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(54) Development apparatus.

(57) An apparatus in which a latent image is developed with marking particles. The marking particles (50) are transported to the latent image by a donor roller (30). As the marking particles are being moved to the latent image, they are electrically charged by a blade (36) in contact with the donor roller. An AC potential is applied on the blade. The AC potential is operator adjustable to change the charge on the toner particles. This corrects for changes in the environment and permits the slope of the tone reproduction curve to be optimized for the latent image being developed.

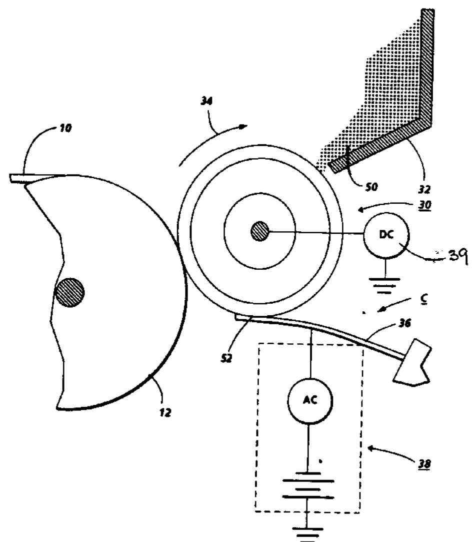

FIG. 2

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This invention relates generally to an electrophotographic printing machine, and more particularly concerns a development apparatus employed therein.

In an electrophotographic printing machine, a photoconductive member is charged to a substantially uniform potential to sensitize the surface thereof. The charged portion of the photoconductive member is exposed to a light image of an original document being reproduced. Exposure of the charged photoconductive member selectively dissipates the charge thereon in the irradiated area. This records an electrostatic latent image on the photoconductive member corresponding to the informational areas contained within the original document being reproduced. After the electrostatic latent image is recorded on the photoconductive member, the latent image is developed by bringing marking particles into contact therewith. This forms a powder image on the photoconductive member which is subsequently transferred to a copy sheet. The copy sheet is heated to permanently affix the marking particles thereto in image configuration.

Various types of development system have hereinbefore been employed. These systems utilize two component developer material or single component developer material. Two component developer material includes toner particles adhering triboelectrically to carrier granules. A single component development system uses only toner particles. In many of the single component development systems, the toner particles are conductive. However, the transfer of conductive toner particles to the copy sheet is usually inefficient. In order to overcome this problem, insulating toner particles are frequently employed. When insulating toner particles are utilized, it is necessary to charge these toner particles to the correct polarity. This may be achieved by employing a flexible blade in contact with a donor roller. As the donor roller transports the toner particles toward the latent image recorded on the photoconductive member, the toner particles pass through a nip defined by the flexible blade and the roll. The toner particles passing through this nip are triboelectrically charged. Furthermore, this nip defines the quantity of toner particles being transported on a roller to the latent image recorded on the photoconductive member.

In a printing machine, it would be advantageous to be able to print high quality pictorial images and text. It is desirable to be able either to print or to suppress the gray tones. Furthermore, the printing machine should also be capable of printing continuous tone or half tone pictorial images with a broader range of gray than is currently available. This is of particular significance for development systems having a tone reproduction curve with a very steep slope which limits the usefulness of electronic tone reproduction manipulation. In addition, it is desirable to have an operator adjustable system which enables tuning of the toner charge to compensate for environmental changes or any other changes.

The following disclosures may be of interest:

US-A-4,459,009
Patentee: Hays et al.
Issued: July 10, 1984

US-A-4,523,833
Patentee: Jones
Issued: June 18, 1954

US-A-4,619,517
Patentee: Ruhland
Issued: October 28, 1986

US-A-4,707,115
Patentee: Bares
Issued: November 17, 1987

The relevant portions of the foregoing disclosures may be briefly summarized as follows:

US-A-4,459,009 and US-A-4,619,517 disclose a development system having a donor roller which contacts a photoconductive surface to develop a latent image with insulating toner particles. An electrically biased charging roller meters the toner particles to the donor roller and imparts a charge thereon. A doctor blade removes wrong sign toner on the charging roller. For a positive toner charging system, the voltage applied to the charging roller varies from about + 25 volts to about + 200 volts.

US-A-4,523,833 describes a development apparatus having a developer roller with the free end portion of a blade resiliently urged into contact therewith. The blade has a plurality of holes. A voltage source is connected to the the blade and creates an electrical field at the holes. By adjusting the level of the voltage source, the intensity of the electrical field in the holes is controlled, and, in turn, the quantity of marking particles passing therethrough regulated.

US-A-4,707,115 discloses a development system in which a donor roller, which is electrically biased, contacts a photoconductive belt having an electrostatic latent image recorded thereon. A flexible steel blade has the free end thereof contacting the surface of the donor roller to define a nip therebetween through which the particles adhering to the donor roller pass. As the toner particles pass through the nip, the quantity of toner particles is regulated and the toner particles remaining adhering to the donor roller are triboelectrically charged.

In accordance with the present invention, there is provided an apparatus for developing a latent image with marking particles. The apparatus includes means for transporting the marking particles to the latent image. Means are provided for electrically charging the marking particles being moved to the latent image by the transporting means. Means apply an AC electrical potential on the charging means.

In accordance with another aspect of the present invention, there is provided an electrophotographic printing machine of the type having a photoconductive member on which an electrostatic latent image can be recorded. The printing machine includes means for transporting toner particles to the photoconductive member to develop the latent image therewith. Means are provided for electrically charging the toner particles being moved to the latent image by the transporting means. Means apply an AC electrical potential on the charging means.

By way of example only, an embodiment of the present invention will be described with reference to the accompanying drawings, in which;

Figure 1 is a schematic elevational view depicting an electrophotographic printing machine;

Figure 2 is a schematic elevational view showing the development apparatus of the Figure 1 printing machine in greater detail; and

Figure 3 is an exemplary tone reproduction curve.

In the drawings, like reference numerals have been used throughout to identify identical elements.

Figure 1 schematically depicts the various components of an illustrative electrophotographic printing machine incorporating development apparatus in accordance with the present invention. It will become evident from the following discussion that this development apparatus is equally well suited for use in a wide variety of electrostatographic printing machines, and is not necessarily limited in its application to the particular electrophotographic printing machine shown herein.

Inasmuch as the art of electrophotographic printing is well known, the various processing stations employed in the Figure 1 printing machine are shown schematically and their operation will be described only briefly.

As shown in Figure 1, the electrophotographic printing machine employs a belt 10 having a photoconductive surface deposited on a conductive substrate. Preferably, the photoconductive surface is made from a selenium alloy with the conductive substrate being made from an aluminum alloy. Other suitable photoconductive materials and conductive substrates may also be employed. Belt 10 is entrained about a pair of opposed, spaced rollers 12 and 14. Roller 14 is rotated by a motor coupled thereto by suitable means such as a drive belt. As roller 14 rotates, belt 10 advances the photoconductive surface, in the direction of arrow 16, through the various processing stations disposed about the path of movement thereof.

Initially, the photoconductive surface passes through charging station A. At charging station A, a corona generating device 18 charges the photoconductive surface to a relatively high, substantially uniform potential.

Next, the charged portion of the photoconductive surface is advanced through imaging station B where the light image of an original document 20 is projected onto the charged portion of the photoconductive surface. The original document 20 is positioned face down upon a transparent platen 22. Imaging of document 20 on platen 22 is achieved by an exposure system which includes a lamp 24, mirror 26, and moving lens 28. The exposure system is a moving optical system. The lamp, mirrors and lens move across the original document illuminating incremental widths thereof to form a light image. One skilled in the art will appreciate that instead of a light lens optical system, a raster input scanner (RIS) in combination with a raster output scanner (ROS) may be used. The RIS captures the entire image from the original document and converts it to a series of raster scan lines. The RIS contains document illumination lamps, optics,a mechanical scanning mechanism, and a photosensing element, such as charge coupled device (CCD array). The ROS, responsive to the output from the RIS performs the function of recording the electrostatic latent image on the photoconductive surface. The RIS lays out the latent image in a series of horizontal scan lines with each line having a certain number of pixels per inch. The ROS may include a laser, rotating polygon mirror blocks, and an modulator. Still another type of exposure system employs only a ROS. The ROS is connected to a computer and the document desired to be printed is transmitted from the computer to the ROS. In all of the foregoing systems, the charged photoconductive surface is selectively discharged to record an electrostatic latent image thereon. Thereafter, belt 10 advances the electrostatic latent image recorded on the photoconductive surface to development station C.

At development station C, a donor roller, indicated generally by the reference numeral 30, receives insulating, non-magnetic toner particles from a toner particle supply reservoir 32. As donor roller 30 rotates, in the direction of arrow 34, toner particles are advanced therewith through a nip defined by a flexible blade 36 having the the free marginal end region thereof in contact therewith. As the toner particles pass through the nip defined by blade 36 contacting donor roller 30, the toner particles thereon are triboelectrically charged. These charged toner particles are transported by donor roller 30 to the electrostatic latent image recorded on the photoconductive surface of belt 10. The electrostatic latent image attracts the toner particles from donor roller 30 to form a powder image thereon. In addition to triboelectrically charging the toner particles adhering to donor roller 30, blade 36 meters the quantity of toner particles being advanced to the electrostatic latent image. As shown, one end of blade 36 is mounted fixedly with the free marginal end region thereof being pressed into contact against the exterior circumferential surface of donor roller 30. Blade 36 is flexible. A voltage source, indicated generally by the reference numeral 38, electrically biases blade 36. Voltage source 38 applies an AC potential and a DC potential, or an AC potential alone. A voltage source 39 electrically biases donor roller 30. The AC electrical field changes the average charge level of the toner particles..Voltage source 38 is operator adjustable. Thus, the machine operator may vary the peak to peak AC voltage and/or the frequency to obtain the desired toner charge so as to optimize development for the type of document being printed. Further details of the system will be discussed hereinafter with reference to Figures 2 and 3.

With continued reference to Figure 1, after the electrostatic latent image is developed with toner particles, belt 10 advances the toner powder image to transfer station D. At transfer station D, a corona generating device 40 sprays ions onto the backside of copy sheet 42 positioned thereat. This attracts the toner powder image from the photoconductive surface of belt 10 to copy sheet 42. After transfer of the toner powder image to copy sheet 42, copy sheet 42 advances, in the direction of arrow 44, through fusing station E.

Fusing station E includes a heated fuser roller 46 and a back-up roller 48. The toner powder image on copy sheet 42 contacts fuser roller 46. In this manner, the powder image is permanently affixed to copy sheet 42. After fusing, copy sheet 42 is advanced by forwarding rollers through a chute to a catch tray where the operator removes the completed copy.

Referring now to Figure 2, the detailed structure of the development apparatus is shown thereat. Donor roller 30 has a fluoropolymer coating thereon. The coating covers the entire circumferential surface thereof. Generally, the coating has a thickness ranging from about 2 micrometers to about 125 micrometers and preferably ranges from about 10 micrometers to about 50 micrometers. Donor roller 30 may be made from any suitable material including, for example, aluminized Mylar coated with the fluoropolymer coating, a seamless extruded polymer sleeve coated with a polymer containing a conductive additive such as carbon black and overcoated with a fluoropolymer, or a bare electroformed nickel sleeve having a fluoropolymer coating thereover. Toner supply reservoir 32 has a supply of toner particles 50 therein. The toner particles 50 in reservoir 32 are weakly charged particles. Flexible blade 36 has the free end region 52 thereof contacting the surface of donor roller 30 to define a nip therebetween through which the particles adhering to donor roller 30 pass. In this way, as donor roller 30 rotates in the direction of arrow 34, toner particles 50 are advanced through nip 52. As the toner particles pass through the nip, the quantity of toner particles is regulated and the toner particles remaining adhering to donor roller 30 are triboelectrically charged. By way of example, blade 36 may be made from a strip of flexible steel. Donor roller 30 is electrically biased to a suitable magnitude and polarity by voltage source 39. Preferably, donor roller 30 is electrically biased to a voltage of from about + 75 volts to about + 350 volts, or from about -75 volts to about -350 volts. In this way, the toner particles adhering to donor roller 30 are electrostatically attracted to the latent image recorded on the photoconductive surface of belt 10. Further details of a development apparatus of the type described herein are disclosed in U.S. Patent No. 4,459,009 issued in 1984 to Hays et al.. Blade 36 is electrically biased by voltage source 38 to an AC potential and a DC potential or to an AC potential alone. The voltages and the spacing of the blade 36 from the roller 30 are chosen to limit the peak electric field in the nip to less than the Paschen limit for air break down. By way of example, blade 36, which is coated, may be electrically biased to an AC potential of 4,000 volts peak to peak at a frequency of 2,400 HZ, and to 100 volts DC. Alternatively, blade 36 may be electrically biased to 4,000 volts peak-to-peak at a frequency of 1,000 HZ, and 0 volts DC. A rod may be used in lieu of a blade 36 for charging/metering toner particles on donor roller 30.

Referring now to Figure 3, there is shown a graph of the tone reproduction curve. The slope of this curve is adjustable by the operator selecting the appropriate AC bias applied on charging blade 36. Adjusting the AC electrical bias on blade 36 changes the average charge level of the toner, thereby changing the slope of this curve. This enables printing or suppressing, as the case may be, of gray tones. By selecting the appropriate AC bias on charging blade 36, continuous tone or half tone pictorial images with a broad range of gray may be printed. In addition, by being able to adjust the toner charge, the toner charge may be adjusted for environmental conditions or other reasons. Furthermore, it has been found that the use of an AC bias increases the toner particle agitation in the metering/charging nip. This agitation reduces the toner size and/or charge distribution effects preventing the occurrence of history effects such as lower or higher density development.

In recapitulation, the described developer unit employs a charging blade to which an AC potential is applied. The potential is adjustable to change the charge on the toner particles. In this way, the slope of the tone reproduction curve may be adjusted to optimize development of the latent image.

Claims

1. Apparatus for developing a latent image with marking particles, including:
   means for transporting the marking particles to the latent image;
   means for electrically charging the marking particles being transported to the latent image by said transporting means; and
   operator adjustable means for applying an AC electrical potential to said charging means to adjust the charge on the marking particles.

2. Apparatus according to claim 1, wherein said transporting means includes a donor roller.

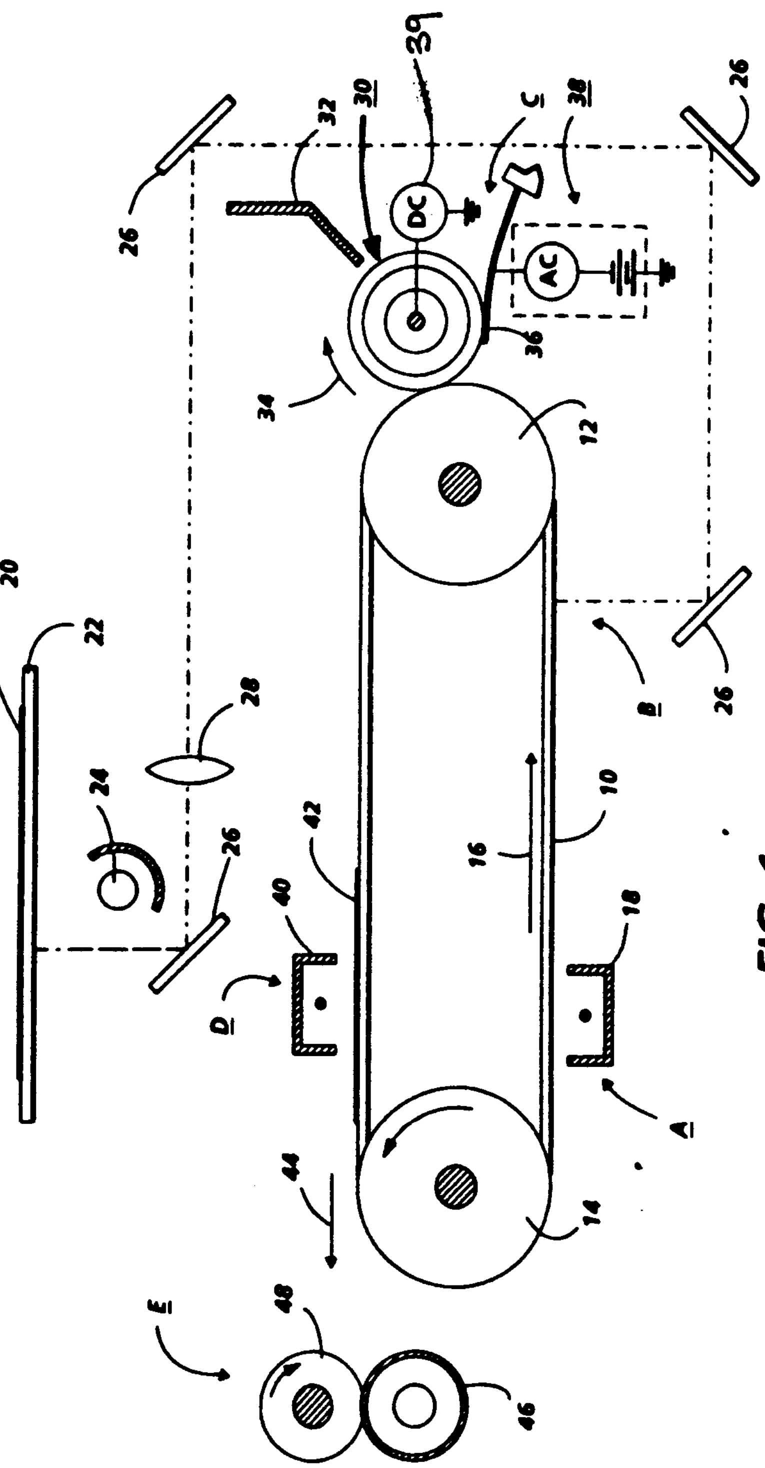
3. Apparatus according to claim 2, wherein said charging means includes a blade contacting said donor roller to define a nip through which the marking particles pass.

4. Apparatus according to claim 2, wherein said charging means includes a rod contacting said donor roller to define a nip through which the marking particles pass.

5. Apparatus according to any one of the preceding claims, further including means for applying a DC electrical bias to said charging means.

6. Apparatus according to any one of the preceding claims, wherein said charging means meters the quantity of marking particles being transported by said transporting means to the latent image.

7. An electrophotographic printing machine of the type having a photoconductive member, on which an electrostatic latent image can be recorded, wherein the machine includes apparatus according to any one of the preceding claims for developing a latent image on the photoconductive member.


DC
AC
39
30
32
26
C
38
34
36
12
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28
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42
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D
18
16
10
B
A
44
14
E
48
46

FIG. 1

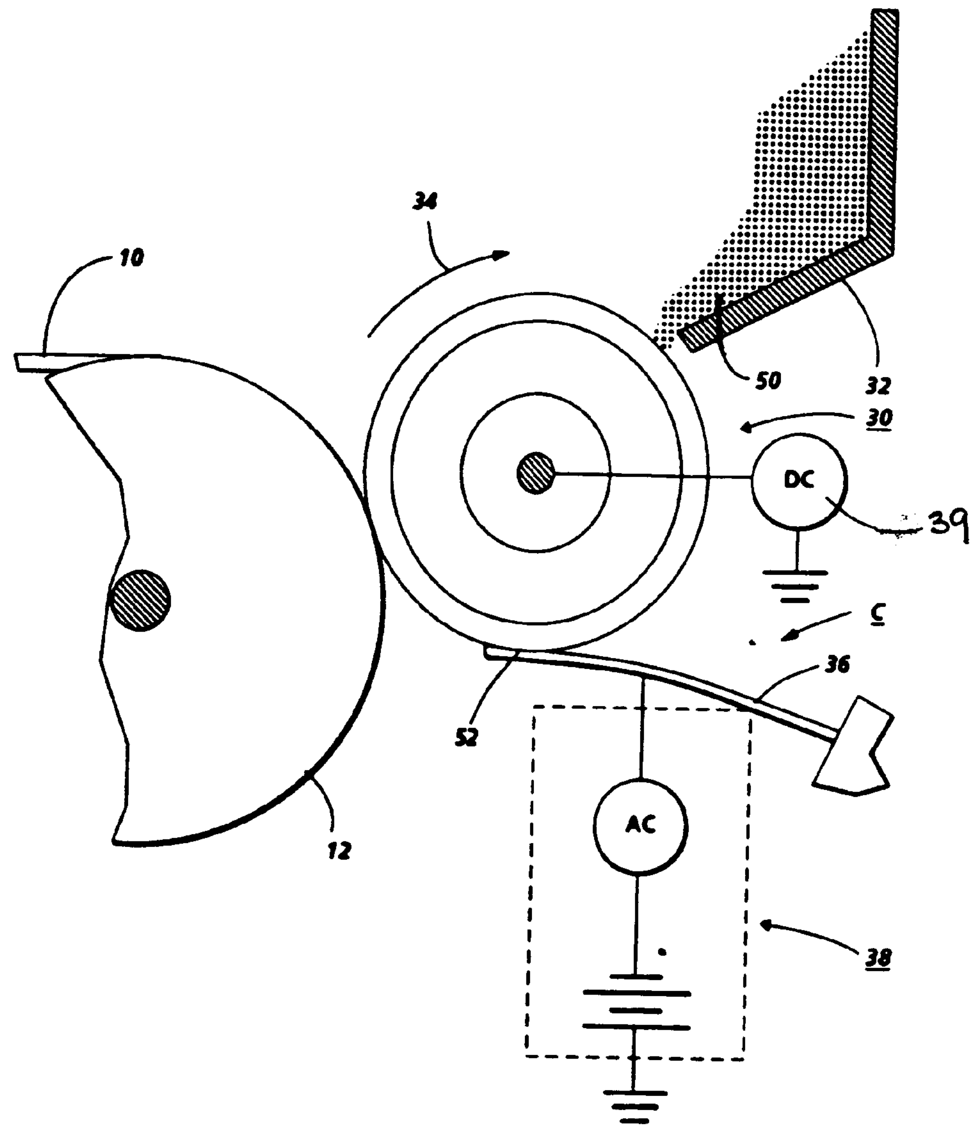

FIG. 2

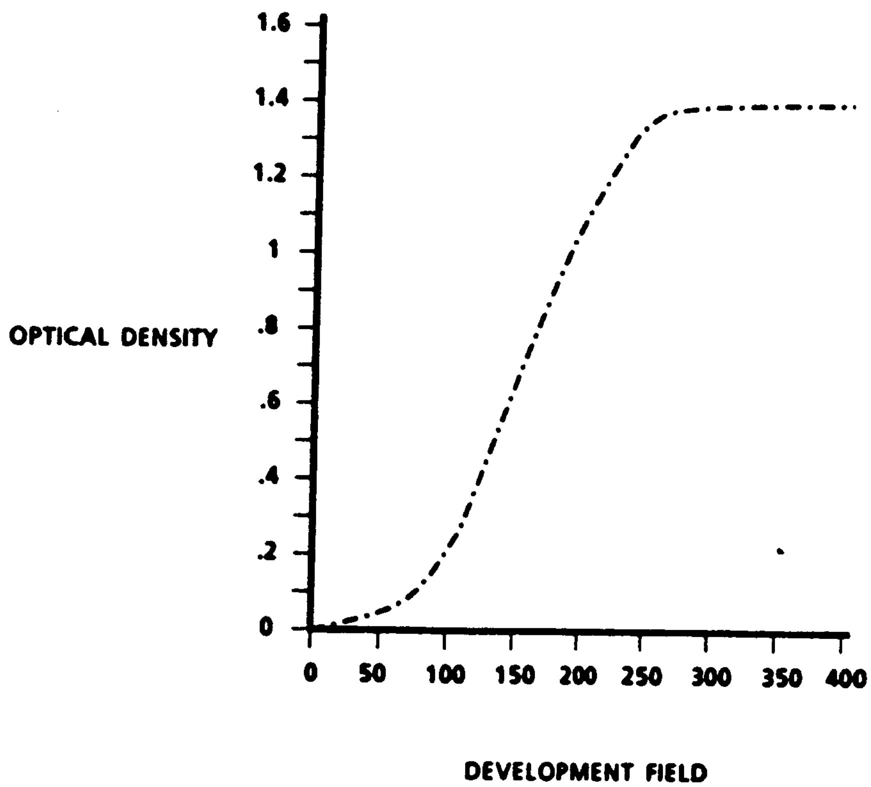
OPTICAL DENSITY
1.6
1.4
1.2
1
.8
.6
.4
.2
0
0
50
100
150
200
250
300
350
400
DEVELOPMENT FIELD

FIG. 3