum **6** so that the toner attaches to the recording drum **1** to carry out the developing operation, while during the recording of a latent image on the recording drum **1**, the magnet drum **6** is rotated in the reverse or clockwise direction and the sweeping plate **15** engaging at one end thereof with the magnet drum **6** interrupts the supply of the powdery developer **5** to the recording drum **1** so that the toner cannot be supplied to the recording drum **1** until the recording of the latent image is completed. It will thus be seen that the supply of the toner to the surface of the recording drum **1** can be selectively controlled depending on the rotating direction of the magnet drum **6** and by the action of the cooperating sweeping plate **15**.

FIG. **3** shows schematically the basic principle of an electrostatic transfer printing system in another embodiment of the present invention.

Referring to FIG. **3** wherein like reference numerals are used to denote like parts appearing in FIGS. **1** and **2**, a recording drum **1** is provided on its surface with a layer **2** of electrically insulating resin having no pinholes. One end of a recording stylus **3** is disposed in close proximity to or with engages the recording drum **1** and an information signal is transmitted to the recording stylus **3** via an electrical circuit system **4**. A powdery developer **5** is contained within a developing unit **7** so that it can be selectively supplied to the recording drum **1** through the medium of a magnet drum **6**. A recording sheet **9** is brought into rolling contact with the recording drum **1** by being guided by guide rollers **11** and **11'** so that a powder image **8** formed on the surface of the recording drum **1** by the developing unit **7** can be transfer printed onto the recording sheet **9** to provide a permanently visible image. An electrostatic charger **16** of polarity opposite to the polarity of the toner and producing an electrostatic force greater than the electrostatic force between the toner in the powdery developer **5** and the recording drum **1** is disposed adjacent to the back face of the recording sheet **9** at a position at which the recording sheet **9** engages

the recording drum **1**. A heater **17** is provided to apply heat to the toner electrostatically transferred onto the recording sheet **9**. A residual charge eraser **18** is disposed adjacent to the recording drum **1** to erase the residual charge on the recording drum **1** so that the residual charge may not adversely affect the next recording by the recording stylus **3**. The charge eraser **18** is of the corona discharge type. The residual charge eraser **18** is available in two types depending on the type of discharge, that is, the A.C. discharge type which produces an A.C. corona discharge for erasing the residual charge and the D.C. discharge type which produces a D.C. corona discharge having a polarity opposite to the polarity of the charge on the recording drum **1** for neutralizing the recording drum **1**.

With a structure as above described, the electrical circuit system **4** is operative in response to transmission of an information signal thereto to apply a signal voltage corresponding to the information signal to the recording stylus **3** and the information is recorded on the resin layer **2** on the recording drum **1** as a latent image. During the recording of the latent image, the magnet drum **6** disposed within the developing unit **7** is rotated clockwise by another drive source (not shown) and thus the toner does not become attached to the recording drum **1**. Upon completion of the recording of the latent image of the information signal onto the recording drum **1**, the magnet drum **6** is driven in the counterclockwise direction to supply the powdery developer **5** to the surface of the recording drum **1** carrying the latent image so that the toner attached to that surface to form a powder image **8**.

When the recording sheet **9** driven by another driving source is fed to make rolling contact with the recording drum **1** carrying the powder image **8**, the powder image **8** is transfer printed onto the recording sheet **9**, since the electrostatic charger **16** applies to the recording sheet **9** an electrostatic force which is greater than the electrostatic force between the latent image and the recording drum **1**. The toner transferred to the recording sheet **9** is then heated by the heater **17** to be fused so that it is firmly attached to the recording sheet **9**. The residual charge eraser **18** removes the charge carried by the toner remaining on the recording drum **1** without being transferred to the recording sheet **9** and erases or neutralizes the residual charge on the resin layer **2** covering the surface of the recording drum **1**, thereby eliminating any adverse effect on the next recording operation.

The need for cleaning is unnecessary by virtue of the provision of the residual charge eraser **18** which will be described with reference to FIGS. **7** and **8**.

As shown in FIG. **7a**, a signal voltage is applied through the recording stylus **3** to the recording drum **1**, which is made from a conductive material having a small insulation resistance and is provided on its surface with the layer **2** of a non-adhesive and highly heat-resistive resin, and thus a laten image (shown by + in FIG. **7a**) corresponding to the signal is formed on the recording drum **1**. Then, as shown in FIG. **7b**, the magnet drum **6** carrying thereon the powdery developer **5** which is a mixture of a carrier such as iron powder and a toner makes friction contact with the surface of the recording drum **1** carrying the latent image theeon. As a result, the toner **20** of the polarity opposite to the polarity of the latent image attached to the recording drum **1** to form a visible image (powder image) **8** in the manner described above.



In FIG. **7c** showing the step of transfer printing under heat, the recording sheet **9** heated by the heating drum **10** is brought into rolling contact with the recording drum **1** carrying the powder image **8** thereon. Since the recording drum **1** having the toner **20** attached thereto is provided on its surface with the non-wetting, non-adhesive, a highly heat-resistive and electrically insulating resin layer **2**, the toner **20** forming the powder image **8** is easily transferred onto the recording sheet **9** heated by the heating drum **10** and is fused to become firmly attached to the recording sheet **9**. Then, when the recording sheet **9** is pulled away from contact with the recording drum **1**, the information is transfer printed onto the recording sheet **9** to provide a permanent image **21** as shown in FIG. **7d**.

The recording is carried out in this manner. When, however, the temperature of the heating drum **10** is too high and the recording sheet **9** is kept pressed against the recording drum **1** for a length of time far greater than is required, a portion of the toner may adhere to the recording drum **1** as shown by **20'** in FIG. **7e**. When, on the other hand, the temperature of the heating drum **10** is to low and the recording sheet **9** is pressed against the recording drum **1** for a length of time far less than is required, the toner **20** would not be substantially transferred to the recording sheet **9** and the greater portion of the toner **20** may remain on the recording drum **1**. In both of these cases, not only the quality of the image (permanent image **21**) to be recorded is extremely degraded, but also the toner portion **20'** which is firmly attached to or that remains on the surface of the recording drum **1** affects adversely the suceeding recording operation and the formation of a latent image so that satisfactory recording cannot be carried out.

In the common xerography system, therefore, means such as a soft brush of wool is employed to forcedly remove the toner portion **20'** remaining on the recording drum **1**. However this requires a very complex mechanism and yet the toner portion **20'** cannot be easily removed. Further, due to the fact that the charge of the latent image still remains on the recording drum **1** even though the toner portion **20'** remaining on the recording drum **1** is removed, the toner **20** may become attached to the previously formed latent image portion during the developing step in the next recording operation, thereby giving rise to a disturbance of the next image.

The above defects are overcome by the present invention in which the residual charge eraser **18** for erasing the charge stored on the latent image and the remaining toner portion **20'** on the recording drum **1** or for charging them slightly in the opposite polarity is disposed opposite to the recording drum **1** and is arranged to move in a direction shown by the arrow in FIG. **8a** while being applied with a suitable A.C. voltage or a D.C. voltage of the polarity opposite to that of the signal voltage. Thus, when the residual charge eraser **18** moves over the recording drum **1**, the charge carried by the latent image and the toner portion **20'** still remains on the recording drum **1** after the transfer printing is completely removed or the latent image and the toner portion **20'** are slightly charged to a polarity opposite to the polarity of the signal voltage. In the next recording operation, information transmitted through the recording stylus **3** is formed as a latent image of charge on the recording drum **1** carrying the remaining toner portion **20'** which is free from any charge as

shown in FIG. **8b.** Then, when the magnet drum **6** carrying thereon the powdery developer **5** which is a mixture of iron powder and the toner makes rubbing contact with the surface of the recording drum **1** as shown in FIG. **8c,** the toner portion **20'** is rubbed away from the recording drum **1** by the magnet drum **6** and the toner **20** in the powdery developer **5** is solely attached to the surface of the recording drum **1** carrying the latent image as the toner portion **20'** is free from any charge.

Thus, the portion of the toner **20'** which still remains after the developing step can be completely removed and a satisfactory recorded image can be obtained without any undesirable disturbance to the image by the preceding record. In the step of the transfer printing under heat as shown in FIG. **8d;** the temperature of the heating drum **10** and the length of time of the pressure contact between the recording drum **1** and the recording sheet **9** may be suitably selected so as not to cause the firm attachment of the toner **20** to the recording drum **1.** Thereafter, the recording sheet **9** is stripped off the recording drum **1** as shown in FIG. **8e.** Any toner portion **20'** remaining on the recording drum **1** does not adversely affect the nest record.

Although the charge carried by the latent image and the toner portion **20'** on the recording drum **1** is removed by the residual charge eraser **18** in FIG. **8a,** the charge may be removed prior to the transfer printing of the image onto the recording sheet **9,** that is, immediately after the step shown in FIG. **8c** so as to facilitate the transfer printing of the image onto the recording sheet **9.** Further, although the above description has referred to the method of transfer printing under heat, it will be apparent that the same applies to the method of electrostatic transfer printing in which an electrostatic charge is applied to the recording sheet **9** for electrostatically transferring the toner **20** on the recording drum **1** onto the recording sheet **9.**

A practical apparatus according to the present invention will be described with reference to FIGS. **4** through **6.** The apparatus includes a base **101** having a pair of stands **102** and **103** upstanding from opposite end portions thereof. End plates **104** and **105** are firmly secured to the respective stands **102** and **103.** As best shown in FIG. **6,** a toner casing **106** contains therein a mass of a powdery developer **111,** and a magnet drum **109** and a sweeping plate **110** are disposed within the toner casing **106.** The magnet drum **109** is composed of a drum member **107** of brass or like material and a plurality of magnets **108** for rubbing, embedded in the outer peripheral portion of the drum member **107** and having an axial length equal to the length of the drum member **107.** The shaft **112** of the magnet drum **109** carries a sprocket **113** at one end thereof, and a chain **114** engages the sprocket **113** to drivingly connect the shaft **112** with a motor **115.** A recording drum **116** is covered on its surface with a layer **156** of resin material of the kind previously described. One end of the shaft **117** of the recording drum **116** is journaled in a bearing **118** and connected to a motor **120** through a coupling **119,** while the other end of the shaft **117** is provided with a clutch **122** and is received in a bracket **121.** A lead screw **123** for a scanner **125** carrying a recording stylus **124** is rotatably supported at one end thereof by the end plate **105** and at the other end by the end plate **104.** A motor **126** drives the lead screw **123** through a gear train such that a gear **127** mounted on one end of the lead screw **123** meshes with a gear **128** and a gear



**129** coaxial with the gear **128** meshes with a gear **130** mounted on the shaft of the motor **126.** The scanner **125** is mounted on a slide rod **131** and a guide **132** so as to be slidable in the axial direction of the recording drum **126.** One end of the slide rod **131** is connected to the end plate **104** through a spring **133** and a holder **134,** while the other end of the slide rod **131** is connected to the end plate **105** through a connecting rod **135** and a rotary solenoid **136.** A rope **137** is anchored at one end thereof to a hook **138** provided at the lower portion of the scanner **125** and at the other end to a spool **141** mounted on a spool shaft **140** through an idler **139.**

A residual charge eraser **142** includes an electrode **143** which is supported by an electrical insulator **144** in such a manner that one end thereof is opposite to the recording drum **116.** The electrical insulator **144** supporting the electrode **143** is covered by a metal cover **145.** The charge eraser **142** is firmly secured at opposite ends to the end plates **104** and **105** through L-shaped members **146.** An electrostatic charger **147** is disposed adjacent to the reverse side of a recording sheet **150** which makes rolling contact with the recording drum **116** by being guided by guide rollers **148** and **149.** The electrostatic charger **147** includes a central discharge electrode **151** of piano wire of the like and a casing **153** securely fixed to a side plate **154.** The casing **153** is provided with an opening **152** opposite to the recording drum **116.**

The scanner **125** having the recording stylus **124** makes a sliding movement so that the recording stylus **124** contacts the recording drum **116** at the topmost portion of the latter. The recording stlyus **124** can swing through an angle $\theta$ by means of a holder **155** mounted on the slide rod **131** so that it can be moved a certain distance away from the surface of the recording drum **116** when not in use.

In operation, when an information signal is transmitted to the recording stylus **124,** the scanner **125** is moved rightwardly from the left in FIG. **4** as the lead screw **123** is rotated so as to make a scanning movement over the insulating resin layer **156** covering the surface of the recording drum **116.** Upon completion of the scanning of a record, the scanner **125** is pulled back to its leftward position by the spool **141** mounted on the spool shaft **140** and the rope **137** anchored to the spool **141.** At this position of the scanner **125,** the holder **155** swings through the angle $\theta$ to urge the recording stylus **124** away from the recording drum **116** by a certain distance. Then, the magnet drum **109** in the toner casing **106** is rotated clockwise or in a direction of the arrow R in FIG. **6** so that the powdery developer **111** attaches to the outer peripheral surface of the magnet drum **109** to constitute a magnet brush and the powdery developer **111** is attached to the latent image portion on the surface of the recording drum **116.**

After complete development of the latent image on the surface of the recording drum **116,** the recording sheet **150** is fed through the guide roller **148** to be brought into pressure contact with the recording drum **116,** and at the same time, the charger **147** applies a charge to the recording sheet **150** so that the toner becomes attached to the surface of the recording drum **116** and is electrostaticallly transferred onto the recording sheet **150.** Subsequently, the recording sheet **150** is stripped off the recording drum **116** by the action of the guide roller **149,** and a heater applies heat to the recording sheet **150** to fix the image. Upon comple-

tion of the transfer printing, the charge eraser **142** erases the charge carried by the toner and latent image on the surface of the recording drum **116.** More precisely, upon completion of the step of transfer printing, a high D.C. or A.C. voltage is applied to the charge eraser **142** with the result that the electrode **143** applies a corona discharge to the recording drum **116** to neutralize or erase the charge on the recording drum **116,** thereby completing all the steps for recording.

FIG. **9** A is a schematic view of a color copying apparatus for obtaining a color print by the use of an apparatus as shown in FIGS. **4** through **6.**

Referring to FIG. **9,** a multiple color signal produced at the transmitting side is transmitted by way of a transmission line **201** to a demodulator **202** where the color signal is demodulated and separated into primary color signals which are then fed to the respective amplifiers **203** for magenta (M), **203'** for cyan (C) and **203''** for yellow (Y). An electrostatic recording stylus **204** is adapted to be applied with the voltage of the primary color signal delivered from the amplifier **203.** The recording stylus **204** is made from a metal material possessing high flexibility and high resistance to wear and may be tungsten wire, piano wire or the like. The recording stylus **204** has a diameter corresponding to the density of the scanning lines for recording and the diameter is of the order of 80 to 90 $\mu$ when, for example, the scanning line density is about 10 lines per mm.

A recording drum **205** is composed of a drum member of a rust-free metal such as brass, stainless steel or aluminum, and a surface layer of a heat-resistive, non-adhesive, electrically insulating resin of the kind previously described. The thickness of the resin coating on the metal drum lies in the range of about 6 to 7 $\mu$ when it is used with an electrostatic recording sheet. However, in order that the resin coating can endure tens of thousands of recordings, the thickness is preferably slightly larger than the above value and experiments proved that a thickness of 20 to 30 $\mu$ is preferable. In lieu of coating the resin to obtain the resin layer, a sheet of such resin may be bonded to the surface of the metal drum.

The three recording drums **205, 205'** and **205''** have the same size and are mounted for fine adjustment so that the center-to-center spacing therebetween can be adjusted to the circumferential length l of the drum **205.** The recording styli **204, 204'** and **204''** are adjustably mounted so that they can be disposed in symmetrical positions relative to the respective recording drums **205, 205'** and **205''**. The recording drums **205, 205'** and **250''** rotate in the direction of the arrow in FIG. **9** in synchronism with a signal sent from a motor $M_1$. The recording styli **204, 204'** and **204''** are movable at a suitable speed in a direction parallel with the axes of the recording drums **205, 205'** and **205''**, and this is done by a motor $M_2$ and a feed mechanism. A magnet drum **207** for development has the same length as the recording drum **205** and is disposed within a developing tank **206.** There are other two similar tanks **206'** and **206''** having therewithin respective magnet drums **207'** and **207''**. The three developing tanks **206, 206'** and **206''** contain therein a powdery developer **208** for magenta, a powdery developer **208'** for cyan and a powdery developer **208''** for yellow, respectively.

After the recording is done on the recording drums **205, 205'** and **205''**, a motor $M_3$ causes rotation of the magnet drums **207, 207'** and **207''** so as to simultaneously carry out the developing of the three primary colors. It is so devised that, when the developing unit is not in operation, the magnet drum **207** is rotated in the reverse direction so that the cooperating doctor plate scrape the powdery developer **208** off the surface of the magnet drum **207** or the developing unit itself is lowered to a predetermined lower position so that the surface level of the powdery developer **208** contained in the tank **206** is spaced away from the recording drum **205.**



A charge eraser **209** is composed of a metal casing having an opening at one side thereof and an electrically insulated wire of very small diameter, of the order of, for exmaple, 0.06 mm. A high A.C. voltage of about 5 and 10 kV is applied to the wire to ionize the ambient air to thereby neutralize the charge carried by the recording drum **205** by means of the ionized ambient air. When it is desired to erase the charge in a short length of time, it is effective to apply a high D.C. voltage of polarity opposite to the polarity of the recording voltage (400 to 700 V peak-to-peak) in lieu of the high A.C. voltage. In the case of the recording signal voltage of about + 500 V peak-to-peak, it was possible to erase the charge to an extent that the charge did not obstruct the next recording by applying a high D.C. voltage of about −5 to −6 kV for about 3 seconds.

A hot plate **210** is provided with a heater **211** and suitable clamping means **213** for clamping a recording sheet **212** in flat relation on the lower surface of the hot plate **210.** The recording sheet **212** onto which powder images are transfer printed has a size equal to the surface area of the recording drum **205.** An effect similar to the above may be obtained by employing, in lieu of the hot plate **210,** a hot roller of the kind previously described to press the recording sheet **212** against each of the recording drums **205, 205' 205''** while heating the sheet **212** so that the sheet **212** makes rolling contact with the powder image on each of the recording drums **205, 205'** and **205''**. The recording sheet **212** clamped onto the hot plate **210** is heated by the heater **211** to a temperature which is slightly higher than the melting point (commonly about 100° to 120° C.) of the toners electrostatically attracted onto the surface of the recording drums **205, 205'** and **205''**. The recording sheet **212** carried by the hot plate **210** is moved in a direction of the arrow in FIG. **9** by a parallel feed mechanism (not shown) while successively making rolling contact with the surface of the recording drums **205, 205'** and **205''**.

In operation, a multiple color signal transmitted to the demodulator **202** by way of the transmission line **201** is separated into primary color signals by the demodulator **202** and the primary color signals are supplied to the respective amplifiers **203, 203'** and **203''**. The color signals are recorded on the surface of the recording drums **205, 205'** and **205''** by combination of the synchronous rotation of the recording drums **205, 205'** and **205''** and the axial movement of the recording styli **204, 204'** and **204''**.

Upon completion of the recording, the developing units **206** – **208, 206'** – **208'** and **206''** – **208''** are actuated to develop the electrostatic latent images on the recording drums **205, 205'** and **205''** with the respective colors. The patterns developed on the recording drums **205, 205'** and **205''** are so set that the junction thereof comes to the topmost portion of each of the recording drums **205, 205'** and **205''**. As the hot plate **210** carrying the recording sheet **212** is advanced

in the direction of the arrow while making rolling contact with the recording drum **205,** the toner of magenta on the recording drum **205** is fused by the heat and the fused toner is transferred onto the surface of the recording sheet **212** because the recording sheet **212** is more adhesive than the surface of the recording drum **205.**

After the toner of magenta on the recording drum **205** is transferred onto the recording sheet **212,** the toner of cyan on the next recording drum **205'** is transferred under heat onto the recording sheet **212,** and similarly the yellow toner on the succeeding recording drum **205''** is transferred under heat onto the recording sheet **212.** The color image of magenta transfer printed under heat onto the recording sheet **212** would not be transferred onto the recording drums **205'** and **205''** for cyan and yellow because the latter toners are less adhesive than the former toner, and there is completely no fear that intermixing of the toners will take place on the recording drums.

After the step of transfer printing, electrostatic residual charge images remain on the recording drums **205, 205'** and **205''** although the toner images on these recording drums have been 100 percent transfer printed onto the recording sheet **212.** Therefore, the charge erasers **209, 209'** and **209''** utilizing the corona discharge are energized to erase the residual charge images so that the next recording cycle can be immediately started.

The above manner of transfer printing is advantageous in that the color image transfer printed onto the recording sheet **212** has a satisfactory quality owing to the fact that the transfer printing of the toner images and the fixing under heat can be simultaneously effected and the color image is subject to the ferrotype effect because of the flatness and smoothness of the surface of the recording drums **205, 205'** and **205''**.

The toners employed have commonly a melting point of the order of 100° ± 10°C. Thus, in order to rapidly carry out the transfer printing by heating, it is necessary that the temperature of the recording sheet **212** is higher by about 50° to 100° C. than the melting point of the toners because the heat of the recording sheet **212** is absorbed by each of the recording drums **205, 205'** and **205''** and a reduction in the temperature of the recording sheet **212** results.

The resin layer of each of the recording drums **205, 205'** and **205''** is required to be sufficiently resistive to heat so that it can withstand such a temperature. However, the metal drum constituting the body of each recording drum **205, 205'** , **205''** may have a large heat capacity and the resin layer may have a small thickness so as to suppress the temperature rise at the surface of the resin layer to a low value thereby to prevent the fused toners from adhering to the surface of the recording drums.

The recording sheet **212** has commonly a thickness of the order of 60 to 100 $\mu$ and it is desirable that the temperature of the hot plate **210** and the time rate of advancing movement of the hot plate **210** in rolling contact with the recording drum be adjusted depending on the thickness of the recording sheet **212.** An experiment was carried out using a recording drum of **24** — **24** stainless steel, a resin layer of tetrafluoroethylene 20 $\mu$ thick, and a recording sheet 60 $\mu$ thick. The experiment proved that the best results can be obtained when the recording drum **205** is rotated at a rate of about 10 to 15 seconds in the case where the temperature of the hot plate was 180° C. and at a rate about 5 to 10 seconds in the case when the temperature of the hot plate was 230°C.



The length of time of the above extent required for the transfer printing under heat does not offer any substantial problem under the conditions for obtaining a color print and thus a great reduction in time can be realized compared with the prior art color printing method which includes repeating the cycle of successively recording, developing and fixing different colors.

While the above description has referred to the case of obtaining a color print of three primary colors, it is preferable to increase the number of colors in order to obtain a print with a better reproduction of colors. Where it is desired to obtain a multi-color print including still more colors, a plurality of units each consisting of the recording drum **205,** recording stylus **204,** amplifier **203,** developing unit **206 – 208** and residual charge eraser **209** may merely be additionally provided.

Further, although the above description has referred to the case in which the recording drums **205, 205'** and **205''** are spaced from each other at a distance equal to the circumferential length thereof for the convenience of explanation, these recording drums can be actually disposed very close to each other by arranging them in such a way that the leading end of the recording sheet **212** always registers with the marginal edge of a pattern when making rolling contact with the recording drum. If, for example, a recording sheet with a size of Japanese Industrial Standards, B **5** (182.0 × 257.0 mm) is employed and the scanning direction is along the shorter side of the sheet, the spacing between the three recording drums **205, 205'** and **205''** can be reduced to about 180 mm.

The present invention described above is analogous to the xerography technique in which a latent image in the form of an electrical charge is formed on a drum of photoconductive selenium by optical means, and after developing the image with a toner, the toner image is transfer printed onto a recording sheet. However, the drum of photoconductive selenium in xerography is very easily damaged, hence expensive, and requires complex handling, and a drum cleaning means is indispensably required because the toner image still remains on the drum after it has been transfer printed onto a recording sheet. In contrast to xerogrphy, any such cleaning means is not required in the present invention and the recording drum can be easily handled since the resin layer on the surface of the recording drum can be simply provided and is inexpensive. Furthermore, inexpensive plain paper can be used as a recording sheet for obtaining a print of a pattern and a color print can also be obtained with such plain paper.

We claim:

**1.** An apparatus for recording an image by transfer printing comprising a recording drum composed of a drum member of conductive metal and a layer of resin covering the surface of said drum member, said layer having a breakdown voltage of not less than 1 KV, a volume resistivity of more than $10^{14}\Omega$ cm, a surface resistivity of more than $10^{14}\Omega$ and no pinholes and preventing fused toner from attaching thereto, means for applying information [in the form of a signal voltage] *of the image* to the surface of said recording drum [through a recording electrode thereby] to form a latent image of an electrical charge on the surface of said recording drum, developing means for selectively supplying a powdery developer [through

the medium of a magnet drum ] to the latent image [ formed ] *to form a powder image* on *the surface of* said recording drum, heating means for applying heat to a recording sheet, and means for transfer printing the powder image [ that is selectively attached to the latent image portion ] on *the surface of* said recording drum onto the heated recording sheet, and at the same time, fusing the powder to firmly fix *the* same to the recording sheet under heat.

**2.** An apparatus for recording an image by transfer printing as defined in claim **1**, in which said layer of resin is made of polyamide imide.

**3.** An apparatus for recording an image by transfer printing as defined in claim **1**, in which said developing means [ is further characterized by a support, ] *includes* a magnet drum which [ comprised ] *comprises a support and* rubber magnets having the same axial length as the support and being embedded radially in the outer peripheral portion of the support, a sweeping plate being engaged at a portion thereof with the outer surface of [ said ] *the* magnet drum for controlling the amount of the powdery developer [ supply ] *supplied* to [ the ] *said* recording drum, and a drive source for *selectively* rotating the magnet drum in [ either ] *both the* normal [ or ] *and* reverse *directions* [ direction ].

**4.** An apparatus for recording an image by transfer printing comprising a recording drum composed of a drum member of conductive metal and a layer of resin covering the surface of said drum member, said layer having a breakdown voltage of not less than 1 KV, a volume resistivity of more than $10^{14}$ Ω cm, a surface resistivity of more than $10^{14}$ [106] Ω and no pinholes and preventing fused toner from attaching thereto, means for applying information [ in the form of a signal voltage ] *of said image* to the surface of said recording drum [ through a recording electrode thereby ] to form a latent image of an electrical charge on the surface of said recording drum, developing means for selectively supplying a powdery developer [ through the medium of a magnet drum ] to the latent image [ formed ] *to form a powder image* on *the surface of* said recording drum, electrostatic charging means disposed adjacent to the back face of a recording sheet in contact with the [ powdery developer selectively attached to the latent image ] *powder image to be transfer printed*, and residual charge erasing means disposed opposite to said recording drum for removing the [ electrostatic force ] *electric charge* remaining on the surface of said recording drum after the powder image on *the surface of* said recording drum has been transfer printed onto the recording sheet so as to make it possible for the following information *of an image* to be applied to *the surface of* said recording drum without cleaning the [ powder image ] *powdery developer* remaining on the surface of [ the ] said recording drum [ after the recording sheet transfer printed ].

**5.** An apparatus for recording an image by transfer printing as defined in claim **4**, in which said layer of resin is made of polyamide imide.

**6.** An apparatus for recording an image by transfer printing as defined in claim **4**, in which said developing means includes [ a support, ] a magnetic drum which comprises *a support and* rubber magnets having the same axial length as the support and being embedded radially in the outer peripheral portion of the support, a sweeping plate being engaged at a portion thereof with the outer surface of [ said ] *the* magnet drum for



controlling the amount of the powdery developer [ supply ] *supplied* to [ the ] *said* recording drum, and a drive source for *selectively* rotating the magnet drum in [ either ] *both the* normal [ or ] *and* reverse [ direction ] *directions*.

**7.** An apparatus for recording an image by transfer printing comprising a plurality of sets each [ consisting of ] *including* a recording drum having a layer of resin covered [ in ] *on* the surface thereof, said layer having a breakdown voltage of not less than 1KV, a volume resistivity of more than $10^{14}$ [106] Ω cm, a surface resistivity of more than $10^{14}$Ω and no pinholes and preventing fused toner from attaching thereto, means for recording information *of the image* on the surface of said recording drum [ through the medium of electrostatic recording means thereby to form ] *in the form of* a latent image *of an electrical charge* on the surface of said recording drum, and means for developing the latent image, said sets being arranged side by side equal and corresponding to the number of required primary colors *of the image*, [ and demodulator ] means for separating a multiple color signal *of the image* into the respective primary color signals so that the primary color signals are *simultaneously* recorded on the *respective* [ surface ] *surfaces* of said recording drums by said *respective* recording means and then developed by said *respective* developing means and [ a recording sheet is successively brought ] *means for successively bringing a recording sheet* into contact with the *respective* [ surface ] *surfaces* of said recording drums for the transfer printing of the [ color ] *developed* images onto the recording sheet.

**8.** An apparatus for recording an image by transfer printing as defined in claim **7**, in which said layer of resin which covers each surface of said plurality of recording drums arranged side by side equal and corresponding to the number of required primary colors is made of polyamide imide.

**9.** An apparatus for recording an image by transfer printing comprising means for forming a latent image on a layer of resin and at a location opposite to the surface of a recording drum driven by an electric motor, said layer covering the surface of the recording drum and having a breakdown voltage not less than 1 KV, a volume resistivity of more than $10^{14}$Ω cm, a surface resistivity of more than $10^{14}$Ω and no pinholes and preventing fused toner from attaching thereto, developing means for selectively supplying a powdery developer to the latent image formed on *the surface of* the recording drum, means for transfer printing the developed image formed by the *powdery* developer selectively attached to the latent image onto a recording sheet contacting [ said ] *the* recording drum, and residual charge erasing means disposed opposite to [ said ] *the* recording drum for removing the electric charge remaining on [ said ] *the* recording drum without cleaning the surface of [ said ] *the* recording drum after the developed image has been transfer printed onto the recording sheet, in which said means for forming a latent image comprises a holder which is mounted on a slide rod so as to be movable in the axial direction of the recording drum and a recording [ stulus ] *stylus* which is mounted on the holder and one end of which contacts the surface of the recording drum only in the case of a signal voltage being applied, said developing means comprises a magnet drum which is housed in a casing and is mounted so as to be *selectively* rotatable in [ either ] *both the* normal [ or ] *and* reverse *direc-*

*tions* [ direction ] , a powdery developer which is supplied to the recording drum by the magnet drum only in the case of the latent image being developed and a sweeping plate which is engaged at a portion thereof with the outer surface of the magnet drum for controlling the amount of the powdery developer [ supply ] *supplied* to the recording drum in response to the rotating direction of the magnet drum, said means for transfer printing comprises [ a recording sheet which is



brought into contact with the recording drum by ] a guide roller *which brings the recording sheet into contact with the recording drum* and a charging means disposed on the back side of the recording sheet, and said residual charge erasing means comprises an electrode which is covered by a cover and one end of which is opposed to the recording drum *and the other end of which is supported by the cover* through an insulator.

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