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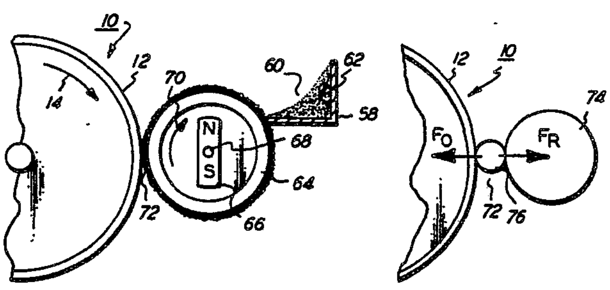
(54) A developer mixture.

(57) A developer mixture (62) for developing an electrostatic latent image comprises magnetic carrier granule (74) having toner particles (76) adhering triboelectrically thereto. The toner particles (76) comprise a non-magnetic portion with a magnetic portion integral therewith. The magnetic portion of a toner particle (76) is from about 1% to about 10%, preferably about 10%, of the volume of the toner particle. Apparatus and method for developing an electrostatic latent image using the developer mixture are also disclosed.



EP 0 057 585 A2

A DEVELOPER MIXTURE

This invention relates to a developer mixture for developing a latent electrostatic image. It also relates to apparatus and method for developing a latent electrostatic image using the developer mixture.

In electrophotographic printing, a light image of an original document is projected onto a charged photoconductive surface. This selectively dissipates the charge to record an electrostatic latent image of the original document on the photoconductive surface. The latent image is subsequently developed with toner particles. These toner particles are transferred to the copy sheet and permanently affixed thereto by the application of heat and/or pressure.

Generally, the developer material comprises toner particles adhering triboelectrically to carrier granules. This two-component developer mixture contacts the electrostatic latent image. The toner particles are attracted from the carrier granules to the latent image rendering it visible. Generally, the carrier granules are made from a ferromagnetic material the toner particles being made from a thermoplastic material.

Various methods have been devised for transporting the developer material to the latent image. For example, the developer material may be cascaded over the latent image and the toner particles attracted from the carrier granules thereto. Other structures employed to develop the latent image include the use of magnetic field producing devices which form brush-like tufts of developer material extending outwardly therefrom in contact with the photoconductive surface.

In developing an electrostatic latent image, the toner particles are deposited thereon. However, frequently the toner particles are not only deposited on the electrostatic latent image but on the background areas. When the toner particles are transferred from the photoconductive surface to the copy sheet, both the areas containing the electrostatic latent image and the backgound are transferred to the copy sheet. This produces a gray background significantly deteriorating the resultant copy. Furthermore, the toner particles frequently escape from the developer housing contaminating the other systems of the printing machine. Various techniques have been devised to overcome the foregoing problem.

U.S. Patent No 3 239 465 discloses a toner particle having magnetic particles held in a binder. The magnetic material may be magnetite or hemitite with the binder being an organic resin. The ratio of binder to magnetic particle can vary from 19 to 1 to 2 to 3 by weight. For best results, there should be at least 20% of the magnetic powder but not over 70%. U.S. Patent No. 3 345 294 describes developer powder which reduces the tendency of the toner to adhere to the background of the print. The toner comprises a polymide resin mixed with a coloring agent and a magnetic substance. The magnetic substance may be present in an amount as small as 1% by weight and preferably between about 5% and about 25% by weight of the developer powder. U.S. Patent No. 3 639 245 describes a dry ink made from magnetite blended with a resin and having carbon particles embedded therein.

In accordance with the present invention, a developer mixture for developing an electrostatic latent image is characterized by a magnetic carrier granule having a toner particle adhering thereto, the toner particle comprising a non-magnetic portion with a magnetic portion integral therewith. Preferably, the magnetic portion is from about 1% to about 10% of the volume of the toner particle, and is best about 10% of the volume of the toner particle.

The invention also provides an apparatus for developing a latent image, including a housing defining a chamber containing a supply of said developer mixture as described above and means operatively associated with the developer mixture in the chamber of said housing, for transporting the developer mixture closely adjacent to the latent image.

Further in accordance with the invention there is provided a method of developing an electrostatic latent image recorded on a photoconductive surface, including the steps of: storing a supply of developer mixture comprising a magnetic carrier granule, and a toner particle adhering to the carrier granule, the toner particle having a non-magnetic portion and a magnetic portion integral therewith, and transporting the developer mixture to a position closely adjacent to the latent image.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings, in which:-

Figure 1 is a schematic elevational view depicting an electrophotographic printing machine incorporating the features of the present invention therein;

Figure 2 is a fragmentary elevational view illustrating the developer unit employed in the Figure 1 printing machine;

Figure 3 is a fragmentary elevational view showing the arrangement of the forces on the developer mixture of the Figure 2 developer unit;

Figure 4 is a graph showing the force variation as a function of the percentage of magnetic material in the toner particles for toner particles having a low charge; and

Figure 5 is a graph depicting the force variation as a function of the percentage of magnetic material in the toner particles for toner particles having a high charge.

For a general understanding of an electrophotographic printing machine incorporating the features of the present invention therein, reference is made to Figure 1 which depicts schematically the various components thereof. Hereinafter, like reference numerals will be employed throughout to designate identical elements. Although the developer mixture of the present invention is particularly well adapted for use in the development system of an electrophotographic printing machine, it should become evident from the following discussion that this mixture is equally well suited for use in a wide variety of printing machines and is not necessarily limited to the particular embodiment shown herein.

Inasmuch as the art of electrophotographic printing is well known, the various processing stations for producing a copy of an original document are represented schematically in Figure 1. Each of these processing stations will be described briefly hereinafter.

With continued reference to Figure 1, the electrophotographic printing machine employs a drum 10 having a photoconductive surface 12 secured to the exterior circumferential surface of a conductive substrate. By way of example, photoconductive surface 12 may be made from a suitable selenium alloy with the conductive substrate being made from aluminum. Drum 10 rotates in the direction of arrow 14 so that successive portions of photoconductive surface 12 pass through the various processing stations disposed about the periphery thereof.

Initially, drum 10 rotates a portion of photoconductive surface 12 through charging station A. Charging station A includes a corona generating device, indicated generally by the reference numeral 16. Corona generating device 16 is located closely adjacent to photoconductive surface 12. When energized, corona generating device 16 charges a portion of photoconductive surface 12 to a relatively high substantially uniform potential.

The charged portion of photoconductive surface 12 is rotated to imaging station B. Imaging station B includes an exposure system, indicated generally by the reference numeral 18, comprising a transparent platen upon which the original document is disposed. Lamps illuminate the original document. Scanning of the original document is achieved by an oscillating mirror in a timed relationship with the movement of drum 10, or, in lieu thereof by moving the lamps and lens system in synchronism to form a flowing light image thereof. The light image of the original document is focused onto the charged portion of photoconductive surface 12. In this manner, photoconductive surface 12 is selectively discharged to record an electrostatic latent image thereon corresponding the informational areas contained within the original document.

Next, drum 10 rotates the electrostatic latent image recorded on photoconductive surface 12 to development station C. At development station C, a developer unit having a housing with a supply of developer mixture therein renders the electrostatic latent image visible. The developer mixture of the present invention includes magnetic carrier granules having toner particles adhering triboelectrically thereto. The toner particles comprise a non-magnetic portion and a magnetic portion. The magnetic portion is preferably about 10% of the volume of the toner particle. The detailed structure of developer unit 20 and the developer mixture employed therein will be described hereinafter with reference to Figures 2 through 5, inclusive. In general, the electrostatic latent image attracts the toner particles from the carrier granules to form a toner powder image thereon.

With continued reference to Figure 1, a sheet of support material is advanced by sheet feeding apparatus 22 to transfer station D. Sheet feeding apparatus 22 includes a feed roll 24 contacting the uppermost sheet of stack 26. Feed roll 24 rotates in the direction of arrow 28 to advance the uppermost sheet from stack 26. Registration rollers 30, rotating in the direction of arrow 32, advance and align the sheet of support material into chute 34. Chute 34 directs the advancing sheet of support material into contact with drum 10 in a timed sequence so that the toner powder image developed thereon contacts the advancing sheet of support material at transfer station D. Transfer station D includes a corona generating device 36. Corona generating device 36 sprays ions onto the side of the sheet of support material opposed from photoconductive surface 12. The toner powder image adhering to photoconductive surface 12 is then attracted therefrom to the surface of the sheet of support material in contact therewith. After transferring the toner powder image to the sheet of support material, endless belt conveyor 38 advances the sheet of support material to fusing station E.

Fusing station E includes a fuser assembly, indicated generally by the reference numeral 40. Fuser assembly 40 heats the transferred toner powder image to permanently affix the toner particles to the sheet of support material. Preferably, fuser assembly 40 includes a heated fuser roller 42 and a backup roll 44. A sheet of support material, with the powder image thereon, is interposed between fuser roll 42 and backup roll 44. The powder image contacts fuser roll 42. Release material applicator 46 applies release material to fuser roll 42. Blade 48, positioned closely adjacent to fuser roll 42, regulates the thickness of release material coating fuser roll 42. After the toner powder image is permanently affixed to the sheet of support material, stripper blade 50 separates the sheet from fuser roller 42. Thereafter, the sheet of support material is advanced by a series of rollers 52 to catch tray 54 for subsequent removal from the printing machine by the operator.

Invariably, residual particles remain adhering to photoconductive surface 12 after the transfer of the toner powder image to the sheet of support material. These residual particles are removed from photoconductive surface 12 at cleaning station F. Cleaning station F includes a cleaning mechanism, generally designated by the reference numeral 56, having a corona generating device and a brush contacting photoconductive surface 12. Initially, the particles are brought under the influence of the corona generating device to neutralize the charge remaining on photoconductive surface 12 and that of the residual particles. Thereafter, the neutralized particles are removed from photoconductive surface 12 by the rotatably mounted fibrous brush in contact therewith. After cleaning, a discharge lamp floods photoconductive surface 12 to return it to the initial level prior to the recharging thereof for the next successive imaging cycle.

Referring now to Figure 2 developer unit 20 is shown transporting the developer mixture into contact with the electrostatic latent image recorded on photoconductive surface 12 of drum 10.

As illustrated in Figure 2, developer unit 20 includes a housing 58 defining a chamber 60 for storing a supply of developer mixture 62 therein. Developer roller 64, mounted in chamber 60 of housing 58, preferably includes a tubular member made from a non-magnetic material such as aluminum. Tubular member 64 is interfit over an elongated magnetic member 66. Preferably, magnetic member 66 is a bar magnetic made from barrium ferrite. Magnetic member 66 is disposed interiorly of tubular member 64 and spaced therefrom. Shaft 58 made preferably from steel, is mounted concentrically within tubular member 64 to support magnetic member 66. A motor (not shown), coupled to tubular member 64, rotates tubular member 64 in the direction of arrow 70. Magnetic member 66 remains substantially stationary. As tubular member 64 rotates relative to magnetic member 66, developer mixture 62 is advanced from chamber 60 to development zone 72. A power supply (not shown) applies an electrical bias to tubular member 64. Preferably, the voltage applied to tubular member 64 is about 500 volts. However, this voltage level is adjustable and depends upon the background voltage level of photoconductive surface 12. In operation, developer mixture 62, in chamber 60 of housing 58, is attracted by the magnetic fields produced by magnetic member 68 to tubular member 64. As tubular member 64 rotates, the developer mixture moves into development zone 72. In development zone 72, the toner particles are attracted from the carrier granules disposed on tubular member 64 to the latent image recorded on photoconductive surface 12. In this way, the toner particles are deposited on the electrostatic latent image forming a toner powder image thereon. In order to minimize development of the background areas, the toner particles include a magnetic portion.

The carrier granules are magnetic and are preferably made from ferromagnetic materials such as magnetite or hemitite. The non-magnetic portion of the toner particle is made from fusable resin such as a polymide. Thus, the toner particles comprise a fusable resin with magnetic particles such as iron, magnetic iron oxide or magnetite, various magnetic metals and alloys, and the like dispersed therein. The magnetic portion of the toner particle comprise preferably 10% of the volume of the toner particle with the resin or plastic material comprising 90% of the toner particle by volume. However, it has been found that ranges of from 1 to 10% of magnetic material by volume improve development. Development is improved when the toner particle charge ranges from about 1 to about 20 microcouloumbs per gram. It is clear that the introduction of the magnetic portion in the toner particle suppresses background development and facilitates development of the electrostatic latent image. This produces sharper, darker copies. Furthermore, magnetic loading causes the toner particles to better adhere to the carrier granules reducing toner particle contamination and dirt throughout the printing machine.

Referring now to Figure 3, there is shown a schematic distribution of the forces involved in development of the electrostatic latent image. As depicted thereat, during development, developer mixture 62 is brought into the vicinity of photoconductive surface 12. Carrier granule 74 acts as a transport for toner particle 76. Toner particle 76 acquires charge through triboelectrification. This charge and the countercharges on carrier granule 74 produces adhesion force F_R between toner particle 76 and carrier granule 74. The internal magnetic field also induces a dipole in particle 76 which adds to F_R. As carrier granule 74 is transported into development zone 72 closely adjacent to and in contact with photoconductive surface 12, toner particle 76 is transported therewith. The electrostatic latent image recorded on photoconductive surface 12 produces an electrostatic field which exerts a stripping force F_D on toner particle 76. When stripping force F_D exceeds retaining force F_R, the toner particles leave carrier granules 74 and move to photoconductive surface 12. In this way, the electrostatic latent image is developed. It has been found that the magnetic portion of the toner particle causes the introduction of a magnetic dipole which adds to F_R. In this way, F_R is increased and the background forces on photoconductive surface 12 are insufficient to separate toner particles 76 from carrier granules 74. However, the fields introduced by the latent image produce a sufficient force to separate the toner particles from the carrier granules resulting in development of the electrostatic latent image with the background remaining substantially devoid of toner particles. In this way, background development is suppressed and electrostatic latent image development enhanced.

Referring now to Figure 4, there is shown the force attracting the toner particles produced by the background electrostatic field on the photoconductive surface as a solid line, i.e. the stripping force, and the force retaining the toner particle to the carrier granule as a dotted line for both 0% magnetic loading and 10% magnetic loading. Figure 4 depicts the foregoing conditions for a low charge toner particle, i.e. one having a 1 microcouloumb per gram charge thereon. As shown, when the magnetic loading is 10% by volume of the toner particle, the electrostatic force produced by the background area is never sufficient to strip the toner particle from the carrier granule.

Referring now to Figure 5, the holding force is once again shown as a dotted line for 0% and 10% magnetic loading with the stripping force being shown as a solid line. The graph depicted in Figure 5 is for a highly charged toner particle, i.e. one having a charge of 20 microcouloumbs per gram. Under these latter circumstances, there is an increase in the required background force necessary to electrostatically strip the toner particles from the carrier granules so as to develop the background areas. Thus, it is clear that magnetic loading of the toner particles produces a significant improvement when there are present toner particles with low charge and a minor improvement when the toner particles are highly charged.

In recapitulation, the present invention is directed to a developer mixture which may be employed to develop an electrostatic latent image. The developer mixture includes a toner particle having a non-magnetic portion and a magnetic portion with the magnetic portion being preferably about 10% by volume of the toner particle. A developer mixture of this type improves development by reducing background development while maintaining image development at a highly satisfactory level. In this way, contrast is improved. Furthermore, machine contamination due to the escape of toner particles from the developer housing is minimized.

CLAIMS:

1. A developer mixture for developing an electrostatic latent image, characterized by a magnetic carrier granule (74); and a toner particle (76) adhering to said carrier granule, said toner particle comprising a non-magnetic portion and a magnetic portion integral therewith.

2. A developer mixture according to claim 1 wherein the magnetic portion is from about 1% to about 10%, preferably about 10%, of the volume of said toner particle (76).

3. A developer mixture according to claim 1 or 2, wherein said toner particle (76) has a charge ranging from about 1 microcouloumb per gram to about 20 microcouloumbs per gram.

4. A developer mixture according to claim 3, wherein the non-magnetic portion of said toner particle (76) is made from a plastic material.

5. A developer mixture according to claim 4, wherein the magnetic portion of said toner particle (76) is made from a ferromagnetic material.

6. An apparatus for developing a latent image, including a housing (58) defining a chamber (60) containing a supply of developer mixture (62) according to any of claims 1 to 5 and means (64, 66) operatively associated with the developer mixture (62) in the chamber of said housing, for transporting the developer mixture closely adjacent to the latent image.

7. An apparatus according to claim 6, wherein said transporting means (64, 66) includes a rotatably mounted tubular member (64) and a magnetic member (66) disposed interiorly of said tubular member (64) for

attracting the developer mixture (62) to the exterior circumferential of said tubular member.

8. A method of developing an electrostatic latent image recorded on a photoconductive surface, including the steps of: storing a supply of developer mixture comprising a magnetic carrier granule, and a toner particle adhering to the carrier granule, and a toner particle adhering to the carrier granule, the toner particle having a non-magnetic portion and a magnetic portion integral therewith, and transporting the developer mixture to a position closely adjacent to the latent image.

9. A method according to claim 8, wherein the magnetic position of the toner particle is from about 1% to about 10%, preferably about 10%, of the volume of the toner particle.

10. A method according to claim 8 or 9, wherein said step of transporting includes the steps of attracting the developer mixture to the exterior circumferential surface of a tubular member and rotating the tubular member to advance the developer mixture to a position closely adjacent to the electrostatic latent image recorded on the photoconductive surface.

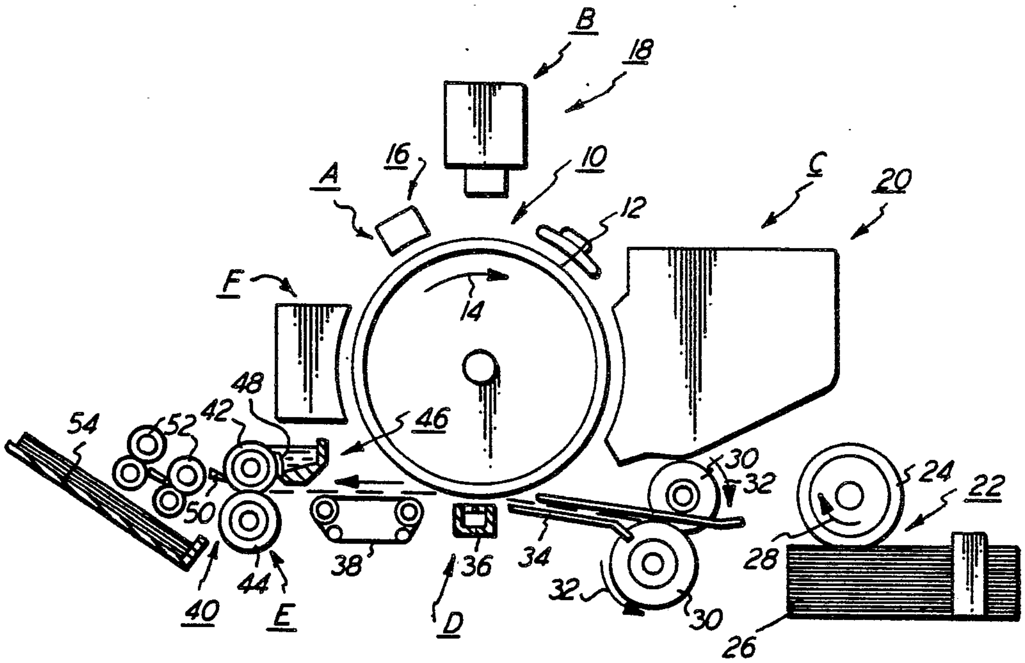


FIG. 1

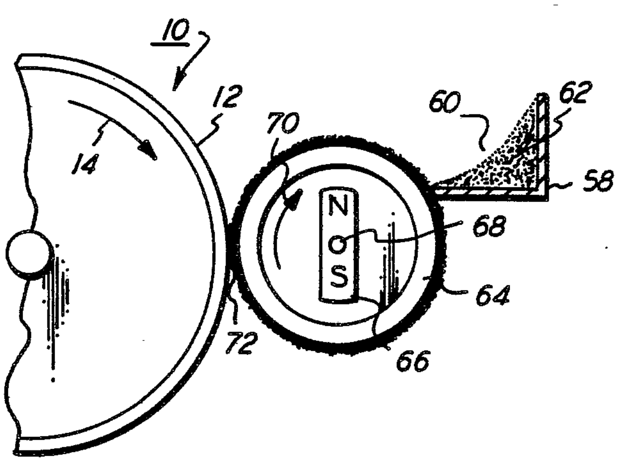


FIG. 2

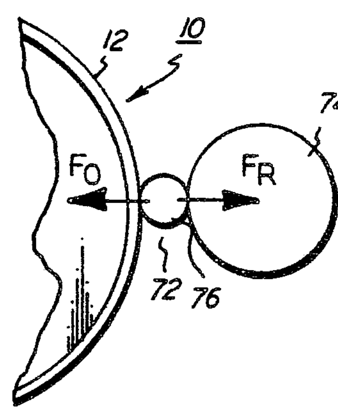


FIG. 3

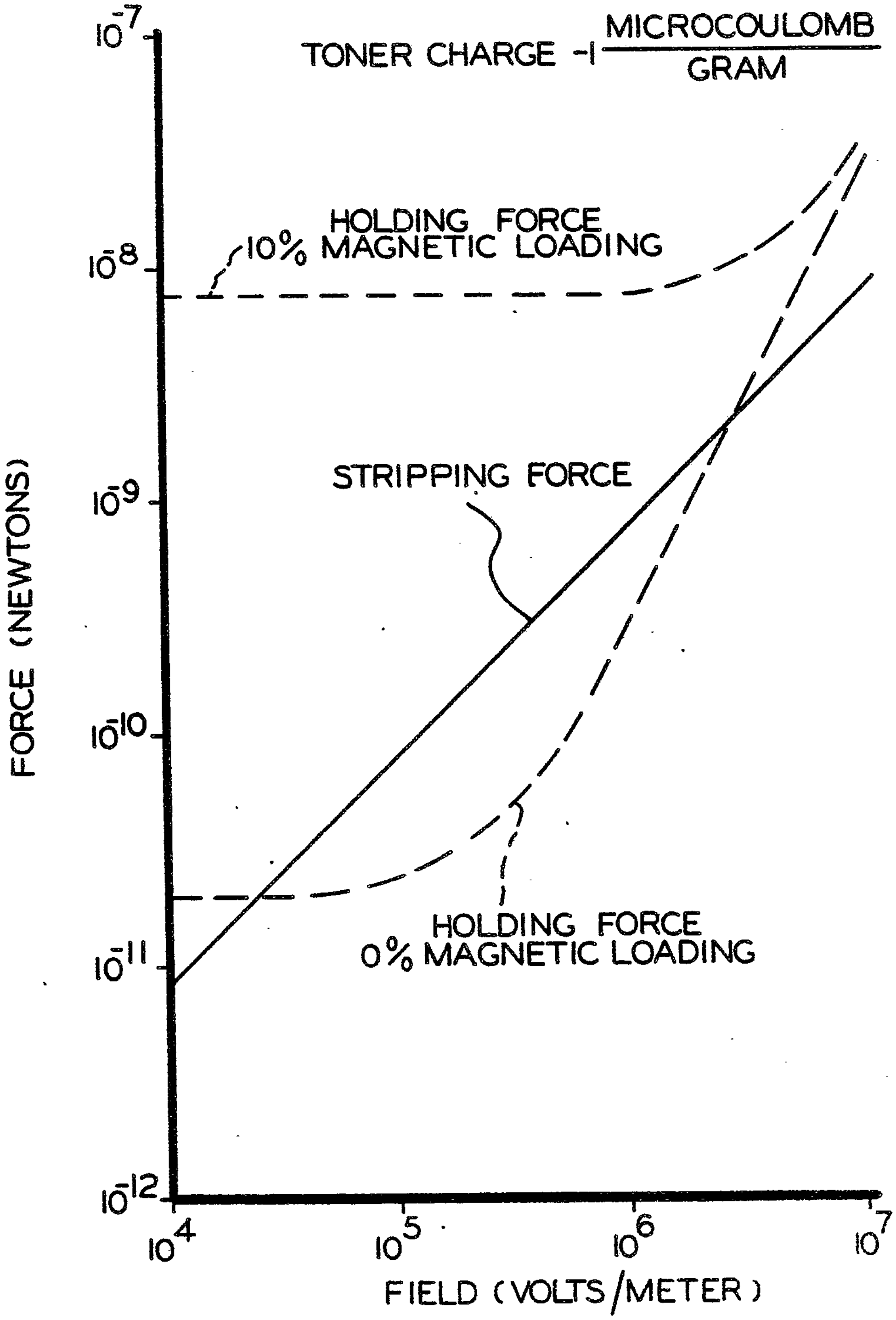

TONER CHARGE -1 MICROCOULOMB / GRAM
HOLDING FORCE
10% MAGNETIC LOADING
STRIPPING FORCE
HOLDING FORCE
0% MAGNETIC LOADING
FORCE (NEWTONS)
FIELD (VOLTS/METER)
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{4}
10^{5}
10^{6}
10^{7}

FIG. 4

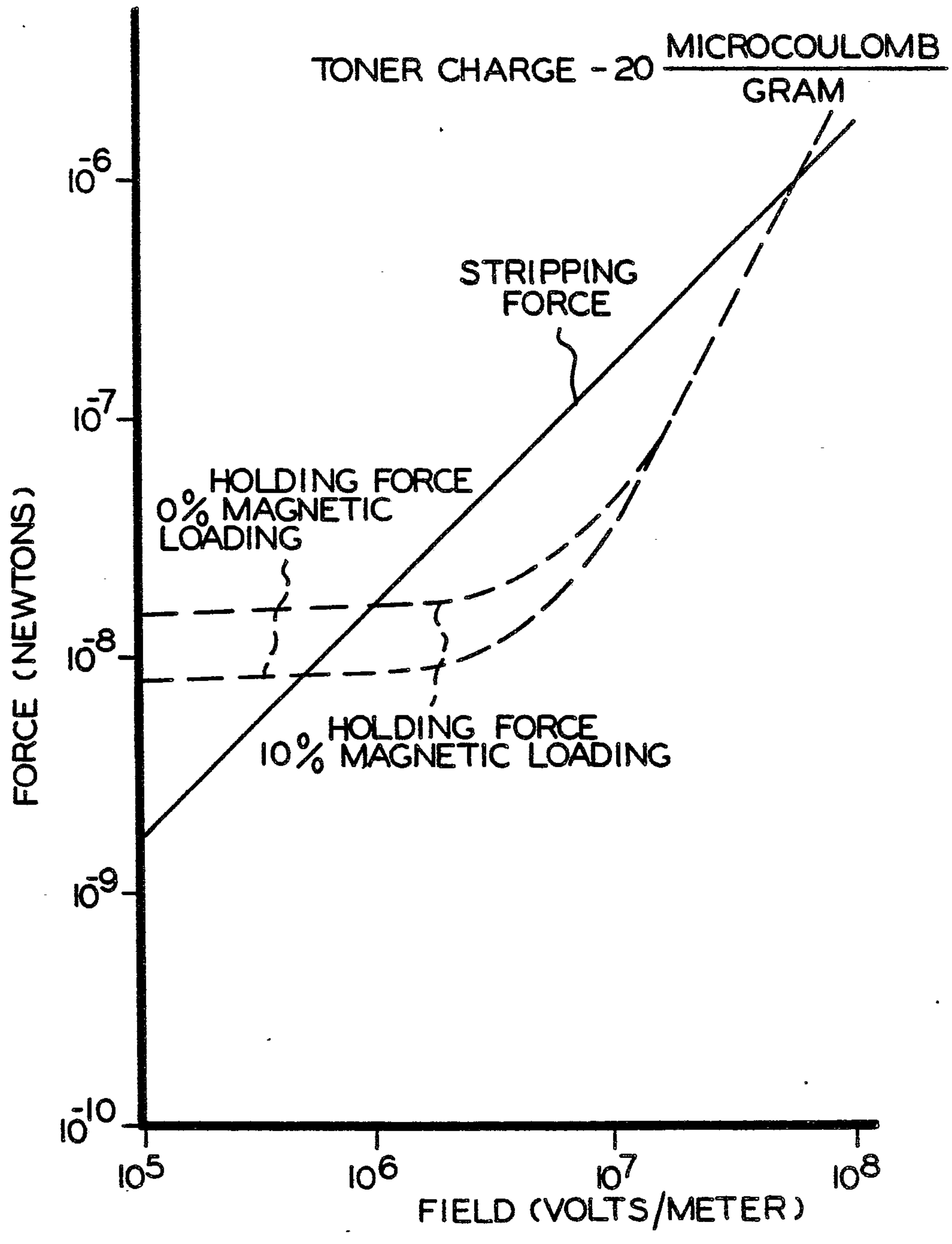

TONER CHARGE -20 MICROCOULOMB / GRAM
STRIPPING FORCE
HOLDING FORCE 0% MAGNETIC LOADING
HOLDING FORCE 10% MAGNETIC LOADING
FORCE (NEWTONS)
10-6
10-7
10-8
10-9
10-10
10^5
10^6
10^7
10^8
FIELD (VOLTS/METER)

FIG. 5