CONTENTS

2 PRINTER OPERATION

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2.1. Introduction

This chapter describes how the printer receives data from the host computer, processes, and prints them on paper. Section 2.2. explains the theory of the electrophotography involving those components of the LED head, drum unit, developer, etc. In later sections in this chapter, an overview on the data processing is provided.

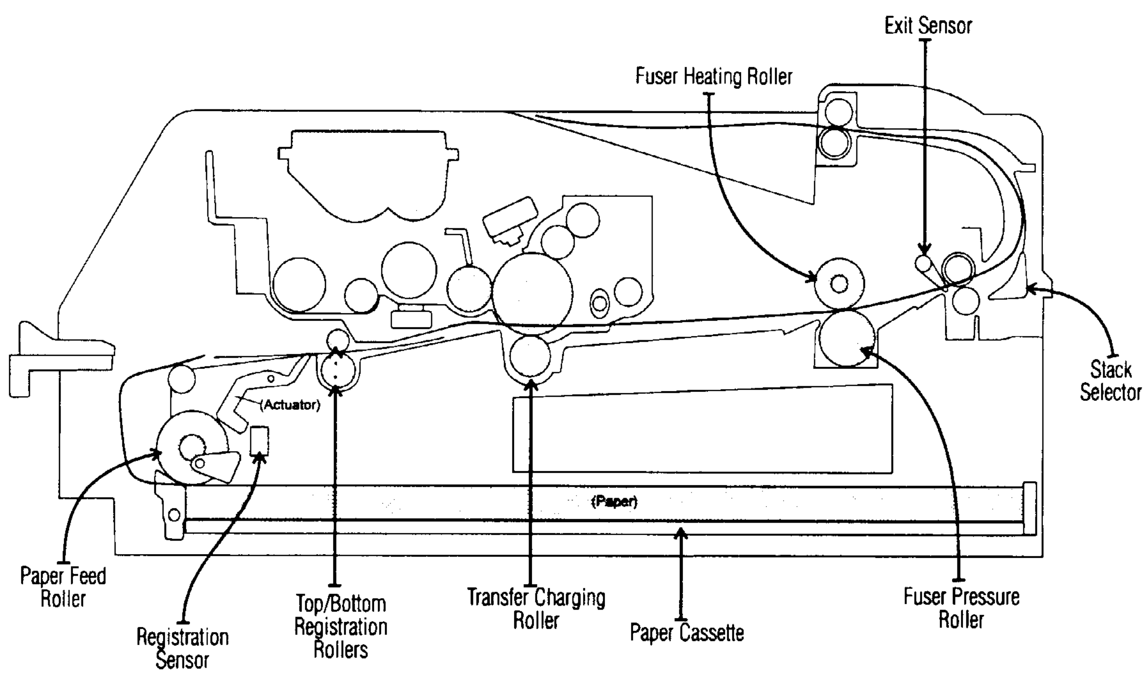
2.2. Main components location

Figure below shows the major components used in the printer.

The printer utilizes the electrophotography system to constitute the print image using the Ecosys, ultra-long-life technology.

To ensure the easy maintenance, the components serving the important functionality such as drum, developer, are modularized for quick removal into one single unit (Process unit).

Figure 2.1. Main components location



2.3. Electrophotography system

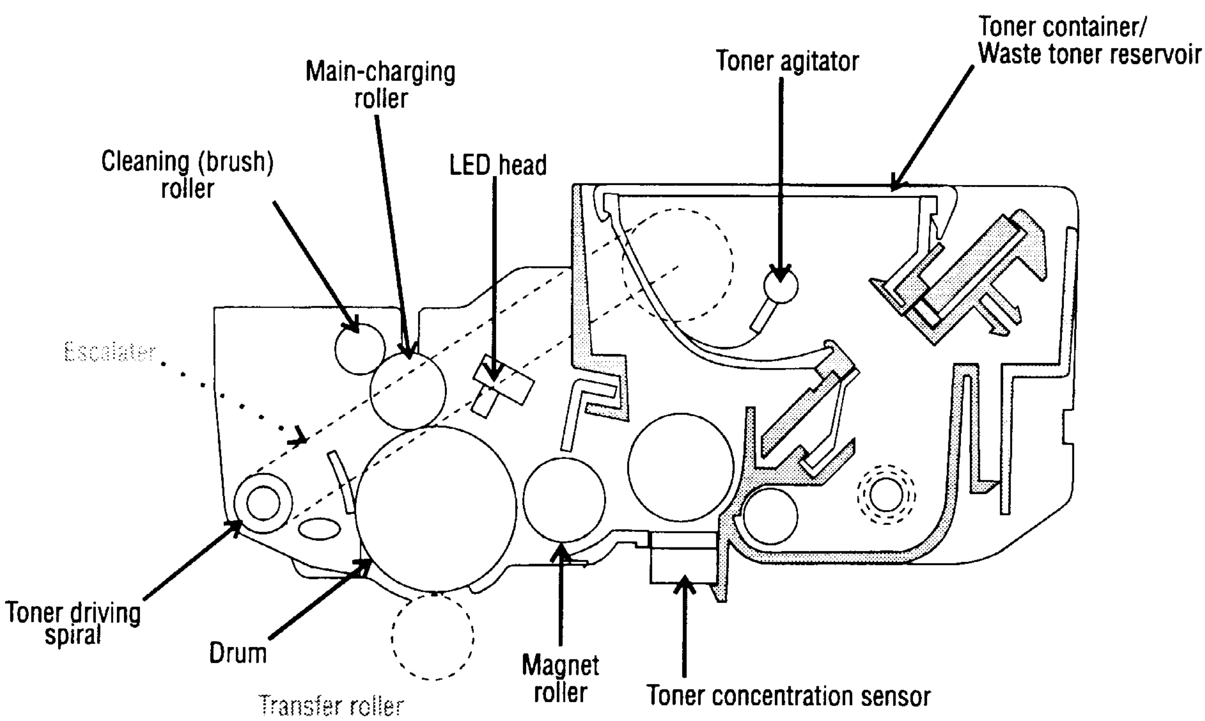
The electrophotography is a technology used very widely in laser and LED printers. The basic theory is to tranfer the electronic data representing texts and graphic objects into a visible image which is then developed by the photoconductor (drum) and toner (black powder ink) to be fused on paper. Two widely known devices for generating and emit the light for development are the laser diode and LED array (head). The FS-400/A printer uses the Kyocera's proprietary LED head.

The following systems constitute the main electrophotography system of the printer.

2.3.1. Electrophotography Overview

The electrophotography system includes the drum unit, developer, main and transfer chargers, and the eraser LED. All these parts excluding the transfer charger (roller) and the eraser LED are included in the process unit. See figure below.

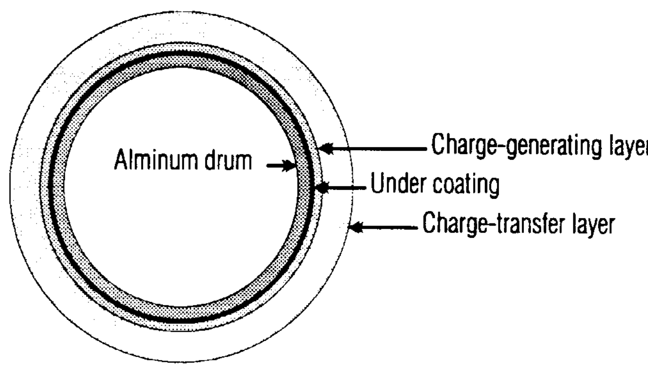
Figure 2.2. Process unit



The electrophotography involves several functional segments that happen with the photoconductor (drum); main charging, exposure, development, transferring, drum cleaning, erasure (neutralization), and fusing. The printer is provided with many newly-developed techniques that substitute the conventional systems for these functional segements: the ozone-less roller -type main-charging, roller-type transferring system, exposure system using the LED head, and long-life design developer system.

Newly-designed OPC drum

Figure 2.3. Drum layers

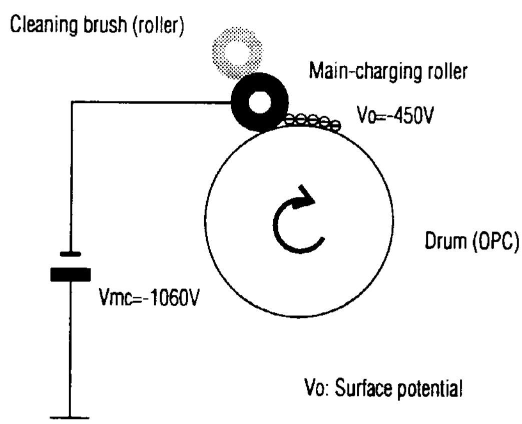


The printer uses the organic photoconductor drum designed exclusively for the printer. This drum has three layes on the drum as diagrammed here.

The drum follows the Ecosys concept that ensures the high reliability and sensitivity, it is redesigned to have many new features. It has the high sensirivity charge-generating layer and the charge carrying layer that assures a high charge transferrability. These layers provide the sufficiently high sensitivity with a limited LED light power, while at the same time ensuring the long service life.

Main charging

Figure 2.4. Main charging



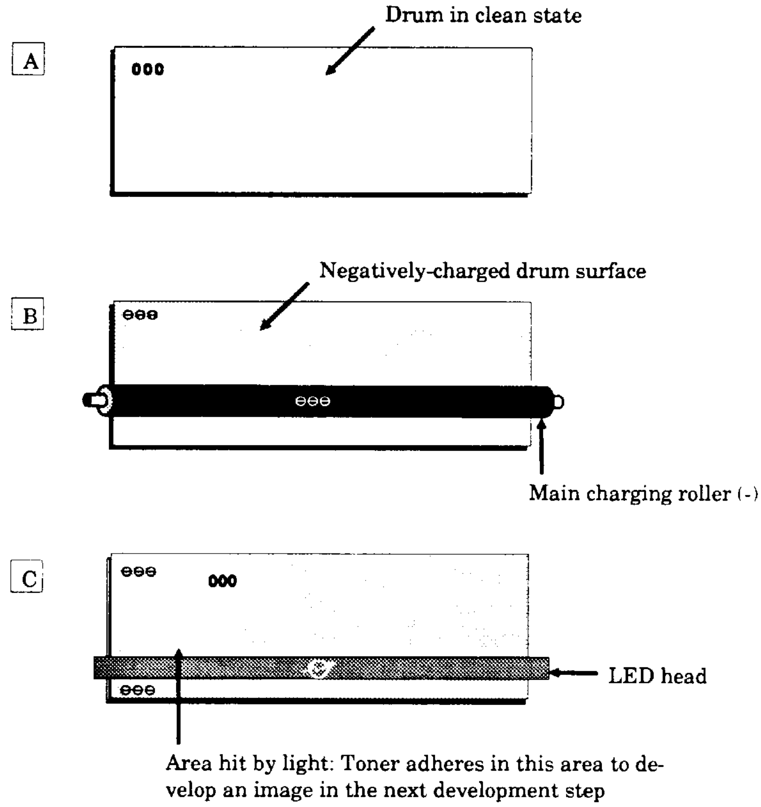
The new roller charging system generates virtually few ozone gasses. In the roller charging system, a special rubber roller is positioned in touch with the photoconductor. The roller is voltage-biased for charging within a microscopic space.

In a conventional corona charging system, a fine wire is applied with high voltage for the glow charging. With layered-organic photoconductors, which are priomarily used for the negatively biased charging, the negative charging tends to byproduce a large amount of ozone gas. On the other hand, the corona charging system, in which only a several percents of the total charging current is concentrated for charging energy. Most of the charging current flows into the main-charger shield case. Since all of the current is constituted with the dissociated ions, the magnitude of the ozone emission is substantial. The total current used is considearably small as the serveral percents of charging current is used for charging; the charging distance is very small; moreover, the DC current is used, therefore, the roller charging system emits only a very few amount of ozone.

The charging roller is provided with the brushing roller for cleaning.

Exposure

Figure 2.5. Exposure



The negatively-charged drum surface is then exposed to the light beam emitted by the LED head at the light power of 0.40 μ J/cm^2 at 740 nm. The LED head has an array of 2,560 LED chips driven dynamically according the computer data to be printed, and an array of lenses, running parallel to the LED array, of the same number of the chips for focusing the LED light beam. Description on how the LED head is driven by the electrical circuit is provided in the electrical overview section later in this chapter.

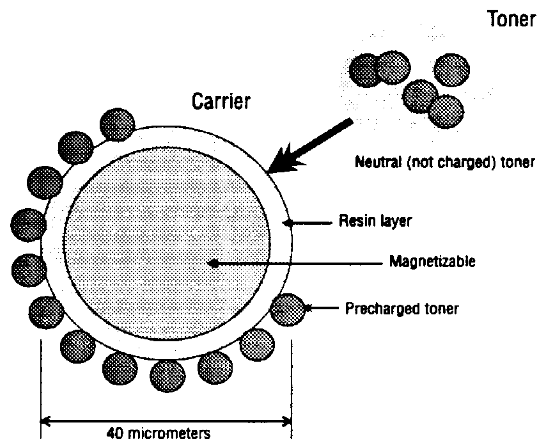
When the LED head scans over the drum lengthwise, the negative charge on the drum surface which is hit by light escapes to the ground as such area becomes electrically conductive. Thus a latent image (electrically neutral area) according to the image to print is constituted on the drum as shown in portion C of Figure above.

Developing

Development refers to as the visualization of electrostatic latent image constitued by the toner poweder statically adhered on the photoconductor (drum). Toner is mixed with *carrier powder* to constitute *devloping powder*. Toner is black powder ink having magnetism. As toner is continuously agitated with carrier, the friction of these two gives a certain charging potential to toner that is needed for the development to be implemented.

Carrier is made of the durable resin-coated ferrite each particle of which has the diameter of approximately 40μ m. The use of this smaller carrier helps achieve finer, crisp printing image. The development of the new resin coating technique allows extending the photoprocess module life to be as long as the machin itself.

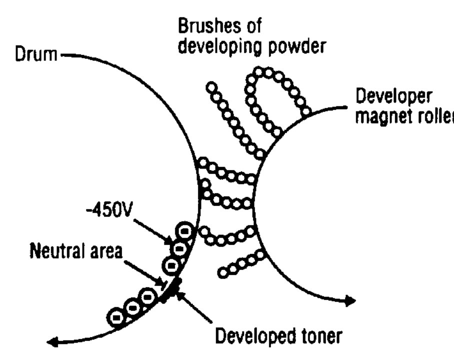
Figure 2.6. Toner and carrier



Toner is applied onto the drum for developing image in the following manner:

The developing powder, the mixture of toner and carrier powder, is continuously agitated inside the developer developer in order that the constant ratio (concentration) of mixture is maintained. To achieve this, a toner concentration monitor sensor is provided at the bottom of the developer unit which in cooperation with the printer electronics acts to monitor and control the predetermined ratio of mixture.

Figure 2.7. Developing



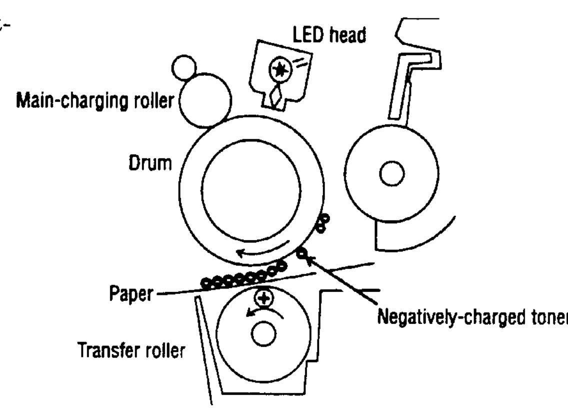
The developing powder adhered to the magnetism of the magnet roller, forms brushes as shown in figure 2.7. The tips of the brushes sweep over the drum surface as shown in the figure on which the latent image is to be developed. When sweeing, the toner on the brush is wrested away from the brush and atttracts to the electrically neutral areas, hit by the LED light, on the drum. Other parts on the drum which has not been exposed to the LED light so remained positive, prevents development.

As the amount of toner in the developer dwindles during printing, naturally the toner concetration ratio lowers, the sensor then requests the engine controller to feed more toner from the toner reservoir.

Step 4: Transfer

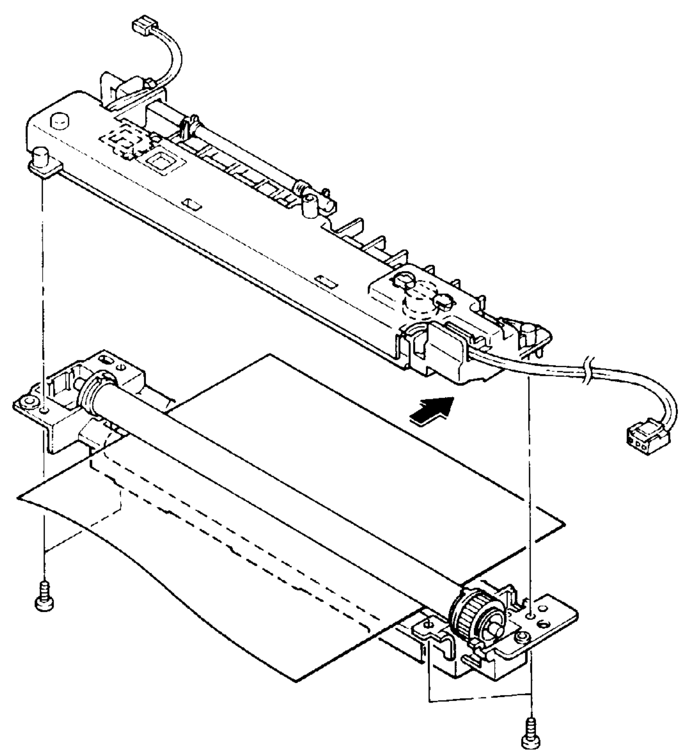
The image developed on the drum by toner is transferred onto paper using the electric charge attraction given by the toner itself and the transfer roller. The transfer roller is positively biased so that the negatively charged toner is electrically attracted onto the paper while it is pinched by the drum and the transfer roller. See figure below.

Figure 2.8. Transfer



Step 5: Fusing

Figure 2.9. Fuser unit



After transferring, the toner on the paper is fused permanently onto the paper as it passes through the heating roller and the pressure roller in the fuser unit. The heat roller has a halogen bulb heater inside which is connected in series with a thermistor controller b y the engine controller to preheat the heating roller at approximately 140ºC during printing.

The fusing temperature is constantly monitored and maintained by the engine controller circuit using a thermistor mounted outside near the heating roller.

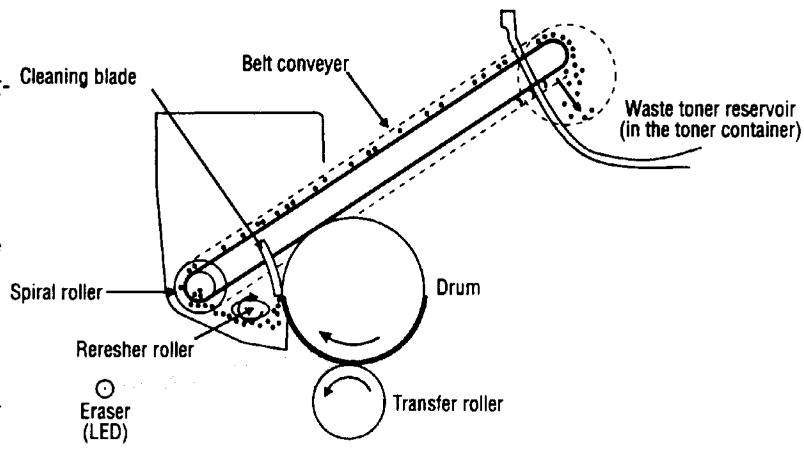
For safety purpose, the fuser system is electronically protected by a thermo-cut which automatically cuts off the heater current in case of an unusually high temperature. Details on the fuser electrical system are given in section 3, Electrical System Overview.

Step 6: Cleaning the drum

In transferring, the toner failed to adhere to the paper and remaining on the drum, is cleaned off of the drum by the cleaning blade which is pressed against the drum, and collected back to the waste toner reservoir inside the toner container as shown figure.

As shown in this figure, the refresher roller located parallel to the drum drives the toner to the spiral roller with which the belt conveyer for delivering the waste toner in the waste toner bottle is connected. The refresher roller also cleans and reconditions the drum in each cycle of processing.

Figure 2.10. Cleaning

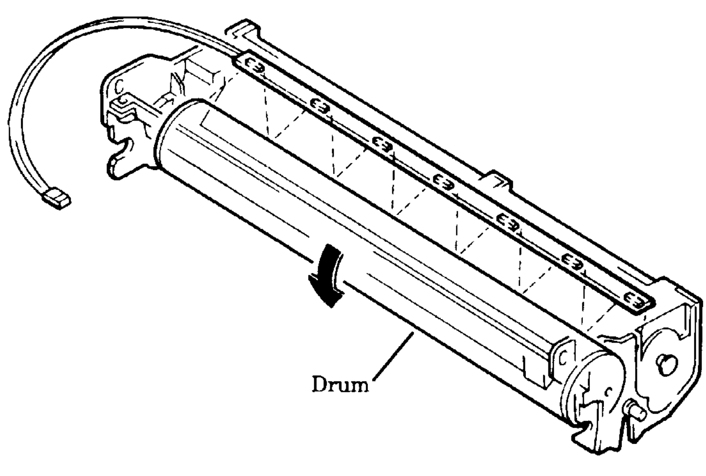


Step 7: Erasing (Quenching)

To prepare the photoconductor (drum) for the next photography cycle after the drum is cleaned, the photoconductor must evenly be exposed to light emitted with the eraser lamp array. Exposure to the light levels the potential over the non-exposed areas on the drum that was previously given with the main charging roller in the first step of the electrophotography cycle.

The eraser is comprised of LEDs positioned as shown in Figure 2.11. The engine controller CPU continuously monitors the current flowing into the eraser. In case the LED array is blown or the driving circuit becames faulty, the printer halts printing and displays *E5: SERV*.

Figure 2.11. Eraser (drum unit)



2.3.2. Summary: Electrophotography parameters

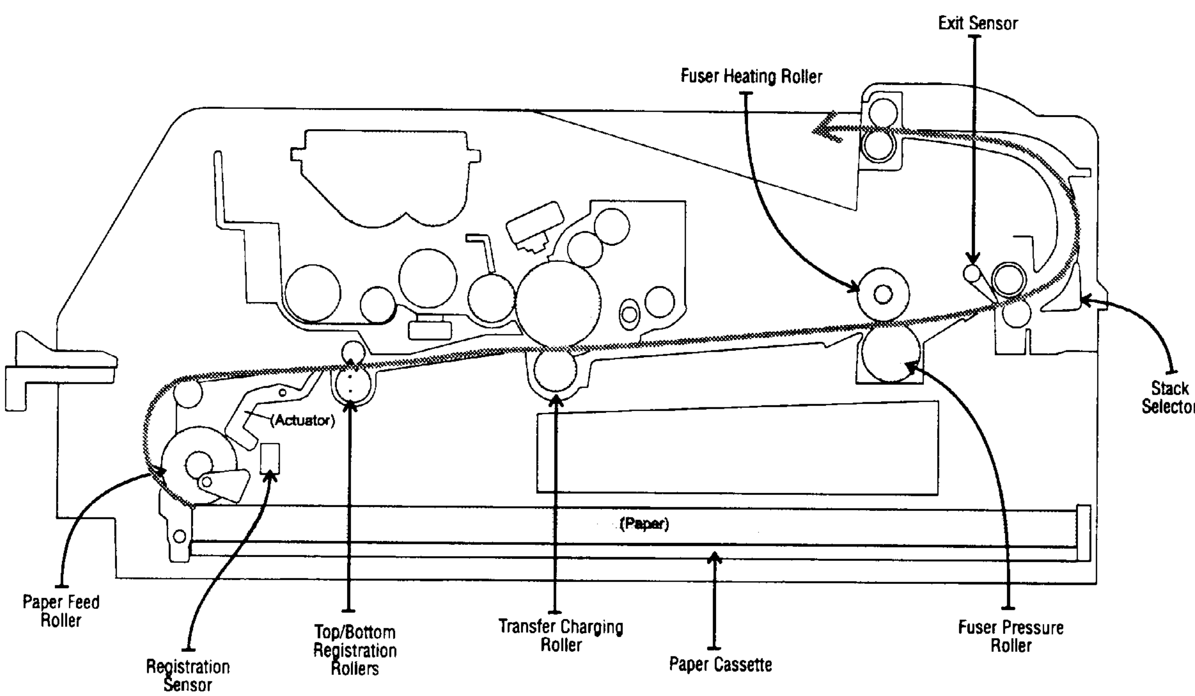
Item		Value
Photoconductor (drum)	Type	Organic (OPC)
	Diameter	30 mm (1.2")
Main-charging	System	Conductive roller
	Surface voltage	-450V
	Source voltage	-1060V
	Source current	-2 to -3μ A
Exposure	Light source	740nm LED light
	Light power	0.40 μ J/cm^2
Development system	Dual component	
Carrier	Type	Coated ferrite
	Diameter	40 to 50 μ m
Toner concentration to developer	7%	
Magnet roller	Diameter	16 mm
	Bias	-320V
Transfer	System	Roller
	Bias	Max. +1.2 kV
	Current	Max. +1.5 μ A
Drum cleaning	Blade scraping	
Erasure	Lamp (3)	
Fuser	System	Heat roller
	Temperature	140°C

2.4. Paper Feeding System

The paper feeding system picks up paper from the paper cassette or the manual feeding tray and feeds it to the electrophotography system for transerring and fusing image on paper. It finally delivers the printerd page to the face-down or face-up tray.

Figure below shows the paper feeding path in the printer.

Figure 2.12. Paper feeding path



The main roler of the paper feeding system, that includes paper pickup, registration, paper eject, etc., is commanded by the printer's engine controller. The instructions from the engine controller is manipulated by motors.

The printer can be installed with an option paper feeder for an extra paper source.

The function of the paper feeding system is explained step by step below, starting with *Paper pickup* .

2.4.1. Paper Pickup

Different pickup systems are used for automatic feeding and manual feeding.

Automatic (Cassette) Feeding

If the cassette is loaded with paper, the stack of paper pushes up the sensor located above the paper cassette whicn in turn turns the appropriate signal to the low level, enabling the engine system ready to feed paper. As the main logic controller has finished processing data, it then turns the feed motor on. The feed motor drives the feed roller in the center of which the paper pickup tire is attached and the top sheet of the paper stack in the paper cassette is thus fed into the printer.

The engine controller system confirms that the paper has properly fed forward as the top of the paper pushes up the feed sensor's acatuator. In order for the printer with a paper feeder installed to feed paper from the paper feeder, the main paper cassette must also be closed; otherwise the printer will show `Add paper`. This occurs because the front end of the paper cassette also doubles as the paper path from the paper to the printer feeding system.

Manual Feeding

The manual feed sensor detects a sheet of paper on the manual feed tray; commands the feed motor to turn on; and the registration rollers start revolving, feeding paper forward.

Paper feeder

The printer can be installed with one PF-8 optioin paper feeder at its bottom. The feeder is recognized by the printer engine system as being assigned CASS2;.

Registration

Registration is referred to as the printer's internal manipulation in which the image that is consituted as the video data over the raster memory (video RAM) and the physical area of the paper of a specific size is coincided mechanically with each other.

The top, metal, registration roller and the bottom, rubber, registration roller are used for the registration: These rollers are driven with the paper feed motor as it turns in the reverse direction. (The feed motor drives the paper feed roller when it turns in the forward direction.)

The registration rollers are not yet activated at the moment the leading edge of the paper has reached the registration rollers: The paper crashes to the registration rollers, being buckled until the rollers starts to turn. This buckling effect is useful to cancel the possible skew, making the paper completely in parpendicular to the registration rollers ensuring a perfect registration with the internal video image.

Right after the paper is buckled, the paper feed roller revolves in the reverse direction and the registration rollers start revolving for feeding the paper toward between the drum and the transfer roller. The engine controller system watches the traing edge of the paper as it passes through the paper feed sensor in the paper cassette. If the paper has passed the sensor within the interval which is stored in the controller, the engine controller recognizes that the paper has been succesfully fed to the subsequent steps; otherwise the paper jam is reported by indicating `Paper jam` on the printer's display.

After clearing the fuser unit, the paper pushes up the exit sensor. The engine CPU does the same routine as does with the feed sensor in front of the registration roller: The engine CPU counts the interval during which the paper end passes by the exit sensor to confirm a normal paper transportation or to detect a paper jam.

The paper finally is delivered to the face-down or face-up paper output tray.

2.5. Electrical System Overview

This section provides explanation on the printer's electrical system. The main logic controller board is more fully detailed in section 2.6.

Figure 2.12. on next page shows the entire wiring diagrams of the printer including all circuit boards and electrical modules.

2.5.1. Board Identifications

Following is the list of all boards and their ID codes (KP-#). The board ID codes are printed on circuit boards.

Board ID*	Board Description
KP-400	Main logic controller
KP-401	Engine controller
KP-402	Board-to-board Joint
KP-403	Developer bias (TPD)
KP-399	Drum zener diode

*Each board ID is followed by a revision code (A, B, etc.) which may vary depending on design revisions.

2.5.2. Engine Controller Overview

The engine controller is included in the KP-401 board. It provides timing control over drum revolution, paper feeding, fuser roller revolution, etc. The temperature is maintained for consistency and stability on the drum and the fuser by the engine controller. It also provides other housekeeping operations in cooperation with the main logic controller. See *Data Processing System Overview* section which follows this section.

This section describes operating information on following segments of the engine controller circuit, starting with the heart of the engine controller, the 8-bit microprocessor, µ PD78001.

- Engine controrller CPU (µ PD78001)
- Fuser heater controller
- Eraser controller
- Front panel controller
- Toner motor controller
- Main motor controller
- LED hear driver
- Paper feeding motor controller

Engine timing charts are attached at the end of this section.

2.5.3. Engine Controller CPU

The μ PD78001DW is a 64-pin shrink-DIP 8-bit single chip processor, operating at 9.984MHz clock. It has an internal ROM size of 8192 bytes and RAM size of 256 bytes.

Table below shows all port assignment of 78001.

Figure 2.14. 782001 pin assignment

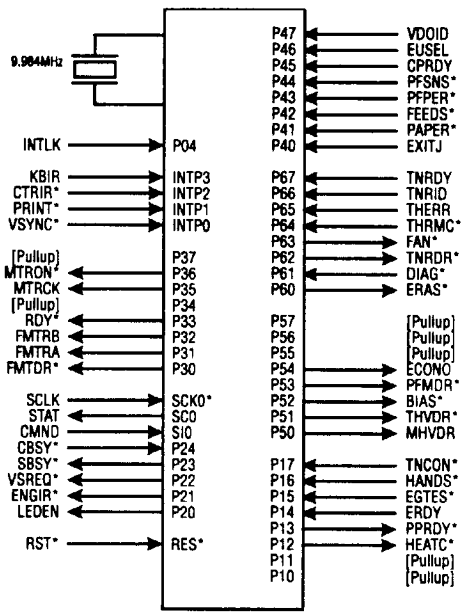


Table 2.1. Engine CPU pin assignment

Port #	Pin #	Signal	Meaning	Input/ Output	Logic
From/to the main controller					
P33	12	RDY*	Printer is ready.	Output	L: Ready
SCK0*	8	SCLK	Serial communication clock	Input	↓
SIO	6	CMND	Command code	Input	H: Command data "1"
P24	5	CBSY*	Command busy	Input	L: Busy
S00	7	STAT	Status code	Ooutput	H: Status data "1"
P23	4	SBSY*	Status busy	Output	L: Busy
INTP0	44	VSYNC*	Vertical sync.	Input	L: Synchronized
P22	3	VSREQ*	Ver. sync. request	Output	L: Request
INTP1	45	PRNT*	Print request	Input	L: Request

Port #	Pin #	Signal	Meaning	Input/ Output	Logic
P20	1	LEDEN	LED enable	Output	H: Enable
INTP2	46	CTRIR*	Controller interrupt	Input	L: Interrupt request
P21	2	ENGIR*	Engine interrupt	Output	L: Interrupt request
P45	23	CPRDY	Controller is ready.	Input	H: Ready
P13	58	PPRDY*	Printer power is ready.	Output	L: Ready
From the keyboard					
INTP3	47	KBIR	Keyboard interrupt	Input	H: Interrupt request
From/to the engine system					
P15	60	EGTES*	Test feed mode	Input	L: Test feed
P46	24	EUSEL	Native switch	Input	H: European
P47	25	VDOID	Video interface identification	Input	L: Kyocera
P54	30	ECONO	Econo mode level	Output	L: Off (H: Normal)
Interlock					
P04	53	INTLK	Cover status	Input	H: Cover is open.
Fan					
P63	38	FAN*	Fan control	Output	L: Fan is on.
Diagnostics Program					
P61	36	DIAG*	Diagnostics	Input	L: Diagnostic mode
Fuser					
P64	39	THRMC*	Thermistor return signal	Input	L: Overheating
P65	40	THERR	Thermistor open	Input	H: Open
P12	57	HEATC*	Heater control	Output	L: Heater (triac) is on.
Sensors					
P41	19	PAPER*	Paper empty	Input	H: Empty
P42	20	FEEDS*	Feed jam sensing	Input	L: Paper jam
P40	18	EXITJ	Exit jam sensing	Input	H: Paper jam
P16	61	HANDS*	Manual feed sensing	Input	L: Paper is present.
High voltag/bias					
P51	27	THVDR*	Transfer charge drive	Output	L: Transfer chg. is on (+cc).
P50	26	MHVDR	Main charge drive	Output	H: Main charge is on (-cv).
P52	28	BIAS*	Developer bias drive	Output	L: Developer bias on (-cv).
Electrophotography control					
P60	35	ERAS*	Eraser drive	Output	L: Eraser is on.
P14	59	ERDY	Eraser error sensing	Input	L: Eraser is error (open).
P62	37	TNRDR*	Toner feed motor drive	Output	L: Motor is on.
P67	42	TNRDY*	Toner feed motor error	Input	H: Error
P66	41	TNRID*	Toner identification sensing	Input	L: ID is affirmative.
P17	62	TNCON*	Toner container sensing	Input	L: Container is present.
Main motor					
P36	15	MTRON*	Main motor drive	Output	L: Main motor is on.
P35	14	MTRCK	Main motor phase pulse	Output	—

Port #	Pin #	Signal	Meaning	Input/ Output	Logic
			Paper feed motor		
P30	9	FMTDR*	Feed motor drive	Output	Feed motor is on.
T01	10	FMTRA	Feed motor phase A	Output	—
T02	11	FMTRB	Feed motor phase B	Output	—
			Option paper feeder presence		
P44	22	PFSNS*	Paper feeder presense	Input	L: Feeder is present.
P43	21	PFPER*	Paper feeder paper empty	Input	L: Paper is present.
P53	29	PFMDR*	Paper feeder motor drive	Output	L: Motor is on.

Table 2.2. Engine gate array port table

Pin#	Signal	Meaning	Input/Output	Logic
		Data bus		
6-13	MD0-MD7	68K data bus	To/from main controller	-
		Front panel		
59-3	FD0-FD7	LCD data	Output to front panel	-
21-15	K1-K7	Key return	Input from front panel	L: Keypad activated
41	KBIR	Key interrupt	Output to main/engine CPUs	H: Interrupt
37	LDS*	Low data strobe	Input from main controller.	L: Enable
38	FPENB*	Front panel enable	Input from main controller.	L: Enable
39	KYBD*	Address decode	Inpur from main controller	L: Enable
40	FPRW*	Read/write	Input from main controller	L: Write
28	FPLE0	Online LED	Output to front panel	L: On
29	FPLE1	ATTENTION LED	Output to front panel	L: On
		Reset		
33	RST*	Reset	Input from main and engine CPUs	L: Reset
		Motor control		
57	MTRCK	Main motor clock	Input from engine CPU	—
52	MTRA	Motor phase A	Output to motor driver	—
53	MTR B	Motor phase B	Output to motor driver	—
48	FMTDR*	Feed motor starter	Input from engine CPU	L: Start
55	FMTRA	Feed motor phase A	Input from engine CPU and motor driver	—
56	FMTRB	Feed motor phase B	Input from engine CPU and motor driver	—
50	FMTRA*	Feed motor phase A*	Output to motor driver	—
51	FMTRB*	Feed motor phase B*	Output to motor driver	—
		LED head control		
36	LEDVDO	Video data input	Input from main controller	H: *Black* data
24	LEDLS*	Line synchro	Input/output from/to main controller	L
25	LEDVCK	Video clock	Input/output from/to main controller	—

Pin#	Signal	Meaning	Input/Output	Logic
34	LEDEN	LED enable	Input from main and engine CPUs	H: Enable
31	VDATA	Video data output	Output to LED head controller	H: *Black* data
22	LHSTR*	LED head strobe	Output to dynamic LED controller	L
30	TCLK	Video clock output	Output to LED head controller	—
Engine system				
49	PPRDY*	Power ready	Output to main controller	L: Ready
46	PPRDY	Power ready	Input from engine CPU	H: Ready
45	ECONO*	Toner saver mode	Input from engine CPU	L: Activated
47	VDOID	Video interface mode	Input from main controller	L: Controller active (LEDLS*: Input, LEDVCK: Input, TESCK: 1.5 MHz); H: Video interface active
35	TESCK	Test clock	Input from engine CPU or TBM	—
44	EGTES*	Engine test mode	Input from engine CPU	L: Test mode
Fuser control				
42	HEATC*	Heater control	Input from engine CPU	L: Heater is on.
43	THRMC*	Temperature control	Input from fuser controller	L: Normal
23	HEAT*	Heater switching	Output to fuser driver	L: Heater is on.

2.5.4. Fuser Heater Controller

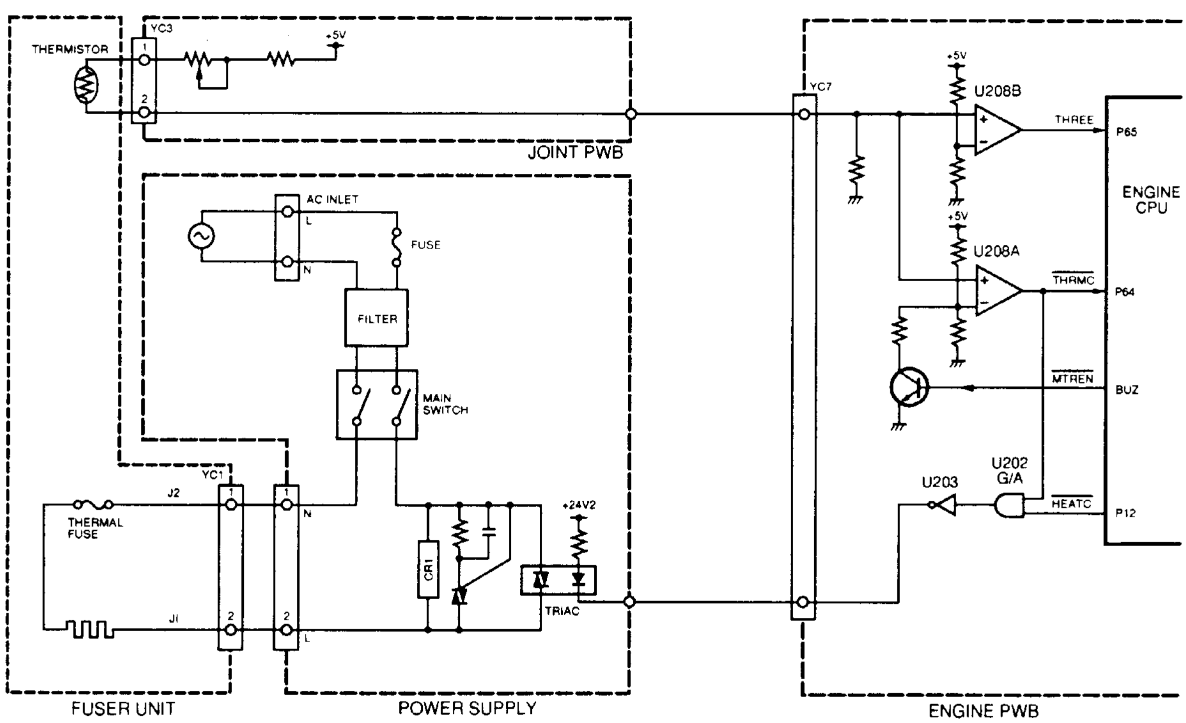
Figure 2.14 below shows a simplified schematic diagram for the fuser heater controller circuit.

The fuser heater controller turns the fuser heater, located coaxially inside the top fuser roller, on and off intermittently so that the surface of the roller maintains a specific, constant temperature needed to permanently fuse the toner on paper as the paper passes between the heater roller and the pressure roller which is located beneath the heater roller.

The fuser heater is directly fed with AC primary power (120V or 220 to 240V) which is supplied from the power supply unit. Comparator U208-A monitors the current flowing into the thermistor located at one end of the top roller and keeps port 64 of the engine CPU low when the thermistor is normal. According to the variance of the thermistor's resistance, as detected by the comparator, the engine CPU drives U202 and U203 which then switches on and off a photo coupler through its port P12. As the other end of the fuser heater is wired to the secondary gate of a triac, it is intermittently switched on and off according to U203 so that the fuser temperature in printing is maintained constantly at approx. 142° C; and at 127° C in standby. This transition is made by transistor Q208, connected to the CPU's own signal for transition MTRON* at port B07 of the engine CPU.

In the event that the thermistor is blown, comparator U208-B sends a high level $\overline{\text{THERR}}$ signal to port P65 of the engine CPU. The CPU then halts the printer and gives the *E4: SERV.* mes sage on the printer's message display.

Figure 2.15. Fuser heater controller

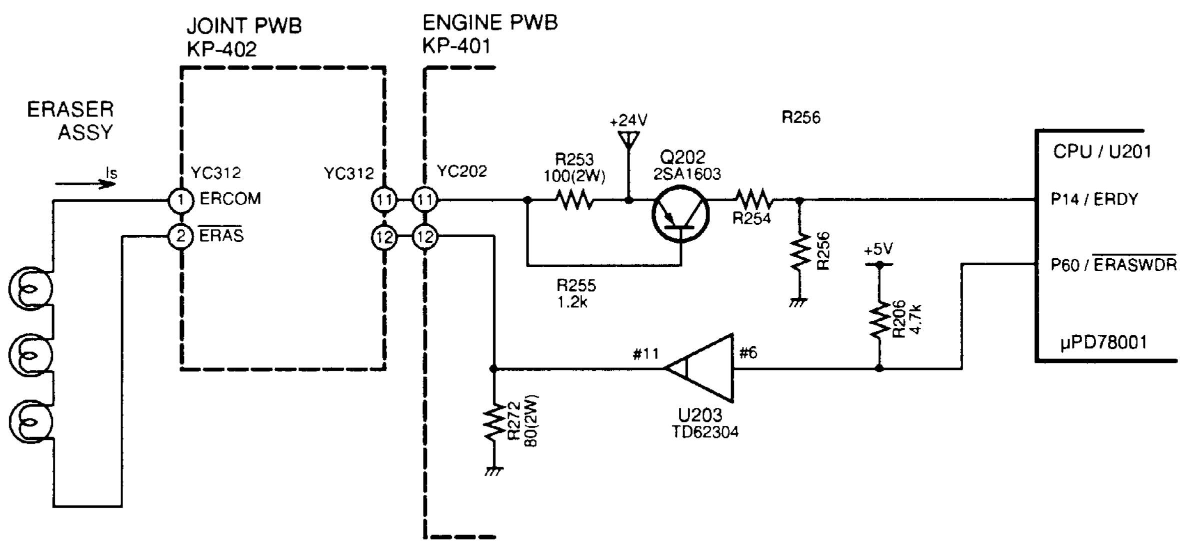


2.5.5. Eraser Controller

The eraser lamp array is wired to the engine [KP-401] board via the joint [KP-402] board. In figure below, the eraser array, one end of which is fed with +5 V DC via R253, is turned on when U203 turns on to ground the other end as the engine controller sends an ERASEDR* signal according to the cyclic photography process to erase the residual charge on the drum.

The eraser circuit has the blow-out detector. The current detector Q202 in figure below monitors the eraser current *Is* . The normal eraser current is 90 to 100mA. Should the current detector detect an abnormal current, the engine controller halts printing and let the message display to display *E5: SERV.* (eraser error).

Figure 2.16. Eraser controller



2.5.6. Toner Feeding Motor Controller

The toner motor controller, located in the engine controller board, can be simply diagrammed as below.

The toner feeding motor, a DC micro-type motor, is wired to the engine [KP-401] board via the PD [KP-403] board. The hot end of the motor is fed with the +24V power through R314. When the engine controller CPU determines the need for replenishment of toner according to the toner concentration sensor, it sends a low-level TNRDR* signal to transistor array U203 for driving the toner feeding motor.