Jan. 2, 1962 R. H. HALL ET AL 3,015,305

DEVELOPMENT OF ELECTROSTATIC IMAGES

Filed May 23, 1958

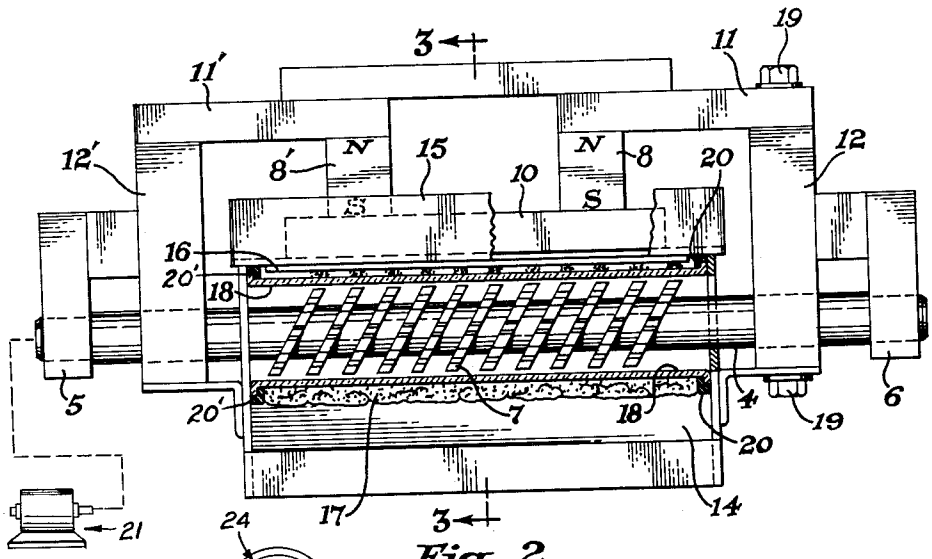


Fig. 2

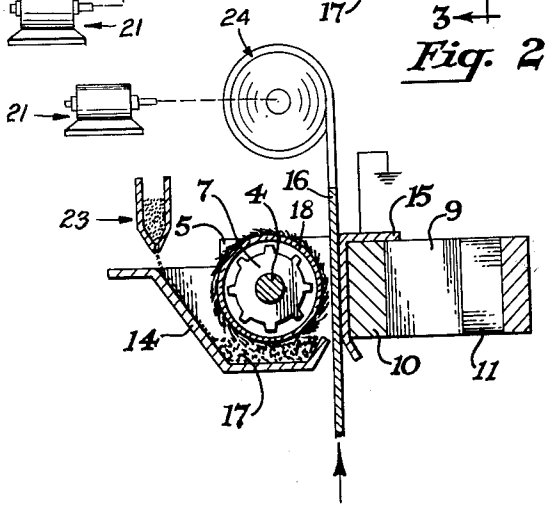


Fig. 3

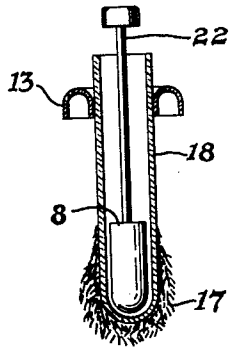


Fig. 1

INVENTORS
RICHARD H. HALL
JOHN W. BIRD, JR.

BY Frank A. Steinhilper
ATTORNEY

United States Patent Office 3,015,305 Patented Jan. 2, 1962

3,015,305

DEVELOPMENT OF ELECTROSTATIC IMAGES

Richard H. Hall, Rochester, N.Y., and John W. Bird, Jr., Royal Oak, Mich., assignors to Xerox Corporation, Rochester, N.Y., a corporation of New York

Filed May 23, 1958, Ser. No. 739,453
14 Claims. (Cl. 118—637)

Our invention relates to xerography and more particularly to improved means for applying electroscopic developer material on to a surface bearing an electrostatic image and a process therefor.

In xerography it is usual to form an electrostatic latent image on a surface. One method of doing this is to charge a photoconductive insulating surface and then dissipate the charge selectively by exposure to a pattern of activating radiation as set forth, for example, in U.S. 2,297,691 to Chester F. Carlson. Other means of forming electrostatic latent images are set forth in U.S. 2,647,464 to James P. Ebert. Whether formed by these means or any other, the resulting electrostatic charge pattern is conventionally utilized by the deposition of an electroscopic material thereon through electrostatic attraction whereby there is formed a visible image of electroscopic particles corresponding to the electrostatic latent image. Alternatively, the electrostatic charge pattern may be transferred to an insulating film and the electroscopic particles deposited thereon to form the visible image. In any case this visible image, in turn, may be transferred to a second surface to form a xerographic print or may be fixed directly to the photoconductive surface.

The usual process of applying the developer to the latent electrostatic image is set forth in U.S. 2,618,552 to E. N. Wise and involves the use of a finely-divided colored material called a toner deposited on a slightly more coarsely divided material called a carrier. This two-component developer is cascaded across the electrostatic image areas. The toner and carrier being rubbed against each other while cascading impart an electrostatic charge to each other by triboelectric charging. To produce a positive of the electrostatic image a toner and carrier are selected such that the toner will be charged to a polarity opposite to that of the electrostatic image, the carrier being charged to the same polarity as the electrostatic image. When a carrier particle, bearing on its surface oppositely charged particles of toner, crosses an area on the image surface having an electrostatic charge, the charge on the image surface exerts a greater attraction for the toner than the carrier and retains the toner in the charged area and separates it from the carrier particles. The carrier particles being oppositely charged and having greater momentum are not retained by the charged areas of the plate. When a toned carrier particle passes over a non-charged area of the plate, the electrostatic attraction of the carrier particles for the toner particles is sufficient to retain the toner on the carrier preventing deposition in such areas as the carrier particles' momentum carries both toner and carrier past. By this mechanism, the image is developed, i.e., made visible.

It has recently been discovered that when a developer mix comprising a toner and a ferro-magnetic carrier material is contacted with a magnet so that streamers are formed which constitute a brush-like mass and the brush then passed over the surface bearing the electrostatic latent image whereby the brush contacts the image-bearing surface, the developer is both triboelectrically charged and deposits on the electrostatic latent image in a manner similar to that wherein the toner and carrier mix is cascaded across the image-bearing surface.

An object of the present invention is to provide a novel means for applying electroscopic developer powder to an electrostatic image-bearing member.

Another object of this invention is to provide suitable means as set forth, wherein the developer mix is applied by a magnetically maintained brush.

A further object is to provide developing means as set forth, wherein the magnetically maintained brush can be easily and quickly cleaned, permitting the use of different developer powder without contamination from the development powder previously used by the magnetic brush.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a reading of the following detailed description in connection with the accompanying drawings in which:

FIG. 1 is a longitudinal section of a hand device for applying developer particles to an electrostatic image.

FIG. 2 is a top plan view of apparatus for applying the developer to the electrostatic image.

In FIG. 3 is a section taken on line 3—3 of FIG. 2.

The apparatus to be described, embodying the invention in illustrative form, may be operated with a developer comprising a toner powder and a carrier material. The carrier material consists of magnetically attractable powders such as magnetic ferrites as described in U.S. patents to J. L. Snoeck Nos. 2,452,529, 2,452,530 and 2,452,531 all dated October 26, 1948, iron carbonyl, alcoholized iron etc. while any of the large number of toner materials known to those skilled in the art such as those described in U.S. 2,618,551 to L. E. Walkup, U.S. 2,618,552 to E. N. Wise and U.S. 2,753,308 to R. B. Landrigan are suitable for mixing with the magnetic carrier to form a developer to be employed in the present invention. The ferrites developed by Snoeck described above may also be used as single component magnetic developers, i.e., the ferrite may act as both carrier and toner.

If alcoholized iron is used as the magnetic carrier, it is possible to develop a reversed image or a direct image by selecting a toner above or below iron in the triboelectric series. As examples, powdered shellac or rosin, each pigmented with a suitable material such as carbon black, when used with alcoholized iron give a direct image with a negative charged surface and a reversed image with a positively charged surface. Similarly, Vinsol resin (an extract from long leaf yellow pine stumps composed principally of an oxidized form of abietic acid and manufactured by Hercules Powder Company, Wilmington, Delaware) colored with a suitable dye such as nigrosine gives a direct image with a positively charged surface and a reversed image with a negatively charged surface. Alternatively, the toner may be kept the same and the magnetic carrier varied to obtain a direct or reversed reproduction of the electrostatic image. Thus, using a polystyrene resin with a suitable pigment as carbon black for the toner one can obtain a direct image of a negatively charged surface when using PMC Z270, a powdered iron produced by the Haloid Company, Rochester, New York, as the magnetic carrier and a reversed reproduction of the negatively charged image when using Carbonyl L, a powdered iron made by the reduction of an iron carbonyl by Antara Chemicals Division of General Aniline and Film Corporation, New York, New York, as the magnetic carrier.

The improved magnetic brush applicator of the present invention, is formed by a magnet having a close-fitting non-magnetic shield removably inclosing that portion of the magnet constituting the brush, together with means for separating the magnet and the shield. The shield is equipped with a non-magnetic projecting collar which completely encircles that portion of the shield from which

the magnet may be separated. This collar extends sufficiently far from the shield so that the magnetic force is too weak at the perimeter of the collar to cause the developer particles to creep around the collar. In the case of a collar concave toward the applicator end of the shield, the volume included by the collar, should be sufficient to hold the mass of developer picked up by the magnetic brush.

Referring now to the drawings in more detail, there is shown in FIG. 1 a magnetic brush constructed in accordance with the present invention, for developing electrostatic latent images by hand. This brush comprises a magnet 8 inserted in a non-magnetic shield 18, such as aluminum, brass, glass or the like. In a particularly preferred embodiment of the instant invention, shield 18 is not only non-magnetic but also electrically insulating as glass, plastic, glass fibre-plastic laminates, etc. Means for separating the magnet and the shield are provided—in this case consisting merely of a rod 22 attached to the magnet 8 whereby the magnet 8 may be manually removed and/or inserted within the shield 18. Shield 11 is also provided with a collar 13 completely encircling the shield.

The method of operation of the device is as follows:

An electrostatic latent image is prepared by any of the means known to those skilled in the art as, for example, those set forth in U.S. 2,297,691 to Chester F. Carlson. The magnet 8 is then inserted manually within the shield 18. The thus constituted magnetic applicator is then inserted into a loose mass of magnetic developer. The magnetic developer particles adhere to the face of the shield 18 in the form of the bristles of a brush. The brush is then placed on the surface containing the latent electrostatic image, so that the surface is just dusted by the developing material. After this, the magnet is moved back and forth on the surface until the image is developed to completion. The toner particles of the developer adhere to the charged portions of the image and the magnetic carrier particles of the developer are retained on the shield 18 by reason of the lines of force of the magnet 8.

In the magnetic processes of the prior art, where the developer particles are picked up directly by a magnet, the particles creep up over the brush in accordance with the action of the lines of magnetic force, thereby coloring the hands of the operator using the brush. In the case of the instant invention, the shield and collar combine to insulate the hand from the developer particles and, thus, eliminate the highly objectionable soiling previously a necessary concomitant of hand-operated magnetic development. Even more important, if it is desired to change developers, as in switching from direct development to reversed reproduction, it was previously necessary to use separate magnetic brushes or engage in a troublesome and time consuming task of cleaning the magnetic brush when the particles were stubbornly retained thereon by action of the magnet. With the brushes of this invention, it is necessary only to remove the magnet 8 from the shield 18 by means of the rod 22. The developer particles 17 are drawn up along the side of shield 18 by reason of the attraction of the magnet 8. However, on reaching the collar 13 they are physically prevented from following the magnet 8 as it is drawn beyond the collar 13. The magnetic lines of force retaining the developer particles 17 against the collar 13 are broken as the magnet 8 progresses further away and, having nothing to enable them to defy gravity, the particles fall into any suitable receptacle provided. A simple wiping with a damp cloth completely and easily cleans the shield 18. Reinserting the magnet 8 in the shield 18 reconditions the applicator for insertion into any type of developer without contaminating either the developer in the container or the developer attracted by the brush.

The instant invention is also applicable to apparatus for the automatic (as opposed to manual) development

of electrostatic images. Such an apparatus embodying the invention in illustrative form is shown in FIGS. 2 and 3. A shaft 4 mounted in bearings 5 and 6 has a plurality of spaced toothed discs 7 secured thereto at an angle to the axis of the shaft. Magnets 8 and 8' (which may be made of alnico) have their south poles connected by pole piece 10. The north poles of the magnets are connected magnetically to the shaft 4 through soft iron members, 11, 12 and 11', 12' respectively. Soft iron member 12 and bearing 6 are removably secured by fastening means 19. The edges of the discs should be in close proximity to the pole piece 10. Enclosing the discs as closely as possible without interference with the radial movement of the discs is cylinder 18 of non-magnetic material, as brass. In a particularly preferred embodiment of the instant invention, cylinder 18 is not only non-magnetic but also electrically insulating as glass, plastic, glass fiber-plastic laminates, etc. Cylinder 18 terminates at each end in shoulders 20 and 20'. Under the cylinder 18 is a trough 14 arranged to support the developing powder 17 so that the cylinder dips therein. The top and forward portions of the pole piece 10 may be covered by a sheet 15 of brass so as to provide a suitable bearing surface against which the plate 16 carrying the electrostatic image may be readily moved in a vertical direction. Any suitable means as motor 21 may be used to rotate the shaft 4, and, through take-up roll 24, to move the plate 16.

In operation, a magnetic circuit passes from the north poles of magnets 8 and 8' through the end pieces 11, 12, and 11', 12', into the rotary shaft 4 and discs 7. A narrow gap of high magnetic flux density exists between the pole piece 10 and the edges of the discs 7. Accordingly, when a quantity of magnetic developer 17 is placed in the trough 14 and the shaft rotated, the upwardly moving edges of the discs 7 adjacent the cylinder 18 attract and pick up the magnetic carrier particles and the powder adhering thereto, and move them along the outside edge of cylinder 18 into the high flux density magnetic gap and over the surface of the plate 16. Here, the powder is attracted to the oppositely charged latent electrostatic image and separated from the carrier particles which are returned to trough 14. As the discs are inclined at an acute angle to the axis of rotation of the shaft, the lines of magnetic force emanating from the edges of the disc brush the developer across the surface of the plate. At the same time, the plate is advanced vertically past the discs as shown by the arrow in FIG. 3 so that the developer will be applied over the entire surface of the charged plate.

As the powder is used up in operation additional powder must be added from time to time as by toner dispenser 23. Any means of fixing the resulting developed images known to those skilled in the art, such as those set forth in U.S. 2,297,691 to Chester F. Carlson, may be used.

If it is desired to change the type of developer used, it is necessary merely to undo fastening means 19, remove the soft iron member 12-bearing 6 assembly, and then remove shaft 4. As the discs are pulled through cylinder 18 the magnetic developer 17 is moved in the direction of motion of shaft 4. Shoulders 20 retain the developer 17 in the space above trough 14. Rotating shaft 4 while it is being removed prevents undue compaction of powder between cylinder 18 and bearing surface 15. When the shaft 4 has been removed from cylinder 18, there is no longer any magnetic force to retain developer 17 on the outer walls of cylinder 18. Accordingly gravity causes the developer 17 to fall into trough 14. The trough is then emptied and the new type of developer added. Reinsertion of shaft 4 into cylinder 18 and securing bearing 6 and soft iron member 12 by fastening 19 quickly and easily reconstitutes the magnetic brush.

If it is desired that the discs 7 be circular, means should be provided for rotating non-magnetic shield 18 so that there is no relative motion between shield 18 and discs 7. By the term "non-magnetic" as used herein is meant a material which does not interfere with the lines of force of a magnetic field, i.e., a material having a permeability not substantially different from that of free space.

As stated above, a particularly preferred form of the instant invention is that wherein the non-magnetic shield is also electrically insulating. Magnetic brush development is similar to cascade development. It differs primarily in that a magnet is used to control the motion of the carrier-toner mixture over the surface of the xerographic plate, rather than the force of gravity. Only the carrier in magnetic brush development is ferromagnetic. This magnetic carrier is itself conductive and hence the mixture of carrier and toner is somewhat conductive, rather than purely insulating. The mass of developer, i.e., toner-carrier mixture, thus acts very much like a grounded conductor and tends to establish strong and uniform fields above the electrostatic image as it passes over. The deposition of toner is thus uniform over large image areas. One disadvantage of this system, however, is its reduced latitude of exposure. Careful measurements show that exposure latitude with cascade development is about 2 to 4 times that using magnetic brush, other conditions remaining the same. One result of this is the difficulty obtained with background control. Unless the xerographic plate has been exposed so as to reduce the non-image areas completely to zero, the result will be a black on gray reproduction of the original, rather than a black on white as desired. Regulating exposure to this extent, particularly when the copy to be reproduced consists of variable quality subjects, is very difficult.

It has been found that using a non-magnetic shield which is also electrically insulating eliminates this problem. In effect such a non-magnetic electrically insulating shield "isolates" the magnetic brush. The average potential of the brush is determined by the average potential it "sees" on the surface bearing the electrostatic image, so that the brush will float to that potential approximating the background potential. Thus, using a shield which is not only non-magnetic, but electrically insulating, not only permits mixing new toner, cleaner operation, etc., but also enables magnetic brush development to be used with an exposure latitude comparable to that obtained with cascade development.

There has thus been provided an improved novel means for applying electroscopic developer powder to an electrostatic image with substantially increased ease of cleaning and using the applying means as well as greater facility in utilizing a variety of carrier-toner combinations. In addition, means have been provided for making the exposure latitude of magnetic brush development comparable to that of cascade development without increasing the complexity of the device.

This application is a continuation-in-part of our earlier filed co-pending application Ser. No. 567,657, filed February 24, 1956, now abandoned.

We claim:

1. A magnet, a close-fitting non-magnetic shield removably enclosing at least one pole of said magnet, a developer powder mix comprising a toner and a ferromagnetic carrier material on the side of said shield adjacent to and opposite from said magnet formed into a brush-like array by the lines of force of said magnet, means for withdrawing said magnet relative to said shield and a projecting non-magnetic collar encircling the portion of said shield from which said magnet may be withdrawn and positioned and adapted thereon so that as the magnet is withdrawn from the shield the developer mix is retained by the collar and thereby restrained from following the magnet as it is withdrawn.

2. A magnet, a close-fitting non-magnetic electrically insulating shield removably enclosing at least one pole of said magnet, a developer powder mix comprising a toner and a ferromagnetic carrier material on the side of said shield adjacent to and opposite from said magnet formed into a brush-like array by the lines of force of said magnet, means for withdrawing said magnet relative to said shield and a projecting non-magnetic collar encircling the portion of said shield from which said magnet may be withdrawn and positioned and adapted thereon so that as the magnet is withdrawn from the shield the developer mix is retained by the collar and thereby restrained from following the magnet as it is withdrawn.

3. Apparatus for making visible an electrostatic image through the deposition thereon of magnetic developer powder particles, the apparatus comprising in combination means for moving a member bearing an electrostatic image past a powder depositing position, a plurality of magnetic field producing means, a continuous non-magnetic shield enclosing said field producing means and closely spaced therefrom, said field-producing means being positioned and adapted so that the magnetic field produced thereby contains a substantial field component perpendicular to said shield and extending externally therefrom, means for supplying magnetic developer particles in contact with the exterior of said non-magnetic shield whereby said particles are formed into a brush-like array by the lines of force of said field producing means, means for withdrawing said field producing means relative to said shield, a projecting non-magnetic collar encircling the portion of said shield from which said field producing means may be withdrawn and positioned and adapted thereon so that as the field producing means is withdrawn from said shield said developer particles are retained by the collar and thereby restrained from following the field producing means as it is withdrawn, and means for rotating said field producing means causing said developer particles to move in contact over said shield in brush-like configuration and through said depositing position.

4. Apparatus according to claim 3 wherein said non-magnetic shield is also electrically insulating.

5. Apparatus for making visible an electrostatic image through the deposition thereon of magnetic developer powder particles, the apparatus comprising in combination means for moving a member bearing an electrostatic image past a powder depositing position, a plurality of magnetic field producing means, a continuous non-magnetic shield enclosing said field producing means and closely spaced therefrom, said field producing means being positioned and adapted so that the magnetic field produced thereby contains a substantial field component perpendicular to said shield and extending externally therefrom, means for supplying magnetic developer particles in contact with the exterior of said non-magnetic shield whereby said particles are formed into a brush-like array by the lines of force of said field producing means, means for withdrawing said field producing means relative to said shield, a projecting non-magnetic collar encircling the portion of said shield from which said field producing means may be withdrawn and positioned and adapted thereon so that as the field producing means is withdrawn from said shield said developer particles are retained by the collar and thereby restrained from following the field producing means as it is withdrawn, and means for rotating said field producing means causing said developer particles to move over said shield in brush-like configuration and through said depositing position and means for adding additional developer particles without interrupting the operation.

6. Apparatus according to claim 5 wherein said non-magnetic shield is also electrically insulated.

7. Apparatus for making visible an electrostatic image through the deposition thereon of magnetic developer powder particles, the apparatus comprising in combination

means for moving a member bearing an electrostatic image past a powder depositing position, a plurality of magnetic field producing means, a continuous non-magnetic shield enclosing said field producing means and closely spaced therefrom, said field-producing means being positioned and adapted so that the magnetic field produced thereby contains a substantial field component perpendicular to said shield and extending externally therefrom, means for supplying magnetic developer particles in contact with the exterior of said non-magnetic shield whereby said particles are formed into a brush-like array by the lines of force of said field producing means, means for withdrawing said field producing means relative to said shield, a projecting non-magnetic collar encircling the portion of said shield from which said field producing means may be withdrawn and positioned and adapted thereon so that as the field producing means is withdrawn from said shield said developer particles are retained by the collar and thereby restrained from following the field producing means as it is withdrawn, means for rotating said field producing means causing said developer particles to move over said shield in brush-like configuration and through said depositing position and flux concentrating means magnetically associated with said field producing means at said depositing position to concentrate the flux through the member bearing the electrostatic image.

8. Apparatus according to claim 7 wherein said non-magnetic shield is also electrically insulating.

9. Apparatus for making visible an electrostatic image through the deposition thereon of developer powder particles, the apparatus comprising in combination means for moving a member bearing an electrostatic image past a powder depositing position, a magnetic field-producing means, a continuous non-magnetic shield enclosing said field-producing means and closely spaced therefrom, said field-producing means being positioned and adapted so that the magnetic field produced thereby contains a substantial field component perpendicular to said shield and extending externally therefrom, means for supplying magnetic powder developer particles in contact with said shield whereby said particles are formed into a brush-like array by the lines of force of said field-producing means and means for producing a relative rotary motion between said shield and said field-producing means by at least rotating said field producing means causing said developer particles to move in contact over said shield in brush-like configuration and through said depositing position.

10. Apparatus according to claim 9 wherein said non-magnetic shield is also electrically insulating.

11. Apparatus for making visible an electrostatic image through the deposition thereon of magnetic developer powder particles, the apparatus comprising in combination means for moving a member bearing an electrostatic image past a powder depositing position, a plurality of magnetic field producing means, a continuous non-magnetic shield enclosing said field producing means closely spaced therefrom, said field producing means be positioned and adapted so that the magnetic field p duced thereby contains a substantial field component p pendicular to said shield and extending exteriorly th from, means for supplying magnetic powder develc particles in contact with said shield whereby said pa cles are formed into a brush-like array by the lines force of said field producing means, means for withdr ing said field producing means relative to said shiel projecting non-magnetic collar encircling the end por of said shield from which said field producing means r be withdrawn and positioned and adapted thereon so as the field producing means is withdrawn from shield said developer particles are retained by the co and thereby restrained from following the field produ means as it is withdrawn, and means for producing r tive rotary motion between said shield and said field p ducing means by at least rotating said field produ means causing said developer particles to move in con over said shield in brush-like configuration and thro said depositing position.

12. Apparatus as in claim 11 wherein said non-n netic shield is also electrically insulating.

13. Apparatus for making visible an electrostatic im through the deposition thereon of developer powder p ticles, the apparatus comprising in combination me for moving a member bearing an electrostatic image p a powder depositing position, a rotatable cylindrical m netic field producing means adjacent said powder dep ing position, a continuous non-magnetic shield enclo said field producing means concentric therewith and clo spaced therefrom, said field producing means being p tioned and adapted so that the magnetic field produ thereby contains a substantial field component per dicular to said shield and extending externally therefr means for supplying magnetic powder developer parti in contact with the exterior of said shield whereby particles are formed into a brush-like cylindrical ar by the magnetic field of said field producing means, means for rotating said array in brush-like configurat including means to at least rotate said field produc means whereby said array passes through said deposi position.

14. Apparatus according to claim 13 wherein said n magnetic shield is also electrically insulating.

References Cited in the file of this patent

UNITED STATES PATENTS

2,786,439	Young	Mar. 26, 1
2,786,440	Giaimo	Mar. 26, 1
2,786,441	Young	Mar. 26, 1
2,791,949	Simmons et al.	May 14, 1