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[54] **ELECTROPHOTOGRAPHIC DEVELOPING APPARATUS**
10 Claims, 3 Drawing Figs.

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[51] **Int. Cl.** **B05b 5/02**
[50] **Field of Search** 118/637, 428, 44, 34; 95/89.94; 117/37LX

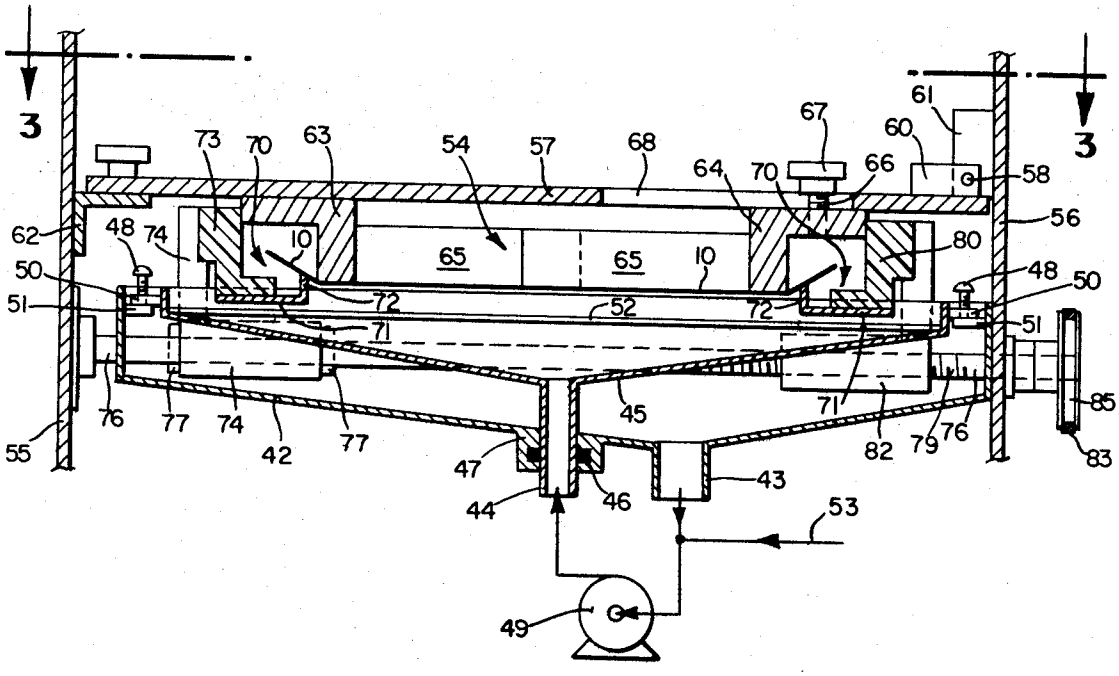
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ABSTRACT: Electrophotographic developing apparatus for applying a liquid developer to one surface of an electrophotographic recording element carrying the electrostatic image thereon so as to render the electrostatic image visible, the apparatus being adapted to apply liquid developer by a surface immersion technique and including edge control means arranged to contact portions of the recording element adjacent the side edges of the recording element as it moves past the reservoir containing the liquid developer, the edge control means preventing immersion of portions of the front surface of the recording element extending inwardly of the side edges for a predetermined distance whereby the back surface of the recording element is kept free from liquid developer.



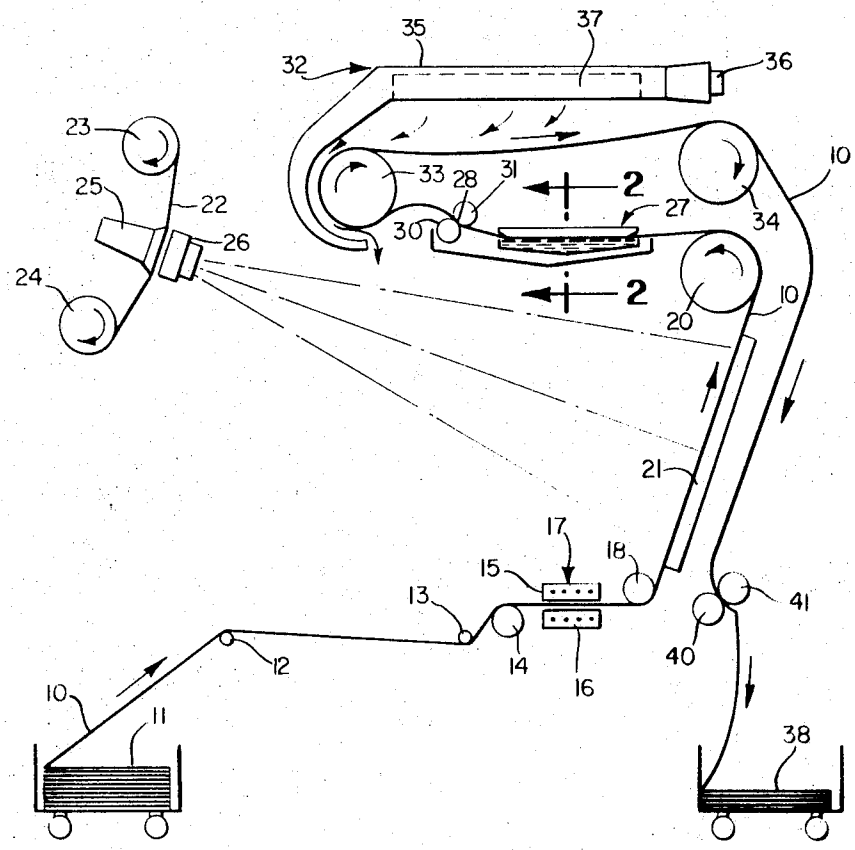


Fig. 1

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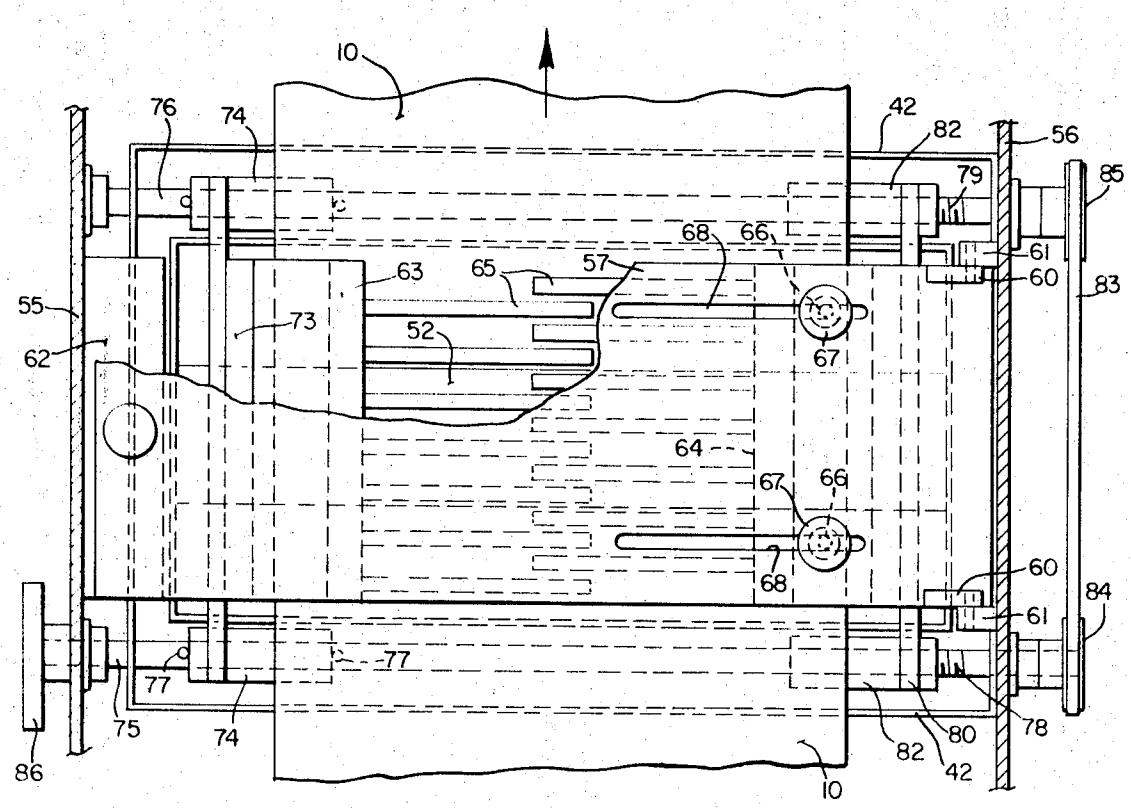


Fig. 3

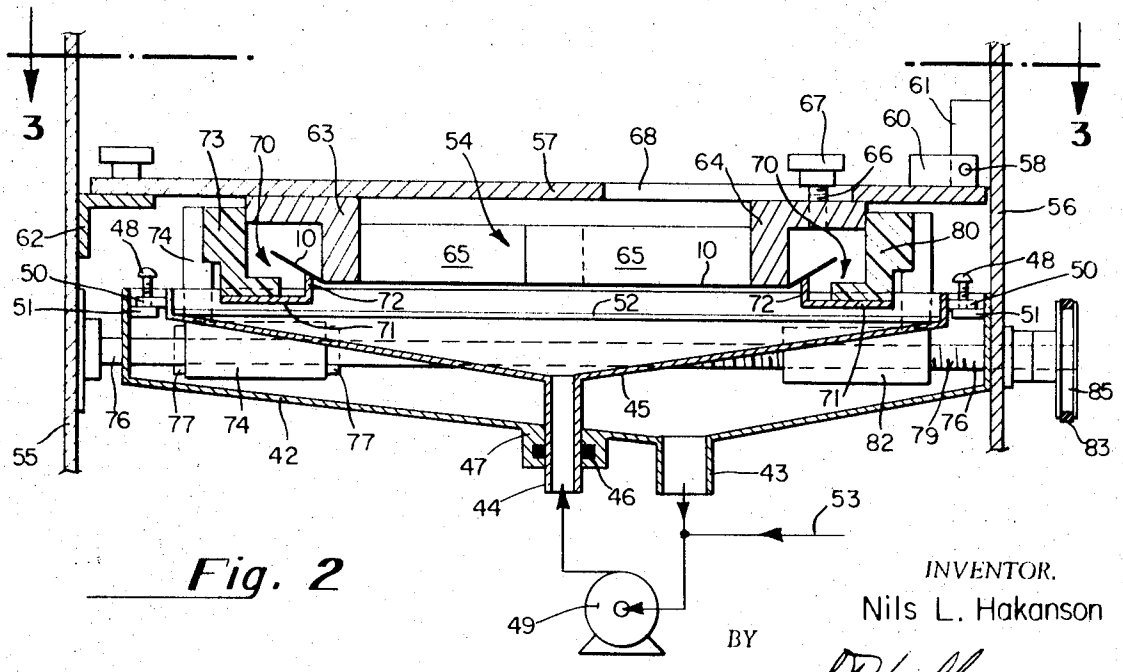


Fig. 2

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ELECTROPHOTOGRAPHIC DEVELOPING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to apparatus for developing an electrostatic image carried on one surface of an electrophotographic recording element, and more particularly, to such apparatus of the surface immersion type in which the recording element is guided so that one surface thereof is immersed in a liquid developer so as to render visible an electrostatic image carried on that surface.

2. Brief Description of the Prior Art

In the past, many different methods have been employed for applying a liquid developer to a recording element so as to render visible a latent electrostatic image carried thereon. Such prior art apparatus was generally utilized for treating single sheets on an intermittent basis and even where it was used and associated with forming images on continuous webs, such webs were generally moved quite slowly or on an intermittent basis. A wide variety of ways of applying the liquid developer material to the sensitized surface of the recording element were employed. In some instances the entire recording element was immersed in the liquid developer and withdrawn and dried as by the use of heat and perhaps mechanical means such as squeegee rolls. In other instances, the liquid developer was applied by spray techniques.

All of these processes generally result in application of the liquid developer not only to the front surface of the recording element carrying the electrostatic image but also to at least portions of the back surface of the recording element. This is especially true where the recording element is of the perforated type perhaps having holes therethrough to assist in folding the strip recording element as into a fan-folded stack, or in separation of the strip recording element into a number of separate sheets, or for engagement of sprocket wheels by means of which, in some instances, the recording element is advanced through the processor or through subsequent apparatus. Because of the intermittent and relatively slow operation of these various forms of apparatus, the wetting of the back surface of the sheet did not cause problems since there was sufficient time allotted for the adequate drying of the sheet before it was utilized or further advanced through the processor.

However, with the advent of higher speed copying processes and particularly those associated with automatic data handling apparatus such as computer readout devices and microfilm copying devices, the speeds of copying have advanced to the point where drying capacity is inadequate if the back surface of the recording element receives any liquid developer. Such systems frequently operate at continuous speeds of up to 200 feet per minute and even higher. It is important in such circumstances to minimize drying capacity so that drying of the recording element can be accomplished in a reasonably short distance of say a few feet so that the process is useable in a commercial office copier. This also results in the use of unnecessary amounts of liquid developer. The back surface of the recording element may be coated with a sealant of some type to prevent absorption of the liquid developer. However this surface will still be stained by the liquid developer which contacts it, which is undesirable. In addition, wetting of the back surface also tends to change the dimensional characteristics of the recording element which results in an inaccurate portrayal of the indicia being copied.

It is therefore a principal object and advantage of the present invention to provide electrophotographic developing apparatus for applying a liquid developer to one surface of an electrophotographic recording element carrying a latent electrostatic image thereon so as to render the electrostatic image visible, which apparatus prevents any liquid developer from contacting the back surface of the recording element during immersion of the front surface thereof in said liquid developer.

It is a further object and advantage of the present invention to provide such apparatus which prevents immersion of portions of the front surface of the recording element extending inwardly from the side edges for a predetermined distance.

SUMMARY OF THE INVENTION

The invention is apparatus for applying a liquid developer to one surface of an electrophotographic recording element carrying an electrostatic image thereon so as to render the electrostatic image visible. The apparatus includes a reservoir containing a liquid developer and the reservoir has an inlet for the introduction of liquid developer and an outlet for the removal of liquid developer. A pump is arranged to communicate with the inlet and the outlet to the reservoir and is adapted to circulate liquid developer through the reservoir. A backing member is disposed above the reservoir and is arranged to immerse the electrostatic-image-carrying front surface of the recording element in the liquid developer. The apparatus also includes edge control means arranged to contact the recording element as it moves past the reservoir so as to prevent immersion of portions of the front surface of the recording element extending inwardly from the side edges for a predetermined distance.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic elevation view of one embodiment of an integrated high-speed electrophotographic copying process illustrating the manner in which developing apparatus of the invention is utilized.

FIG. 2 is a sectional end view of developing apparatus of the invention taken along lines 2–2 of FIG. 1.

FIG. 3 is a sectional top view of apparatus of the invention taken along line 3–3 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the high speed electrophotographic apparatus shown in FIG. 1, a recording element **10** in the form of a continuous strip is fed from a fan-folded stack **11**, that is, a stack **11** formed by the successive reverse folding of the recording element **10** along transverse lines equidistantly spaced along the strip. The recording element **10** generally comprises a base sheet which is generally paper but which may also be metal, plastic or the like and a photoconductive layer thereon which in most instances comprises a homogeneous mixture of a film-forming resin containing photoconductor particles. The film-forming resin may be, for example, silicone resin, polyvinyl chloride resin, polyethylene, phenolic resins, polyester resin, methacrylate resin, polystyrene resin, styrenated alkyd resins, or vinylacetate-vinylchloride copolymer resin. The preferred photoconductor is zinc oxide such as, for example, the photoconductive zinc oxide sold by the New Jersey Zinc Company as Florence Green Seal 8. The photoconductor particles can be any known photoconductor such as the oxides of zinc, antimony, aluminum, bismuth, cadmium, mercury, molybdenum and lead; the iodides, selenides, sulphides or tellurides of these metals; selenium, arsenic trisulfide, lead chromate and cadmium arsenide. It is also contemplated that various types of organic photoconductors might be used. These materials have been recently developed and are well known to those skilled in photosensitive resins.

The surface of the recording element **10** which is photoconductive is the surface containing the electrostatic image to be developed and will be referred to throughout this application as the "front surface." The opposite surface of the recording element **10** will be referred to throughout this application as the "back surface."

The recording element **10** passes over a guide roll **12** and under a guide roll **13** and over another guide roll **14** and is advanced under tension between two charging grids **15** and **16** of a corona discharge unit **17**. The grid **15** is positively charged, while the grid **16** is negatively charged. The recording element **10** issues from between the corona discharge grids **15** and **16**

with a uniform electrostatic charge on its upper or front surface. It passes beneath a guide roll **18** and is advanced in tension to another guide roll **20** across a flat plate **21**. Preferably, a slight vacuum is applied by the flat plate **21** to the back or uncharged surface of the recording element **10** to insure that the recording element **10** lies in the plane of the flat plate **21** during exposure to an image. Such a vacuum may be applied by attaching a vacuum source (not shown) to the back side of the plate **21** and providing perforations (not shown) through the plate **21** so that the vacuum communicates to the front surface of the plate **21** through such holes or perforations and draws the recording element **10** into contact with the plate **21**.

A latent electrostatic image is created on the recording element **10** as it moves over the plate **21** by exposure of the front surface thereof containing the photoconductive material to a pattern of light and shadow illumination. Such a pattern may be created as by moving a strip **22** of film which may be microfilm fed from the reel **23** to the reel **24** past a light source **25**. The film **22** contains the image which is to be copied and the light source **25** projects the image through a lens system **26** and onto the front surface of the recording element **10**. The lens system **26** may be provided with means for enlarging the light image to the desired size. When the pattern of light and shadow illumination contacts the front surface of the recording element **10**, the illuminated areas of the surface are discharged and a charge image remains which corresponds to the shadow pattern presented to the sensitive recording element **10**.

This latent charge image is then developed by means of the developing apparatus of the invention, indicated generally by reference numeral **27**, which will be specifically described with reference to FIGS. **2** and **3** of the drawings. However, it should be noted that the front surface of the recording element **10** is immersed by the developing apparatus **27** in a liquid developer.

The liquid developer may comprise any one of the conventional types of toner materials utilized which generally comprise finely divided pigment particles carried in a carrier solution, the pigment particles being of a nature enabling them to receive a triboelectric charge thereon of a predetermined polarity so that they tend to gravitate toward a charged image portion of the recording element **10** so as to develop that image and render it visible. Such liquid developers are well known to those skilled in the art of photocopying processes of the electrostatic type.

The recording element **10** is withdrawn from the developing apparatus **27** and passed through a squeegee nip **28** formed by two squeegee rolls **30** and **31** which remove excess liquid developer from the front surface of the recording element **10**. The recording element **10** is then advanced through a dryer section **32** of the apparatus in which it is entrained about a heated roll **33** and suspended for a short distance and then entrained about a subsequent guide roll **34**. A hood **35** is disposed over the portion of the recording element **10** contacting the heated roll **33** and over the suspended portion extending between the heated roll **33** and the guide roll **34**. The hood **35** is adapted to receive air at the inlet **36** which air is heated by heaters such as electrical resistance elements located in the section indicated by reference numeral **37**. This heated air is emitted over the front surface of the recording element **10** in generally countercurrent flow, most of it being removed from the hood **35** at the point beneath the heated roll **33** and adjacent the squeegee rolls **30** and **31**. A fan (not shown) may be employed at the inlet **36** to drive the air through the hood **35** or the air may be fed into the hood **35** under pressure. This drying section **32** removes most or all of the residual volatile components of the liquid developer from the recording element **10**, leaving the recording element **10** entrained over the guide roll **34** substantially dry. The resulting recording element **10** containing the developed image thereon may be refolded into a fan-folded stack **38** and transferred to another position for ultimate use. The refolding is accomplished by a pair of rolls **40** and **41** which feed the recording element **10** downwardly in a fashion such that it reassumes its original fan-folded condition.

FIGS. **2** and **3** illustrate the developing apparatus of the invention in greater detail. Looking at FIGS. **2** and **3**, it can be seen that the apparatus has an outer catch basin **42** having an inwardly and downwardly sloping bottom leading to a drain **43**. The drain **43** communicates through a pump **49** to an inlet duct **44** which leads into the bottom of an inner tank **45** which serves as a reservoir for liquid developer and is disposed above and within the catch basin **42**. The inlet duct **44** passes through the sloping bottom surface of the catch basin **42** and a seal is maintained between the duct **44** and the bottom surface of basin **42** by an O-ring **46** carried in a mounting **47** secured to the bottom surface of the catch basin **42**. The relative height of the inner tank **45** is adjustable by screws **48** disposed on either side of the tank **45** and threadedly attached to flanges **50** depending outwardly from each side of the inner tank **45** and bearing against a lower flange **51** depending inwardly from each side of the catch basin **42**. This permits the inner tank **45** to be moved up and down relative to the catch basin **42**.

A baffle plate **52**, which may comprise an imperforate metal plate is positioned generally over the inlet duct **44** at the point where it enters the inner tank **45** and from one side of the inner tank **45** to the other side. The baffle plate **52** serves to distribute liquid developer entering the inner tank **45** from the inlet duct **44** so that it does not impinge directly against the surface of the recording element **10** above it. The baffle plate **52** has a dimension in the direction of travel of the recording element which is less than that of the inner tank **45** so that liquid developer is free to surround the baffle plate **52** and to circulate over the immersed surface of the recording element **10**. In practice, the liquid developer is pumped into the inner tank **45** until it overflows over the sides thereof. The liquid developer overflows into the catch basin **42** and is then recirculated by means of the pump **49**. The catch basin **42** may also be used as a reservoir for additional liquid developer or a separate additional reservoir (not shown) may be supplied. Additional liquid developer may be added to the system either into the catch basin **42** or into another reservoir (not shown) or into the duct connecting the catch basin **42** to the pump **49**, as by insertion at the point indicated by the arrow **53**.

The recording element **10** is fed over the upper surface of the liquid developer carried in the inner tank **45** and has its lower surface, that is, its front surface carrying the latent electrostatic image thereon, immersed in the liquid developer carried in the inner tank **45** so as to develop that image and render it visible.

A backing member indicated generally by reference numeral **54**, is disposed above the recording element **10** and is fixed to the side plates **55** and **56** which also carry the catch basin **42**. Thus, the height of the backing member **54** relative to the catch basin **42** is fixed. The backing member **54** comprises a top plate **57** on one side of which is hingedly attached to the side plate **56** by means of a pin **58** connecting a flange **60** on the top plate **57** to a flange **61** depending inwardly from the side plate **56**. The opposite end of the top plate **57** rests on an angle bracket **62** depending inwardly from the side plate **55**. Two comb members **63** and **64** are secured to the lower surface of the top plate **57** and are adapted to contact the back surface or top surface of the recording element **10** with their lower surfaces as the recording element **10** passes over the inner tank **45** and to form a flat supporting grid surface over which the recording element **10** slides. In order to provide for varying width of the recording element, the comb members **63** and **64** are moveable relative to one another and have a plurality of spaced elongate elements **65** which interfit with similar elements **65** of the other so that the width of the surface of the backing member **54** may be increased by pulling the comb members **63** and **64** apart and yet a broken or gridlike but substantially evenly supporting surface is still maintained by the two comb members **63** and **64**, as shown in FIG. **3**. The comb member **63** is fixed to the top plate **57** while

the comb member **64** is moveable relative to the top plate **57**, its sliding support being accomplished by pin members **66** having knobs **67** on the upper ends thereof which pass through slots **68** in the top plate **57**.

The liquid developer is initially brought into contact with the lower or front surface of the recording element **10** by raising the inner tank **45** to a point sufficient to cause the liquid developer therein to contact the recording element **10** before it overflows from the inner tank **45** and into the catch basin **42**.

In accordance with the invention, edge control means **70** are provided which contact the recording element **10** as it moves past the inner tank **65** or reservoir containing the liquid developer. The edge control means **70** prevent immersion of portions of the front surface of the recording element **10** extending inwardly from its side edges for a predetermined distance. In the embodiment shown, these edge control means **70** comprise an elongate flange member **71** having an upstanding rib **72** which emerges above the surface of the liquid developer in the inner tank **45** and hence above the edge of the inner tank **45** for a distance sufficient to raise the side edges of the recording element **10** above the level of the liquid developer contained in the inner tank **45**. This prevents wetting of the portions of the recording element **10** which are elevated by these upstanding ribs **72** which is important in that these prevent leakage of liquid developer over the side edges of the recording element **10** and onto the back surface thereof which would otherwise occur. Such a provision is extremely important where the recording element **10** has holes along each side edge, as where it is adapted to be sprocket fed through processing apparatus such as perhaps through the apparatus shown in FIG. **1**.

In accordance with the invention, these edge control means **70** are moveable relative to one another so as to permit their use with recording elements **10** of different widths. It also permits adjustment of the amount of the recording element **10** which is to be kept out of contact with the liquid developer.

Thus on one side, the flange **71** is fixedly attached to an elongate angle **73** which is carried at each end by spaced brackets **74** rotatably carried by the rotatable rods **75** and **76**. The rods **75** and **76** are rotatably carried by the side plates **55** and **56**. Movement of the brackets **74** along the rods **75** and **76** is prevented by collars **77** on the rods **75** and **76** which are fixed thereto. The rods **75** and **76** contain threaded portions **78** and **80**, respectively, along their opposite ends and the flange **71** on that side is also carried by an elongate angle **81**, each end of which is carried by a bracket **82** threadedly mounted on the rods **75** and **76**. These rods **75** and **76** are rotatably affixed together as by a belt **83** passing over pulleys **84** and **85** disposed on the ends thereof, respectively, and affixed thereto so that upon rotation of the rod **75**, the other rod **76** also rotates an equal amount, thereby assuring that the position of the moveable upstanding rib **72** remains parallel to the stationary upstanding rib **72**. The rod **75** may be turned as by a knob **86** affixed to the opposite end thereof.

It has been found desirable to utilize an electrical bias voltage in the developing apparatus to assist in the development of the latent electrostatic image. In this regard, the top plate **57** of the backing member **54** is normally made of insulating material while the comb members **63** and **64** are made of an electrically conductive material to which a biasing direct current voltage may be applied. The voltage may be of either a positive or negative polarity depending upon the triboelectric properties of the particular photoconductive particles utilized in the liquid developer. The inner tank **45** is normally electrically grounded so as to complete the circuit from the comb elements **63** and **64** through the recording element **10** and through the liquid developer to the inner tank **45**.

Thus it can be seen that the invention provides apparatus for applying a liquid developer to one surface of an electrostatic recording element without getting liquid developer on the back surface thereof. The apparatus of the invention also makes it possible to hold predetermined portions of the recording element adjacent the side edges thereof out of the liquid developer so that if such portions contain perforations, no wetting of the back surface will occur due to passage of liquid developer through the perforations.

From the above, it can be seen that many changes and modifications can be made in the apparatus described above without departing from the spirit and the scope of the invention. For example, both of the edge control means might be moveable laterally. Similarly, the inner tank might be stationary and the backing member might be moveable so as to press the recording element into the liquid developer. In view of the numerous changes which might be made to the particular embodiments described above, the invention is not intended to be limited to these particular embodiments except as may be required by the following claims.

I claim:

1. Apparatus for applying a liquid developer to one surface of an electrophotographic recording element carrying an electrostatic image thereon so as to render said electrostatic image visible, comprising:

a reservoir containing a liquid developer, said reservoir having an inlet for the introduction of liquid developer and an outlet for the removal of liquid developer;

a pump communicating with said inlet and said outlet and adapted to circulate liquid developer through said reservoir;

a backing member disposed above said reservoir and arranged to immerse the electrostatic-image-carrying front surface of said recording element in said liquid developer; and

edge control means arranged to contact the recording element as it moves past said reservoir so as to raise the side edges of the recording element above the level of the liquid developer to prevent immersion of portions of the front surface of said recording element extending inwardly from the side edges for a predetermined distance.

2. Apparatus according to claim **1**, including a baffle member disposed in the liquid developer in said reservoir and between the front surface of said recording element and said inlet, whereby the flow of liquid developer being introduced at said inlet is distributed throughout at least a portion of said reservoir.

3. Apparatus according to claim **2**, wherein said inlet is located at the bottom of said reservoir, and said baffle member comprises a flat plate, said plate extending substantially from one side of said recording element to the other and disposed beneath the front surface thereof.

4. Apparatus according to claim **1**, wherein said backing member is arranged to vary in width depending upon the width of said recording element.

5. Apparatus according to claim **4**, wherein said backing member comprises at least two parts, each of said parts having a plurality of elongate elements which interfit with corresponding elements on the other part, said parts being adapted for relative movement therebetween so as to permit the effective area of said backing member to vary depending upon the width of said recording element.

6. Apparatus according to claim **2**, wherein said baffle member and said reservoir are electrically connected to ground potential, and said backing member is electrically connected to a direct current potential.

7. Apparatus according to claim **1**, including means for adding additional liquid developer to said reservoir.

8. Apparatus according to claim **1**, wherein said edge control means are adapted to cooperate with said backing member so as to hold said portions above the surface of said liquid developer.

9. Apparatus according to claim **1**, wherein said edge control means comprise an elongate element extending along each side of said recording element, said elongate element having an upstanding rib portion extending above the surface of said liquid developer, said rib portion being adapted to prevent wicking of said liquid developer outwardly beyond

said rib portion toward the side edges of said recording element.

10. Apparatus according to claim 1, wherein at least one of said edge control means is mounted for lateral movement relatively toward and away from the other to permit the handling of recording elements having different widths.