INTER-OFFICE MEMORANDUM

TO: Distribution

DATE: April 27, 1982

FROM: R. Buba

SUBJECT: IBM - Graphics

In dealing with our 3270 Plug Compatable Manufacturers (PCM's), the topic of graphics has often come up in a way in which many of us are unfamiliar. The purpose of this paper is to discuss the problem (IBM - Graphics) so that we, as a company, will have better insight into our customers problems. Through this better understanding, we will be better prepared to aid our customers in solving this problem resulting in more printer sales for Centronics.

R.J. Buba

R.J. Buba
Director, Product Development

P69/B23

IBM GRAPHICS PRIMER

The entry of IBM into graphics was late and seems to be rather disjointed. This becomes apparent when we look at the variety of grid sizes that are available to the user on various models of the 3278 (CRT's). The grid varies from low resolution 7 X 7 to high resolution 12 X 16 with interlace and one in between 9 X 12. This variety of resolutions becomes troublesome when it comes to printers because, they like us, are limited to the number of dots they can put down vertically and horizontally efficiently. The concept of faster graphics (Pin Data) is immediately thrown out because of the various types of screens available. The number of tubes installed is easily greater than 1 million.

To solve this problem, IBM developed a graphics system which utilizes Programmed Symbols (PS). The programmed symbols are user generated via an applications program and these shapes can be different for each user. These programmed symbols are not unlike the building block printing method used in the 306C except that these blocks are soft-loaded at the beginning of every application!

The 3 varieties of PS sets that are available are:

PS2 - 2 sets of 190 symbols each
PS4 - 4 sets of 190 symbols each (requires PS2)
PS4A - 3 sets of 190 symbols each plus 1 tri plane set

NOTE: PS2 and PS4 can be combined in the same printer. PS4A cannot be mixed with PS2 or PS4.

In addition to the programmed symbols, the printer may have APL/TEXT (221 characters) and a standard ASCII (96 characters) set. So, as we continue our discussion, we should bear in mind that the user can select at any time characters from any of the sets and can intermix characters on a given line. The restraints are simply the sequence in which they are presented as it affects non-APA and APA print modes.

The method used to select the characters to be printed is clearly a function of the format controller and is memory intensive. This problem is also one which cannot be solved with the micro bus concept.

Figure 1 shows how the PS sets are organized. Each block is made up of 190 characters which have a block identifier. The loading sequence begins with a header followed by the offset and data is loaded until the buffer is full; the last byte of the 190 possible characters.

The IBM requirements for graphics are:

1. o 100 dPI horizontally
   o 69.82 dPI vertically
   o 10 X 8 print cell

   Aspect ratio 1.432:1

NOTE: See attachment CDCC vs. IBM graphics.

This compares to the 350B blue in that we can attain 68.56 (with 13 steps) resulting in a ratio of 1.45:1.

2. The ability to load downline the PS sets:

PS2 = 2 X 190 characters	=	380 characters	
PS4 = 4 X 190 characters	=	760 characters	
	TOTAL	1140 characters	

3. Plus the storage of APL/TEXT characters.

4. The PS4A set comprises the following:

3 X 190 characters	=	570 characters
1 X 190 (Triplane)	=	190 characters
	TOTAL	760 characters

NOTE: The Triplane set has a memory location in each colour which must be translated by the F.C. to the P.C. one line, colour at a time.

In addition to the number of characters that must be handled, the type of characters are also varied. They are:

- o Standard 7 X 8 - (No adjacent dots horizontally) 4 of 7 plus 3 inter characters with dots.
- o 10 X 8 - Non APA same rules as standard 7 X 8, 32 dots/cell.
- o 10 X 8 - Non APA normal alternating dots - Non all points available, 50 dots/cell.
- o 10 X 8 APA - All points available, 80 dots/cell.

COLOUR

The implementation of colour as it relates to the IBM 3287-2C and PS sets in another dimension. There are three modes:

1. Choice of colour, red, green, blue, black for standard 7x8 characters.

2. Single colour printing of a 10x8 cell.

3. 4 colour printing with a 10x8 cell.

One and two can be accomplished with the standard 3287-2C utilizing the CRT screen attributes for blinking, bold, etc. to control colour. The P.S. colour selection is chosen by field or character attributes as part of the data stream.

In order to perform term 3 the use of the PS4A must be part of the hardware.

The characters are still soft loaded but each plane of memory is mapped over the other two so that for a character cell there are three planes; red, green, blue. When a character contained in this region is to be printed the printer will automatically cycle through each plane printing the data for that character then shifting colours and repeating. The printer will compare character shapes for each location. When dot information for a row/column appear in two or more locations that location row/column will be printed in black.

The data stream on the SDLC channel is quite complex. The SNA data stream includes field and character attributes which must be separated by the format controller. This data must then be organized and the appropriate character location must be loaded in the CRAM to allow for printing. The organization of the FC to accomodate complete 3287 emulation, therefore, is not trivial. The 350 blue architecture somewhat simplifies this operation. This is so because the OEM can choose to do any of the following:

1. Provide character generators on the CRAM bus to be accessed, matching the character shapes to be printed.

2. Store character shapes, locations on the FC and load the pin buffer with the characters to be printed.

The FC would then set the print byte appropriately for the type of data to be printed, APA, non-APA, etc.

Updates to the IBM graphics solution will be published on a continuing basis to improve our appreciation for the problem which our major OEM's are trying to solve.

IBM 3287 ASPECT RATIO

VS

CENTRONICS ASPECT RATIO

THE DERIVATION OF THE IBM ASPECT RATIO WAS ARRIVED AT BY A COMBINATION OF ANALYTICAL AND IMPERICAL INFORMATION. THE 3287 (BASE PRODUCT USED FOR IBM GRAPHICS) GEAR TRAIN WAS ANALYZED TO DETERMINE THE VERTICAL PAPER PATH RESOLUTION OF THE PRINTER AND WAS COMBINED WITH PRINTHEAD MEASUREMENT DATA AND IBM MANUAL DOCUMENTATION. BECAUSE OF THE BACKLASH CONSTANT IN THE GEAR TRAIN, WHICH IS SUBSTANTIATED BY THEIR PRINT QUALITY SPEC, THE VERTICAL DPI HAS QUITE A RANGE. THE CONCLUSION BEING THAT THE 350 CAN ADEQUATELY MEET THE REQUIREMENTS FOR A COMPATIBLE ASPECT RATIO.

THE VARIANCE BETWEEN THE ANALYTICAL AND EMPIRICAL CALCULATIONS CAN BE SEEN BY LOOKING AT THE PRINT QUALITY SPEC (ATTACHED).

THE RANGE OF ASPECT RATIOS FOR IBM CAN BE BETWEEN:

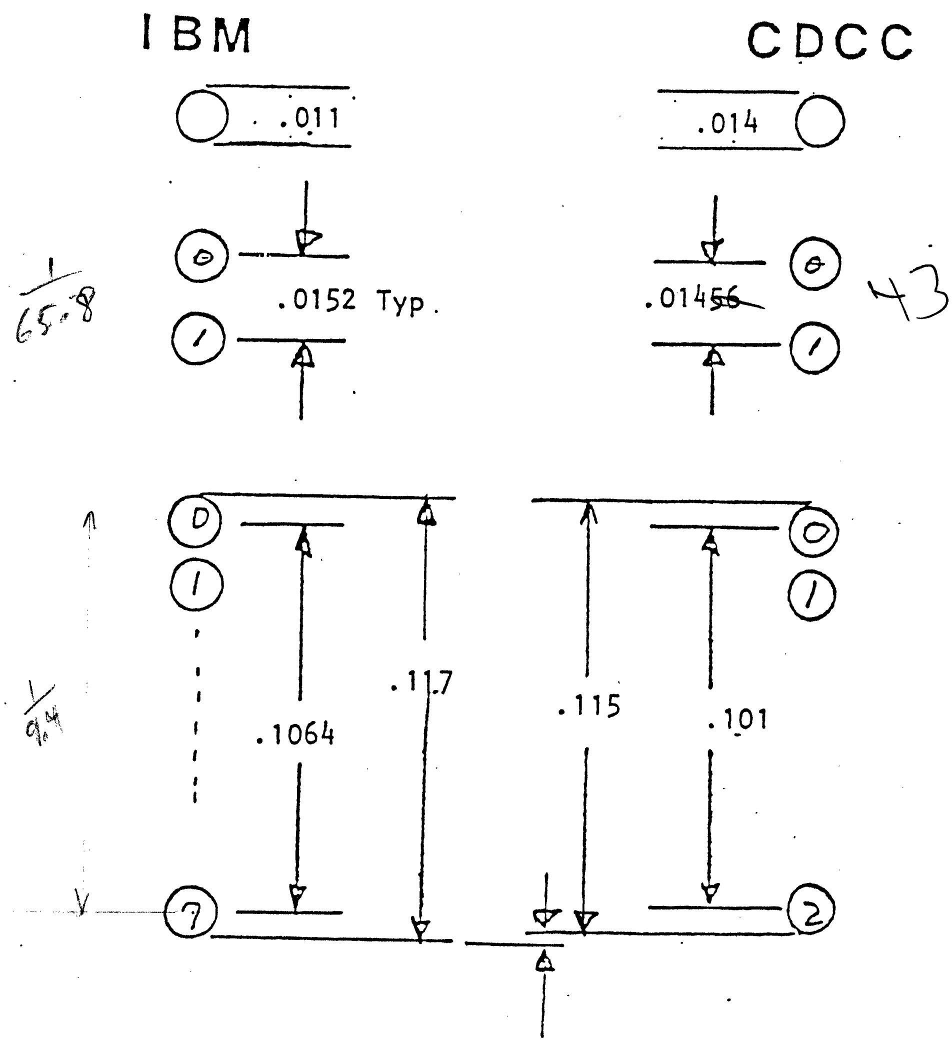
1.46:1 to 1.43:1

COMPARED TO OUR NOMINAL

1.45:1

Q.E.D.

ANALYTICAL BACK-UP



CDCC △ IS .002 LESS THAN IBM HEAD

IBM VS CENTRONICS PRINT WIRE DIMENSIONS AND OVERALL CHARACTER HEIGHT.

IBM CHARACTER HEIGHT (CH) CALCULATION

NUMBER OF WIRES X CENTER TO CENTER DIMENSION + 1 WIRE DIAMETER

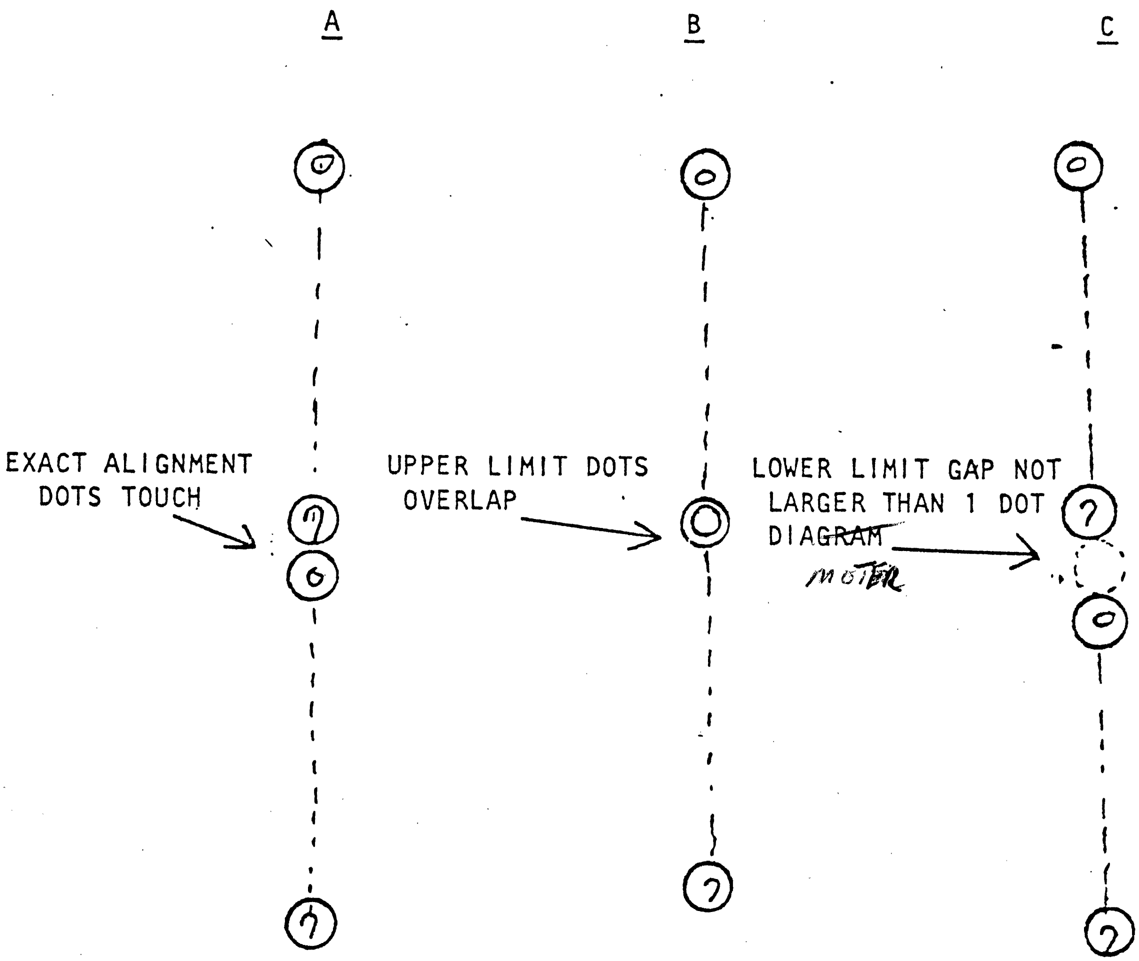
EQUALS = CHARACTER HEIGHT.

NOTE: THIS DOES NOT INCLUDE INK SPLAY

IBM	CDCC
7 x .0152 = .1064	7 x .014 = .101
.1064 + .011 = .117	.101 + .014 = .115
IBM - ch = .117	CDCC - CH = .115

IBM

VERTICAL REGISTRATION



DOTS/INCH CALCULATION

A. $\frac{1}{.117}$ = 8.54 -- 8 dot cells/inch = ------------------------ **68.376 dPI**

B. $\frac{1}{.117}$ = 8.54 -- 9 dots cells/inch = ------------------------ 76.86 dPI

C. $\frac{1}{117}$ = 7.81 -- 9 dots cells/inch =-------- = **70.31 dp**

NB the 9th dot not present - 7.81 N

62.5 -------- 62.5 dPI

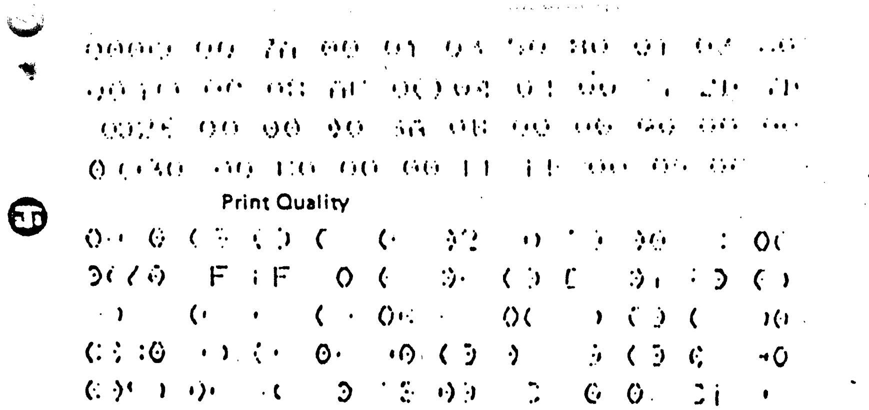


Figure 5-11 (Part 2 of 2). Print Quality Problems

5-4006 Programmed Symbols Cell Alignment Check

See Figure 5-11.1.

Lines of the special Z characters can be printed by entering Diagnostic Test 3. Press switch 8 twelve times and then press switch 0 to start the printing.

Figure 5-11.1 shows:

1 Exact Alignment

2 Upper Limit

3 Lower limit

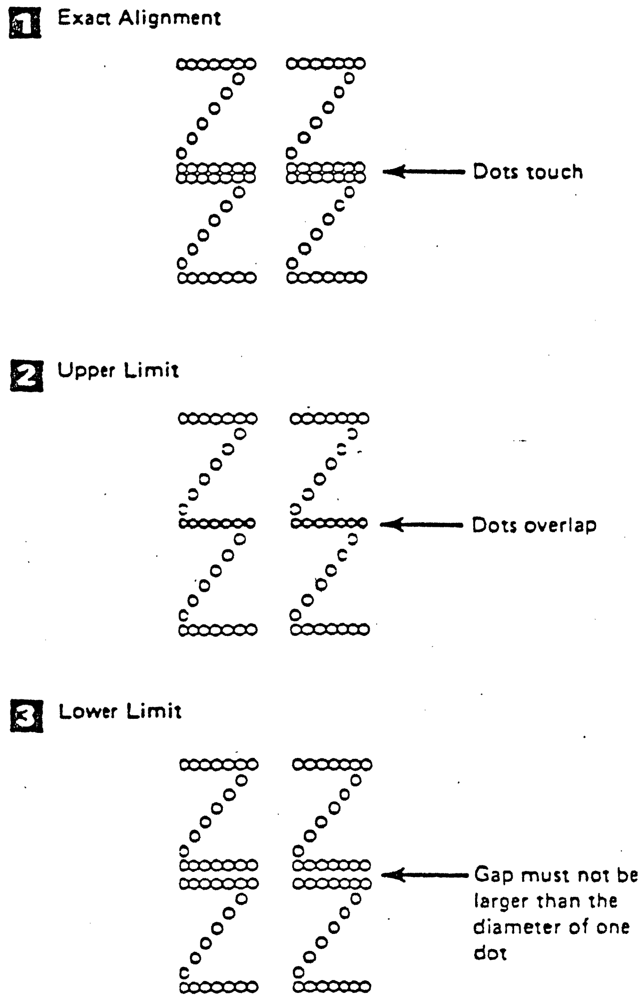


Figure 5-11.1. Programmed Symbols Alignment

CDCC - LINE SPACING RESOLUTION

.00833 "/Step LPI 8/Dots DPI / VERTICALLY

20 steps /LF = .167 $\frac{in}{LF}$ = 6 x 8 = 48

15 steps /LF = .125 $\frac{in}{LF}$ = 8 x 8 = 64

Closet To IBM → **14 steps /LF = .11662 $\frac{in}{LF}$ = 8.57 x 8 = 68.56**

13 steps /LF = .10829 $\frac{in}{LF}$ = 9.23 x 8 = 73.86

12 steps /LF = .09996 $\frac{in}{LF}$ = 10 x 8 = 80.00

14 steps equaling 68.56 DPI (V)

IBM ASPECT RATIO CALCULATION

Horizontal

- IBM Graphics cell is 10 x 8 dots (h x v)
- Standard density is 10 CPI (H)

  therefore 1 inch contains 10 x 10 ------------ = **100DPI (H)**

Vertical

Exact alignment specification has 68.376 DPI (V)

therefore $\frac{100}{68.376}$ = 1.46 empirical $\frac{100}{69.82}$ = 1.432 analytical

Aspect Ratio = 1.432 to 1.46 1:

Centronics Aspect Ratio

H = 100 DPI (By definition)

V = @ 14 steps for LF = 68.56 DPI V

therefore $\frac{100}{68.56}$ = 1.45

Aspect Ratio = 1.45 1:

EMPIRICAL CALCULATION BACK-UP

NOTE: REFERENCE DRIVE TRAIN SKETCH

THE SOURCE OF PAPER DRIVE IS A STEPPER MOTOR. THIS MOTOR IS LABELED 2 DEG. PER STEP.

- 20 TOOTH GEAR IS ATTACHED TO THE STEPPER SHAFT AND DRIVES
- 72 TOOTH IDLER GEAR WHICH DRIVES
- 48 TOOTH GEAR ATTACHED TO THE ROLLER PLATEN SHAFT
- OVERALL RATIO STEPPER TO PLATEN 2.4 TO 1

- 66 TOOTH GEAR ALSO ATTACHED TO THE PLATEN SHAFT DRIVES
- 76 TOOTH IDLER GEAR WHICH DRIVES
- 44 TOOTH GEAR ATTACHED TO THE TRACTOR DRIVE SHAFT
- OVERALL RATIO PLATEN SHAFT TO TRACTOR SHAFT 1 TO 1.5

- OVERALL RATIO STEPPER TO TRACTOR SHAFT 1.6 TO 1

- 6 TOOTH GEAR DRIVEN BY THE TRACTOR SHAFT DRIVES THE TRACTOR BELT. RATIO IS ONE TOOTH TO ONE PIN. PIN SPACING IS STANDARD (.5 INCHES).

THEREFORE:

ONE REVOLUTION OF THE TRACTOR SHAFT = 3.0 INCHES OF PAPER MOTION = 1.6 REVOLUTIONS OF THE STEPPER.

1.6 REVOLUTIONS OF STEPPER = 288 STEPS = 3.0 INCHES PAPER
288 STEPS / 3.0 INCHES = 96 STEPS / INCH
96 STEPS / INCH = .0104167 INCHES / STEP

TO VERIFY THESE CONCLUSIONS:

16 STEPS / 96 STEPS PER INCH = 1/6 INCH = 6 LPI
12 STEPS / 96 STEPS PER INCH = 1/8 INCH = 8 LPI

THE FOLLOWING ASSUMPTIONS ARE MADE BASED ON INFORMATION SUPPLIED BY RICHARD BUBA CONCERNING WIRE SIZE AND TOTAL HEAD HEIGHT.

HEAD HEIGHT FOR IBM HEAD MEASURED FROM TOP OF PIN ONE TO BOTTOM OF PIN EIGHT IS .1173 INCHES.

GIVEN THIS DIMENSION IT IS REASONABLE TO ASSUME: IN GRAPHICS MODE 11 STEPS OF IBM'S STEPPER WOULD GIVE .114583 INCHES OF PAPER DISPLACEMENT. THIS WOULD GIVE APPROXIMATELY .0015 INCHES DOT OVERLAP (NOT INCLUDING INK SPLAY).

FROM THIS WE CAN CALCULATE VERTICAL DOT DENSITY AND ASPECT RATIO (ASSUMING 100 DPI HORIZONTAL). WHICH ARE:

69.82 DOTS PER INCH
1.432 ASPECT RATIO

HEAD HEIGHT FOR CDCC HEAD MEASURED FROM TOP OF PIN ONE TO BOTTOM OF PIN EIGHT IS .11592 INCHES. IF WE STEP 14 STEPS AT 120 STEPS PER INCH, PAPER DISPLACEMENT WOULD BE .11667 INCHES. THIS GIVES US A DOT UNDERLAP OF .0007 INCHES (NOT INCLUDING INK SPLAY).

VERTICAL DOT DENSITY AND ASPECT RATIO FOR CDCC WOULD BE:

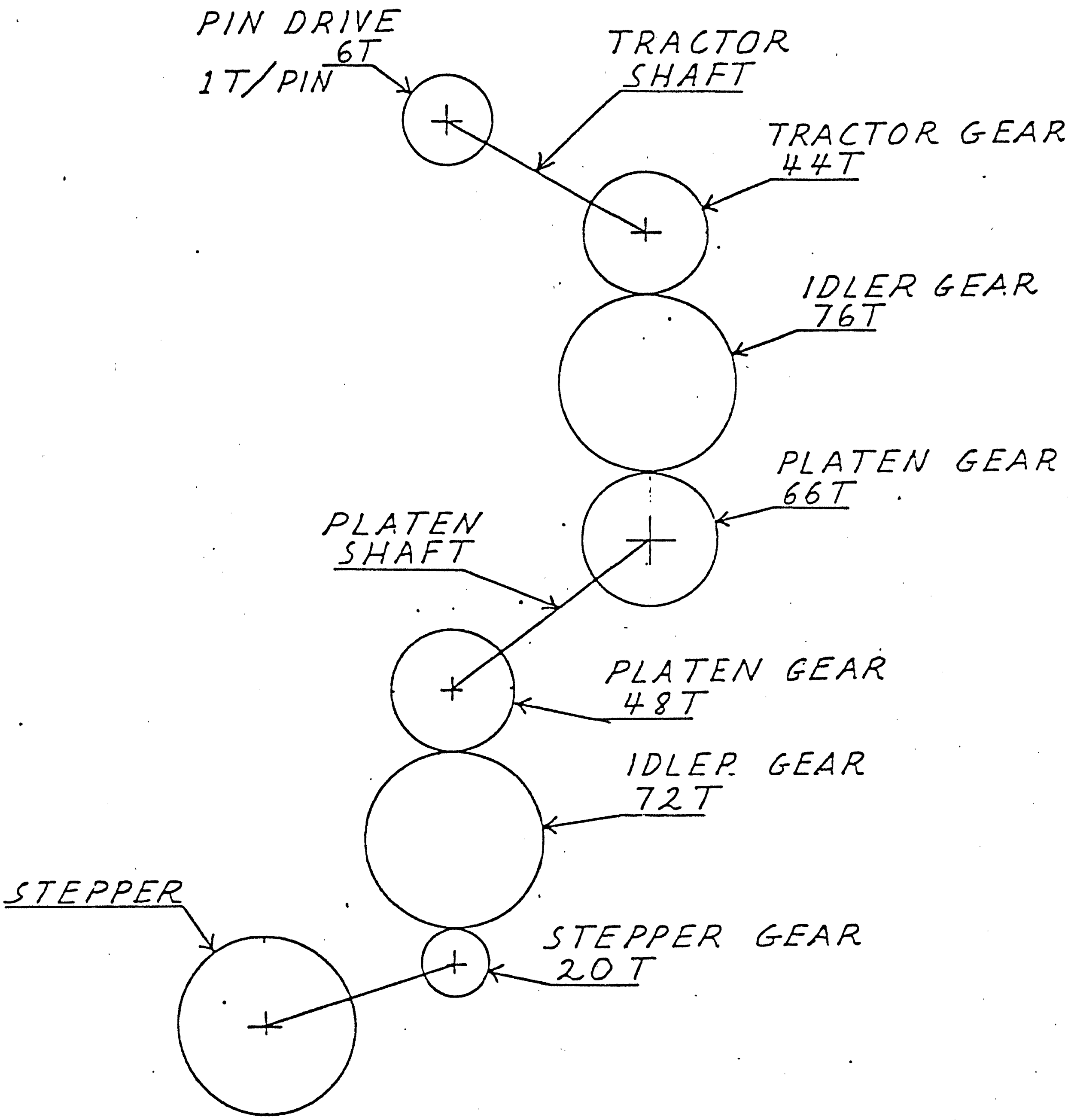
68.57 DOTS PER INCH
1.458 ASPECT RATIO

GIVEN THE ABOVE DIMENSIONS. WE CAN CALCULATE THE ERROR EXPECTED BETWEEN IBM AND CDCC.

TOTAL ERROR IN AN ELEVEN INCH PAGE:

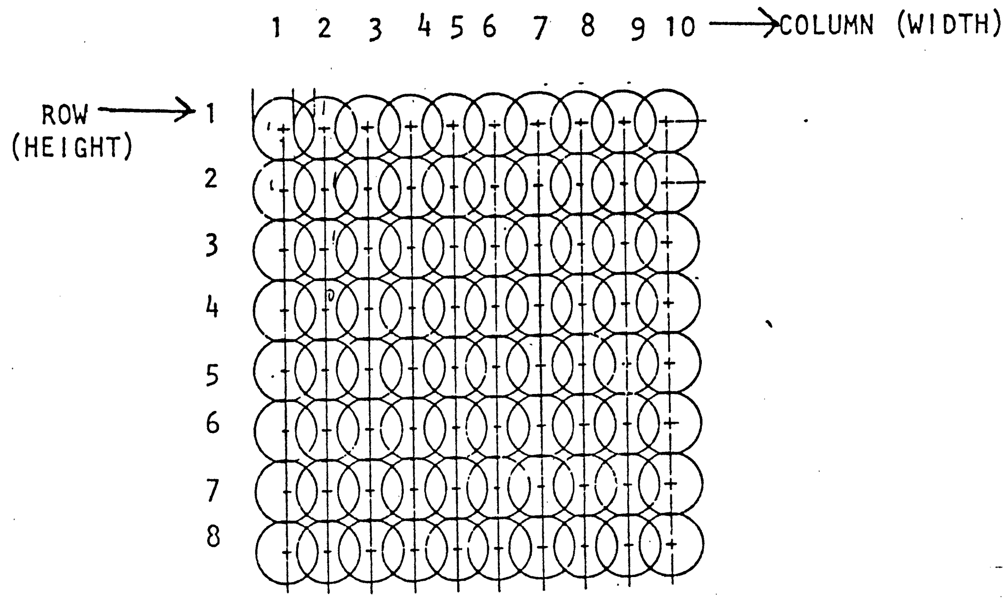
IBM 96 LINES PER PAGE
CDCC 94.286 LINES PER PAGE
DELTA CDCC - 1.7143 LINES OR .200 INCHES
PERCENT ERROR = .2/11 = 1.8%

PAPER MOTION TRAIN
IBM 3287



IBM GRAPHICS CELL INFORMATION

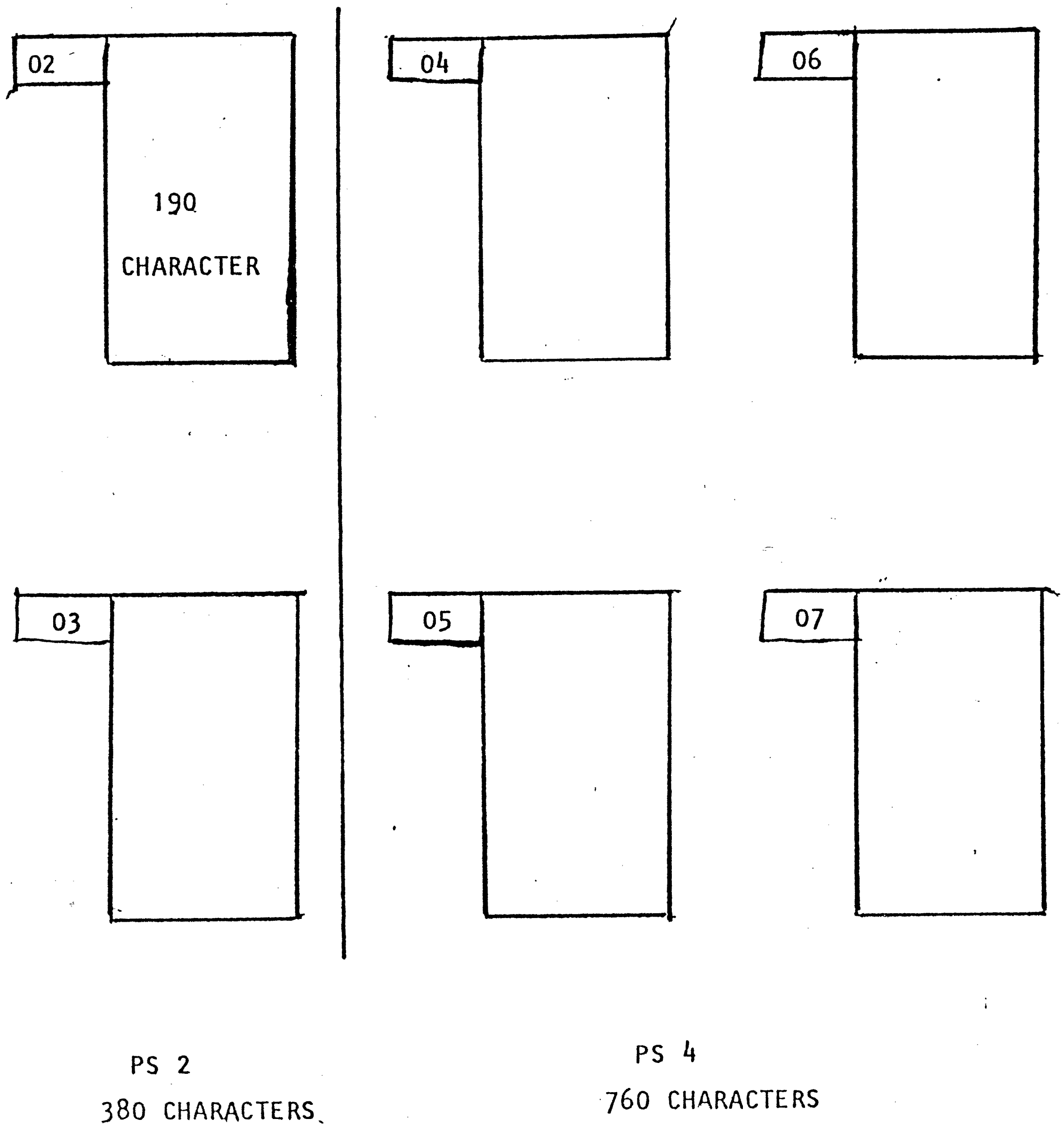
IBM 10 x 8 PRINT CELL



- STANDARD CHARACTER 7 X 8 (W x H) COLUMNS 8,9,10 MUST CONTAIN 0's , 32 DOTS MAX. PER CELL.
- NON-APA- NORMAL SAME AS STANDARD CHARACTER ABOVE.
- NON-APA - GRAPHICS - EVERY OTHER DOT CAN BE FIRED INCLUDING THE INTERCHARACTER GAP LOCATIONS, 50 DOTS MAX PER CELL.
- APA-GRAPHICS EVERY DOT IN THE CELL MAY BE FIRED, 80 DOTS PER CELL.

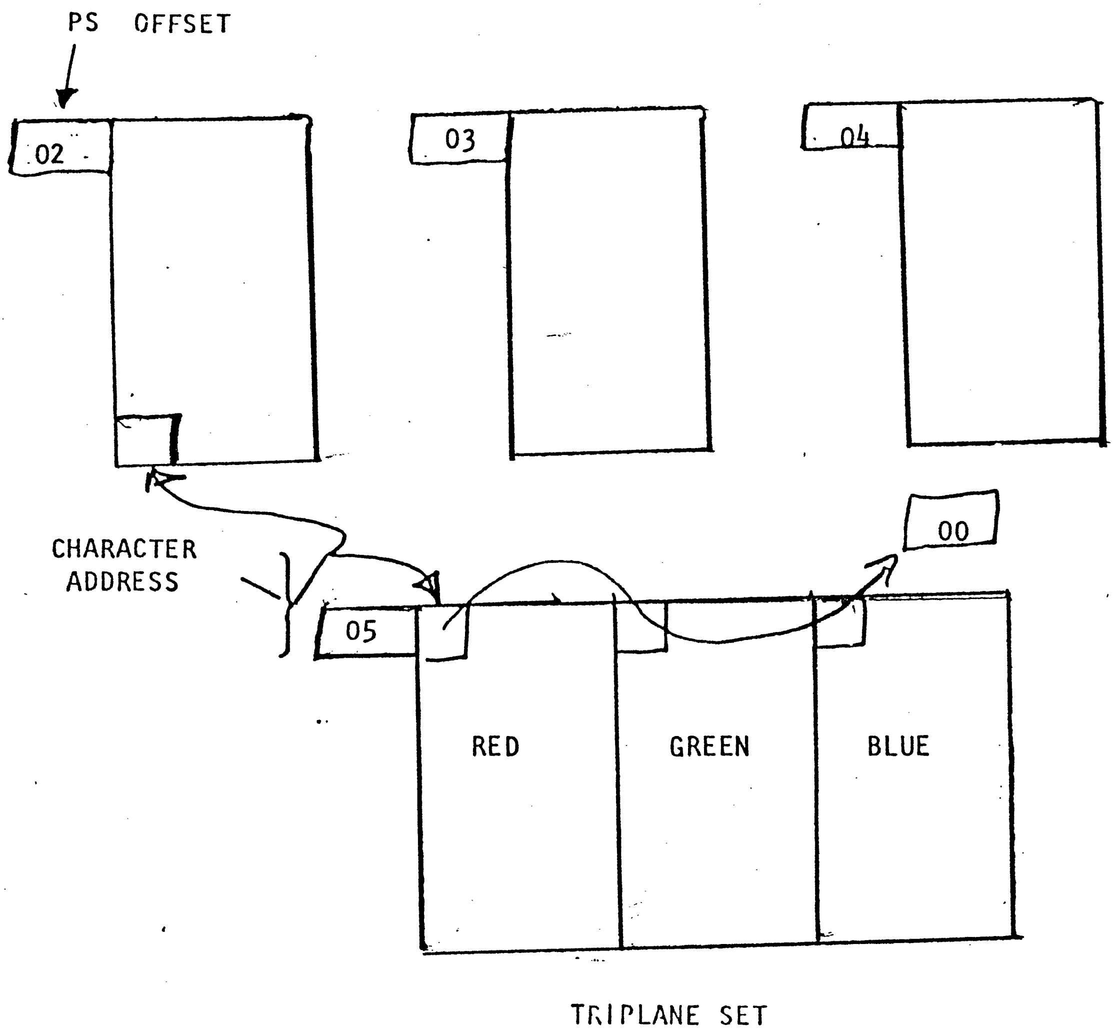
PROGRAMMED SYMBOLS (PS) 2 & 4

PS SET NUMBER, OFFSET



- EACH SET CONTAINS 190 CHARACTERS APPROXIMATELY 2K MEMORY.
- PS 2 CAN BE INSTALLED SEPARATELY
- PS 4 CAN BE ADDED TO PS 2

PS 4A



- PS SETS 2,3,4 OPERATE AS DESCRIBED, EACH CHARACTER ADDRESS CAN BE LOCATED BY USING THE PS OFFSET TO LOCATE THE CORRECT BLOCK

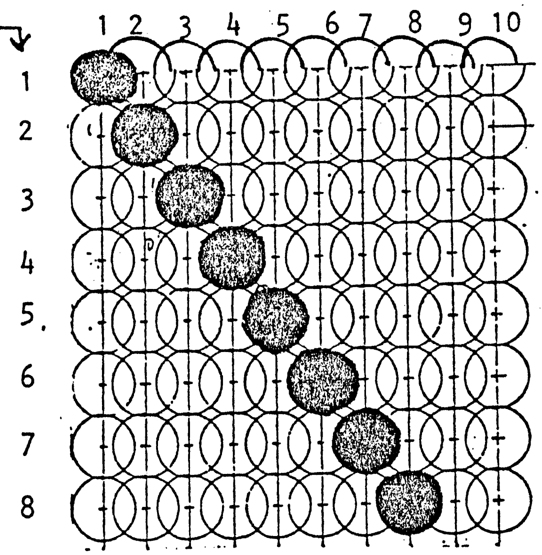
- PS 5, WHEN THIS SET IS ACCESSED AND A CHARACTER ADDRESS IS SELECTED THE CELLS ARE MAPPED. EACH LOCATION IS THEN PRINTED WITH A COLOR SHIFT IN BETWEEN EACH PASS.

PS 4-A, LOCATION 00, MAPPING

R_0 ROW

COLUMN (C)

RED PLANE "R"

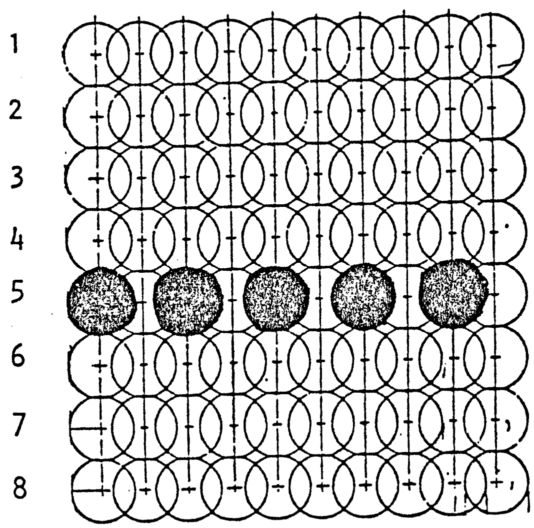


COINCIDENT DOTS

- R 5, 5 (R_0, C) G (5,5) and B (5,5)
- R (6,6), B (6,6)

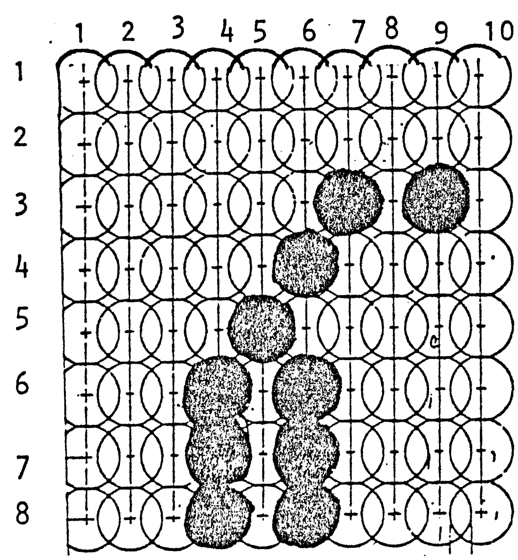
●● These locations must be printed in black

GREEN PLANE "G"



- Other locations will be printed in the color of the plane in which they reside.

BLUE PLANE "B"



PRELIMINARY

FUNCTIONAL SPECIFICATION

EXTENDED BASE PAN

FOR

35X SERIES PRINTERS

Date: April 22, 1982

P21/B20-25

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1.0 SCOPE

This specification defines the functional characteristics and requirements applicable to the design and construction of an extended base pan attachable to the 350 Series printers. Its function is to house control logic or interface devices as may be required to broaden the applications of these products.

2.0 RELATED DOCUMENTS

A.	80001126-9001	350 Functional Specification
B.	80002126-9001	350 Engineering Specification
C.	80001129-9001	351 Functional Specification
D.	80002129-9001	351 Engineering Specification
E.	80001130-9001	352 Functional Specification
F.	80002130-9001	352 Engineering Specification
G.	80001131-9001	353 Functional Specification
H.	80002131-9001	353 Engineering Specification
I.		Universal Print Stand Specification
J.		350/705 Bridge Board Eng. Spec.

3.0 REQUIREMENTS

The Extended Base Pan (EBP) will attach to and become an integral part of the printer designated for this configuration. Field or customer attachment of the EBP will be described in a set of installation instructions which is a part of the EBP assembly. Manufacturing process sheets will allow for CDCC plant build when justified. Installation of 705 designed formatters and control panels will be made in the EBP in conjunction with the 350/705 Bridge Board for 705 to 350 migration purposes. A version of the EBP will accept and be compatible to interface devices normally associated with the 6000 and 700 Series products.

3.1 PHYSICAL REQUIREMENTS

3.1.1 Description

The EBP is dimensioned to fit the underside of the 350 Series printers and attached via the mounting holes provided for print stand attachment. Overall size front to back and side to side, follows the printer lines for an aesthetically pleasing appearance.

Provision for a 705 full sized control panel is in the hinged front (operator) section of the EBP. Detachment of the control panel section and usage of a "plain" front can be accomplished for applications not utilizing the 705 style control panel.

Electrical connections for power to the 705 formatter in the EBP and signal connections to the 705/350 Bridge Board residing in the printer formatter area are provided for. Host signal cabling will enter from the back of the EBP with provisions for various sizes of connectors or strain reliefed cables.

A version of the EBP will have the functional components for installing an interface device assembled onto a removable "drawer" which is accessed from the front of the printer. A low profile which minimizes the overall height of the printer yet allows for I/O connector devices, such as the System 34, will be a requirement.

A set of 22 position dual edgecard sockets will provide for the installation of an interface board. Cabling to these sockets will be signals and power lines compatible to the 700 and 6000 Series interface adapters. The power lines consist of a harness arrangement which attaches to the formatter power connector. The data connection is through the parallel I/O connector on the back of the printer.

I/O signal connection to the host device is provided by a simple connector mounted on the drawer and accessible from the back of the printer, a cable strain relief bracket assembly, or an I/O block such as used on the System 34.

3.1.2 Size

3.1.3 Weight

3.1.4 Finish

3.1.5 Interconnect Cable Shielding

A cover system for the interface to printer data cable and connector is provided. This cover is easily detachable for printer maintenance.

3.1.6 ESD-RFI

The EPB will not change any ESD/RFI specifications for tolerance or emissions from those specified for the basic printer.

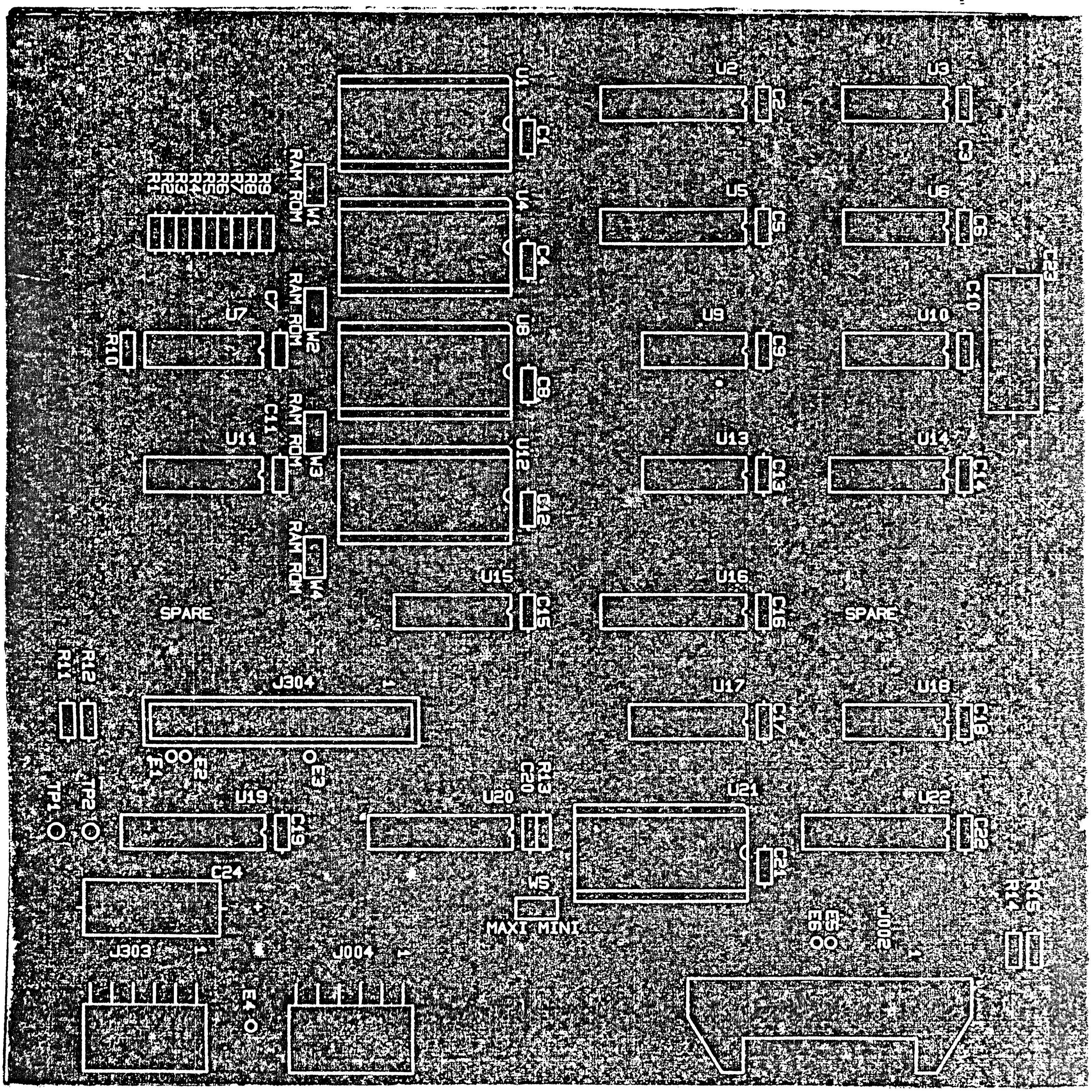
3.1.7 Cooling

A baffle arrangement allows for air from the printer cooling fan to move across the interface logic elements and exhaust from the EBP. This baffle also directs outside air into the intake area of the printer power supply.

3.1.8 Feet/Print Stand

Rubber feet on the underside of the EBP facilitates table-top operation. The location of these feet also allow for mounting to the Universal Print Stand.

705/350 Bridge Board



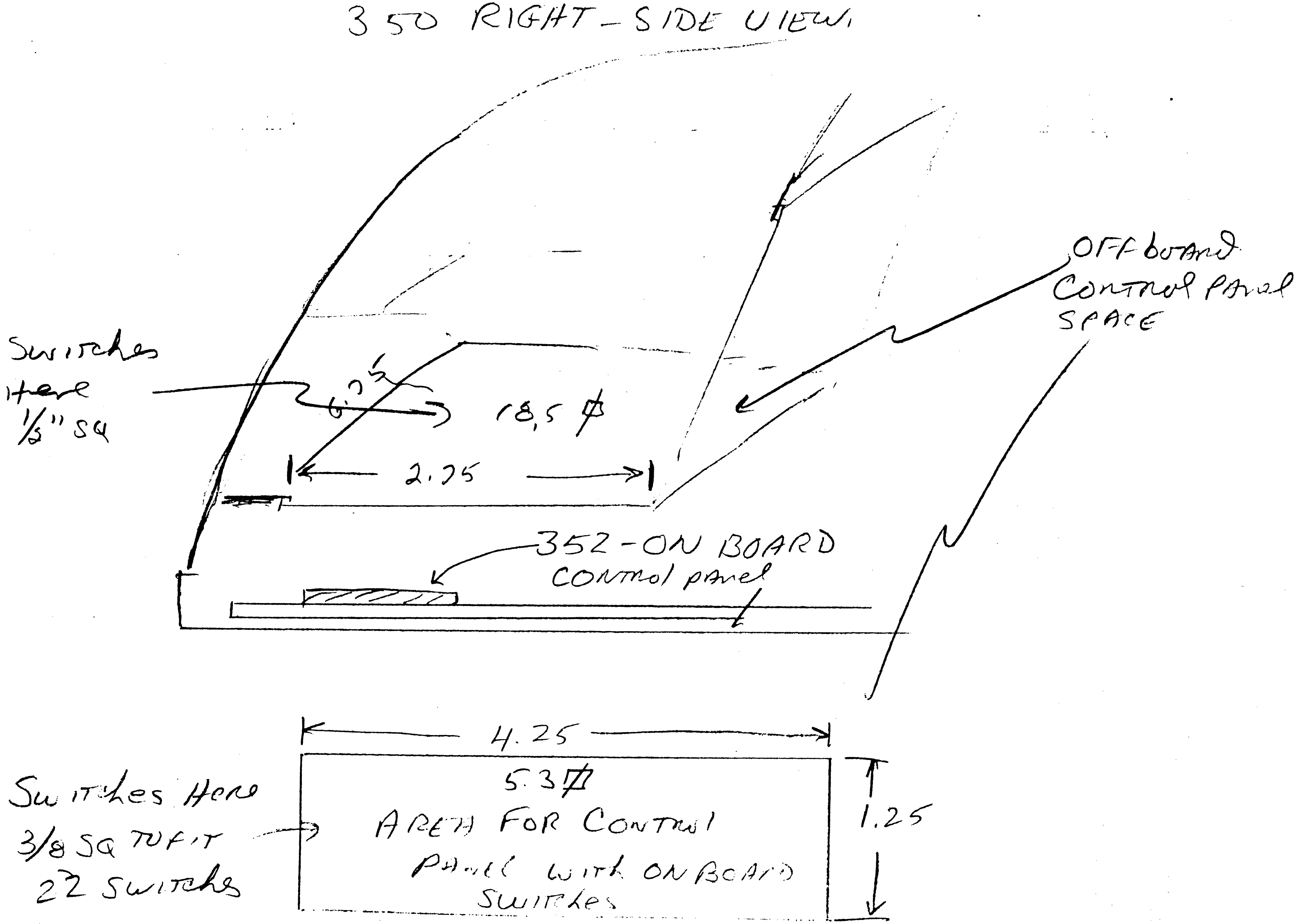

350 RIGHT-SIDE VIEW
Switches here
1/2" SQ
6.75
18.5 Ø
2.25
OFF board
Control panel
SPACE
352-ON BOARD
Control panel
4.25
5.3 Ø
AREA FOR CONTROL
PANEL WITH ON BOARD
SWITCHES
1.25
Switches Here
3/8 SQ TO FIT
22 Switches

FIG 1

350 - CONTROL PANEL INFO.

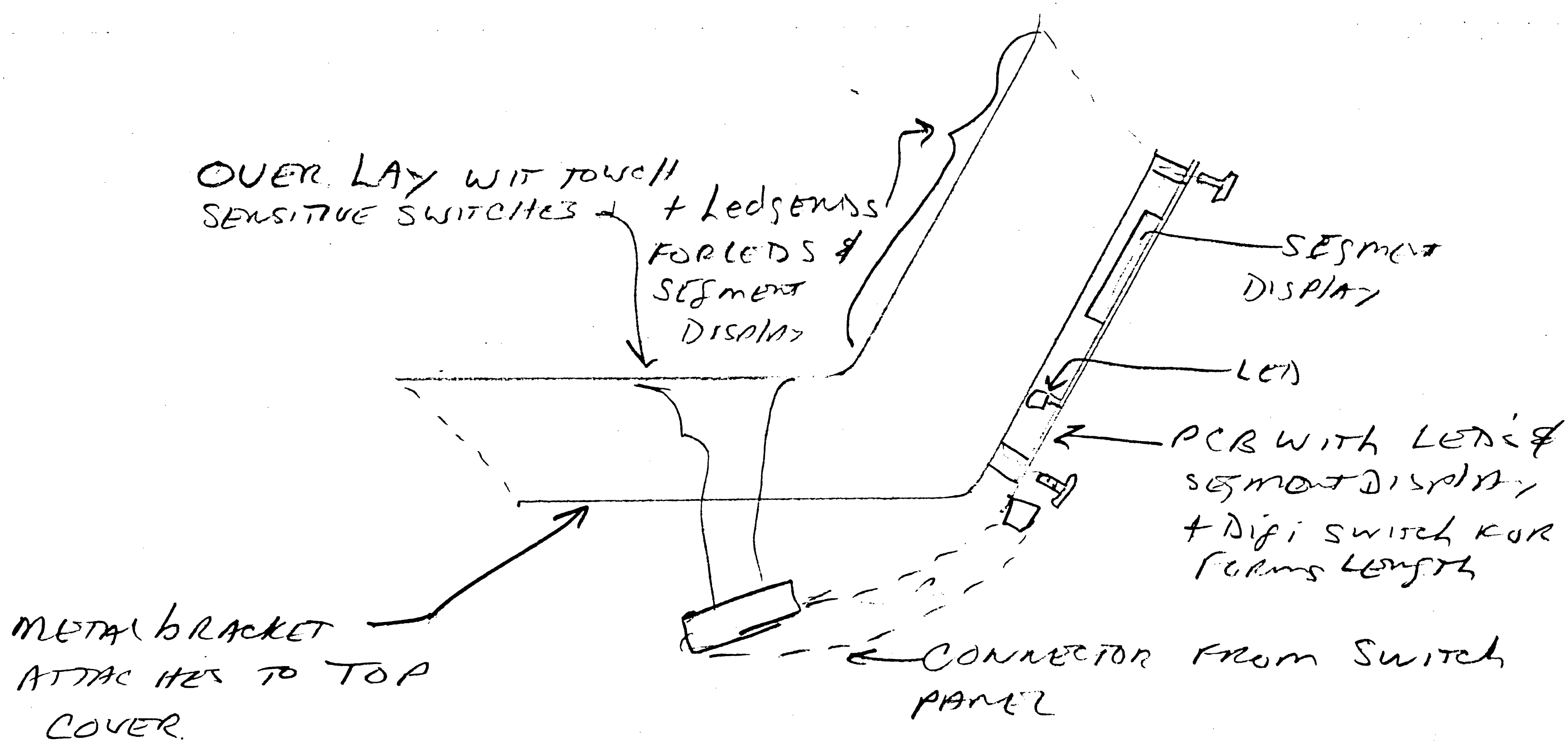


FIG 2

FUNCTIONAL SPECIFICATION

705 to 350 BRIDGE BOARD

PRELIMINARY

5/03/82

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1.0 SCOPE

This specification defines the functional characteristics and requirements applicable to the design and construction of a 350 to 705 C-RAM emulator (bridge board). Its function is to allow existing 705 style formatters to be used with 350 type print controllers.

2.0 RELATED DOCUMENTS

A.		705 Functional Specification.
B.		705 Engineering Specification.
C.	80001126-9001	350 Functional Specification.
D.		350 Engineering Specification.
E.		Extended Base Pan. Functional Specification.

3.0 REQUIREMENTS

The bridge board is an intermediary circuit device that satisfies the C-RAM electrical and code requirements of the 350 print controller (PC) and a 705 style formatter. It resides in the location normally used to house the 350 formatter. Cable connections for power and data transfer is compatible to the 350 requirements for formatter boards. Extensions for power and data are provided with sufficient length to attach to a 705 formatter residing in an extended base pan (EBP).

3.1 PHYSICAL REQUIREMENTS

3.1.1 Assembly Description

The bridge board is a single circuit card with a form factor for fitting in the aft portion of the 350 formatter area. The rear tabs and center nylatch holding devices for the formatter are used for securing the bridge board in place.

Residing on the circuit card are the C-RAM, 4 character generator locations, and support logic for data and control function interface between the 350 PC and 705 formatter.

3.1.2 Operation Description

Two modes of operation, mini and maxi, are available. The mode is selectable via a switch on the bridge board. The mini mode is hardware and software compatible with existing 705 formatters. The maxi mode simulates a 705 electrical interface and enables existing 705 formatters to access all 350 functions.

3.1.2.1 Mini Mode

The mini mode simulates a 705 print controller interface with the exception of:

A. The 350 PC returns control of the C-RAM to the formatter with 00H in the data buffer instead of 20H as does the 705 PC. The 705 formatter also typically writes 20H in space fields. Stripping of leading print spaces will not occur by the 350 PC if 20H is used.

B. Bits 2, 4 & 5 of the self test register always reports 0 from the 350 PC. This is a positive status of items not applicable to the 350 PC.

C. Bit 1 & 2 of the print command will select 1 of 4 possible character generators on the bridge board. Default of 00 will select character generator number 1.

3.1.2.2 Maxi Mode

The maxi mode takes advantage of the expanded argument and data fields of the 350's 2K C-RAM. This consists of a 32 byte argument register followed by up to 2016 data bytes.

The bridge board splits the 2K address space into the 32 command arguments and 9 pages of 224 byte segments for data. Page selection is controlled by the low order 4 bits of address 011H of the command argument.

PAGE MAP REGISTER

CRAM ADDRESS 011H

B7	B6	B5	B4	B3	B2	B1	B0
X	X	X	X	P3	P2	P1	P0

P3-P0	0000	Page 0
	0001	Page 1
	0010	Page 2
	0011	Page 3
	0100	Page 4
	0101	Page 5
	0110	Page 6
	0111	Page 7
	1000	Page 8
	1001	Not Used
	1010	Not Used
	1011	Not Used
	1100	Not Used
	1101	Not Used
	1110	Not Used
	1111	Not Used

At the end of each 224 byte page (020H to OFFH), the formatter changes the current page by writing to the page map register at 011H. Writing to the map register changes the page immediately.

3.1.3 Circuit Description

The bridge board uses a 512 x 8 PROM that converts the upper 4 address lines from the formatter (mini mode) and 4 bits from the page map (maxi mode) into 8 address lines for the C-RAM. In the case of the mini mode this addres conversion causes the second 16 command arguments available in the 350 to be skipped. This now allows the first 16 command arguments applicable to the 705 to be followed by data transfer from the 705 formatter. Maxi mode address conversion consists of reading the page map register for page numbers and applying the resulting C-RAM address to the data from the formatter.

3.1.4 Character Generators

The bridge board supplies four 2K x 8 character generator sockets. These can be either RAM or ROM. The formatter selects the active socket by setting bits 1 & 2 of the print command byte.

Bits	Char. Gen.	Relative Address
00	#1	0000H
01	#2	0800H
10	#3	1000H
11	#4	1800H

ENGINEERING PRODUCT SPECIFICATION

PHOENIX BLUE

PRELIMINARY

Spec. No.: 80002176-9001

May 18, 1982

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

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PRELIMINARY

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

1.0 SCOPE

This specification defines the functional characteristics and requirements applicable to the design and construction of the 350 (code named "Phoenix") serial matrix printer. The 350 contains the printing mechanism, print head, power supply, and the electronics (hereinafter referred to as the "Print Controller" or P.C.) which controls the printing mechanism. Machine functions are determined by an additional electronics board (hereinafter referred to as the "Format Controller" or F.C.) either customer or Centronics supplied which receives the data and from it dictates the method of printing. The Format Controllers are not covered by this specification. The means of communication between the two controllers and the versatility and restrictions of the basic machine are herein described.

2.0 RELATED DOCUMENTS

2.1 SPECIFICATIONS

A. 80002149-9001 Engineering Product Specification, 350 Mechanism

B. 80002150-9001 Engineering Product Specification, 350 Power Supply

C. 80002139-9001 Engineering Product Specification, High Speed Head

D. 80002151-9001 Engineering Product Specification, 350 Ribbon Cassette

E. Centronics Engineering Standard 001.

F. Centronics Engineering Standard 002.

G. Centronics Engienering Standard 003.

H. Centronics Engineering Standard 011.

I. Centronics Engineering Standard 014.

J. FCC Docket #20780, Part 15, Subpart J.

K. UL 114, 478 Regulatory Agency Requirements

L. CSA 22.2 #154 Regulatory Agency Requirements

M. VDE 0550,0730, 0830,0871,0875 Regulatory Agency Requirements

3.0 GENERAL

The Model 350 Serial Matrix Printer with Print Controller is modular in design concept where all effort has been made to de-personalize the basic machine giving flexibility of function and character to the design and implementation of the Format Controller.

The P.C. analyzes arguments and data passed to it by the F.C., performs the printer operation (described later) and returns status information. The machine is capable of 9-wire printing at a speed of 20 ips or 200 characters per second at 10 cpi printing a 7 wide matrix. The P.C. handles the logic seeking and bi-directional printing by analyzing the data and determining the most efficient method of printing. The machine is also capable, dependent on the format controller design, of high density, multi-pass printing.

The printing speed is determined by the pitch of the horizontal dots. Paper motion, reverse or forward is defined in actual steps of the stepper motor. Each step is equal to 1/120 (.00833) of an inch. Paper slew rate is 8 ips.

4.0 ELECTRICAL DESCRIPTION

4.1 POWER REQUIREMENTS

4.1.1 Print Controller

The following power is required to operate the Print Controller.

<u>Average</u>

+5V	-	2 Amps max.
+35V	-	3.5 Amps max.
+12V	-	.1 Amp max.

For details on the power supply specification, see Engineering Product Specification, 350 Power Supply, 80002150-9001.

4.1.2 Format Controller

The following power is available for the Format Controller.

+5V	-	5 Amps max.
+12V	-	.65 Amps max.
-12V	-	.75 Amps max.

4.2 POWER CONNECTORS

4.2.1 To Print Controller

Power is provided to the Print Controller by two connectors as follows:

6 Pin Molex #09-74-1061, CDCC #31301029-1006.

Pin Number	Description
1	+12 VDC
2	+12 Return
3	+5 Return
4	+5 VDC
5	+35 Return
6	+35 VDC

9 Pin Molex #09-74-1091, CDCC #31301029-1009.

Pin Number	Description
1	Chassis Ground
2	+5 VDC
3	+5 V Return
4	NC
5	NC
6	NC
7	+35 VDC
8	+35 V Return
9	Power Fail

4.2.2 To Format Controller

Power is provided to the Format Controller by a 6 pin Molex #26-03-4061 as follows:

Pin Number	Description
1	+12 VDC
2	±12 Return
3	∓12 VDC
4	+5 Return
5	Chassis Ground
6	+5 VDC

5.0 INTERFACE DESCRIPTION

5.1 C-BUS

This is the Centronics standard universal printer/formatter controller interface. It is used to pass data, control and character generator information between the formatter and the printer controller. See Figures 1 and 2 for read/write timing.

5.1.1 Signal Description

5.1.1.1 Data Bus - D0 Thru D7

These 8 bidirectional data lines allow the Printer Controller to communicate with the character generator ROM's or RAM and the C-RAM buffer.

5.1.1.2 Address Bus - A0 Thru A12

These 13 unidirectional lines are used to address an 8K block of contiguous memory addresses. Two additional select lines are provided (CGSEL, CRSEL) to select either the C-RAM or character generator address block. The format controller uses additional decoding logic under firmware control to allow the character generator options to use the same address block.

5.1.1.3 Control Bus

There are seven (7) control lines available at the remote C-BUS connector.

5.1.1.3.1 $\overline{\text{RESET}}$

RESET originates from the Print Controller and is used to reset the logic on the Format Controller during power-on. A low level indicates the RESET condition.

5.1.1.3.2 HOLD IT

This handshake originates from the Format Controller. A high level indicates that the Format Controller has read/write control of the C-RAM. The Print Controller is prohibited at this time from accessing the C-RAM. When this level goes low, it means that the Format Controller has relinquished control of the C-RAM and is requesting the Print Controller to act on the data in the C-RAM.

5.1.1.3.3 PWR FAIL

Originates from the power supply. It indicates that the power supply will continue to remain in spec for only 4 msec before failing.

Figure 1.

Figure 2.

5.1.1.3.3 GOT IT

This handshake signal originates from the Print Controller. A high means that the Print Controller has read/write control of the C-RAM and action is in progress. The Format Controller is prohibited from accessing the C-RAM at this time. When this signal goes low, it means that the Print Controller has relinquished control of the C-RAM, and that action is complete.

5.1.1.3.4 $\overline{\text{CGSEL}}$

This line originates from the Print Controller and is used to select the 8K block of memory addresses for the character generator. A low level indicates that a READ or WRITE operation to the character generator is in progress.

5.1.1.3.5 CRSEL

This line originates from the Print Controller and is used to select the 4K block of memory addresses for the C-RAM and graphics RAM buffer. A HIGH level indicates that a READ or WRITE operation to the buffer is in progress.

5.1.1.3.6 WRITE

This line originates from the Print Controller and is used to strobe data into the C-RAM or character generator RAM. A low level indicates a data write to memory.

5.1.2 Connector Pin Out

The 34 way connector on each P.C. board and F.C. board will use the following pin out.

34 WAY PIN #	DESCRIPTION	
30	DATA D0	DATA
13	DATA D1	
29	DATA D2	
12	DATA D3	
28	DATA D4	
11	DATA D5	
27	DATA D6	
10	DATA D7	
1	ADDR A0	ADDRESS
18	ADDR A1	
2	ADDR A2	
19	ADDR A3	
3	ADDR A4	
20	ADDR A5	
[illegible]	ADDR A6	
[illegible]	ADDR A7	
14	ADDR A8	
15	ADDR A9	
16	ADDR A10	
17	ADDR A11	
32	ADDR A12	
7	$\overline{\text{RESET}}$	CONTROL
6	HOLD IT	
23	GOT IT	
8	CRSELH	
31	$\overline{\text{CGSEL}}$	
25	$\overline{\text{WRITE}}$	
5	GROUND	
22	GROUND	
9	GROUND	
26	GROUND	
24	PWR FAIL	
34	N.C.	

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5.1.3 Physical Description

Cable shall be ribbon cable compatible with the mating connector for receptacle defined by Centronics part number 31240080-1040. The maximum cable length shall be 6 inches. The T/B Ansley part number for the 34 way connector is 609-3429M.

5.1.4 C-RAM Interface Drive Characteristics

All interface lines are driven by or terminate into a Low Power Schottky device on the Print Controller, with the exception of the GOT IT line as discussed below.

GOT IT is driven by an TTL 07 pulled up to +5V with a 1.2K ohm resistor.

Good engineering practice must be maintained when interfacing with the Print Controller such as minimizing cable lengths, locating the drive and receive devices close to the interface connector, not exceeding the fan out of the devices and minimizing termination capacitance.

5.2 DATA/ARGUMENTS DEFINITION

Action by the printer is dictated by the placement of parameters in the C-RAM by the Format Controller and the signaling of the Print Controller with the lowering of the 'Hold It' line that action is requested. The C-RAM is divided into two sections, the Control Block and the Data Area (Figure 3). Control information is located at addresses 00_{16} to $1F_{16}$. The data area is located from 20_{16} to $7FF_{16}$. Arguments for the print functions and status of the printer are passed in the control block.

5.2.1 Status Bytes

The status occupies, location 00-04 and OE while the arguments occupy locations 05_{16} - 11_{16} except for OE. Arguments for five events are defined, four for paper motion, and one for print action. The five events are performed in sequence. (See Figure 3). If a self-test or a head prime is requested, self-test takes top priority and head prime is next.

COMMUNICATIONS RAM MAP

BYTE	DESIGNATION	SOURCE	COMMENTS
00	PRINTER STATUS	PRINT CONTROLLER	
01 02	ACCUMULATED PAPER MOTION STEPS	PRINT CONTROLLER	STATUS INFO.
03 04	UNCOMPLETED PAPER MOTION STEPS	PRINT CONTROLLER	STATUS OF FAILED MOTION
05 06	REVERSE PAPER MOTION BEFORE PRINT	FORMAT CONTROLLER	EVENT 1
07 08	FORWARD PAPER MOTION BEFORE PRINT	FORMAT CONTROLLER	EVENT 2
09	PRINT COMMAND	FORMAT CONTROLLER	EVENT 3
0A 0B	REVERSE PAPER MOTION AFTER PRINT	FORMAT CONTROLLER	EVENT 4
0C 0D	FORWARD PAPER MOTION AFTER PRINT	FORMAT CONTROLLER	EVENT 5
OE	SELF TEST BYTE	PRINT CONTROLLER	STATUS OF SELF TEST
OF	DENSITY SELECTION	PRINT CONTROLLER/ FORMAT CONTROLLER	
10	MACHINE OPTIONS	FORMAT CONTROLLER	MECHANICAL FEATURES
11	GRAPHIC OPTIONS	FORMAT CONTROLLER	
12 1E		RESERVED	
1F	MATRIX SIZE	FORMAT CONTROLLER	OPTIONAL
20 FF	ASCII DATA	FORMAT CONTROLLER	
20 7FF	GRAPHICS PIN DATA	FORMAT CONTROLLER	

Figure 3.

Status is updated by the Print Controller before each transfer of control of the C-RAM to the Format Controller. The print function arguments are not changed by the Print Controller, only acted upon. After the completion of a 'Print Command', the data buffer is returned to a reset mode, i.e., full of null codes, however, the 'Print Command' byte is not changed. Should an abort occur, the data is left intact and passed back to the Format Controller. If no print action is requested, Print Command, Bit 4 = 0, the print buffer is neither interrogated nor changed.

5.2.2 Paper Motion Argument Description (Figure 4)

The four paper motion arguments (Bytes 05_{16} - 08_{16} and $0A_{16}$ - $0D_{16}$) are stated as a 2 byte numbers. The argument forms a 12 bit binary number. Bits 0 - 7 of the lower order address bytes contain the eight (8) least significant bits of the argument value. Bit 0 - 3 of the higher order address bytes form the four (4) most significant bits of the argument values Bits 4 - 7 of the higher order address bytes are ignored.

PAPER MOVEMENT ARGUMENT

7 ———————— 0		LS BYTE
7 ———— 4 DO NOT CARE	3 ——— 0	MS BYTE

2 BYTES FORM 12 BIT BINARY NUMBER

ONE BIT REPRESENTS 1 STEP = .00833 INS PAPER MOVEMENT (FANFOLD PAPER)

120 FULL STEPS = 1 INCH
20 FULL STEPS = 1/6 INCH PAPER MOVEMENT
15 FULL STEPS = 1/8 INCH PAPER MOVEMENT

TOTAL MOVEMENT IS 4095 FULL STEPS = 34.125 INCHES (86.67 cm)

CUT SHEET MODE

180 FULL STEPS = 1 INCH ———— 108 ??
18 FULL STEPS = 1/6 INCH
13 to 14 FULL STEPS = 1/8 INCH

NOTE: Formatter should alternate 13 steps for first movement and 14 steps for second movement, as actual moement in this mode is 13.5 steps.

Figure 4.

5.2.3 Byte 00 - Printer Status (Figure 5)

This byte is written by the Print Controller after each printer action (prior to the return of the control of C-RAM to the Formatter) and shows the printer status as defined below. The transfer of control from the Format Controller to the Print Controller with all events zero will update paper out only.

PRINT STATUS BYTE 00

BIT NO.	DESIGNATION
7	EVENT ABORTED
6	ABORT ON EVENT 1
5	ABORT ON EVENT 2
4	ABORT ON EVENT 3
3	ABORT ON EVENT 4
2	ABORT ON EVENT 5
1	FAULT/TEST FAIL
0	PAPER OUT

Figure 5

SELF TEST ERROR MAP BYTE 0E

BIT NO.	DESIGNATION
7	Head Jam/No Video
6	Bad Video Count
5	Reserved
4	Reserved
3	P.C. Ram Check
2	Reserved
1	CRAM Check
0	CRC on Program ROM

Figure 6

5.2.3.1 Bit 7

When set shows that one of the five events was aborted because of either a fault or paper out condition. If this bit is set along with Bit 1 and none of the event bits are set, then a head prime has been aborted because of an open interlock, video processor failure or a head jam.

5.2.3.2 Bit 2 - 6

When bit 7 is set showing an abort of one of the events, one of the bits 2 thru 6 may be set showing the event in progress when the abort occured.

The events are polled in order with event one first and five last. The abort of an event prior to the last will flag that event only although subsequent events, if any, will not have been processed.

5.2.3.3 Bit 1

There are three conditions for which bit 1 can be set:

A. If a print head jam or an open interlock occurs during a print cycle, bit 7, 4 and 1 will be set indicating a print cycle aborted has been terminated.

B. When a self test has been initiated and a failure has been recognized, self test byte should then be polled.

C. If during a head prime the video processor indicates a failure or an open interlock has occurred, this bit along with Bit 7 will be set.

5.2.3.4 Bit 0

When set, indicates a paper out condition. Bits 7-2 should be checked to determine if any event in progress was aborted because of this condition.

5.2.4 Byte OE - Self Test Status Byte (Figure 6)

The self test status byte is located in OE_{16}. Figure 6 shows the error map that is possible for this location. The format controller initiates the self test by setting the appropriate bit in the print command byte (see Figure 7). The print controller will then proceed with a self test and write the results in the self test byte location.

On power-up the print controller performs the test associated with Bits 0, 1 and 3 and places the results in the self test byte location.

When the bit is set, it indicates a failure in the test being performed.

5.2.4.1 Bit 0

CRC check on the firmware program chips on the P.C. A one signals an error condition.

5.2.4.2 Bit 1

Checks that reading and writing C-RAM is functioning correctly. A one signals an error condition. This test is a non-destructive data test.

5.2.4.3 Bit 2

Reserved.

5.2.4.4 Bit 3

Checks that reading and writing the scratch pad RAM are functioning correctly. This test is a non-destructive data test. A one signals an error condition.

5.2.4.5 Bit 4

Reserved.

5.2.4.6 Bit 5

Reserved for expansion.

5.2.4.7 Bit 6

Checks video circuitry. If set, it indicates a video count greater than 2% of the accepted value was received.

5.2.4.8 Bit 7

If set, it indicates no video signals were received.

5.2.5 Byte 01_{16} and 02_{16} - Accumulated paper motion steps.

This two byte, 16 bit number is a two's complement count of the number of steps that paper has moved. Zeroed on initializtion, forward paper motion steps are added to the number and reverse are substracted. The Format Controller can zero this at each logical top of form if the total steps per form are to be accumulated. Each step of motion is equal to 0.00833 inches (120 steps/inch) when using fanfold paper.

5.2.6 Byte 03_{16} and 04_{16} - Paper Motion steps remaining after abort

If the Print Controller is forced to abort a paper motion event because of a power failure, the number of forward paper motion steps that were not completed during that ~~event~~ are stored here by the Print Controller.

5.2.7 Byte 05_{16} and 06_{16}

Event no. 1, reverse paper motion before print.

5.2.8 Byte 07_{16} and 08_{16}

Event no. 2, forward paper motion before print.

5.2.9 Byte 09

Event no. 3, Print Command (Bit 0 - LSB) (Figure 7) - The Print Command indicates to the Print Controller the action, other than paper motion, that is requested.

Results will be placed in the status word.

PRINT COMMAND

BIT NO.	DESIGNATION
7	PRIME
6	PRINT UNDERLINE
5	PRINT EXPANDED
4	PRINT DATA
3	OVERRIDE
2	CHARACTER SET
1	SELECTION
0	TEST

Figure 7.

5.2.9.1 Bit 7 - Prime

When set causes the print head to move to the left home position. This takes priority over all other events except self-test.

5.2.9.2 Bit 6 - Print Underline.

When set causes the data in the print buffer to be printed with an underline. Embedded nulls are not underlined.

5.2.9.3 Bit 5 - Print Expanded

When set causes the data in the print buffer to be printed expanded.

5.2.9.4 Bit 4 - Print

When set indicates that data is to be printed. This bit must be set to initiate any print action. To print underline expanded, bits 6, 5, and 4 must be all set to ones. For normal print only bit 4 would be set. Bits in the Print Command Word are processed MSB to LSB with the exception of the test bit (bit 0) which is interrogated and acted upon first (any failure will cause an abort). If bit 7 was set in the above examples the head would move to the left before printing.

5.2.9.5 Bit 3 - Override

When set the requested events will be processed regardless of a paper out condition.

5.2.9.6 Bit 2 and 1

These bits provide the four 2K offset arguments into the character generator (see table below). The P.C. will add the relative address as defined by Bits 1 and 2 to the base address of the 8K character generator block.

B2	B1	Relative Base Address
0	0	0 0 0 0
0	1	0 8 0 0
1	0	1 0 0 0
1	1	1 8 0 0

5.2.9.7 Bit 0 - Test

When set will cause the Print Controller to self-test. This will include a RAM check, program CRC check and the moving of the head from the left margin to the right and back to verify video count.

Results will be placed in the status word.

5.2.10 Byte OA_{16} and OB_{16} - Event no. 4, reverse paper motion after print.

5.2.11 Byte OC_{16} and OD_{16} - Event no. 5, forward paper motion after print.

5.2.12 Byte OF - Print Density/Type

Bits 0 through 2 are used by the Format Controller for the selection of character density as follows:

B2	B1	B0		
0	0	0	=	10 cpi
0	0	1	=	not used
0	1	0	=	not used
0	1	1	=	12 cpi
1	0	0	=	13.3 cpi
1	0	1	=	15 cpi
1	1	0	=	16.67 cpi
1	1	1	=	not used

Bit 3 is set to indicate a graphics mode. To determine whice mode has been selected, Byte 11, the print options byte, should be interrogated. When Bit 3 is set, Bits 0 through 2 are ignored. When printing graphics, the pin data comes from the F.C. (see Paragraph "Character Pattern Generation").

Bit 4 is set to indicate high density printing. When Bit 4 is set, Bits 0 through 2 are ignored. Multi-pass printing must be performed by setting Bit 4 and changing character set locations with Byte 09. Bit 7 will also be interrogated to determine uni-directional or bi-directional printing.

Bit 5 - Not used.

Bit 6 - When Bit 6 is set, the P.C. will interpret the data in C-Ram as character set information. The P.C. will transfer 2K bytes of the C-Ram data into the character generator location as defined by the setting of Bits 1 and 2 in the Print Cmd Byte (see 5.2.9.6). During the transfer, a read after write check is performed on each byte for load validity. If an error is detected, the transfer is aborted at that point and the C-Ram is returned to the F.C. with Bit 6 left set. If the transfer is completed with no errors, Bit 6 is cleared before returning C-Ram control to the F.C. In either case, the 2K block of C-Ram is always cleared before releasing control. No other events will be acted on.

Bit 7 - If this bit is set along with either Bits 3 or 4, uni-directional printing will take place. If it is not set and either Bits 3 or 4 are set, bi-directional printing is assumed. The exception to this is APA Graphics, which is always uni-directional.

10 → 17

5.2.13 Byte 01 - Machine Options

If Bit 0 is set, cut sheet mode is indicated. The P.C. will shift the margin in from the left side. Also the maximum line lengths will be adjusted to reflect this shift.

5.2.14 Byte 11 - Graphics Mode

If Bit 3 of the print density byte was set, ~~the~~ byte should be checked to determine which of the three possible graphics modes is to be selected. Those modes are as follows:

Byte 11 = 00 - APA Graphics (all points available) is assumed. This type of graphics can only be done in the uni-directional mode. Dot spacing is every six encoder lines (.0100 inch) and adjacent dots can be fired.

Byte 11 = 01 - Non-APA normal printing is assumed. Pin data is still taken directly from the C-Ram and dot spacing is every six encoder lines (.0100 inch), however, adjacent dots cannot be fired. The first seven columns out of ten will contain printable dot information. The remaining three columns must contain null codes for inter-character spacing. Failure to do this could cause serious damage to the head. Printing can be done uni or bi-directionally.

Byte 11 = 02 - Non-APA Graphics printing is assumed. Dot spacing is every six encoder lines (.0100 inch) and adjacent dots cannot be fired. Printing can be done uni or bi-directionally. It is assumed that every column will have printable dot information.

5.2.15 Byte 1F - Matrix Size

This binary number indicates the horizontal character width and is used to calculate the address of the character within the character generator (see Paragraph 5.4 'Character Pattern Generation'). ~~When zero, the character is assumed to be seven wide (except for High Density Print).~~ For a value of 0 to 7, the character is assumed to be seven wide. For any other value, it is assumed to be nine wide.

5.3 POSITIONAL INFORMATION AND USE

Positional information comes in as quadrature from an encoder mounted on the horizontal drive motor. This information comes directly into a separate microprocessor which signals the main microprocessor with both column and positional information on divide-by arguments it is presented. The encoder with dual sensors gives positional information at a rate of ~~660~~ 600 edges per inch or every (0.00167 inch). See Engineering Product Specification 80002149-9001 for signal specification.

5.3.1 Standard Character Placement

For the standard 7 wide character, column spacing is as follows:

CPI	Lines/Columns	Dot Spacing (In)	Lines/Interchar.	Total Lines
10	6	0.0100	24	60
12	5	0.0083	20	50
13.3	5	0.0083	15	45
15	4	0.0067	16	40
16.67	4	0.0067	12	36

When the character width is changed to a 9 wide dot matrix with the placement of a binary 1001 in argument $1F_{16}$ of the C-RAM, the standard spacing for the 9 wide character is used. This spacing is as follows:

CPI	Lines/Columns	Dot Spacing (In)	Lines/Interchar.	Total Lines
10	5	0.0083	20	60
12	4	0.0067	18	50
13.3	4	0.0067	13	45
15	3	0.0050	16	40
16.67	3	0.0050	12	36

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NOTE: In the above, adjacent dot positions cannot be fired.

5.3.2 Graphics Modes

When Bit 3 of the print density argument is set indicating grahics, byte 11_{16} is interrogated to determine which of the three modes is to be used. In any case, dot placement will be every six encoder lines or every 0.010 inches. Differences between them are outlined below.

APA Graphics - Adjacent dots can be fired. Printing is ~~doen~~ uni-directionally only. Printing speed is 3.9 IPS.

Non-APA Graphics - Adjacent dots <u>cannot</u> be fired. Every column can contain printable dot information. Printing speed is 7.5 IPS.

Non-APA Normal - Adjacent dots <u>cannot</u> be fired. Out of every ten columns, seven can contain printable dot information. The other three columns must be nulls. The resulting print density is 10 CPI. Printing speed is 20 IPS.

5.3.3 High Density Print

When Bit 4 of the print density arguments is set indicating high density, the dot placement is every 3 encoder lines or every 0.0050 inches. In this mode, adjacent dots cannot be fired.

Printing is done in multiple passes. For each pass, Bits 1 and 2 of the print command are interrogated to determine which 2K block of character generator the pin data should be taken from for that pass. A density of 10 cpi is assumed. Matrix size is 15 wide. Print speed is 9.35 ips.

Lines/Column	Dot Spacing	Lines/Interchar	Total Lines
3	.0050	18	60

5.4 CHARACTER PATTERN GENERATION

It is the responsibility of the Format Controller to insure that the character generator complies to the method of printing requested. When printing standard characters the address as shown below and a ROM select are presented by the P.C. on the address lines of the character generator connector and eight bits of data representing pin fire information are read. The LSB represents Pin 1 (top most pin) and the MSB is Pin 8 information. When printing characters, only alternate dots can be fired. Pin 9 is only available (other than underline) for the 7 wide character.

5.4.1 Character Generator - Standard 7 Wide Character

The following is the address presented to the character generator for standard 7 wide characters. All numbers are hexadecimal. The eighth byte of each character code contains the ninth pin data. The first bit of the byte (Bit 0) represents the left-most column of the character and the seventh bit (Bit 6) represents the right column or seventh column of the character. The eighth bit (Bit 7) is ignored. However, in the case of under, this information is ignored.

↑ Line

Char. Code	Char. Gen Address
00	000-006
01	008-00E
02	010-016
03	018-01E
⋮	
41 (A)	208-20E
⋮	
7E	3F0-3F6
7F	3F8-3FE
80	400-406
⋮	
C1	608-60E
⋮	
FE	7F0-7F6
FF	7F8-7FF

5.4.2 Character Generator Address - Non-Standard Width

In this case, Pin 9 is not available except for underline. Addresses for other than 7 wide are computed in the following manner:

(Character Code) x (Width) = First Column
First Column + Width - 1 = Last Column

Example: For a character 9 wide (Shown in Hex)

Character Code 00 =	(00) x (09) = 00	First Column
	00 + (09) -1 = 08	Last Column
Character Code 03 =	(03) x (09) = 1B	First Column
	1B + 09 - 1 = 23	Last Column
Character Code 41 =	(41) x (09) = 249	First Column
	249 + 09 - 1 = 251	Last Column

5.4.3 Graphic Mode

When Bit 3 is set in the print density argument of the C-Ram, the graphics byte (Byte 11) is interrogated to determine which of the three possible graphics modes is to be used. Pin data is taken directly from the C-Ram with the eight bits representing the eight pins on the print head that can be fired. The first column comes from Location 20_{16} and the last column from 547_{16} for a total of 1320 possible column firings.

5.4.4 High Density Print

High density print is defined as a 15 (0F Hex) wide matrix with dot firings every 3 encoder pulses or .0050 inches. Adjacent dots cannot be fired. Using the method described in Section 5.4.2, the dot formation in the character generator is as follows (calculations shown in hex):

Character Code 01 = 01 x 0F = 0F First Column
0F + 0F - 1 = 1D Last Column

Character Code 41 = 41 x 0F = 33F First Column
33F + 0F - 1 = 34D Last Column

5.5 RESTRICTIONS

The following restrictions apply when printing with the 350 Print Controller.

A. Logic seeking is done on any leading or trailing nulls in a line. Any other code is considered a printable character.

B. Any embedded nulls in a line are not underlined.

6.0 DRIVE CIRCUITRY

6.1 PAPER TRANSPORT

6.1.1 Stepper Motor Excitation Sequence

CW ROTATION	01	02	03	04	
	ON	OFF	ON	OFF	NORMAL
	ON	OFF	OFF	ON	4 STEP
	OFF	ON	ON	ON	SEQUENCE (FULL STEP)
	OFF	ON	OFF	OFF	

ON = 1 = +5
OFF = 2 = 0V

6.1.2 Stepper Driver

Figure 8 describes the driver circuitry for the stepper motor. The energy level in the motor is maintained by chopping the current in each winding with the upper stage drivers. During paper motion, the motor current per winding is 1 AMP with V hold at 0V. When no paper motion is required, current per winding is approximately 250ma with V hold at +5. This minimizes power loss when paper motion is not required.

Average current per winding:

V hold ON 250 ma
V hold OFF 1 Amp

Voltage required:

+35V, +5V

Figure 8. STEPPER MOTOR DRIVER

6.2 CARRIAGE SERVO SYSTEM

6.2.1 DC Motor Controller

Figure 9 describes the DC motor drive circuitry and velocity control circuit.

Control	Signal	DC Motor Shaft Rotation	Carriage Direction
FWD REV	0 0	None	-
FWD REV	1 0	CCW	Forward Left Side Frame to Right Side Frame
FWD REV	0 1	CW	Reverse Right Side Frame to Left Side Frame
FWD REV	1 1	None	-

1 = ON = +5
0 = OFF = 0V

Carriage Motion is achieved by applying the control signals described above as well as the TACH signal described below.

Velocity control is achieved by maintaining a constant error voltage between an internal reference and the voltage derived as a result of the input TACH frequency. TACH frequency is derived as a sub-multiple of the video feedback. That is, given the 600 position feedback points per linear inch of carriage motion a variable divider is used to generate the TACH FREQ for the desired carriage velocity.

The count for the divider is selected by considering the rep rate of the matrix head and the number of possible dot firings per inch. The following head speeds are used for the standard densities for a 7-part character:

10 CPI	20 IPS
12 CPI	16.4 IPS
13.2 CPI	14.76 IPS
15 CPI	13.02 IPS
16.5 CPI	11.45 IPS
High Density	9.35 IPS
Graphics Non-APA	7.55 IPS
Graphics APA	3.9 IPS
[illegible]	[illegible]

Component selection maintains the above speeds ±10%. There is no speed adjustment. A cap is used to shut the motor down if no video information is received after 46 msec.

6.3 RIBBON MOTOR DRIVER

The ribbon motor driver is a +12V DC motor, controlled by a single transistor shown in Figure 9. The ribbon motor is turned ON when the DC carriage motor is turned on.

Voltages required = +12V

6.4 HEAD DRIVER CIRCUIT

The head driver circuit features a "pick and hold" circuit to quickly energize the pin solenoids. This drive technique enables high speed printing with minimum power loss since all stages are run in saturation mode. The maximum rep rate per pin is 909us.

Signals required = Pin 1 through Pin 9

1 = ON = +5 = FIRE PIN
0 = OFF = 0V = DO NOT FIRE PIN

Pin Data Strobe = 1-3 us negative going TTL signal

Logic level requirements = TTL

Voltages required = +35V, +5V

Figure 9. CARRIAGE DRIVE - RIBBON DRIVE VELOCITY

7.0 ENVIRONMENTAL CONDITIONS

7.1 TEMPERATURE/HUMIDITY

The printer will meet the requirements as specified for a "Class B" product in Paragraph 3.0 of Centronics Engineering Standard 001.

7.1.1 Operating

Temperature 10 degrees (50°F) to 40 degrees C (104°F).
Relative Humidity 10% to 90% with maximum wet bulb 28 degress C (82°F) and minimum dew point 2 degrees C (36°F).

7.1.2 Non-Operating

-40 degrees C (-40°F) to 66 degrees C (105°F) and 10% to 95% RH.

7.2 ALTITUDE

As per Paragraph 4.0, Centronics Engineering Standard 001, 2.4 Km (8,000 ft.) to -.303 Km (-1,000 ft.).

PRELIMINARY
SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

7.3 MECHANICAL SHOCK

As per Paragraph 5.0, Centronics Engineering Standard 001.

7.3.1 Operating

Half sine shock pulse of 10 Gpk and 10 $\pm$ 3 ms duration applied once in either direction of three orthogonal axes (3 pulse total).

7.3.2 Non-Operating

Table top products shiped in individual packages shall be designed to withstand half sine shock pulses of 40 feet Gpk and 30 $\pm$ 10 ms duration.

7.4 VIBRATION

As per Paragraph 6.0, Centronics Engineering Standard 001.

7.4.1 Operating

5-22	Hz	0.010"	DA
22-500	Hz	0.25	Gpk
500-22	Hz	0.25	Gpk
22-5	Hz	0.010"	DA

Sweep rate of 1 octave/minute.

7.4.2 Non-Operating

The printer when packaged will withstand the random vibration listed below when the packaged product is affixed to a shaker table.

(These profiles are equivalent to measured vibration spectra in various transportation modes.)

Vertical Axis Excitation - 1.40 Grms overall from 10-300 Hz. Power Spectral Density .029 g2/Hz from 10-50 Hz with 8 dB/octave rolloff from 50-300 Hz.

Longitudinal and Lateral Axis Excitation - 0.68 Grms overall from 10-200 Hz. Power Spectral Density 0.007 g2/Hz from 10-50 Hz with 8 dB/octave rolloff from 50-200 Hz. (See Figure 6).

Test duration shall be one hour in each axis (3 hours total).

7.6 ELECTROMAGNETIC COMPATIBILITY

7.6.1 ESD

The printer will meet the requirements set forth in Centronics Engineering Standard 002 and be tested as per Centronics Engineering Standard 003.

7.6.2 EMI/RFI

As per Centronics Engineering Standard 002. Emission requirements will meet those specified for an international product (i.e., VDE 0871 and VDE 0875 along with the FCC requirements as stated in Docket #20780, Part 15, Subpart J.

8.0 SAFETY

The printer will meet the requirements as specified in Centronics Engineering Standard 011.

9.0 RELIABILITY PROVISIONS

9.1 DEFINITIONS

9.1.1 Failure

A failure is any stoppage or malfunction of the product mechanism or electronics specified herein which prohibits full use of the product as defined by the specifications and is directly caused by the mechanism or electronics.

This excludes stoppages or sub-standard performance caused by operator error, power failure, or environmental conditions exceeding specified limits. Failures are classified into two categories.

A. Critical Failure - A critical failure is defined as any failure which cannot be corrected by a trained operator and requires the services of a trained technical or field service representative for repair.

B. Inconvenient Failure - An inconvenient failure is any failure which can be readily corrected by an operator without requiring the services of a field representative. Ribbon jams, paper jams, etc., are examples of inconvenient failures.

9.1.2 Reliability

Reliability is defined as the probability of failure-free performance of the product through a time period at a specified operating environment and duty cycle.

9.1.3 Power-On Time

The period of time during which A.C. Power is applied to the product is defined as Power-On Time. Unless stated otherwise, all hours are expressed in terms of Power-On Time.

9.1.4 Operating Time

Operating Time is defined as that period of time which the product is moving paper or the print head carriage is in motion.

9.1.5 Duty Cycle

Duty Cycle is defined as the ratio of Operating Time to Power-On Time.

9.1.6 Operating Environment

The Operating Environment for reliability parameters for the printer shall be as follows, unless otherwise specified herein:

A. Nominal voltage - 115/230 VAC.
B. 50/60 Hertz.
C. Ambient room temperature of 70° ±5°F.
D. Ambient relative humidity of 50% ± 5%.

9.1.7 Mean-Time Between Failure (MTBF)

The MTBF shall be defined only during the product Useful Life and is calculated as follows:

$$MTBF = \frac{\text{Power-On Time}}{\text{Number of Critical Failures}}$$

9.1.8 Mean-Time to Repair (MTTR)

The MTTR is the average value of time required to perform on-site repair of the product by a properly trained and equipped service representative after it has failed. MTTR is calculated as follows:

$$MTTR = \frac{\text{Total Product Repair Time}}{\text{Number of Repair Actions}}$$

9.1.9 Infant Mortality period

Infant Mortality Period is defined as that time period of early product life when an initially high failure rate decreases to a specified Useful Life failure rate level.

9.1.10 Useful Life

The Useful Life of the product is defined as that period of time during the life of the product when the failure rate is maintained at a constant value due to random failures.

9.2 RELIABILITY PARAMETERS

All Reliability Parameters are based on the following:

A. A Duty Cycle of 25%.
B. The Operating Environment specified in Section 9.1.6.

9.2.1 Population MTBF

The Population MTBF shall exceed 1900 hours per failure (4400 hours excluding print head).

9.2.2 Reliability During Useful Life

The Reliability, R(t), at Time (t), for any time period during Useful Life shall be defined as being equal to EXP -(t/MTBF).

9.2.3 Infant Mortality Period

The Infant Mortality period shall be no longer than 100 hours.