Formation and Evaluation of Image Obtained By the Toner Jet Printing Technology

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Abstract

There are various non-impact printing methods used in printers in general use. Each method has its advantages and disadvantages in terms of price, quality, reliability, speed, and equipment size etc. We have investigated an imaging method using the Toner Jet in which a visible direct image is obtained using an electrostatic field to make the toner stick to the paper. Images obtained from the Toner Jet are of equal quality to those obtained by an electrophotographic method. We have confirmed that the Toner Jet method will be an effective non-impact printing method in the near future.

Introduction

Recording methods currently in use can largely be classified as optical, thermal, ink based, ion based or mechanical. Printers which are typical of those which use these various methods include laser printers, thermal printers, inkjet printers, wire dot matrix printers; each of which has its own strengths and weaknesses in terms of price, quality, reliability and speed. Various improved and novel printing methods have been devised over the years to satisfy these demands more fully, but no completely ideal printing method has yet appeared. We have therefore been investigating a new process know as the Toner Jet in which a visible image is formed by using static electricity to make the toner stick to the surface of the paper. A Toner Jet printer (TJP) was used in this study in which we evaluated dot images of 8 lines by 48 columns and symbols and letters formed by partial printing of dots along such lines and columns and in which we investigated whether this could be a viable printing method in the future.

The Printer Mechanism and How it Works

Figure 1 shows the basic mechanism of a Toner Jet printer. The developing unit is at the top, the rear electrodes are at the bottom and there is a mesh-shaped control in between. In this study there was a control electrode and a flexible printed circuit (FPC) on the control electrode. Figure 2 illustrates the principles by which the Toner Jet printer makes recordings. The developer unit conveys the toner uniformly, the control electrode comprises two layers for lines and columns and produces an electrical field when a signal voltage is applied to the two layers. Further, a high-voltage d.c. current is applied to the rear electrode. The statically negative toner which is uniformly conveyed in the developer unit experiences a positive field due to the signal voltage applied to the control electrode, and the toner particles will be drawn towards the control electrode when the coulomb force which attracts the toner due to this field is greater than the coulomb force which holds the toner on the magnetic roller. The toner is further accelerated by the high-voltage d.c. current on the rear electrode, and it passes through the control electrode before adhering to the recording medium (PPC paper). Conversely, when a negative field is at work, the toner is not attracted, does not pass through the control electrode and does not adhere to the recording medium. The Toner Jet conditions appear to be as shown in Table 1.

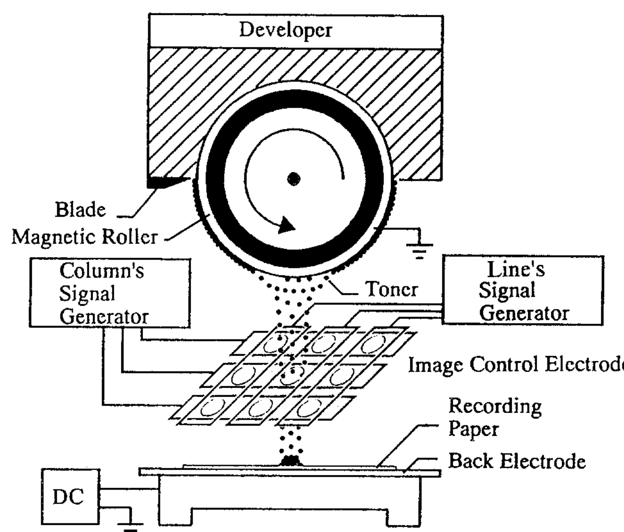

Figure 1. The basic mechanism of a toner jet printer.

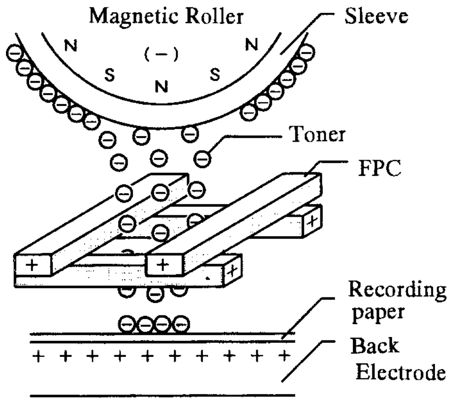

Figure 2. The recording process of TJP.

Table 1. The Toner Jumping Conditions

Column's Direction	+	−	+	−
Row's Direction	+	+	−	−
Jet state of Toner Particles	○	×	×	×

Experimental Device and Experimental Materials

(1) Experimental Equipment

- Toner Jet Printer, made by Company A
- Photoelectric pixel evaluator (Model IT3), Tokyo Denshi Kogyo
- Fixing unit, made by Company A
- Oscilloscope, Kikusui Denshi
- High-voltage voltmeter (0 to 10kV), Kikusui Denshi
- Surface electrometer, TREK Japan
- Digital multimeter, Takada Riken

(2)Experimental Materials

- One component developer (insulating magnetic toner), made by Company A
- One component developer (insulating magnetic toner), made by Company A
- Two component developer (carrier+non-magnetic toner), made by Company B

Experimental Method

Procedure for Test A

(1) Setting the effective range. Based on our distribution analysis[1,2], Table 2 shows the range of effective setting values for a variety of parameters such as the distance between the roll/control electrode and the control electrode, the signal voltages applied to the control electrode (VPB,VPW, VTB and VTW), the pulse width(time), the rear voltage and the rotational speed of the magnetic roll in the developer unit.

(2) Determining the standard settings. The standard settings were any desired setting value where printing was possible within the effective setting range of (1). The values are shown in Table 3.

(3) Determining the variables for the voltages. The variables for the signal voltages VPB, VPW, VTB and VTW and the rear voltage were extracted arbitrarily in 3 to 4 places for each applied voltage within the range of the valid setting values. Table 4 shows the variables for each voltage.

(4) Tests. One of the applied voltages VPB, VPW, VTB and VTW and the rear voltage was charged from the standard voltage progressively through variable 1 to variable 3 (variable 4) while carrying out 3 different types of printing: full printing, column-controlled printing and line-controlled printing. Table 5 shows the settings table.

(5) Evaluation. The results were subjected to an image evaluation and compared.

Table 2. The standard value for each parameter

Item				Set value	
Kind of TONER				Mono Component Toner	
Voltage of Drive Motor (V)				5.326	(V)
MAGNET ANGLE			(°)	0	(°)
Magnetic			(GAUSS)	500	(GAUSS)
D	ROLL-FPC		(mm)	0.05 ~ 0.15	(mm)
D	FPC-Back Electrode		(mm)	0.40 ~ 0.50	(mm)
ON/OFF TIME			(mS)	0.21/0.19 ~ 2/2	(mS)
V	C	VPB	(V)	0.38 ~ 200	(V)
V	C	VPW	(V)	200 ~ 340	(V)
V	L	VTB	(V)	10 ~ 20	(V)
V	L	VTW	(V)	200 ~ 340	(V)
Back Electrode			(KV)	0.3 ~ 1.8	(KV)

D: Distance V: Voltage B: Record W: unrecord C: Column L: Line

Table 3. The standard values for each parameter

Item				Set value	
Kind of TONER				Mono Component Toner	
Voltage of Drive Motor (V)				5.326	(V)
MAGNET ANGLE			(°)	0	(°)
Magnetic			(GAUSS)	500	(GAUSS)
D	ROLL-FPC		(mm)	0.05	(mm)
D	FPC-Back Electrode		(mm)	0.45	(mm)
ON/OFF TIME			(mS)	10/5	(mS)
V	C	VPB	(V)	140	(V)
V	C	VPW	(V)	200	(V)
V	L	VTB	(V)	110	(V)
V	L	VTW	(V)	200	(V)
Back Electrode			(KV)	1.3	(KV)

D: Distance V: Voltage B: Record W: unrecord C: Column L: Line

Table 4. Set Value of Applied Voltage

Applied Voltage		V.N. 1	V.N. 2	V.N. 3	V.N. 4
VPB	(V)	30	100	180	—
VPW	(V)	150	200	250	280
VTB	(V)	10	60	110	—
VTW	(V)	120	170	220	280
Back Voltage (kV)		0.5	1.0	1.8	—

Table 5. Sets Table of Experiment A

No.	Applied Voltage VPB (V)	VPW (V)	VTB (V)	VTW (V)	B.V. (kV)
(1)	30				
(2)	100	200	110	200	1.3
(3)	180				
(4)		150			
(5)		200			
(6)	140	250	110	200	1.3
(7)		280			
(8)			10		
(9)	140	200	60	200	1.3
(10)			110		
(11)				120	
(12)				170	
(13)				220	
(14)	140	200	110	280	1.3
(15)					0.5
(16)	140	110	110	200	1.0
(17)					1.8

B. V. : Back Voltage

Procedure for Test B

(1) Parameter adjustment. We tried to improve the image quality of the controlled printing characters in Experiment A by altering the parameters in sequence giving due consideration to the relationships between the various parameters and the extent of their influence.

(2) Test. Controlled printing was carried out (one column omitted, two columns omitted, three columns omitted, one line omitted, one line and one column controlled, oblique A and B etc.) while adjusting the parameters.

(3) Evaluation. The results were subjected to an image evaluation and compared.

Procedure for Test C

(1) Determining the settings. The appropriate parameters were determined using the setting in Table 3 giving due consideration to focusing the dots.

(2) Test. A number of print runs were tried with the parameters fixed as determined in (1)(Tables 4, 5) using two types of one-component developer (insulating magnetic toners made by Company A and Company B) and a two-component developer (carrier+non-magnetic toner).

(3) Evaluation. The results were subjected to image evaluation and compared.

Evaluation Method

The results of the tests were fed into an image evaluation device which determined (1) the dot diameter, (2) the density and (3) fogging. The results of this evaluation were compared with the results of an evaluation of dot images obtained using an electrophotographic method. We also assessed whether printing had been completely suppressed in the non-printed areas.

Test Results and Discussion

In the tests in this study, the images were formed with printed areas and non-printed areas (control of columns, control of rows, and simultaneous control of rows and columns) using FPC on the control electrode. Moreover, images were formed using three different types of toner. The results of these tests are given separately below and evaluations are also discussed separately.

Image Achieved Through an Electrophotographic Recording Method (Sample Dot Image)

Figure 3 shows the density distribution chart and the density cross-section of an electrophotographic image (made by Company A) for comparison with the results of the tests. This gave a dot diameter of 197 to 214 μm, a maximum density of 1.85 and scattering of about 61 to 121. These results were taken as the standard for the dot images in the tests to aim for.

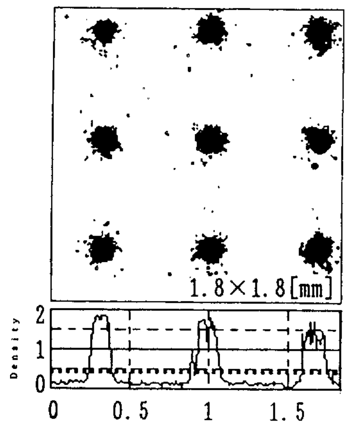

Figure 3. The density distribution chart and density cross-section of an electrophotographic image.

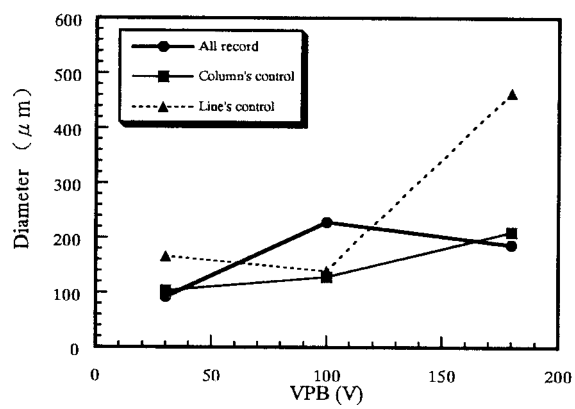

Figure 4. The relation of VPB and dot diameter.

Test A

In an overall evaluation of the images from Test A using Tables 6 to 10, there were good results, 2 for the full printing, 3 for the column-controlled printing and 2 for line controlled printing. Test procedure 96, setting No. 60 for full printing gave a dot image with a dot diameter of 173 μm, a density of 1.48 and scattering of 120, and there were no problems with the image quality. Test procedure 98, setting No. 62 for column controlled printing (1 column omitted) gave a dot diameter of 148 μm, a density of 1.46 and a scattering of 37, which were adequate values for the image quality, the control was good and printing was completely

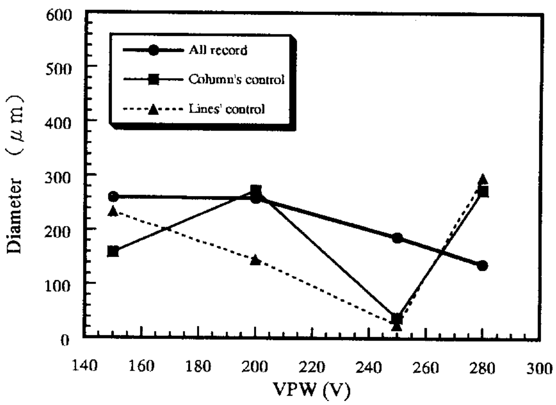

Figure 5. The relation of VPW and dot diameter.

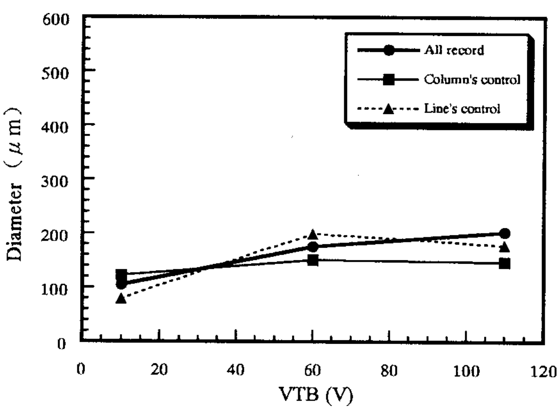

Figure 6. The relation of VTB and dot diameter.

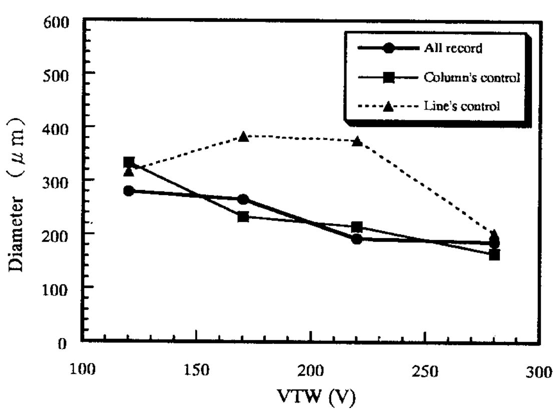

Figure 7. The relation of VTW and dot diameter.

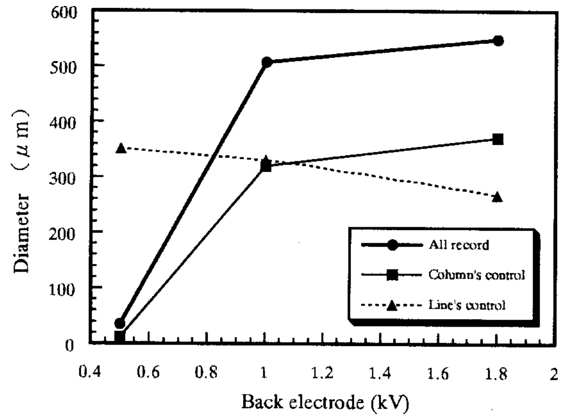

Figure 8. The relation of back electrode and dot diameter.

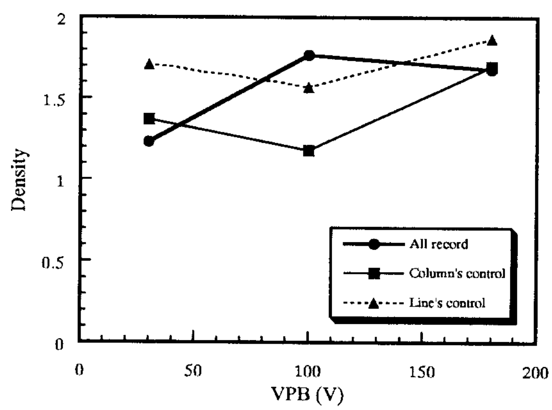

Figure 9. The relation of VPB and density.

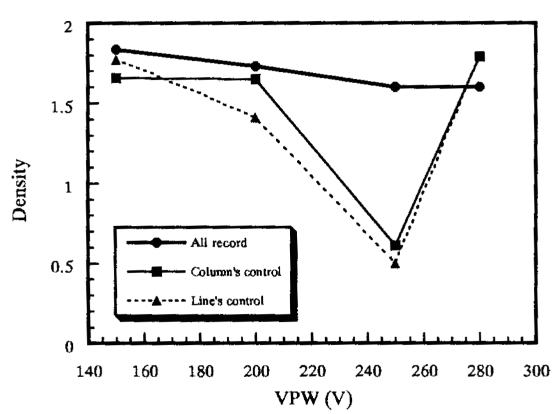

Figure 10. The relation of VPW and density.

suppressed in the non-printed portions. Test procedure 61, setting No.105 for line controlled printing (one line omitted) gave a dot diameter of 234 µm, which was rather large, but there were no problems with image quality since the dots were focused, the density was 1.76 and scattering was 87. Further, the printing was well controlled and completely suppressed in the non-printed portions. This proves that high-quality printed characters can be achieved not only in full printing, but also in row and column controlled printing (1 column omitted, 1 row omitted). As outlined below, graphs (Figures 4 to 13) were used to determine which voltages affected the density and dot diameter and the differences in the effect in full printing, row controlled printing and column controlled printing.

(1) In general, the dot diameter and image density tended to increase at higher voltages of VTB and VPB. The charges were larger with VPB than with VTB.
(2) In general, the dot diameter and image density tended to decrease at higher voltages of VTW and VPW. The extent was roughly the same for both variables.
(3) In general, the dot diameter and image density tended to increase at a rear voltages . The characteristics were clearly found to charge in row controlled printing and other printings.

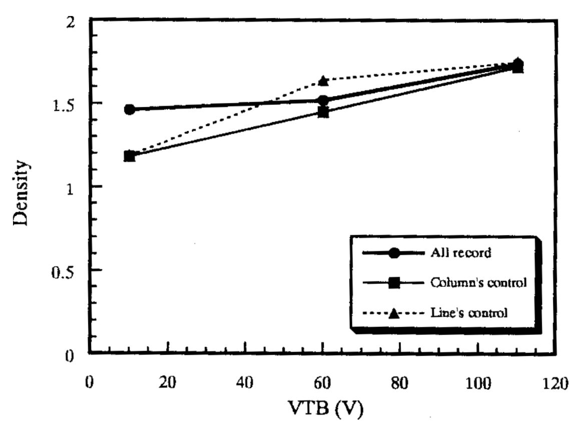

Figure 11. The relation of VTB and density.

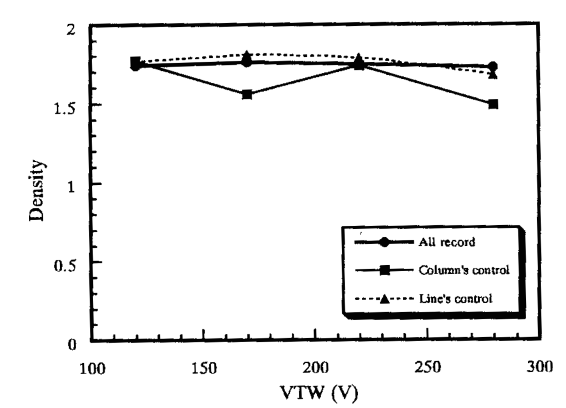

Figure 12. The relation of VTW and density.

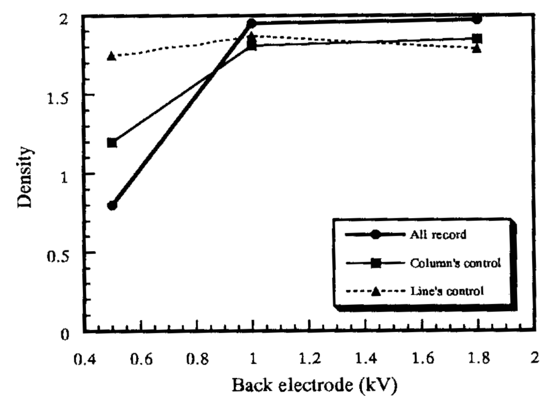

Figure 13. The relation of back electrode and density.

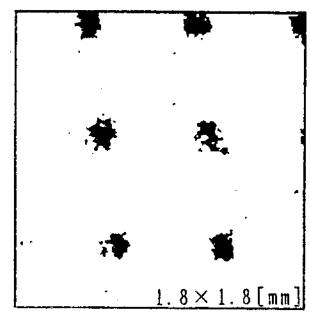

Figure 14. The density distribution using an old FPC.

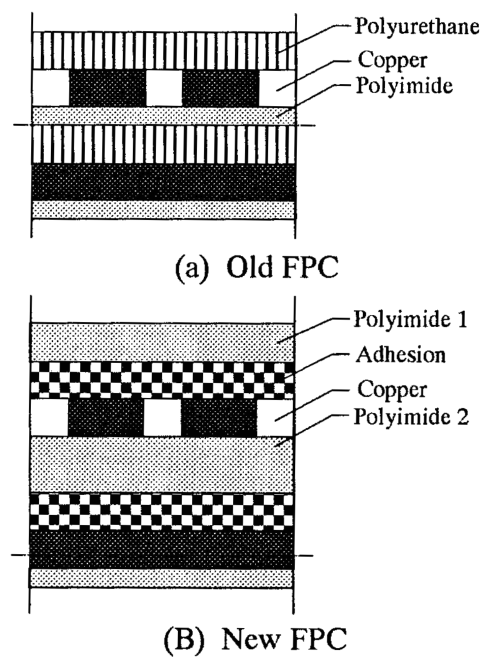

Figure 15. The cross-section of FPC.

Upon comparing the density and dot diameter, graphs with much the same characteristics were found at the various voltages. With VTB, the density and dot diameter were proportional under all controls, while, conversely, they were inversely proportional with VTW. Additionally, the characteristics differed in VPB/VPW full printing and row and column controlled printing. Just looking at full printing, the density and dot diameter were proportional for VTB and VPB and were inversely proportional for VTW and VPW. This reveals that the effects of the various voltages differ for different types of controlled printing. This appears to be because the control electrode comprises two layers and the effects of VTB and VTW are suppressed by VPB and VPW since the row layer is below the column layer. Further, the reason why there are few changes with the rear voltage in line controlled printing appears to be because the row layer always sustains the effects of the rear voltage.

Test B

We printed a full printing, a line controlled and a column controlled printing, and a letter A under the parameters shown in Table 11. Figure 14 shows the results of printing done using an old FPC. It proved possible to print to roughly the same quality as an electrophotographic method with a diameter of 205 μm and a maximum density of 1.25, but non-printing was difficult apparently because the applied voltage leaks into the FPC film. The FPC structure was therefore altered as shown in Figure 15 to overcome this problem. Further, a control electrode without a film was used as a countermeasure against leaking, but, although non-printing was possible, this did not give a clear image with a focused print. The reason appears to be the reverse polarity of the toner. We therefore investigated the effects of the toner. Figure 16 shows the results of full printing and the density cross section (using FPC on the control electrode). This image was close to an electrophotographic image and had a dot diameter of 210 μm, the dots were focused, fogging was restricted to about 38% of the sample image, and a comparison of the densities on the density cross section revealed that the test printings had an adequate density with a maximum of 1.73 which compared with a maximum density of 1.83 for the electrophotographic image. This means that a high quality dot image can be obtained in a fully printed image. Because the fully printed image was satisfactory, we tried controlled printing (column and line omitted). Printing was completely suppressed in the non-printed areas as shown in Figure 17 which shows the density distribution in 1 row-omitted printing and Figure 18 which shows the density distribution in 1 column omitted printing. Then we tried simultaneous control of rows and columns. Figure 19 shows the results of printings and density cross sections in 1 row and 1 column controlled printing. The lines and columns were both controlled in the image obtained and the non-printed areas were completely clear. Even though the dot diameter was large at 260 μm, the dots were focused. There was also a satisfactory maximum density of 1.72. This means that rows and columns can be simultaneously controlled without losing the image quality. We therefore tried to print more complex images. Figure 20 shows the results and the density cross section of a printing of the letter "A" formed of dots. The non-printed areas were completely clear, the dots were focused with a diameter of 214 μm and the maximum density was 1.77, all satisfactory values. This proves that Toner Jet printer functions adequately as a printer.

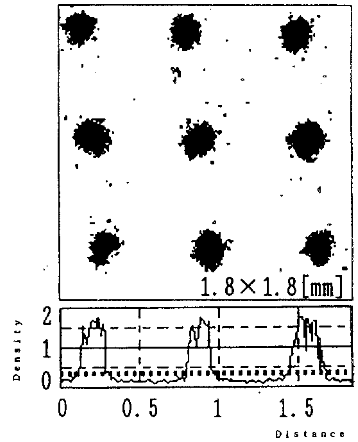

Figure 16. The results of all-over printing (density distribution) and cross-section of density.

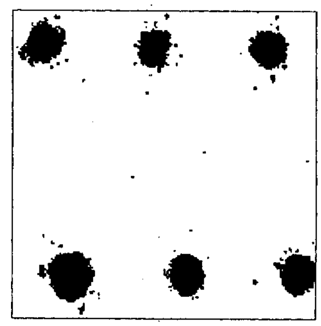

Figure 17. The density distribution in 1 row-omitted printing.

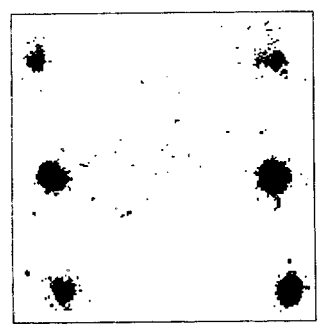

Figure 18. The density distribution in 1 column-omitted printing.

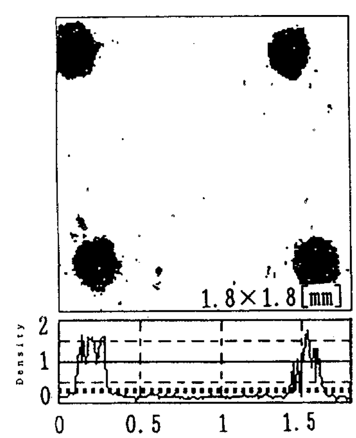

Figure 19. The results of printings and density cross-section in 1 row and 1 column controlled printing.

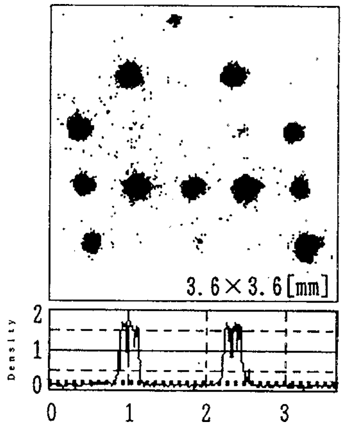

Figure 20. The results and density cross-section of a printing of the letter "A".

However, it proved impossible to print a full 8 × 48 columns and dot sizes varied in the column direction. This appeared to be be because there were slight differences in the distance between the cylindrical magnetic roll and the flat FPC.

Test C

To investigate the effects of the toner in the image, we changed the TJP toner made by Company A to commercially available toners, one toner made by Company B (one component) and one made by Company C (two component) and we investigated the image quality. We first ran a print using the toner made by Company B and the toner made by Company C under the parameters appropriate for the TJP toner which are shown in Table 12. The results when these were evaluated are shown in Table 13. Neither the B toner nor the C toner proved capable of giving good results. We then tried to obtain higher quality images by adjusting the parameters for the B toner and the C toner. Figure 21 shows the results of printing with the B toner and Figure 22 shows the results of printing with the C toner. Table 14 shows the static percentage of each toner. The B toner gave an image quality roughly the same as that of the TJP toner made by Company A. However, the C toner proved incapable of giving a clear image and the dots were unfocused, however many adjustments were tried. This appears to be because the two-component toner consists of a statically negative toner (of about 10 μm) and a statically positive carrier (of about 10 μm), and the polarity of the carrier is not compatible with the principle by which the TJP records nor are the grains of the carrier suitable for the developing unit used here. Further, hardly any difference was observed on comparing the images obtained using the A toner and the B toner. Table 13 shows that there were no differences even though the B toner was 15% more negative than the A toner. It therefore appears that positive toner hardly has any effect on the image quality.

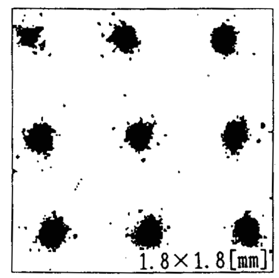

Figure 21. The results of printing using the toner made by Company B.

Table 6. The result with each values of VPB

No.	Experi-mental Order	Recording form	Applied Voltage VPB (V)	VPW (V)	VTB (V)	VTW (V)	B.V. (kV)	Diameter (μm)	Detaes A.D. (μm)	Density	Average	Scattering	Evaluation
1	(47)							60		0.80		135	Δ
2	(46)	A.R.						135	92	1.70	1.23	102	○
3	(45)							82		1.20		47	○
4	(48)	C.C.	30	200	110	200	1.3	117	103	1.23	1.37	43	×
5	(49)							90		1.50		67	×
6	(50)							234		1.76		89	⊙
7	(52)	L.C.						109	166	1.60	1.70	87	Δ
8	(51)							156		1.76		42	○
9	(40)							270		1.80		235	Δ
10	(37)	A.R.						211	228	1.77	1.77	152	Δ
11	(36)							203		1.76		114	○
12	(39)							86		1.00		58	Δ
13	(41)	C.C.	100	200	110	200	1.3	242	128	1.80	1.18	74	Δ
14	(38)							56		0.75		39	×
15	(43)							105		1.43		64	○
16	(44)	L.C.						117	139	1.50	1.57	66	Δ
17	(42)							195		1.79		203	Δ
18	(33)							156		1.70		126	⊙
19	(28)	A.R.						200	187	1.60	1.68	76	○
20	(35)							206		1.76		153	○
21	(29)	C.C.	180	200	110	200	1.3	179	210	1.60	1.70	82	○
22	(30)							241		1.79		112	⊙
23	(34)							436		1.85		854	×
24	(32)	L.C.						526	464	1.90	1.87	1816	×
25	(31)							429		1.86		953	×

B. V. : Back Voltage A.D.: Average Density A. R.: All Record C.C.: Column's Control L.C.: Line's Control

Table 7. The result with each values of VPW

No.	Experimental Order	Recording form	Applied Voltage VPB (V)	Applied Voltage VPW (V)	Applied Voltage VTB (V)	Applied Voltage VTW (V)	B.V. (kV)	Diameter (μm)	A.D. (μm)	Detaes Density	Average	Scattering	Evaluation
26	(4)	A.R.						248	260	1.82	1.84	336	Δ
27	(5)							273		1.85		360	Δ
28	(6)	C.C.	140	150	110	200	1.3	156	195	1.62	1.66	187	○
29	(7)							234		1.70		130	○
30	(8)	L.C.						273	234	1.82	1.77	159	×
31	(9)							195		1.72		49	○
32	(1)							234		1.75		127	Δ
33	(2)	A.R.						250	259	1.72	1.73	180	○
34	(3)							292		1.73		192	Δ
35	(10)	C.C.	140	200	110	200	1.3	234	273	1.50	1.65	62	×
36	(11)							312		1.79		130	×
37	(12)							98		1.48		58	○
38	(13)	L.C.						117	146	1.00	1.41	68	Δ
39	(14)							224		1.76		53	○
40	(15)							250		1.75		119	Δ
41	(16)	A.R.						82	188	1.25	1.60	116	×
42	(17)							234		1.81		111	Δ
43	(18)	C.C.	140	250	110	200	1.3	59	39	0.81	0.61	103	×
44	(19)							19		0.40		37	×
45	(20)	L.C.						10	25	0.30	0.50	6	×
46	(21)							40		0.70		44	×
47	(22)	A.R.						78	137	1.43	1.60	80	×
48	(23)							195		1.76		96	Δ
49	(24)	C.C.	140	280	110	200	1.3	273	274	1.79	1.79	67	Δ
50	(25)							275		1.79		113	Δ
51	(26)	L.C.						361	298	1.82	1.79	48	○
52	(27)							234		1.76		641	×

B. V. : Back Voltage   A.D.: Average Density   A. R.: All Record   C.C.: Column's Control   L.C.: Line's Control

Table 8. The result with each values of VPB

No.	Experimental Order	Recording form	Applied Voltage VPB (V)	Applied Voltage VPW (V)	Applied Voltage VTB (V)	Applied Voltage VTW (V)	B.V. (kV)	Diameter (μm)	A.D. (μm)	Detaes Density	Average	Scattering	Evaluation
53	(101)	A.R.						130	104	1.50	1.46	92	Δ
54	(102)							77		1.41		106	Δ
55	(103)	C.C.	140	150	10	200	1.3	128	122	1.40	1.18	28	○
56	(104)							116		0.96		19	○
57	(105)	L.C.						61	78	1.27	1.19	58	○
58	(106)							34		1.10		39	○
59	(95)	A.R.						176	175	1.56	1.52	65	○
60	(96)							173		1.48		120	⊙
61	(97)	C.C.	140	200	60	200	1.3	152	150	1.43	1.45	63	○
62	(98)							148		1.46		37	⊙
63	(99)	L.C.						162	199	1.58	1.64	95	○
64	(100)							235		1.70		128	○
65	(89)	A.R.						197	202	1.72	1.74	170	Δ
66	(90)							206		1.75		135	×
67	(91)	C.C.	140	200	110	200	1.3	180	197	1.71	1.72	34	×
68	(92)							213		1.73		73	×
69	(93)	L.C.						183	177	1.76	1.75	50	×
70	(94)							171		1.73		52	×

B. V. : Back Voltage   A.D.: Average Density   A. R.: All Record   C.C.: Column's Control   L.C.: Line's Control

Table 9. The result with each value of VTW

No.	Experi-mental Order	Recording form	Applied Voltage VPB (V)	VPW (V)	VTB (V)	VTW (V)	B.V. (kV)	Diameter (μm)	A.D. (μm)	Detaes Density	Average	Scattering	Evaluation
71	(87)	A.R.	140	200	110	120	1.3	240	280	1.68	1.74	130	Δ
72	(88)							267		1.72		65	○
73	(65)							333		1.82		1531	×
74	(63)	C.C.						233	333	1.70	1.77	362	○
75	(64)							433		1.84		660	×
76	(66)	L.C.						300	317	1.75	1.77	273	Δ
77	(67)							334		1.79		611	×
78	(68)	A.R.	140	200	110	170	1.3	307	266	1.86	1.76	1142	×
79	(69)							243		1.75		1212	×
80	(70)							247		1.68		335	Δ
81	(71)	C.C.						200	234	1.45	1.56	60	Δ
82	(72)							267		1.66		363	Δ
83	(73)	L.C.						400	384	1.80	1.81	860	×
84	(74)							367		1.81		275	×
85	(75)	A.R.	140	200	110	220	1.3	179	193	1.72	1.75	130	○
86	(76)							207		1.78		145	○
87	(77)	C.C.						157	216	1.73	1.74	67	○
88	(78)							274		1.75		137	Δ
89	(79)	L.C.						430	376	1.80	1.79	373	×
90	(80)							321		1.78		512	×
91	(81)	A.R.	140	200	110	280	1.3	183	187	1.76	1.73	37	Δ
92	(82)							190		1.70		117	○
93	(83)	C.C.						127	165	1.44	1.49	82	⊙
94	(84)							203		1.53		142	○
95	(85)	L.C.						207	204	1.70	1.68	140	○
96	(86)							201		1.65		54	○

B. V. : Back Voltage A.D.: Average Density A. R.: All Record C.C.: Column's Control L.C.: Line's Control

Table 10. The result with each value of back electrode

No.	Experi-mental Order	Recording form	Applied Voltage VPB (V)	VPW (V)	VTB (V)	VTW (V)	B.V. (kV)	Diameter (μm)	A.D. (μm)	Detaes Density	Average	Scattering	Evaluation
97	(53)	A.R.	140	200	110	200	0.5	35	35	0.80	0.80	110	×
98	(54)	C.C.						117	117	1.20	1.20	113	×
99	(55)	L.C.						351	351	1.75	1.75	119	×
100	(56)	A.R.	140	200	110	200	1.0	507	507	1.95	1.95	2310	×
101	(57)	C.C.						320	320	1.81	1.81	233	Δ
102	(58)	L.C.						330	330	1.87	1.87	562	×
103	(59)	A.R.	140	200	110	200	1.8	549	549	1.97	1.97	4145	×
104	(60)	C.C.						371	371	1.85	1.85	1220	×
105	(61)	L.C.						234	268	1.76	1.79	87	⊙
106	(62)							302		1.81		138	○

B. V. : Back Voltage A.D.: Average Density A. R.: All Record C.C.: Column's Control L.C.: Line's Control

Table 11. The setting values of each printing patterns

		Item	All record	Column & Row	Character A
D		Roll-FPC (mm)	0.05	0.05	0.05
		FPC-B.E. (mm)	0.40	0.40	0.40
		ON/OFF Time (ms)	10/5	10/5	10/5
V	C	VPB (V)	180	144	60
		VPW (V)	200	250	340
	L	VTB (V)	110	110	70
		VTW (V)	200	200	330
		B.E. (kV)	1.3	1.5	1.0

B: Record W: Unrecord B.E.: Back Electrode D: Distance V: Voltage L: Line C: Column

Table 12. The setting values of each parameter in the toner exchange test

		Item	Set Value
D		Roll-FPC (mm)	0.08
		FPC-B.E. (mm)	0.41
		ON/OFF Time (ms)	10/5
V	C	VPB (V)	93
		VPW (V)	297
	L	VTB (V)	104
		VTW (V)	304
		B.E. (kV)	1.3

B: Record W: Unrecord B.E.: Back Electrode
D: Distance V: Voltage L: Line C: Column

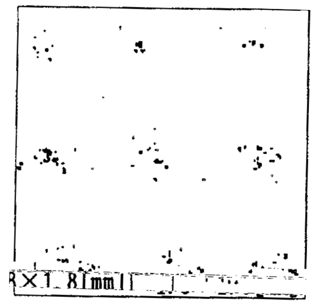

Figure 22. The results of printing using the toner made by Company C

Table 13. The evaluated results of Test A (Experiment C)

Experimental Order	Developer	Recording form	Detaes 4 Line Diameter (μm)	4 Line Density	5 Line Diameter (μm)	5 Line Density	Scattering	Evaluation
(1)	A Company	All Record	231	1.53	223	1.42	127	Δ
(2)		Column's Control	203	1.40	195	1.38	63	❍
(3)	B Company	All Record	—	0.28	—	0.31	92	×
(4)		Column's Control	—	0.41	—	0.37	38	×
(5)	C Company	All Record	31	1.03	25	1.15	41	×
(6)		Column's Control	98	1.35	73	1.29	121	×

B. V. : Back Voltage A. R.: All Record C.C.: Column's Control L.C.: Line's Control

Table 14. Toner characteristics in three toner types

Kinds of Developer \ Electric Polar		Negative	Positive
Mono-Component Developer	A Company	70.2%	28.8%
	B Company	85.5%	14.5%
Two-Component Developer	C Company	97.1%	2.9%

Conclusion

(1) Full printing with a Toner Jet printer gave images equivalent to an electrophotographic technique.
(2) Controlled printing with Toner Jet printer also allowed printing without losing the quality which had been achieved in full printing.
(3) The effects of a reverse polarity toner can be said to have proved minimal when a commercial one-component toner was used in the printing instead of the toner manufactured for the test device.
(4) Two-component toners were difficult to print with since they contain a statically positive carrier.

Issues for the Future

(1) Cleaning and the durability of the control electrodes is a problem and maintenance needs to be considered further.
(2) The distance between the magnetic roll and the control electrode (FPC) is not constant in the column direction so the dots are of irregular size. The distance between the magnetic roll and the FPC therefore needs to be made uniform in the test device.
(3) If more complex printed shapes are to be achieved, the diameter of the FPC holes will need to be reduced and the distance between holes in the FPC will need to be narrowed.

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