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PROCESS AND APPARATUS FOR EVALUATING LIQUID TONERS FOR ELECTROSTATIC PRINTING

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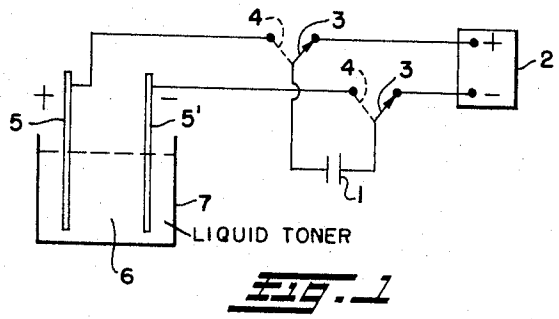


Fig. 1

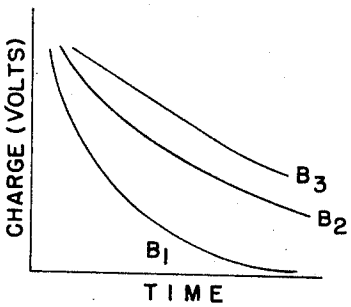


Fig. 3

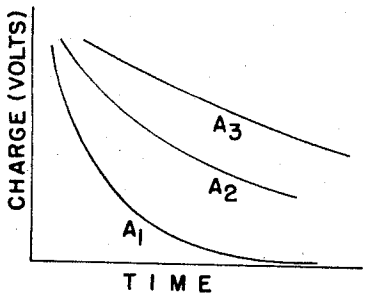


Fig. 2

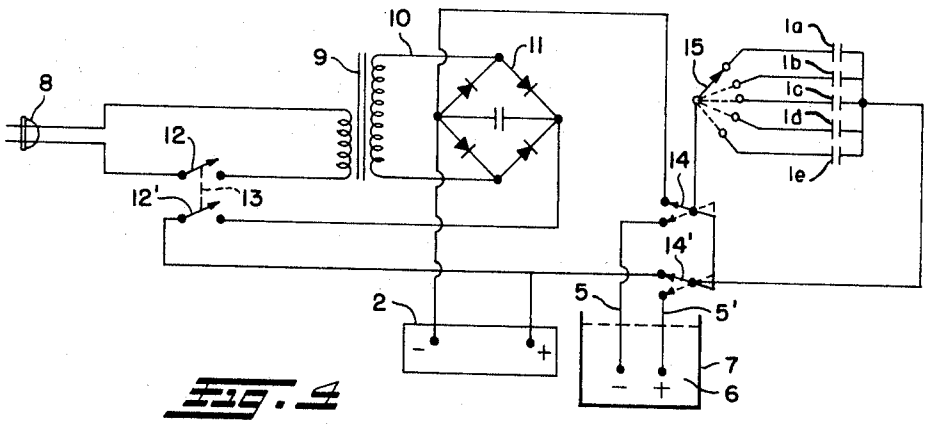


Fig. 4

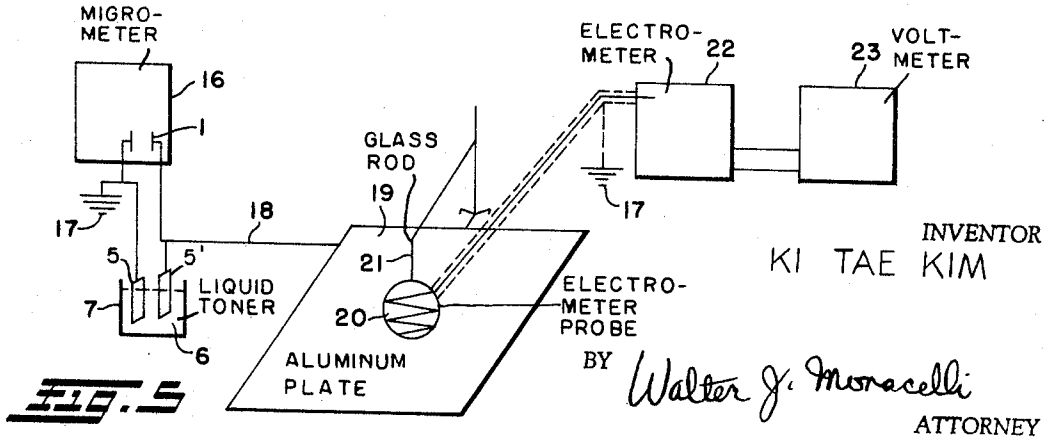


Fig. 5

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PROCESS AND APPARATUS FOR EVALUATING LIQUID TONERS FOR ELECTROSTATIC PRINTING

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6 Claims

ABSTRACT OF THE DISCLOSURE

The process and apparatus disclosed herein comprise a method and apparatus for predetermining the suitability of a liquid toner for the electrostatic printing of paper. The process and apparatus involve the use of a condenser having a capacitance approximately equal to the charge density which will eventually be placed on the paper to be printed. This condenser is connected with a source of direct current in order to place the appropriate charge density on the condenser and then, simultaneously with the disconnection from the electrical source, the condenser is connected with two electrodes spaced from each other and partially submerged in a bath of the liquid toner. As the charge is dissipated from the condenser, it causes an amount of deposition of pigment from the toner in accordance with the charge density on the condenser. Since the charge density on the condenser is equivalent to that on the paper to be used for the printing, the amount of deposition on the electrode is a measure of the amount that will be deposited on the paper using this same liquid toner. The amount of deposited pigment is measured by appropriate means, such as visual measurement or electrical means. This method of evaluating the liquid toner is an improvement over the prior art method of testing the efficacy of the toner by actual printing, which prior art method takes much longer and has various other disadvantages.

This invention relates generally to electrostatic printing. More specifically, it relates to a method and apparatus for evaluating a liquid toner for use in electrostatic printing.

In electrostatic printing, electrostatic images are produced on an insulating surface such as paper. The image comprises a pattern of electrostatic charges on the surfaec of the paper, etc. Originally physical images were produced by applying to the surface, a dry mixture of finely divided developer particles and substantially larger carrier particles. The paper carries an electrostatic charge in accordance with the image or design to be produced on the paper. The developer particles are advantageously triboelectrically charged in the opposite polarity to the electrostatic charges on the paper and thereby position themselves in the charged areas to produce a visible image in accordance with the pattern of the electrostatic charges. If the developer particles have the same polarity as the electrostatic charge, the image produced is in reverse configuration to the pattern of electrostatic charges.

For various reasons, the dry powder method, commonly known as the cascade or powder-cloud method has not proved completely satisfactory and has generally been replaced by a method using a suspension of pigment and a suitable liquid vehicle. The liquid toner used in the wet method of electrostatic printing generally comprises a number of components serving various functions.

In order to evaluate the various types of components and the appropriate proportions thereof, it has been the practice to test the efficacy of the toner by actual printing. However, printing evolution gives little information in the

way of telling why one toner composition works well while another does not. Furthermore, evaluation by actual printing takes approximately 30–60 minutes and is generally done in the dark. Therefore, it would be desirable to have an evaluating test which can be performed very rapidly and without the requirement for darkroom facilities.

In attempting to duplicate or to measure the electrical characteristics of a liquid toner, it is necessary to duplicate exactly the effect of a charged electrostatic paper in the toner bath. When a charged paper is immersed in the toner bath, the surface charge density is decreased as the oppositely charged toner particles are attracted to the surface. In addition to this, the surface charge leaks away because of the conductivity of the liquid in which the toner particles are dispersed. Therefore, there is a discharge pattern characteristic for a given toner. It is essential to duplicate these characteristics in testing a liquid toner.

In accordance with the present invention, it has now been found possible to evaluate a liquid toner in approximately 30 seconds with no need for protection against light. Moreover, the method of evaluation duplicates the discharge conditions characteristic of the liquid toner.

In the method and apparatus of this invention, an appropriate electrostatic charge is applied to a condenser. Then the accumulated charge is applied to electrodes in the toner solution so that the deposition of the toner particles on the electrode and the dissipation of the condenser charge in the toner liquid corresponds closely to that effected when a charged paper is inserted in the toner liquid. The resultant black deposit on the negative electrode is measured with a reflectometer of one type or another.

By selecting a condenser charge approximately that on the charged paper, it is possible to duplicate closely the dissipation curve of a charged paper so that the black deposit on the negative electrode is a true indication of the behavior of a charged paper in the liquid toner. If a similar test is made by direct connection with a source of DC voltage applied across two conductive electrodes immersed in the toner bath, the results are not a true indication of the characteristics of the liquid toner since the charge is not dissipated in the same manner in which the charge is dissipated from the charged paper.

In the drawings, FIG. 1 represents a simplified system in which the condenser is first charged by a source of DC current and after the source of DC current is cut off, the charge on the condenser is applied to two conductive electrodes immersed in a liquid toner.

FIG. 2 is a graphical representation of the discharge curve of electrostatically charged paper in liquid toners of various degrees of conductiveness.

FIG. 3 is a graphical representation of the discharge curve of the charge from a condenser as applied to electrodes in the corresponding liquid toners.

FIG. 4 is a diagram of an apparatus of this invention in which a bank of condensers are available for charging by a source of DC current derived continuously from an alternating current which is converted to higher voltage and rectified to DC current by a transformer and full-wave rectifying bridge circuit.

FIG. 5 is a schematic diagram of an arrangement of equipment used in measuring the discharge pattern of a condenser system, herein described generally as a migrometer.

In the simplified modification of this invention shown in FIG. 1, condenser **1** is charged by current from DC source **2** when switches **3** are in the position shown in FIG. **1**. When the appropriate electrostatic charge has been stored in condenser **1**, switches **3** are moved to the position shown by dotted lines **4** thereby simultaneously cutting off the current from the DC source **2** and connecting the con-

denser with the electrodes 5 and 5' which are immersed in liquid toner 6 in container 7.

As described above, the dissipation of the electrostatic charge stored in the condenser 1 by the deposition of charged particles in liquid toner 6 onto electrode 5' as well as dissipation of some of the charge into the liquid, duplicates approximately the dissipation of a corresponding charge from an electrostatically charged paper when placed in the liquid toner.

In FIG. 2, curve A_1 represents a plotting of the rate of discharge of electrostatically charged paper in a highly conductive toner. Curve A_2 represents a corresponding plotting of values in a less conductive liquid toner, and curve A_3 represents a corresponding discharge curve in a non-conductive liquid toner.

FIG. 3 shows corresponding curves B_1, B_2 and B_3 for the actual discharge of a condenser in the corresponding liquid toner referred to with regard to FIG. 2, as measured by the migrometer or condenser system of this invention.

It will be noted that the respective curves in FIGS. 2 and 3 are substantially identical. Therefore, in carrying out the process of this invention, the main problem is in the selection of the condenser, which will have an electrostatic charge corresponding to that of the paper for which the liquid toner is being evaluated. Therefore, for a direct current of a constant voltage, the amount of charge available for deposition is determined by the capacitance of the condenser. Thus $C \times V = Q$, wherein C, V and Q represent capacitance, voltage and amount of charge respectively. Therefore, for a constant voltage, the amount of charge is dependent on the capacitance of the condenser.

In more complex modification of the apparatus of this invention shown in FIG. 4, an alternating current is applied from a 115 volt source 8, and transformed in the transformer 9 to 300 volts and supplied to circuit 10 which feeds into rectifier 11 for conversion into D.C. current. This situation exists when switches 12 and 12' are moved from the open position shown in FIG. 4 to the closed position shown by the dotted lines. This closing of the switches is effected simultaneously by cross bar 13. When switches 14 and 14' are closed in the position shown in FIG. 4, the direct current is applied to one of the condensers 1 shown in the bank of condensers. Switch 15 can be moved to the appropriate terminal for charging whichever of the condensers is selected.

After the appropriate charge has been applied to the particular condenser being charged, switches 14 and 14' are moved to the position shown by the dotted lines, thereby cutting off the D.C. current being applied to the condenser and connecting the charged condenser to the electrodes 5 and 5' immersed in liquid toner 6 in container 7. As the electrostatic charge is dissipated from the condenser into the liquid toner 6, the particles in the liquid toner are deposited on electrode 5. By reflectometer measurement of the amount of the particles deposited on this electrode, it is possible to determine the behavior of the liquid toner with respect to an electrostatically charged paper if immersed in the same liquid toner. Also by having a bank of condensers of different capacitance which vary in accordance with the various electrostatic charges that may be applied to a paper to be tested in the liquid toner, it is possible to select an appropriate condenser by movement of switch 15 to the appropriate post or terminal for the application of D.C. charge to the desired condenser.

The composition of the liquid toner being tested, as well as the type of elecrostatically charged paper and the amount of charge thereon, are not critical to this invention. These are advantageously the types generally being used for the purpose of preparing a printed image on an electrostatically charged paper by the use of a liquid toner. Typical compositions and conditions used in the art are described in U.S. Patents Nos. 2,877,133, 2,890,-174, 2,891,911, 2,899,335, 3,010,842, 3,041,168, 3,053,-688, 3,076,722, 3,150,976, etc.

It is critical, however, that the condenser be appropriately selected to have a capacitance corresponding to the electrostatic charge that is to be applied to the paper on which the tested liquid toner is to be used. This selection of a condenser system having a capacitance corresponding to the charge that will be applied to the paper on which the tested liquid toner is to be used is simplified by the apparatus shown in FIG. 5.

FIG. 5 shows the liquid toner 6 in toner bath 7 in which are immersed conductive electrodes 5 and 5'. These electrodes are connected to the migrometer 16 which contains condenser 1, one side of which is connected to the ground 17, and the other side of which is connected to the plate 19 which is a large aluminum plate. About ½ inch above this plate is held an electrometer probe 20 which is a web of very thin wire held in position by a glass rod 21. This probe is connected to the electrometer, which is a device that can measure static charge in volts without drawing any current. The output of the electromer 22 is fed to a recording voltmeter 23. Such recording voltmeters are available on the market and one is sold under the trademark "Recti-Riter." This equipment is commonly used to measure the charge capacitance and charge dissipation of electrostatic papers, such as the values plotted in FIG. 2. FIG. 3 shows corresponding curves for the migrometer 16.

The migrometer comprises a direct current voltage source for charging the condenser, having in the connecting circuit a switch which simultaneously disconnects the capacitor from the direct current source and connects it to the electrodes and electrometer. The direct current source generally consists of a transformer which converts 115 voltage alternating current input to about 300 volts together with a full wave rectifying bridge circuit which rectifies this alternating current to direct current.

Since liquid toners vary so widely in performance, the migrometer is so equipped that an operator can choose one of several different capacitances for a test. In operation, the chosen capacitor is charged fo ronly a few seconds since the capacitance required is very small. Therefore the time of charging is not critical. Then when the capacitor is charged, a switch is operated to disconnect the capacitor from the direct current source, and simultaneously to connect it to the electrodes. The condenser is discharged by the deposition of toner particles on one of the electrodes and by leakage through the toner solution exactly as the charge is dissipated from an electrostatically charged paper in the liquid toner bath.

Various methods can be used to measure the amount of toner particles deposited on the probe electrode. Since the toner's quality is determined by the blackness of the deposited particles, a visual or light reflecting measurement is preferred.

One such visual method is the use of a photovolt reflectometer. This instrument is standardized using a small panel having a gray porcelain coating whose reflectance is known. A suitable reflectance on this equipment is one having a value of about twenty-three. Since the readings are used primarily for comparative purposes with other readings on the same instrument, it is generally preferred, in standardizing the meter, to set the meter on the value of 50 for the standard panel having a reflectance of 23. Since most of the deposits are darker than the standard, this permits an expansion of the usable scale on the meter. This is permissable where the readings are used for comparative purposes with other readings on the same instrument.

Another commercially available instrument known as the "I.D.L. Color I.D." is also suitable.

Another method of measuring the deposit consists of placing on the electrode, after it is dried, a piece of cellophane adhesive tape and to lift it quickly. The deposited toner particles are thus transferred from the electrode to the tape. In this way the blackness of the deposit can be determined by measuring the amount of light which

passes through the tape. This coated cellophane tape can be retained as a permanent test sample for visual inspection or for comparison with other tests.

The invention claimed is:

1. Apparatus for evaluating a liquid toner for electrostatic printing on paper comprising the combination of:
(1) a condenser of preselected capacitance;
(2) a source of direct current;
(3) a first function switch;
(4) a first means for connecting said source of direct current and said condenser, in which said first connecting means the said first function switch is interposed so that when said switch is closed the said source and the said condenser are connected, and when said switch is open the said source and the said condenser are not connected;
(5) a container at least partially filled with a liquid toner to be tested for electrostatic printing;
(6) two electrodes positioned substantially vertically in said container and partially submerged in said liquid toner in said container;
(7) a second means adapted to connect said condenser with each of said electrodes;
(8) a second function switch interposed in said second connecting means between said condenser and said electrodes, said second connecting means connecting said condenser and said electrodes when said second function switch is closed and not connecting said condenser and said electrodes when said second function switch is open, said second function switch being adapted to operate simultaneously with said first function switch so that when either switch is closed the other switch is open.

2. The apparatus of claim 1, which also comprises a means for measuring the amount of deposition of toner particles on said electrodes.

3. The apparatus of claim 2, in which said measuring means is a visual measuring means.

4. The apparatus of claim 1, in which said condenser is one of a series of condensers of different capacitance arranged in parallel and in which apparatus there is also a series of switches arranged individually in series with the respective condensers, each of said respective condensers being adapted to being selected by the closing of its said corresponding switch for connection with said electrodes.

5. The process of evaluating a liquid toner adapted for use in electrostatic printing comprising the steps of:
(1) applying a direct current to a condenser having a capacitance approximately equivalent to the charge density of the electrostatically charged paper eventually to be used in said liquid toner for a time sufficient to impose an equivalent charge density on said condenser;
(2) cutting off said direct current from said condenser;
(3) immediately thereafter connecting said condenser to each of two electrodes immersed in said liquid toner; and
(4) measuring the amount of toner particles deposited from said liquid toner onto the receiving electrode.

6. The process of claim 5, in which said measuring of deposited toner particles is performed visually.

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C. F. ROBERTS, *Assistant Examiner.*

U.S. Cl. X.R.

88—14; 324—29, 71, 72