Sept. 20, 1971 W. R. MALONEY ET AL 3,605,692

ELECTROSTATIC LIQUID DEVELOPING APPARATUS

Filed July 2, 1969 2 Sheets-Sheet 1

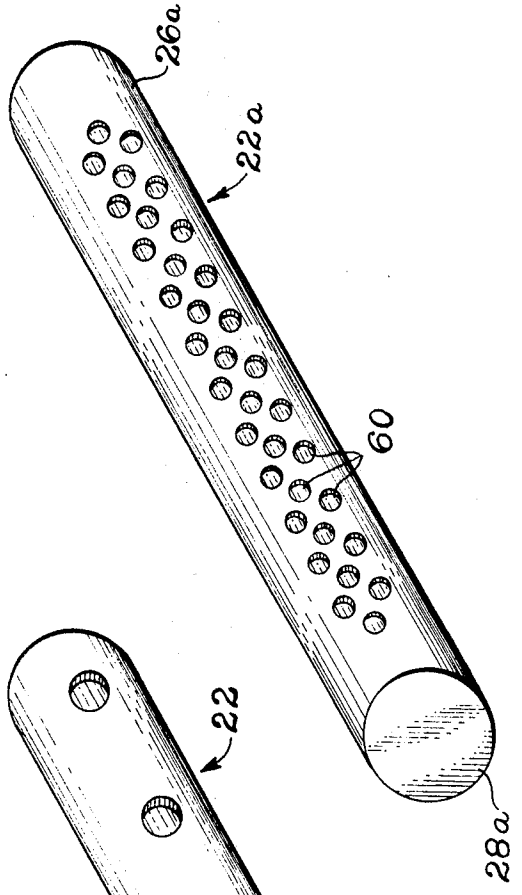

FIG 4

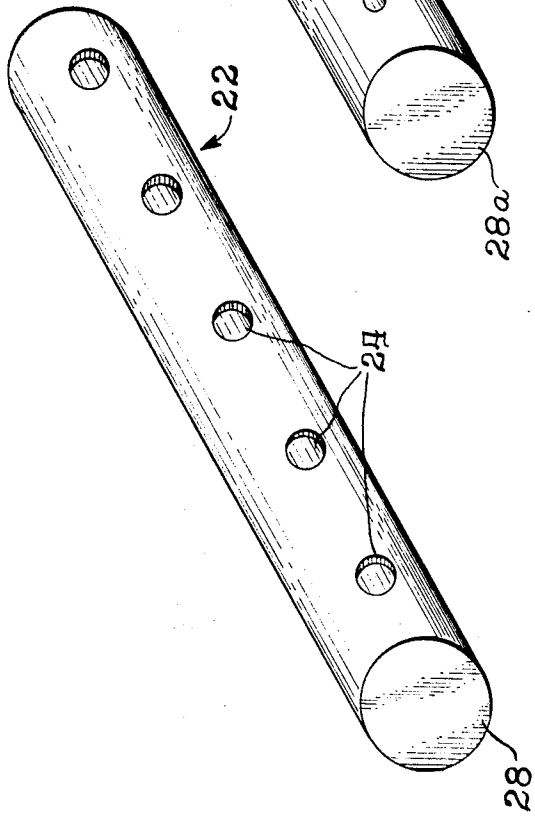

FIG 3

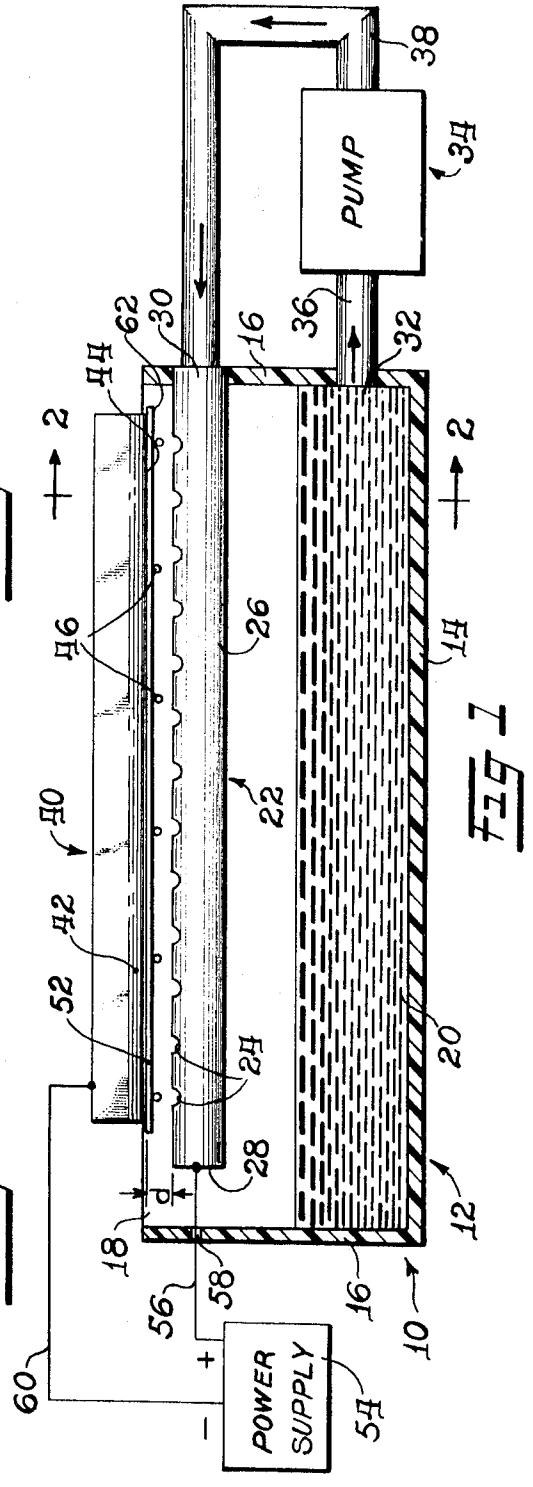

FIG 1

INVENTOR.
William R. Maloney
Richard J. Pleitt
BY Sol L. Goldstein and
Ronald J. La Porte
Atty's

Sept. 20, 1971 W. R. MALONEY ET AL 3,605,692

ELECTROSTATIC LIQUID DEVELOPING APPARATUS

Filed July 2, 1969 2 Sheets-Sheet 2

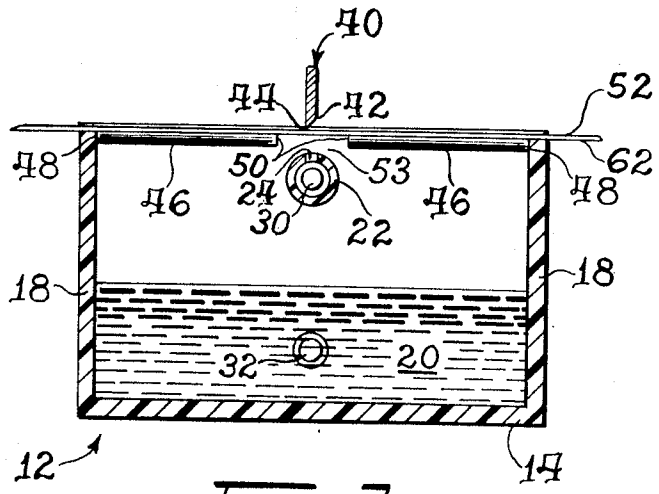

Fig 2

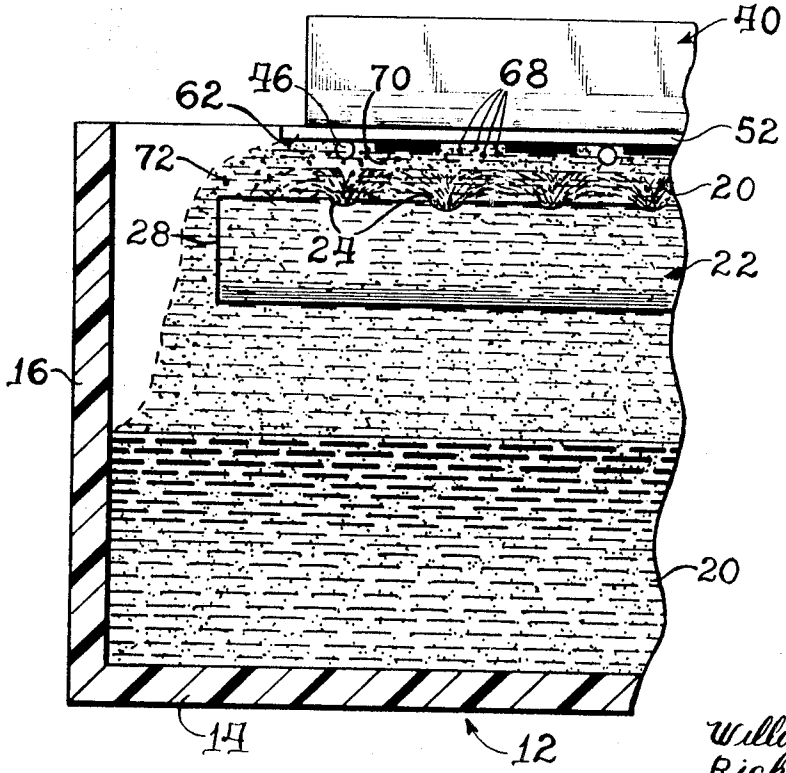

Fig 5

INVENTOR.
William R. Maloney
Richard J. Pleitt
BY Sol L. Goldstein and
Ronald J. La Porte,
Atty's

United States Patent Office 3,605,692 Patented Sept. 20, 1971

3,605,692

ELECTROSTATIC LIQUID DEVELOPING APPARATUS

William R. Maloney, Deerfield, and Richard J. Pleitt, Chicago, Ill., assignors to Addressograph-Multigraph Corporation, Mount Prospect, Ill.

Filed July 2, 1969, Ser. No. 838,396
Int. Cl. G03g 13/00
U.S. Cl. 118—637 6 Claims

ABSTRACT OF THE DISCLOSURE

Liquid developing apparatus includes a reservoir of developer fluid connected by means of a pump to a feed tube adjacent which electrostatically imaged copy material is passed for development. Developer liquid is pumped from the reservoir to the tube whereat the liquid is expelled from apertures formed in the tube wall. A knife edge electrode is spaced from the feed tube opposite the apertures. The feed tube and knife edge electrode are connected to a voltage source to provide a biasing effect, causing toner particles to be attracted toward the knife edge electrode and to accumulate within the developer liquid near the copy material thereby to aid in the development thereof without wetting the copy material excessively.

BACKGROUND OF THE INVENTION

This invention relates generally to developing apparatus for use in developing electrostatically imaged copy material and more particularly, to developing apparatus which uses a liquid developer.

Many varieties of liquid developer arrangements are now being used in electrostatic copying machines. For the most part, however, the liquid developer arrangements cause copy material being developed to be wetted considerably, either on both the imaged and back surfaces or merely on the imaged surface. In either case, drying of the copy sheets is often required. In addition, wherein both sides of the copy material are wetted, the back surface is sometimes left in an unclean state since a quantity of toner from the developer fluid often remains on the back surface after development.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide new and improved liquid developing apparatus for use in an electrostatic copying machine which avoids the above-described shortcomings of prior art liquid developing arrangements.

It is a further object of this invention to provide new and improved liquid developing apparatus wherein the developer solution contacts only the imaged surface of the sheet being developed.

Briefly, a preferred embodiment of developing apparatus according to the invention comprises a hollow feed tube member having a plurality of spaced apertures or openings in the wall thereof. The feed tube is connected by means of a pumping device to a reservoir of developer fluid. Spaced from the feed tube is a knife edge electrode, the edge of the electrode extending in a direction parallel to the length of the tube and in alignment therewith. Interposed between the tube and electrode are supporting means for copy material to be developed. A potential is applied to the feed tube and electrode, the value of the potential depending upon the distance between the tube and electrode.

In operation, developer fluid is pumped into the feed tube so that a fountain of fluid is produced at each of the apertures in the tube. Copy material held by the supporting means against the knife edge electrode is passed between the tube and electrode with the imaged surface facing the tube and being contacted by a layer or wall of developer fluid formed by the plurality of fountains of liquid. The potential applied to the electrode and feed tube causes toner particles carried in the fluid to move therein along a line parallel to the electrode toward the latter and from there are attracted by the charged image to the surface of the copy material.

DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention and its organization and construction may be had by referring to the description below in conjunction with the accompanying drawings, wherein:

FIG. 1 is a front sectional view of a preferred embodiment of a liquid developing apparatus according to the invention;

FIG. 2 is a side sectional view of the developing apparatus of FIG. 1 taken along the line 2—2 thereof;

FIG. 3 is an enlarged perspective sectional view of a feed tube used in the liquid developing apparatus according to the invention;

FIG. 4 is an enlarged perspective sectional view of an alternative embodiment of a feed tube according to the invention; and

FIG. 5 is an enlarged fragmentary view of the developing apparatus as it appears in the operation of developing copy material transported therethrough.

DETAILED DESCRIPTION

Referring now to the drawings and in particular FIGS. 1 and 2 thereof, there is shown a developer apparatus **10** according to the invention. The apparatus **10** comprises a reservoir or tank **12** having a base **14**, side walls each designated **16** and a front and rear wall each designated **18**, only one of which is shown in FIG. 1. The top of the reservoir is open.

The tank **12** is partially filled with developer fluid **20** of the usual kind for developing electrostatically imaged copy material, comprising an insulative liquid carrier in which there are dispersed toner particles having a given polarity. Mounted above the tank within the confines thereof and between side walls **16** is an elongated, hollow member or feed tube **22** constructed of a conductive metal or the like material to serve as an electrode as will be explained hereinafter. The feed tube includes a plurality of aligned, spaced outlet apertures or openings **24** therein, each of a similar size. One end **28** of the hollow member is sealed and the other end **30** is open to provide an inlet. The construction of feed tube **22** can best be seen in FIG. 3 of the drawings.

Connected between the open end **30** of feed tube **22** and an opening **32** in the wall **16** of container **12** is a pump **34**. Pump **34** is connected to container opening **32** via a conduit **36** and to the open end or inlet **30** of feed tube **22** by means of a conduit **38**.

Mounted above feed tube **22** in spaced relation therewith is a knife edge electrode **40**, also formed of a conductive material, such as, metal or the like. The knife edge electrode is blade-like in construction with a narrowed portion **42** thereof extending toward feed tube **22**. The knife edge electdode extends in a parallel relation with respect to feed tube **22** so that the extreme edge **44** of the electrode is positioned in alignment with openings **24** (FIG. 2).

Interposed between knife edge electrode **40** and feed tube **22**, and extending transversely to the direction of elongation of the tube and electrode, is a plurality of support members, each designated **46**. The support members, which may comprise insulative rods, are connected

at ends 48 (FIG. 2) thereof to walls 18, respectively, of the reservoir in opposing relation as shown. The support members are spaced from each other and provide a supporting means for copy material 52 being transported through the developer apparatus for development. As will be noted in FIG. 2, the ends 50 of the rods are separated to form a gap or space 53 (FIG. 2) between the feed tube 22 and knife edge electrode 40 so as not to interfere with the developing of the copy material.

A power supply 54 is connected to the knife edge electrode 40 and to feed tube 22, and provides a biasing potential, the value of which is determined by the distance *d* (FIG. 1) between the feed tube electrode and the knife edge electrode. For example, for a distance *d* equal to 0.5 inch, it has been found that an initial satisfactory voltage supplied from power supply 54 is 3 kv. This may be reduced during the processing of copy material as will be explained hereinafter.

In FIG. 1 the positive terminal of power supply 54 is connected to feed tube electrode 22, by means of a lead wire 56 which extends through an opening 58 in the wall 16 of reservoir 12 and the negative terminal is connected to knife edge electrode 40 via a lead wire 60. The connections of the terminals to the respective electrodes, however, are dependent upon the polarity of the toner particles incorporated in the developer fluid. For the connections as shown in FIG. 1, the toner particles are of a positive polarity.

Referring now to FIG. 4 of the drawings, there is shown therein an alternative embodiment of a feed tube according to the invention designated 22*a*. The feed tube is essentially like the tube of FIGS. 1–3 including a sealed end 28*a* and an open end (not shown). Instead of including a single row of spaced apertures, tube 22*a* comprises a plurality of randomly located openings 60 formed in the wall of the tube. The openings 60 cover more area of the tube wall 26 than do apertures 24, and are therefore able to bring more liquid to the surface of the copy material being fed through the developer. The action of the biasing voltage applied to the knife edge electrode 40 and tube 22*a* nevertheless remains most effective along the group of openings 60 in the tube 22*a* nearest the knife edge 44 of the electrode 40.

FIG. 5 of the drawings illustrates in an enlarged view of the developing apparatus in operation, the influence of the biasing voltage provided by power supply 54, on the toner particles 68 dispersed within the liquid carrier of the developer fluid, and will be discussed hereinafter in regard to the operation of the apparatus 10.

For purposes of affording a more complete understanding of the invention, it is advantageous now to provide a functional description of the mode in which the component parts thus far described cooperate.

Copy material which has been charged and imaged is transported along support members 46 through developing apparatus 10, with the imaged surface 62 of the copy material facing the feed tube 22 (FIGS. 1, 2, and 5). Pump 34 causes liquid developer fluid 20 to flow from reservoir 12 into the open end 30 of feed tube 22 so that the developer fluid is bubbled upwardly and outwardly from openings 24 along the feed tube, in a fountainlike fashion. The liquid flowing from the apertures 24 is commingled along the wall 26 of tube 22 to form a uniform layer of developer fluid or miniscus 72 (FIG. 5). The height of the fountains of developer fluid emerging from apertures 24 can be regulated by the action of pump 34 to cause a narrow bead of fluid to contact the imaged surface of the copy material while not wetting the material excessively.

Power supply 54, connected to knife edge electrode 40 and to the feed tube 22, provides a potential difference between the electrode 40 and the feed tube. In the case wherein the toner particles dispersed in the liquid carrier have a positive polarity the voltage difference is negative. The difference in polarity of the toner particles 68 and the potential between the knife edge electrode 40 and tube 22 causes the toner particles 68 to be attracted within the confines of the liquid carrier toward the electrode 40, thereby accumulating a greater quantity of toner particles 68 in the portion of the fluid disposed along the feed tube 22 near the imaged surface of the copy material moving therealong.

As seen in FIG. 5, the fountains of liquid developer fluid and miniscus 72 of fluid provided along feed tube 22 thereby, cause a narrow bead of fluid to contact the imaged surface. Due to the action of the biasing electrode, toner particles 68 are concentrated at the portion of the liquid bead adjacent the copy material and are attracted from the liquid onto the charged area 70, thus forming a developed image.

The advantage of using the knife edge electrode 40 is that the biasing potential applied thereto is concentrated along a line formed by the extreme edge 44 thereof. The concentration of the potential makes the latter more effective to move a greater quantity of toner particles dispersed in the liquid carrier toward the copy material along a given line and thereby to effect an efficient development of the material without having to wet the latter excessively.

As mentioned heretofore, for a distance *d* between electrodes if approximately 0.5 inch, an operational initial voltage applied to the electrodes 22 and 40 has been found to be approximately 3K volts. After the pumping of fluid has taken place for a time and the toner particles have begun to be moved within the fluid toward the electrode 40, however, the voltage potential required to maintain the toner particles moving in the same direction is lessened. Thus, the potential may be reduced to 1.5 to 2 kv. for the 0.5 inch distance. Changes in the distance *d* will of course require a corresponding change in the voltage applied to the electrodes. Likewise, a change in the height at which the fluid is pumped from openings 24 in tube 22 will also require a corresponding change in the applied potential. No formula for the above-mentioned changes has been developed, however, the changes are ones which could be made easily by one skilled in the art.

A developing apparatus according to the invention utilizing the feed tube 22*a* of FIG. 4, operates in the same manner as the apparatus described heretofore. The use of the feed tube 22*a*, provides less of a fountain effect when the developer fluid is pumped into the tube because of the many more holes distributed in the wall 26*a* of the tube. The liquid emerging from apertures 60, however, forms a continuous layer of fluid more rapidly than the liquid emerging from apertures 24 of tube 22, because of the greater number of openings 60 and because of the close arrangement thereof. Also, the openings 60 form a wider strip along tube 22*a* than do apertures 24, giving the copy material greater width exposure. As mentioned heretofore, however, the action of the biasing potential along knife edge electrode 40 nevertheless remains more effective along a corresponding line of the randomly formed openings 60 along the wall of the tube parallel to the axis thereof as in the case of the feed tube 22.

In either case, whether the developing apparatus is equipped with a feed tube 22 or 22*a*, the apparatus provides a highly efficient, relatively simple, low cost liquid developer which serves to wet only one surface of the copy material, avoids excessive wetting of the copy material and prevents the non-image surface of the copy material from becoming dirtied in the process.

While particular embodiments of the developing apparatus according to the invention have been illustrated and described, it should be understood that the invention is not limited thereto, since many modifications may be made. It is therefore contemplated to cover by the present application any and all such modifications as fall within the true spirit and scope of the appended claims.

What is claimed is:

1. Apparatus for developing electrostatically imaged copy material, comprising:

a supply of developer fluid including toner particles of a predetermined polarity dispersed in a liquid carrier;

a hollow feed member of conductive material arranged transverse the movement of said copy material and including inlet means and outlet opening means;

pump means connected to said supply of developer fluid and said hollow feed member at said inlet for delivering developer fluid from said supply to said hollow feed member so that said fluid is expelled at said outlet opening means in said hollow feed member, said fluid forming a narrow bead along the hollow feed member;

electrode means positioned a predetermined distance from said hollow feed member opposite said outlet opening means and forming a path between said hollow member and electrode for the passage of copy material, said electrode means including an elongated member extending generally parallel to the hollow feed member to provide a biasing effect along the length of the hollow feed member, said elongated member having a knife edge portion facing toward the feed member to concentrate the biasing effect along a line adjacent said outlet opening means in the hollow feed member; and

a source of voltage connected to said hollow member and electrode for providing a biasing potential, thereby to cause said toner particles to be attracted toward said electrode and to accumulate within said liquid carrier near said copy material as the latter passes along said copy material path.

2. Apparatus as claimed in claim 1 wherein said outlet opening means includes a plurality of random openings formed in said hollow feed member.

3. Apparatus as claimed in claim 1 wherein said hollow feed member includes an elongated tubular member having a plurality of aligned apertures each of a predetermined size provided along the wall thereof comprising said outlet opening means.

4. Apparatus for developing electrostatically imaged copy material, comprising:

a container of developing fluid comprising conductive toner particles dispersed in liquid carrier;

a tubular feed member including an inlet, and a plurality of outlet openings disposed along the wall thereof, said feed tube member being mounted above said container of developing fluid;

pump means connected to said container and to the inlet of said feed tube member for pumping developing fluid from said container into said feed tube member, said fluid flowing outwardly of said feed tube member from said outlet openings to form a layer of developing fluid along the outer surface of said feed tube member, excess liquid developing fluid spilling back into said container, the rate of flow of said liquid developing fluid from said openings being regulated by the action of said pump means;

an elongated bladelike electrode being mounted above said feed tube member a predetermined distance therefrom in an aligned parallel relation therewith, opposite said outlet openings, and forming a copy material path between said electrode and said feed member, said bladelike electrode having a knife edge portion facing toward the tubular feed member to concentrate a biasing effect along a line adjacent the outlet openings in the feed member; and

power supply means connected to said electrode and said feed tube member providing a biasing potential for attracting toner particles within said liquid carrier toward said copy material to aid in the development of the latter as said copy material passes along said copy path.

5. Apparatus as claimed in claim 4 further including copy material support means disposed between said electrode means and said feed member, said support means being spaced from said electrode a predetermined distance so that copy material passing along said copy material path with the imaged surface thereof facing said feed member contacts the knife edge portion of said electrode means along the back surface thereof.

6. Apparatus as claimed in claim 4 wherein each of said outlet openings in said tubular feed members is of a predetermined size and wherein said openings are predeterminedly spaced from each other along the length of said tubular member.

References Cited

UNITED STATES PATENTS

2,956,494	10/1960	Tyler et al.	118—637LX
3,079,272	2/1963	Greig	117—37LX
3,392,707	7/1968	Marx	117—37LX
3,435,802	4/1969	Nail	118—637

OTHER REFERENCES

T. M. Crawford: Developing Electrostatic Charge Patterns, I.B.M. Technical Disclosure Bulletin, vol. 8, No. 4, September 1965, p. 527.

MERVIN STEIN, Primary Examiner

L. MILLSTEIN, Assistant Examiner

U.S. Cl. X.R.

117—37L