Oct. 29, 1963 R. S. HOWELL 3,108,895

METHOD AND APPARATUS FOR ERASING DEVELOPED IMAGES

Filed Dec. 24, 1959 2 Sheets-Sheet 1

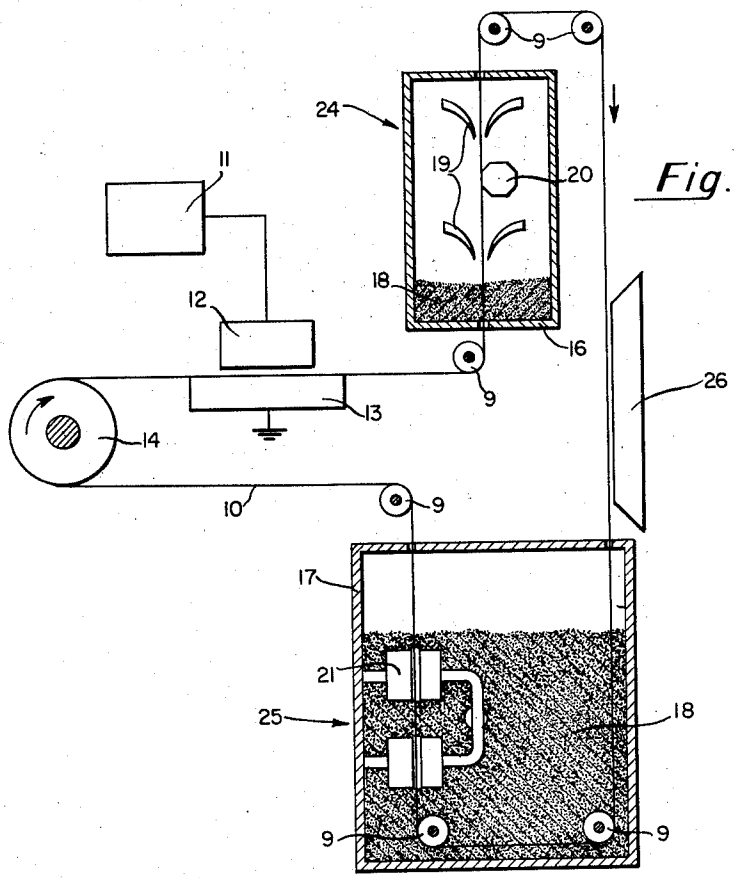


Fig. 1

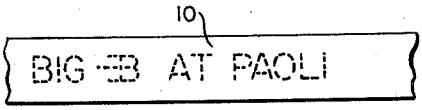


Fig. 3

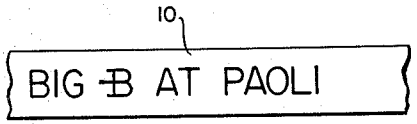


Fig. 4

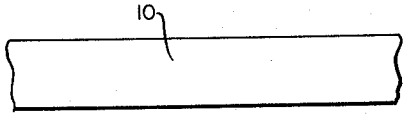


Fig. 5

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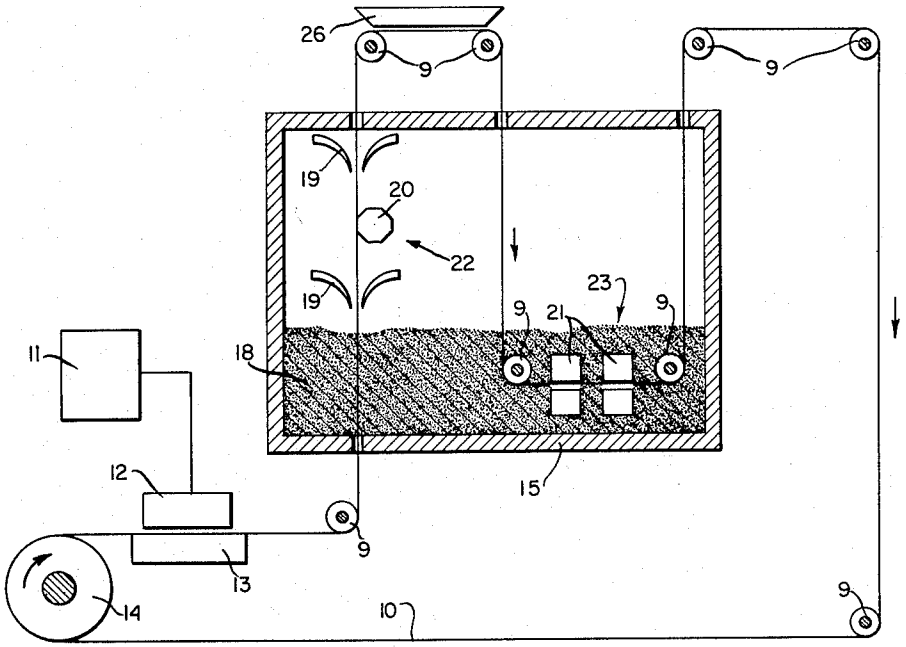


Fig. 2

Fig. 6

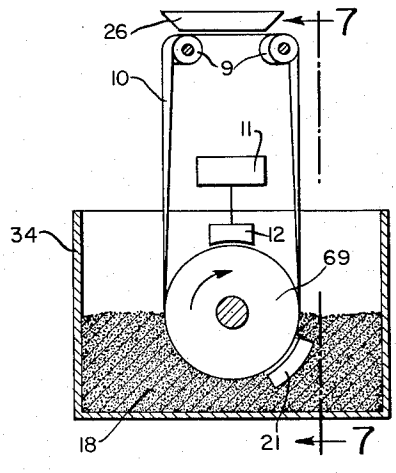
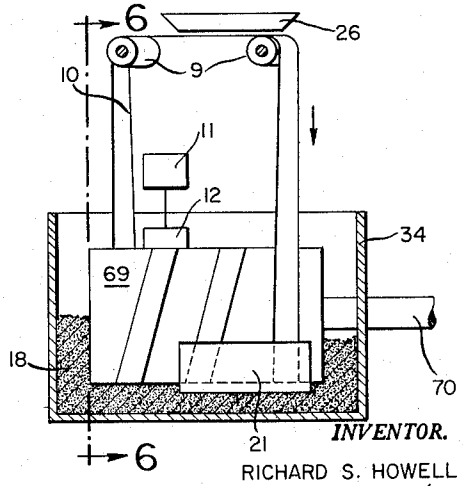


Fig. 7



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METHOD AND APPARATUS FOR ERASING DEVELOPED IMAGES

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5 Claims. (Cl. 117—19)

This invention relates to electrostatic reproduction and apparatus therefor.

The art of electrostatic printing consists basically of the production on a charge-retentive surface of a pattern of electrical charges whose distribution is later indicated by the adherence to the charged areas of a visible substance analogously denoted as ink, although it is commonly a particulate or powdered non-liquid. The application of the ink to the charge-retentive medium in such fashion that it adheres visibly differently to the charged areas than to the non-charged or oppositely charged areas is known, by obvious analogy, as development; and any process aimed at making the adherence of the ink permanent even after dissipation of the charges which originally caused its adherence is known, by similar analogy, as fixing.

Some references pertaining to the art of electrostatic printing are the following applications for patents; they have all been assigned to the assignee of the present invention: United States patent application Serial No. 443,646, filed July 15, 1954, by Epstein and Innes, and now Patent No. 3,012,839; United States patent application Serial No. 714,767, filed February 12, 1958, by Epstein and Benn. A publication is "The Electrographic Recording Technique," by H. Epstein, Proceedings of the Western Joint Computer Conference, March 1955.

Most of the efforts of the practitioners and investigators of the art of electrostatic printing have been aimed at the creation of charge patterns and the attachment of ink. However, some transfer processes are known in which particulate ink formed into a pattern on a dielectric surface by the electrostatic process is then transferred by some mechanical means to another base, and the residual charge on the dielectric must be removed to prepare the dielectric for reuse by the formation of a different pattern of charges upon its surface. The removal of charge is often performed by ionizing the air adjacent to the dielectric surface, either by corona discharge or by radioactive emanations; or the dielectric may be brought into an extremely humid atmosphere, or even immersed in a conductive liquid.

The simultaneous removal of ink image and charge pattern is desirable where it is purposed to examine the developed image only briefly and then destroy it and its associated charge pattern and reuse the recording medium. Such mode of operation is taught in a copending application for United States patent by Percy J. Barnes, entitled "Electrostatic Data Display," Serial No. 861,906, filed December 24, 1959, and asigned to the assignee of this application. The excellent insulating qualities of many modern dielectrics, such, for example, as the plastic sheet material known in the trade as Mylar, render the destruction of charge patterns quite difficult. It has, for example, been found that a tape of such material preserved in an office at ordinary humidities is capable of retaining a charge pattern for a quarter of a year and, upon development after that period, presenting a perfectly legible image. My invention comprises a means and method for removing particulate ink and stored charges simultaneously from a record medium.

It is described in application for United States patent Serial Number 714,767, filed February 12, 1958, by Herman Epstein and Robert E. Benn, "Electrographic Recording Process," which application is assigned to the asignee of this application, how a pattern of charges deposited upon a dielectric medium having a conductive backing may be rendered visible, or developed, by being drawn through a mass of electrically conductive particulate ink which mass is in electrical connection with the conductive backing of the medium. It is an observed fact, essential to the operativeness of the invention of the referenced patent application, that the electrically conductive particulate ink mass does not, as might have been expected a priori, merely discharge the dielectric medium and leave it to pass from the mass of ink devoid both of charges and visible pattern; instead, ink particles cling to the dielectric surface wherever charges have been deposited on the dielectric, thus rendering visible the charge pattern. This effect is not a critical one, producible only sporadically and with painstaking control of critical conditions, but a highly reliable and reproducible effect which has been preferred for use in reproducing equipment where reliability is essential.

My own invention is based upon the surprising discovery that a dielectric medium bearing a charge pattern rendered visible by development with particulate ink, by the process described in the preceding paragraph of this specification, may be divested both of its visible pattern of particulate ink and of its invisible pattern of electric charges by passing it a second time through a mass of conductive ink identical with that employed in the original developing process.

Thus it is an object of my invention to erase both the visible ink image and the invisible electric charge pattern by simple mechanical means not requiring the use of radioactive material or high voltages.

Other objects and advantages of my invention will become apparent to those skilled in the art in the course of the following detailed description and specification of the preferred mode of practicing my invention.

For the better explanation of my invention I provide figures of drawing as follows:

FIGURE 1 is a schematic view representing a recording station for applying electric charge patterns to a dielectric tape surface, a developing station for rendering such patterns visible by adherence of particulate ink, a viewing station, and an erasing station for removing both the ink and the charge pattern from the tape to render it available for reuse;

FIGURE 2 is a schematic view representing a second embodiment of the invention including a recording station for applying electric charge patterns to a dielectric tape surface, a developing station for rendering such patterns visible by adherence of particulate ink, a viewing station, and an erasing station located in the same ink chamber with the developing station;

FIGURE 3 represents a dielectric medium bearing a charge pattern not yet developed, and therefore represented by dotted lines;

FIGURE 4 represents a dielectric medium as in FIGURE 3, but as it would appear after development with particles of ink pigment adhering in the region of the charge pattern;

FIGURE 5 represcents a dielectric medium as in FIGURE 3 and FIGURE 4, but after passage through an erasing station which leaves it divested of both charge pattern and ink particles; and

FIGURE 6 represents a front view, and FIGURE 7 represents a profile view, of a third embodiment of apparatus for practicing my invention.

In FIGURE 1, a dielectric record medium **10** in the form of a tape which may be of Mylar and may have an electrically conductive backing is represented as passing over drive drum **14**, which is rotated clockwise by

means not shown, and causes tape medium **10** to pass to the right of the figure between grounded electrode **13** and electrostatic recording head **12** which, in consequence of the application to its electrodes of voltages from the apparatus represented by **11**, deposits a pattern of invisible electric charges on the upper surface of the dielectric of record medium **10**. The charged medium passes around an idler **9** to developing station **24**, where a chamber **16** is represented as containing a mass of powdered particulate electrically conductive ink **18** which becomes attached, by electrostatic attraction, to the dielectric surface of medium **10** in those areas where electric charges have been stored. Baffles **19**, supported by means not represented, serve to prevent any accidental adhesion of ink agglomerate from moving upward with the medium **10**; and vibrator **20**, represented as a rotating polygonal shaft, driven by means not represented, vibrates the medium **10** sufficiently to shake loose any ink accidentally adhereing to regions where no charge has been deposited. The preceding brief summary of the operations of electrostatic printing and developing is descriptive of art previously disclosed, in much more detail, in the applications for United States patents by Epstein and Innes and Epstein and Benn, to which reference has been made in the introductory portion of this specification.

An ink satisfactory for such uses as here described may be composed of approximately spherical particles having a range of diameters from twenty to eighty microns, having a specific gravity, referred to water, between three and four, and with each particle having at least its outer surface electrically conductive. A satisfactory form of such ink may be produced by silvering, by the Brashear process, small glass spheres having the size range specified. An alternative product is approximately spherical particles of clay, of specified size range, coated and to some extent permeated with carbon by pyrolysis of hydrocarbon vapors; such carbon is conductive. Details of the production and use of such inks are to be found in application for United States patent Serial No. 784,300 filed December 31, 1958, by David W. Seymour. Both the glass spheres of this above-described Brashear process silvered ink and the clay particles of this above-described Seymour application ink have a melting point above 2000° C. and as described above and in that Seymour application S.N. 784,300, the particles have a specific gravity not greater than four.

FIGURE 3 represents a portion of the dielectric of record medium **10** after it has left the printing head **12**. The dotted lines represent a pattern of electric charges which are in fact invisible. Passage through the developing station **24** alters the appearance of the tape record medium **10** to that represented in FIGURE 4, where the charge patterns represented in FIGURE 3 appear as visible patterns delineated by adherent ink particles which are retained in place by the field of the electrical charges represented in FIGURE 3. It should be emphasized that the exact location and the mechanism of storage of the electric charges in the dielectric of medium **10** are not known at this time. It is known that passing the charged dielectric surface of tape **10** over a grounded metal roller does not discharge the image, since such treatment is standard in operative electric printers which are so designed that the latent charge pattern or image on the dielectric medium is developed after being passed over a grounded electrically conductive roller. It is not known whether the charges are located on the surface of the dielectric of a medium such as **10** and are not discharged by the metal roller because there is, in fact, only negligible actual contact between the dielectric and the roller; or whether the charges are actually stored slightly below the surface of the dielectric and can flow only with difficulty and over an appreciable time to the surface, to be discharged. At all events, it is an experimental fact that simple forcible removal of the ink pigment from a developed dielectric record medium such as **10** removes or dissipates only a negligible part of the electric charge pattern which originally attracted the ink. Thus mere removal of the ink particle image does not place the record medium **10** in condition for the deposition of a new charge pattern, since the original charge pattern still persists.

The recording medium **10** with the developed visible image thereon is passed through a viewing station represented by a rectangular frame **26** when a message as exemplified in FIGURE 4 may be shown. The tape may be moved continuously at a rate of speed through the viewing station sufficient to understand the message or it may be intermittently advanced so that the message bearing portion of the medium is stopped in the viewing frame. After the developed medium **10** has been observed sufficiently in the viewing station **26**, it moves to erasing station **25**. At erasing station **25** a container **17** holds a mass of ink **18**, into which the developed medium **10** is plunged. It passes over idler rollers **9** and between two sets of wipers **21**, which may be of felt, and which strip any ink particles which may be adhereing to the medium. If the medium **10** is provided with a conductive backing layer, the portion of the ink mass in contact with that layer will constitute means to connect the backing layer with the rest of the ink mass. An alternate path may be provided by the idlers **9** if they are of conductive material and are in electrical connection with the mass of ink **18** as, for example, through container **15**. If the depth of the ink mass **18** is sufficiently great that its pressure near the bottom of container **17** prevents easy flow of ink particles through the mass, and thus shears the adherent ink particles away from the moving tape **10**, the wipers may be dispensed with. At any event, it is necessary that ink once brought into intimate contact with the surface of medium **10** be forcibly removed, and that more ink **18** be brought in contact with the dielectric surface of medium **10** and then forcibly removed. This process permits the tape medium **10** to be removed from the mass of ink **18** at the end of its passage through erasing station **25** with no ink particles adherent to it, and devoid of its original charge pattern. It has been found that passage through four inches of ink at a speed of about twenty inches per second is sufficient to eliminate both ink and charge pattern. It is believed that this process works becausse the passage of the medium through the ink brings ink particles in contact with substantially every point of the surface of the medium **10**, and that the stored charges in the medium are carried away by the ink particles which successively contact the surface.

The arrangement of the path of the medium **10** in FIGURE 1 is such that, after leaving the erasing station **25**, the medium passes to drum **14** for further use. Thus, the recording medium may be an endless tape as shown, passing either intermittently or continuously, through the recording station represented by the head **12** and through the developing, viewing and erasing stations **24**, **26** and **25** respectively. A surplus of ink **18** will gradually be deposited in container **17** of the erasing station **25** and may be returned by any suitable means to container **16** of the developing station **24**. This gradual contamination with developing ink of the conductive particles used for the erasing operation is the reason why the ink **18** in both the developing station **24** and the erasing station **25** has been represented by the same reference number; obviously it is to be preferred in general that the same ink be used in both so that the nominal contamination of the ink in the erasing station **25** is actually non-existent because the additions from the original content of developing station **24** are the same as the ink already present in erasing station **25**. It is possible to employ conductive particles devoid of pigment for purposes of erasure, and, if they are of different density from the particles of ink, the ink contamination may be removed from the mass of erasing particles by differential flotation. The practical usefulness of such a procedure would obviously be some-

what limited, although it would effectively apply the principles of my invention.

An alternative arrangement of developing and erasing stations is represented in FIGURE 2. In FIGURE 2, the drive drum 14, ground electrode 13, electrostatic recording head 12, apparatus 11 all perform exactly the same functions as in FIGURE 1. The record medium 10 passes, after imposition of a charge pattern upon its dielectric surface, through a mass of ink 18 at developing station 22, the elements 19 and 20 of the developing station 24 and the viewing station 26 perform the same functions as at those described in connection with FIGURE 1. However, erasing station 23 is embodied in the same receptacle or housing 15 as is developing station 22. The medium 10, after development, is carried up out of the developing station, passes horizontally through station 26 for viewing, and then moves downward again to erasing station 23 where it plunges into the mass of ink 18, moves horizontally between two wipers 21, which may be of felt, and then turns upward again to move in a path which ultimately returns it to drum 14 for reuse.

An advantage of the embodiment of FIGURE 2 is that the ink removed from the medium 10 at erasing station 23 will ultimately flow back to replenish the supply at developing station 22, and thus the removed ink may be reused with no special provision to achieve this.

An extremely simple example of a combination developing and erasing station is to be found in FIGURES 6 and 7, FIGURE 7 being a profile view of the elevation of FIGURE 6, each being a section of the other. Actually, the effect of the sections is substantially as if a phantom drawing had been made in which the nearer wall of container 34 was removed to permit free vision of the worikng parts represented. In these figures, drum 69 is represented as supported on a shaft 70 which is supported by bearings and driven by rotating means not here represented. Record medium tape 10 is passed three times helically around drum 69, and, during the clockwise (as represented in FIGURE 6) rotation of drum 69, the tape is carried for two turns past a wiper 21, passing through the mass of electrically conductive ink 18 in the process of being erased. After its second trip past the wiper 21, the tape medium 10 passes under the recording head 12, where a new message is applied to it in the form of a pattern of invisible electric charges, which pattern is rendered visible by the adherence of ink 18 which occurs during the third trip of the medium 10 through the mass of ink 18, but without contact with the wiper 21. The developed and thus visible pattern is carried upward by movement of the medium 10, turns to move horizontally for viewing at 26 and then moves downward again to the drum 69 for repetition of the erase-record-develop cycle. Drum 69 may be of conductive material, or have a surface of conductive material, which will make contact with any conductive backing layer of medium 10 and will also make electrical contact with the mass of ink 18. As represented in FIGURES 1 and 2, the ink 18 ordinarily constitutes its own means for making electrical connection with such conductive backing layer. It is quite possible to arrange the erasing station so that the back of the medium is not in contact with the mass of ink 18, requiring the provision of more obvious connection means as here described.

It is obvious that a considerable variety of mechanical variations may be made to practice this invention. Also, I have found that this invention is operative for dielectric media having an electrically conductive backing, as taught in the aforesaid patent application by Epstein and Benn, but also functions to erase specific charge patterns on dielectric media not having such a backing. However, it is found that repeated erasures on media not having an electrically conductive backing tend to build up a background of electric charge which tends to produce a somewhat dark background upon development. This does not preclude the possibility of applying my invention to the erasure of patterns of charge upon such media, however, provided the number of repetitions of erasure in a given period is not too great. The advantages achieved by the use of a conductive backing, as taught by Epstein and Benn, are so great that there is usually no great motive for employing a medium without conductive backing. The disadvantages attendent upon erasure of charge patterns on a medium not having an electrically conductive backing are comparable with those attendant upon its use as an electrostatic recording medium, so that it may fairly be said that my invention may be limited in its utility to the operativeness of the medium, not by any inherent limitations of the invention itself.

It is suspected that the operation of my invention is so effective as it has in fact been proven to be because the passage of the dielectric charge through the conductive ink particles permits electrical contact with substantially all of the area of the dielectric surface. The ink particles are approximately spherical in shape, and would thus not make direct physical contact with more than a small part of the area which they obscure to view. Consequently, a continual rolling of ink particles over the dielectric surface might be adequate to make conductive electrical contact with substantially all of the dielectric surface, and thus remove from the surface charges which cannot flow across the surface to discharge conductors. However, this hypothesis must be evaluated in the light of the fact that simple rolling of the dielectric over a grounded metal roller does not destroy the stored charge pattern.

Having described the nature of my invention, and described in detail three different embodiments of its practice, I claim:

1. In an electrostatic recording device comprising a dielectric record medium of high resistivity having an electrically conductive backing layer, means to establish patterns of electrical charges on the exposed surface of the said record medium, developing means comprising a container, a mass of electrically conductive particulate ink of predetermined amount contained in said container, and means to move said record medium into and out of the said mass of electrically conductive ink with the said ink in intimate contact with the said exposed surface of the said record medium, and with the said electrically conductive backing layer in electrical connection with the said mass of ink, whereby the said ink particles adhere to and render visible the said patterns of charges: means to move the developed medium back into and out of said developing ink and through a sufficient amount of said developing ink to effect substantially complete removal of both the said visible adhering ink and the said charges, and means to remove from adherence to the surface of the said dielectric medium during its passage back into and out of the said developing ink substantially all of the ink particles held adherently thereto by the said electrical charges.

2. In an electrostatic recording device comprising a dielectric record medium of high resistivity having an electrically conductive backing layer, means to establish patterns of electrical charges on the exposed surface of the said dielectric medium, developing means comprising a container, a contained mass of electrically conductive particulate ink disposed in said container and means to move the said record medium a first time into and out of the said mass of electrically conductive ink with the said ink in intimate contact with the said exposed surface of said record medium and with the said electrically conductive backing layer in electrical connection with the said mass of ink, whereby the said ink particles adhere to and render visible the said pattern of charges: means to move the said record medium a second time into and out of the said mass of electrically conductive ink, with the said exposed surface of the said record medium in intimate contact with the said mass of electrically conductive ink,

means to make electrical connection during said second time between the said electrically conductive backing layer of said medium and the said mass of electrically conductive ink, the amount of said ink and said container being in cooperating relationships such that said second time moving of said record medium is of sufficient duration to effect substantially complete removal of said pattern of charges, and means to restrain particles of said ink from moving adherently with the moving said exposed surface of the said medium during said second time.

3. In an electrostatic printing system: a container and a mass of electrically conductive particles contained in said container; means for moving a dielectric record medium having an electrically conductive backing layer and having a visible charge pattern of adherent ink particles into and out of said mass of electrically conductive particles in said container with the ink particles on the dielectric record medium in intimate contact with said mass of electrically conductive particles in the container to establish electrical connection between the said electrically conductive backing layer of said medium and the said mass of electrically conductive particles, the electrically conductive particles in the container being ink particles of low specific gravity and similar to said adherent visible ink particles; and stationary wiping means operable during said intimate contact between the mass of said electrically conductive particles and the said ink particles on the dielectric record medium for applying shearing force to restrain any particles from moving with the dielectric medium in its direction of motion, said mass of electrically conductive particles being of amount and said intimate contact and said motion restraining being of duration sufficient and in coacting relationship to remove substantially all of the said charges of said charge pattern and said adherent ink particles from said dielectric record medium by the time of its emergence from said container.

4. In an electrostatic recording device having means for applying a pattern of electric charges upon a charge-retentive dielectric surface of a record medium composed of a substantially continuous film of a synthetic organic resin overlying an electrically conductive backing and further means for causing an electrically conductive particulate ink composed of electrically non-conductive particles having an electrically conductive surface coating to adhere to the portions of said surface where the said pattern of electric charges exists: a chamber, a mass of similar electrically conductive particulate ink contained in said chamber, said last-named ink comprising coated substantially spherical particles of small diameter and of material of high melting point and of specific gravity not greater than four to enable erasing in said chamber while enabling the adhering of the ink to said charge-retentive surface without erasing in said means for causing adherence of the ink to the charge pattern portions of said surface, and means for bringing a portion of said similar electrically conductive mass of ink into intimate contact with said surface and for causing relative motion between the charge-retentive surface and the portion of the mass of ink while in electrical connection with the said electrically conductive backing so as to expose said charge-retentive surface to the conductive ink surface of sufficient ink particles to remove substantially all of said charges as well as said ink adhering to said charge-retentive surface.

5. A method of removing, from a record medium having an electrically conductive backing and a coating of material having an electric charge-retentive surface bearing a record pattern of electric charges rendered detectable by the adherence to the portions of said surface bearing the said pattern of charges of solid electrically conductive particles, substantially all of both the said pattern of electric charges and the said adherent electrically conductive particles, comprising: the step of immersing the medium in a mass of conductive particles of specific gravity of an order less than four by drawing the said charge-bearing record medium to pass it into and out of said mass of conductive particles and in intimate contact therewith to establish through the conductive particles and the backing an electrically conductive path between the surfaces of the coating and the step of restraining the said conductive particles from moving together with said record medium, said restraining step being interposed with providing said intimate contact for at least a portion of the period of said immersing step, said passing of said record medium through said conductive particles in intimate contact being effected a duration of time sufficient to cause substantially complete removal of both said pattern of charges and said adhering conductive particles.

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