NATIONAL RADIO ASTRONOMY OBSERVATORY
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WIRE LIST PROGRAM FOR INTEGRATED CIRCUIT-WIRE WRAP BOARDS

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I. INTRODUCTION

This report describes a 360/65 Computer program designed to reduce the work required to produce a wiring list for a printed circuit-integrated circuit-wire wrap card.

The program specifically applies to NRAO type D13520M1 (or CDP201) and D13520M2 (or CDP202) cards but could be adaptable to other configurations. In a later project and report this program will be modified to apply to the background wiring of the NRAO standard printed circuit chassis.

The system described here allows a logic designer to go directly from a logic diagram to the computer, via prepunched IBM cards or CRT terminal input, and obtain a wiring list for the wire wrap card as seen from the front (IC List) and another list as seen from the back of the card (Pin List). A deck of cards for use by a semi-automatic or automatic wire wrap concern is also produced. The pin list contains an input card listing, a from-to listing, a lenght of wire listing, a suggested color code and a sequentially running count. A deck of cards called "CRT Punched Output" can also be obtained for filing with the drafting department in case of loss of data in the computer.

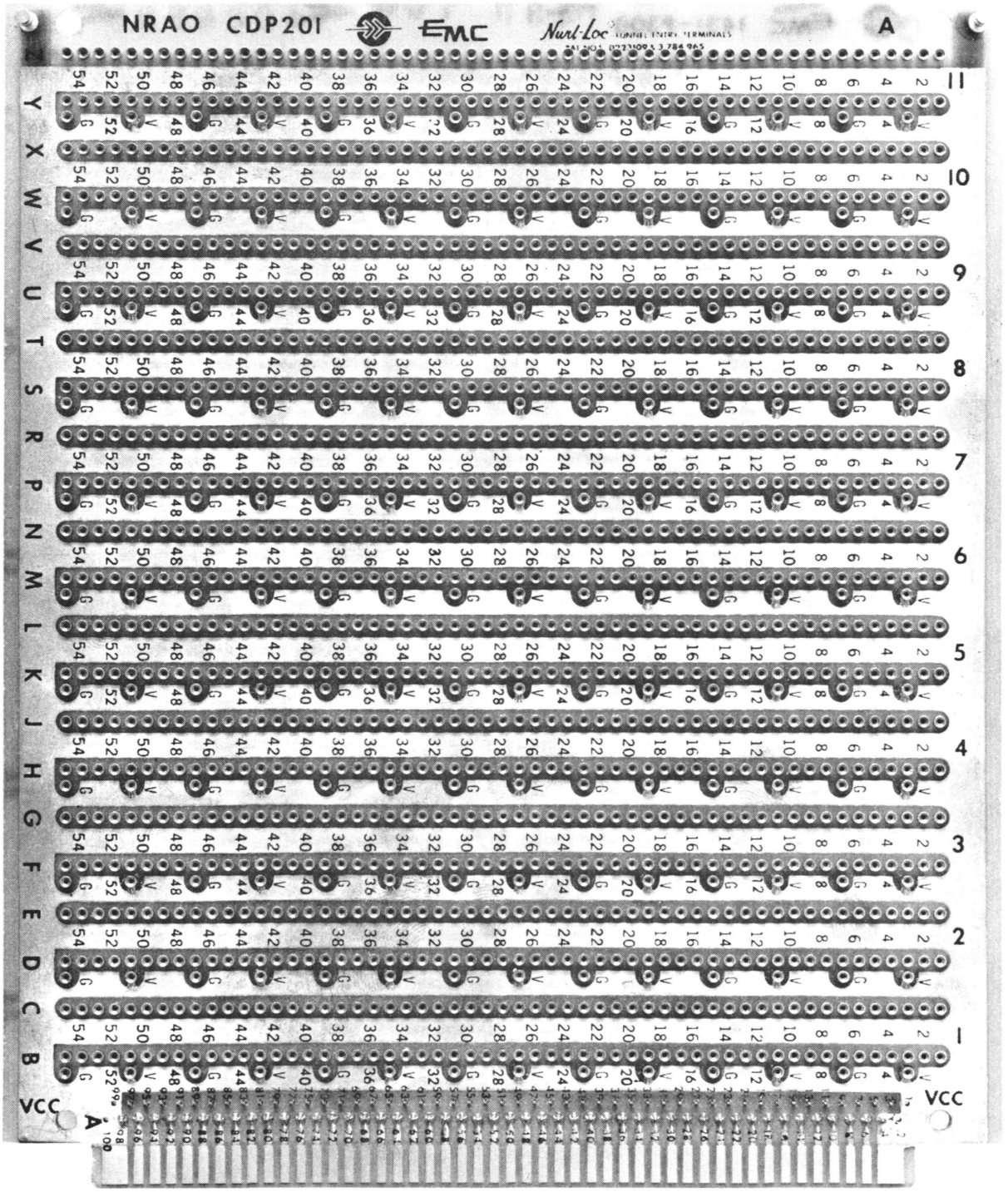
II. WIRE WRAP BOARD

Description

The two wire wrap boards are shown in Figures 1 & 2. They are identical except for the number of rows of pins. CDP 201 and D13520M1 will accept 77 each 14-pin IC's. CDP 202 and D13520M2 will accept 35 each 14-pin IC's.

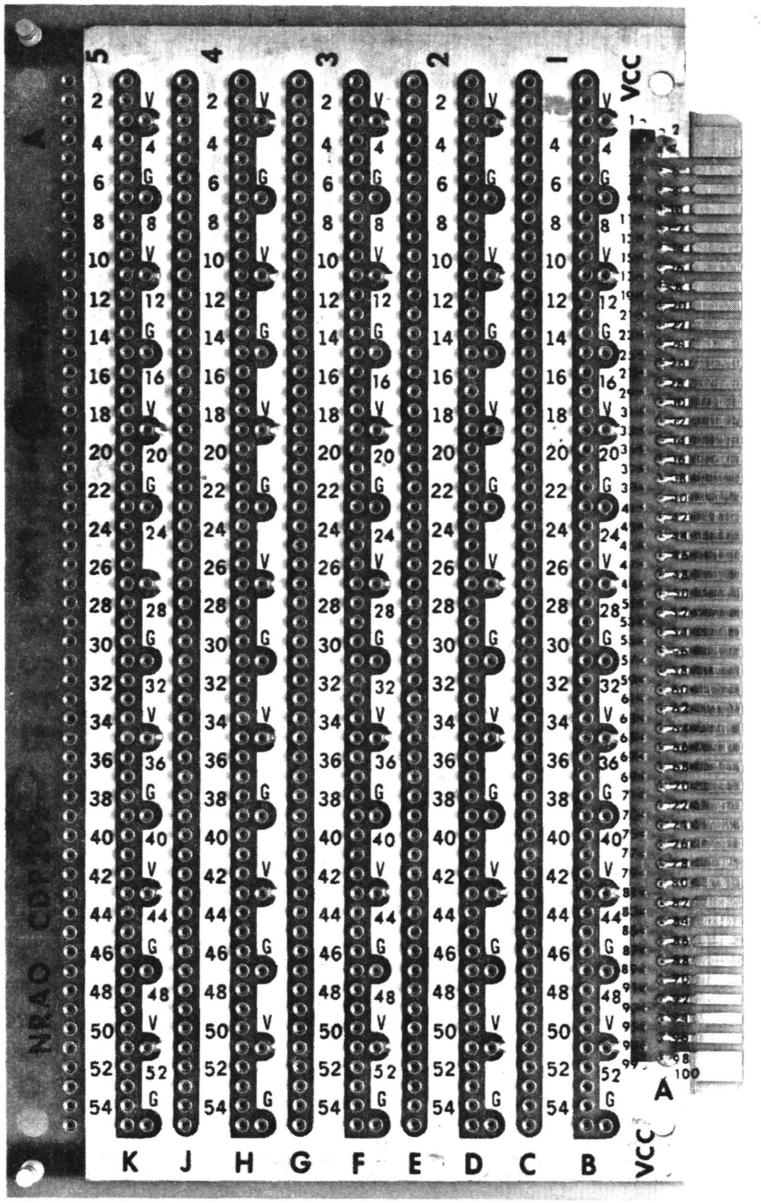
Features of these boards are as follows:

1. Input-output pins = 100 rhodium or heavy gold plated fingers.
2. Vcc plane on component side.
   Gnd plane on wire-wrap pin side.
3. CDP201 & D13520M1 - 22 rows of IC pins. 55 pins per row.
   7 Vcc & 7 Gnd pins per 2 rows of IC pins.
   CDP202 & D13520M2 - 10 rows of IC pins. 55 pins per row.
   7 Vcc & 7 Gnd pins per 2 rows of IC pins.
4. Two ground terminals per card for scope probes.



CDP201 or D13500M1

FIGURE 1



CDP202 or D13500M2

FIGURE 2

column: 6 pin - A to P
8 pin - A to M
14 pin - A to G
16 pin - A to F
18 pin - A to E
20 pin - A to E
24 pin - A to D
28 pin - A to C
40 pin - A to B

pin: 1 to number of pins on IC

Power Pins = row: based on 0.300" wide IC rows
1 to 11

column: A to G

pin: V or G

Examples: P12 would be input-output pin 12. 3C8 would be pin number 8 on an IC located on row 3 in column C. 4DV would be the Vcc pin on row 4 in column D.

Wiring Side Coordinate System:

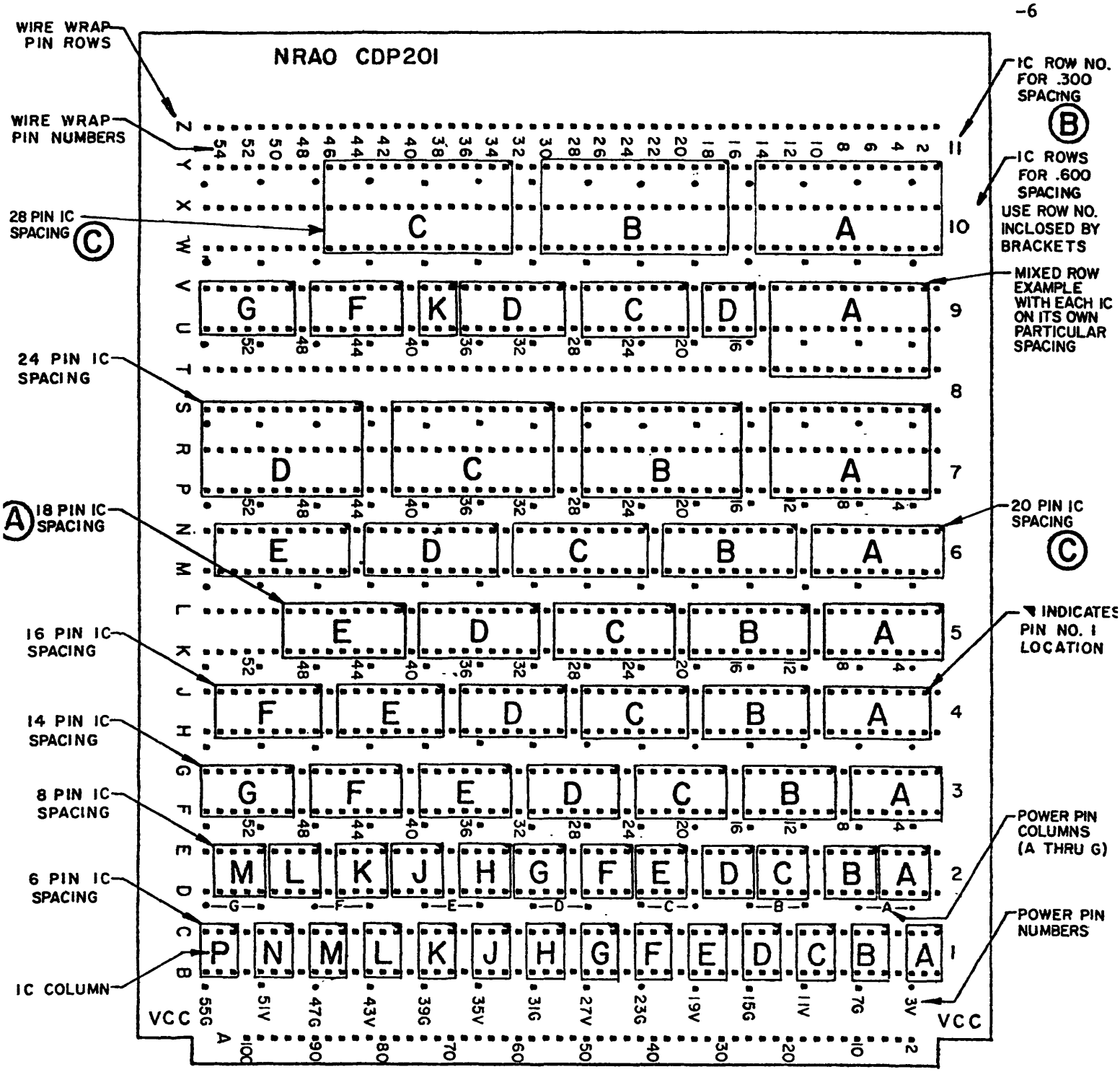
Row = A to Z

Column = 1 to 55 (pin number in row)

Row A is a one to one transformation with row P on the component side. For example:

P5 = A5

Table 1 is the power pin conversion chart stored in the program. This table shows which power pins for the various IC types that the computer wires the power pins of the IC to. Figures 3 & 4 illustrate the standard positions for each size IC. AN IC of a certain size must use the positions assigned to it except the special case of a 14 pin IC in a 16 pin position and a 6 pin IC in an 8 pin position as described on page . If an IC is not positioned as specified, the wiring must be taken care of manually.



NOTES:

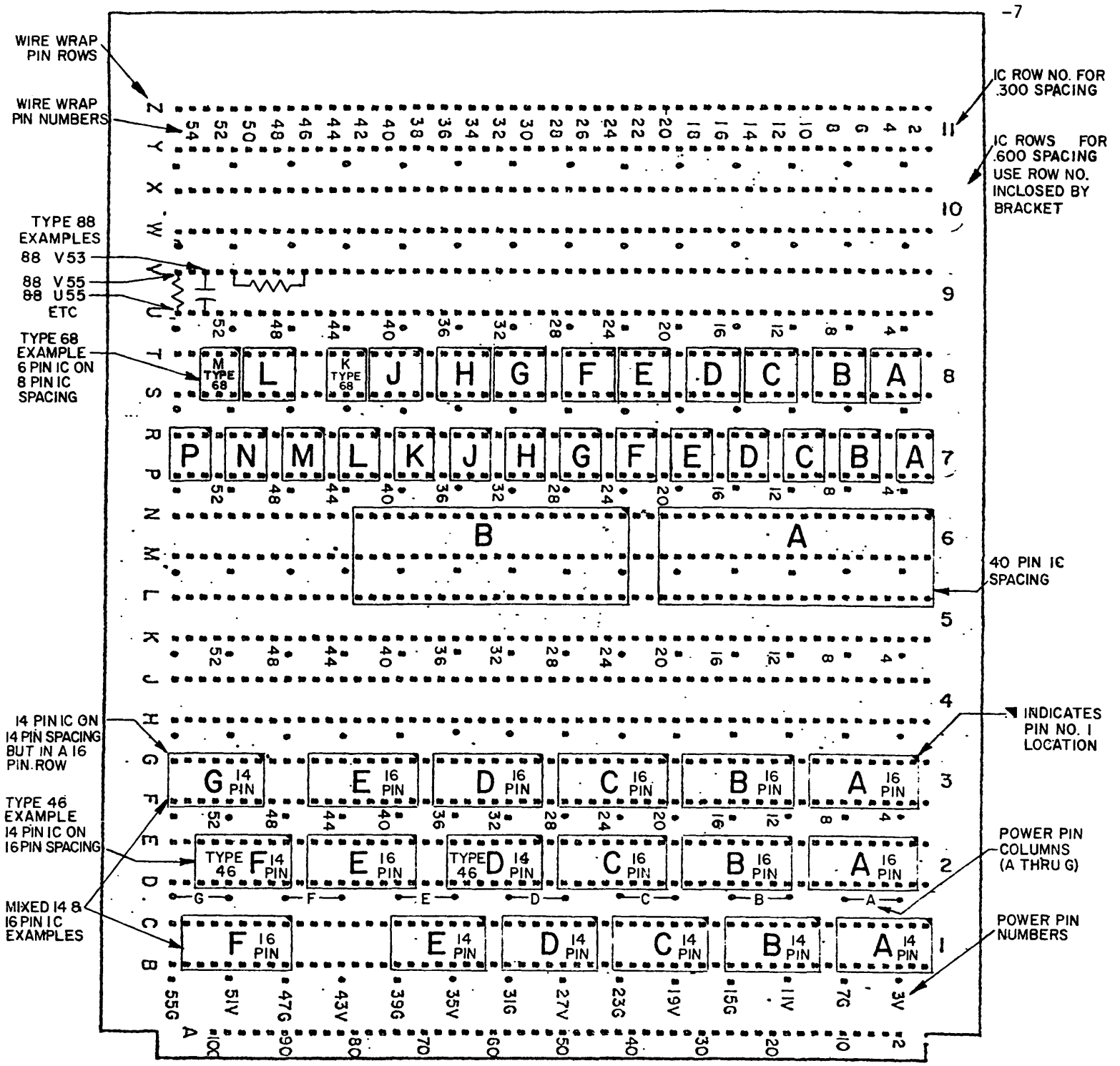
1. COMPONENT SIDE OF BOARD SHOWN
2. THE CDP202 BOARD HAS ONLY 5 IC ROWS AVAILABLE INSTEAD OF THE 11 IC ROWS SHOWN.
3. Vcc PLANE I/O CONNECTIONS: 2, 4, 98, 100
4. GND PLANE I/O CONNECTIONS: 1, 3, 27, 28*, 49, 50*, 73, 74*, 97, 99
5. 6 & 14 PIN ICs ARE ON SAME SPACING
6. 8 & 16 PIN ICs ARE ON SAME SPACING

* GND BUS CONNECTIONS ONLY.
NO P.C. CONNECTIONS ON W.W. BOARD

A	ADDED 9-25-73 JE
B	.300 WAS .030 .600 WAS .060 1-17-74 JE
C	ADDED 9-19-74 SSR
D	CHANGED .600 SPACING NOTATION 10-10-74 SSR

WIRE WRAP BOARD IC LAYOUT (SHEET 1 OF 2)

FIGURE 3



SEE NOTES ON SHEET 1 (FIGURE 3).

WIRE WRAP BOARD IC LAYOUT (SHEET 2 OF 2)

FIGURE 4

TABLE 1

NRAO

Wire Wrap Printed Circuit Board
Wire List Power Conversion Chart

November 9, 1972

Rev. A Added 18 Pin
Rev. B Added 20 & 28 Pin

6 PIN IC			8 PIN IC			14 PIN IC			16 PIN IC			24 PIN IC		
IC Column	Power Pin Column		IC Column	Power Pin Column		IC Column	Power Pin Column		IC Column	Power Pin Column		IC Column	Power Pin Column	
A	AV	AG	A	AV	AG	A	AV	AG	A	AV	AG	A	AV	AG
B	AV	AG	B	AV	AG	B	BV	BG	B	BV	BG	B	CV	CG
C	BV	BG	C	BV	BG	C	CV	CG	C	CV	CG	C	EV	EG
D	BV	BG	D	BV	BG	D	DV	DG	D	EV	EG	D	GV	GG
E	CV	CG	E	CV	CG	E	EV	EG	E	FV	FG			
F	CV	CG	F	DV	DG	F	FV	FG	F	GV	GG			
G	DV	DG	G	DV	DG	G	GV	GG						
H	DV	DG	H	EV	EG									
J	EV	EG	J	EV	EG									
K	EV	EG	K	FV	FG									
L	FV	FG	L	GV	GG									
M	FV	FG	M	GV	GG									
N	GV	GG												
P	GV	GG												

18 PIN IC			28 PIN IC		
IC Column	Power Pin Column		IC Column	Power Pin Column	
A	AV	AG	A	AV	AG
B	BV	BG	B	CV	CG
C	CV	CG	C	EV	EG
D	EV	EG			
E	FV	FG			

20 PIN IC		
IC Column	Power Pin Column	
A	AV	AG
B	CV	CG
C	DV	DG
D	EV	EG
E	GV	GG

Power Pin Column		V Pin Number	G Pin Number
A	=	3V	7G
B	=	11V	15G
C	=	19V	23G
D	=	27V	31G
E	=	35V	39G
F	=	43V	47G
G	=	51V	55G

0.60" IC Row Spacing	Power Pin Row Used
1	B
3	H
4	H
6	P
7	P
9	W
10	W

III. WIRING RULES

The program accomplishes several time consuming jobs for the logic designer but with some limitations. It arranges the order of wiring to accomplish two things:

1. Provide the shortest path.
2. Alternates levels in a wiring string to simplify repairs.

In ordinary low frequency layouts, the designer assembles cards or types the points in on a CRT terminal which represent wire wrap pins - which are to be wired to each other - together in any order. The program takes care of the rest of the work. If he questions whether a particular string assembled by the computer will be the best connections, he can obtain a coordinate graph of the connections by using a GRAPH instruction. If the designer wants a specific path followed he puts the cards together in the desired order and precedes the group with an EXACT instruction.

When the designer has a gate or F-F output operating at high speed, or with a heavy load on the output of a gate or F-F; he may wish to have 2 or 3 w.w. wires from that output to various loads. The designer may accomplish this by using a DRIVE instruction to designate the drive point and then use DS cards to group the load points into the specific groups that he has chosen. From the assembled cards the computer will then calculate the shortest wire path from the drive point to each of the designated load groups.

The following sections describe, in detail, the use of the program.

IV. WIREWRAP PROGRAM

A. General Description

The WIREWRAP Program is a system to aid in translating from an IC logic diagram to the actual wiring instructions for the wire wrap board. It is a three step procedure that involves organizing data and running two computer programs. The final output consists of: two pin listings, a cross reference IC LIST and a PIN LIST with the wiring instructions; card output for commercial wirewrapping; and CalComp plots of wiring paths.

If a CRT terminal is not used, the first step is to run the CARD program (see Sections C & D). The input to this program is punched cards which tell the program what type IC chip (how many pins), what IC row, and the number of cards per pin to produce. The output from this program ia a deck of cards representing the IC pin positions used on the wire wrap board.

The second step is to arrange these cards into sets that represent the groups of pins to be wired together. The groups are separated by cards which tell the WIREWRAP Program how to treat each group (see Sections C and D). This data deck is preceded by a set of cards which gives the program title page information about the wire wrap board being processed, and must precede each data deck that is run.

The third step is to put the data deck into the WIREWRAP Program and run it (see Section D). The program will take the groups of pins and translate them into the wire wrap board notation. Then it will choose a wiring path in one of three ways is instructed by the user: it will select the shortest single path connecting all the pins; or it will connect all the pins to a certain drive pin by selecting the optimum configuration of three wires from the driver with the shortest lengths; or it will take certain defined sub-groups of the pins, find the shortest wiring path in each of these groups, and connect them to a specified drive pin; or it will produce wiring instructions for the pins in the same order that they are read in. The program will produce CalComp plots of the wiring paths it chooses, if specified; it will print the wiring instructions in the PIN LIST with the length of each connection and color code of the wiring path; it will punch the connections on cards, if specified; and it will print an IC LIST, a cross reference listing of the connections in the IC chip notation, if specified.

B. Data Organization - For Inputing Data with Cards

1. General Information

The cards used by the WIREWRAP Program are divided into three input data fields (see Figure 5b) which are used exclusively throughout the program (except for board data following a DD card). The first two columns are the Type Field, it defines the type of IC pin in the data field (i.e. the number of pins on the type of IC chip) or it defines an action to be taken by the program (ST, DR, DS, DD). Card columns five through ten are the Data Field, this field is used to input the IC pin position to the program. Card columns fifteen to nineteen are the Instruction Field, this field is used to input additional instructions to the program and is used only on the ST card.

2. IC Data

At present the WIREWRAP Program can handle six, eight, fourteen, sixteen, eighteen, twenty, twenty-four, twenty-eight and forty pin IC chips, and this number is read into the program from the type field. The Data Field is broken into three sub-groups, the IC row, position and pin. These positions are derived from the IC coordinate systems for the wire wrap board described in the first part of this report.

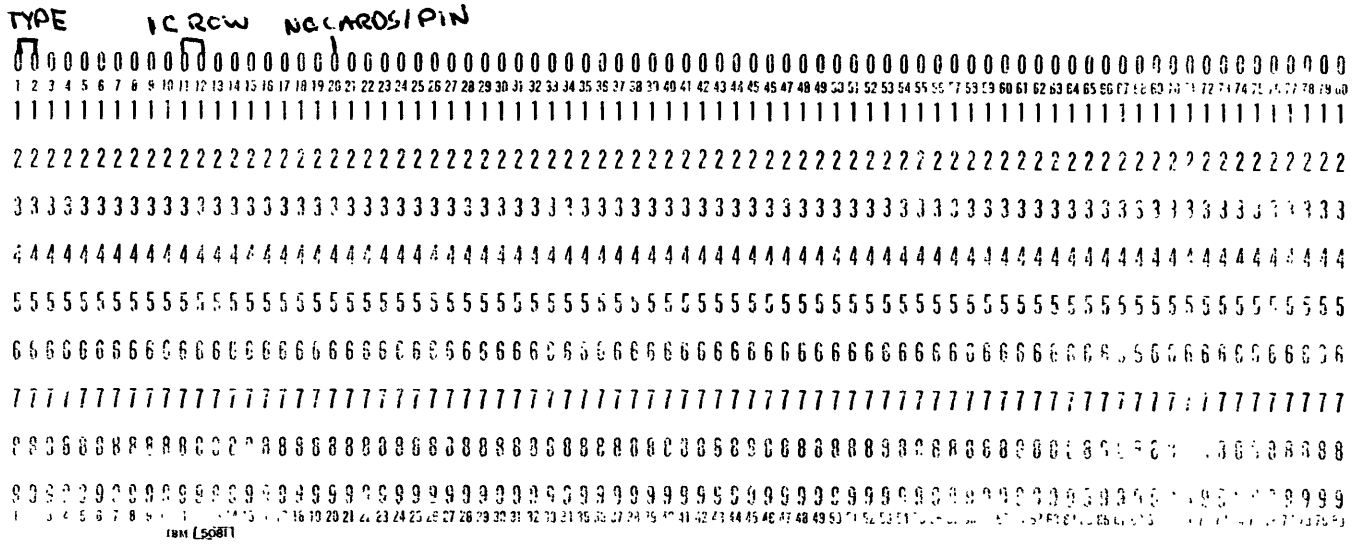


FIGURE 5a

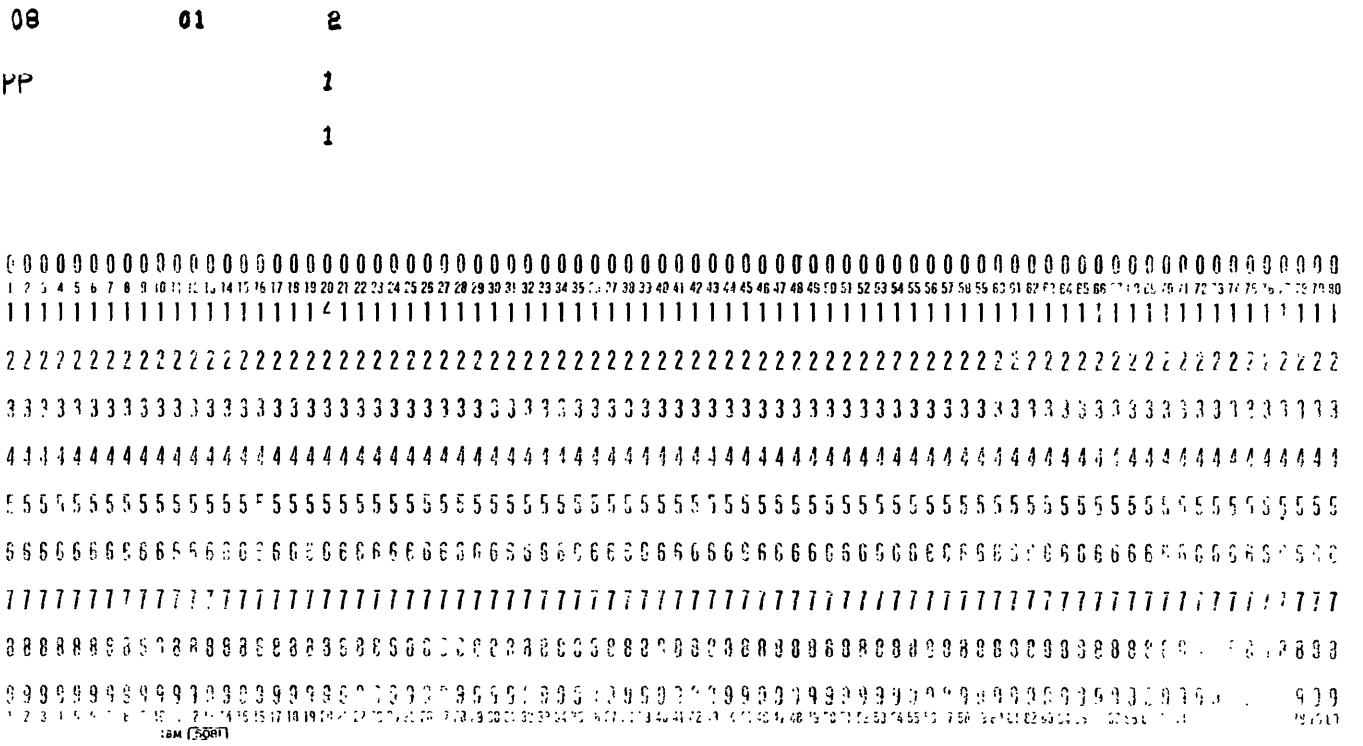


FIGURE 5b

Although different IC chips may be mixed on any row, care must be taken to preserve the individual coordinate systems of the chips used; i.e. a row that starts with two fourteen pin chips cannot have a sixteen pin chip immediately following the second fourteen pin chip, but must follow in the next sixteen pin IC location, with four empty pins in between (see Figure 3&4). There are two exceptions to this rule; six and fourteen pin chips may be inserted into eight and sixteen pin chip positions when type is specified as 68 and 46 (see Figures 3&4), respectively. They must be right justified and the original coordinate system must be preserved by leaving an extra empty pin. See Figure 7 for IBM card format.

An 88 in the type field indicates that the data is being entered in the backplane notation and will not be converted. This type of data is useful when discrete components such as resistors, transistors, etc. are to be intermixed with IC components. In using type 88 data, the row letter goes in the data IC row (as defined in Figure 6) position and the pin number goes into the data IC pos position the data IC pin position remains blank.

Power pins (Voltage and Ground) are denoted by a PP in the type field and a corresponding V or G in the IC pin field. Power pins are referenced in the fourteen pin coordinate system. Connector pins are denoted by a blank type field and IC row field, a P is in the IC position field with the corresponding connector pin listed in the IC pin field. Since the IC pin field has only two characters P100 is listed as P00.

3. ST, DR, DS, DD - ACTION and INPUT FORMAT

ST in the type field is the general delimiter for the WIREWRAP Program, it separated and initiates processing for each group of pins; adding instructions to the ST card, or adding DR and DS cards into the data cards that follow tells the program how to process each set of pins. A ST card with EXACT in the instruction field (Figure 7) tells the program to produce wiring instructions for the pins in the same order that they appear in the input stream. A ST card with blanks or GRAPH in the instruction field initiates one of the program's wiring routines (see Section D for explanations of the wiring procedures mentioned here). A ST card with VCC or GND in the instruction field will start a wiring routine that will read the next group of pins and connect each pin to the nearest VCC or GND pin according to its

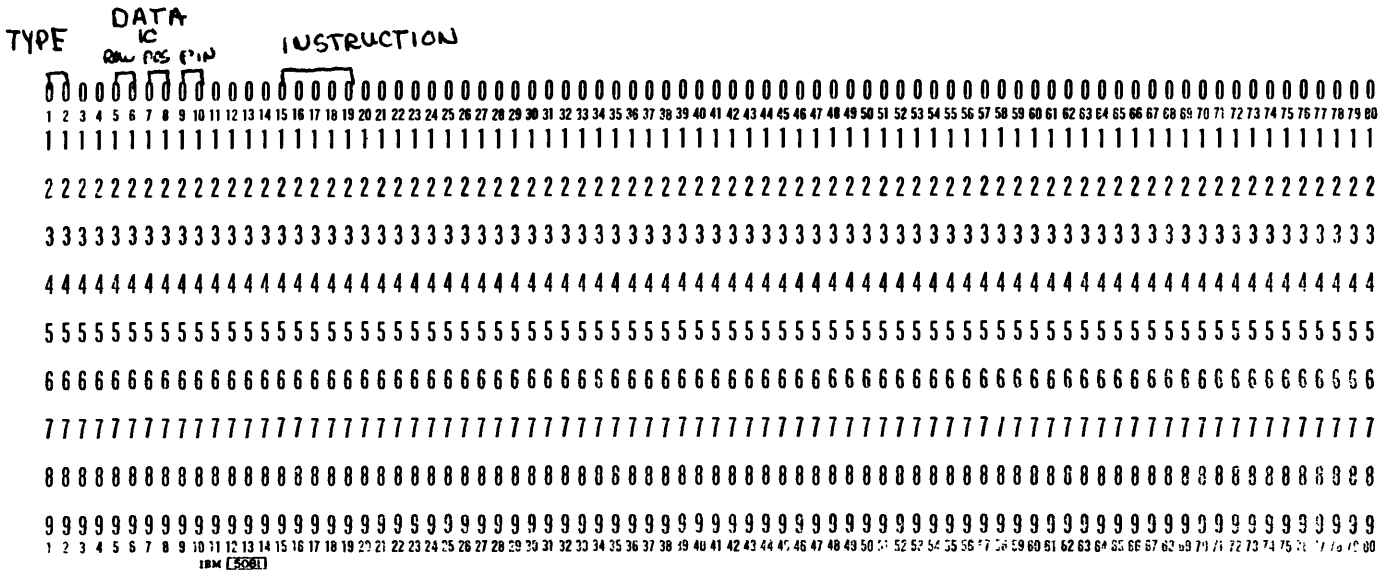


FIGURE 6

```
68  10 J 5

46  01 B 8
```

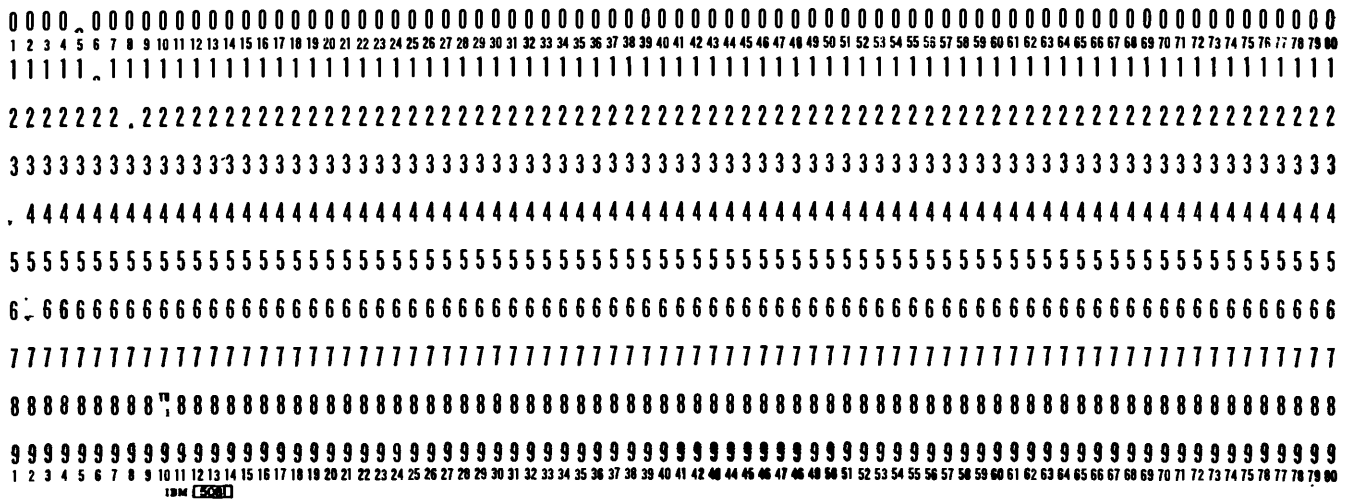


FIGURE 7

```
14  01 B 6
14  01 A11
14  01 D 5
ST              EXACT
```

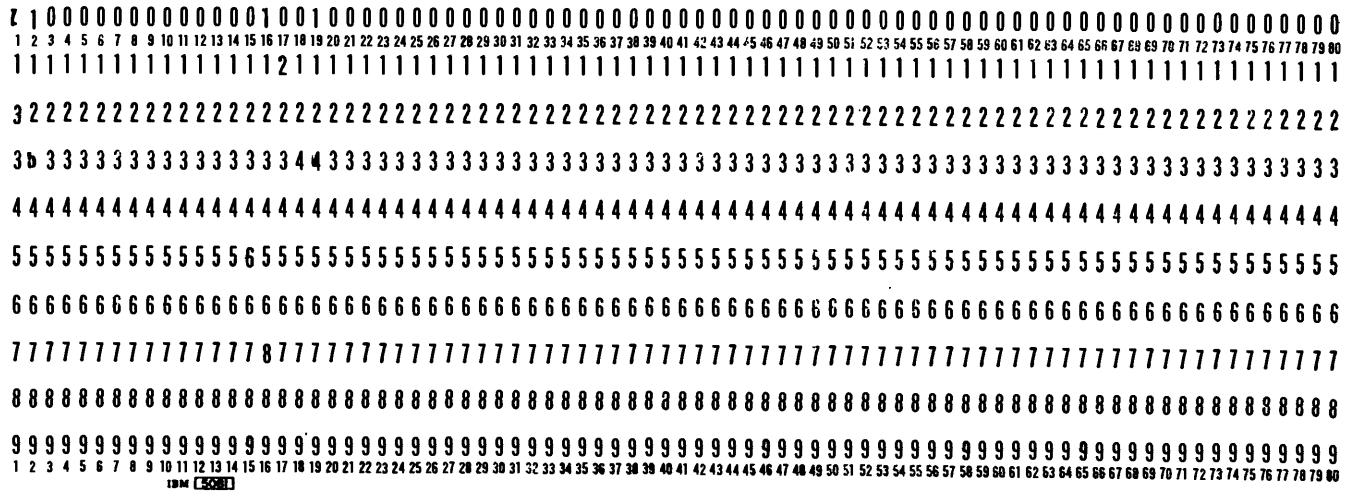


FIGURE 8

IC type. Table 1 is used in the program and indicates which power pins the input data will be connected to.

The ORDER procedure, which finds the shortest, unbroken wiring path connecting the pins, is called when there are no DR or DS cards indicating special pins or subgroups within the data deck following the ST card (Figure 9). The DRIVER procedure, which connects the pins to a certain drive pin, is called by indicating the drive pin with a DR card immediately preceding it (Figure 10), and may appear anywhere in that particular group of pins. The SDRIVE procedure, which finds the shortest wiring path of certain subgroups of pins and connects them to a drive pin, is called when a DR card followed by a drive pin immediately follows the ST card (Figure 11); the first subgroup of pins immediately follows the drive pin, the second subgroup of pins is indicated by a DS card immediately preceding it, and a third subgroup may be added in the same way. A CalComp plot of all the wiring paths chosen by the program will be produced when GRAPH appears in the instruction field of the ST card.

DD in the type tells the program the board data and program options follow. This data must be entered in a certain order and format. In Figure 12: TITLE and BDATE refer to the board title and data; VERSION is used to indicate changes and revisions made and the date when they were made; DES is a fifty character job description which is printed in two 25 character lines on the title page of IC LIST and PIN LIST. Two program options must be specified: PINLIST with PINCH or NOPUNCH options will tell the computer whether or not to punch the wiring instructions; WIRELIST with PRINT or NOPRINT options will tell the program whether or not to print an IC LIST. Figure 13 can be used as a guide for keypunching the above mentioned cards.

A DD group must precede each board that is run.

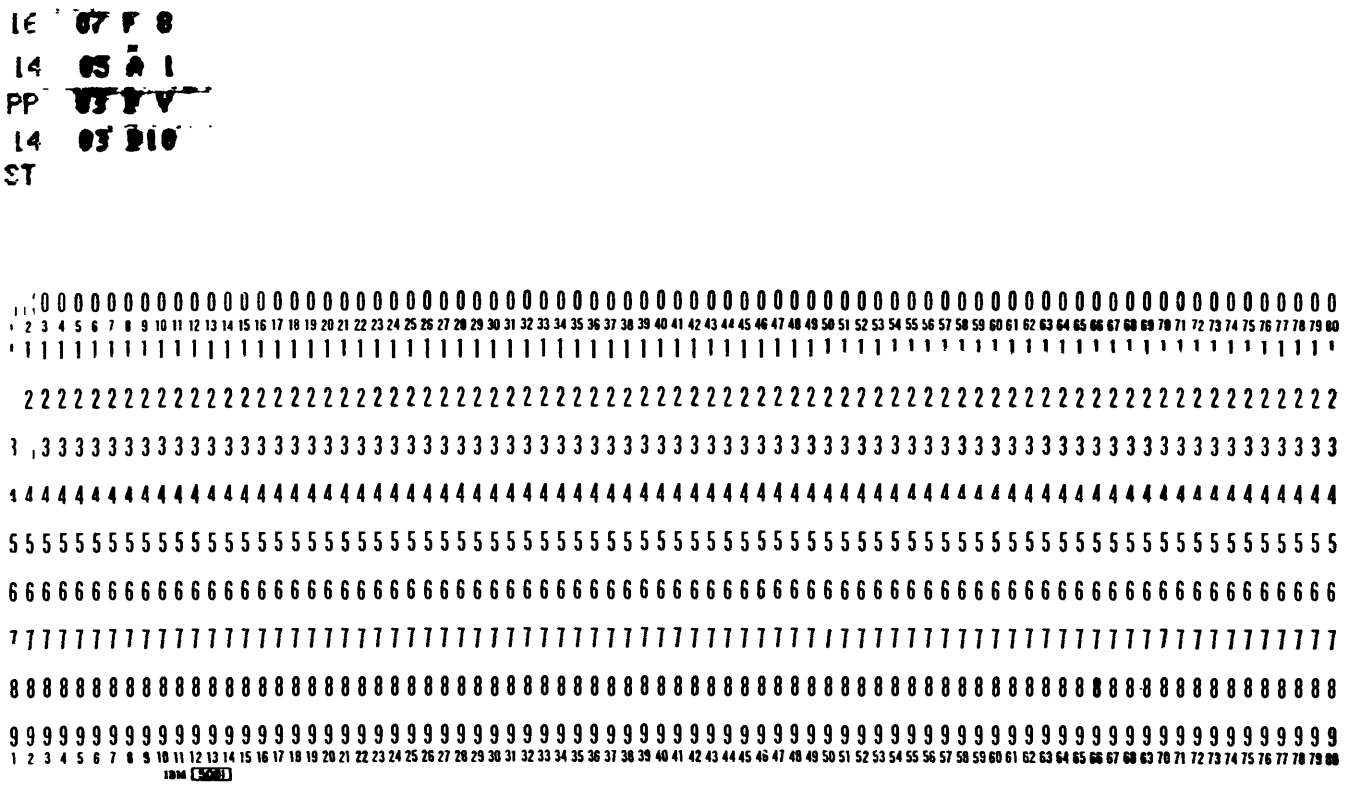


FIGURE 9

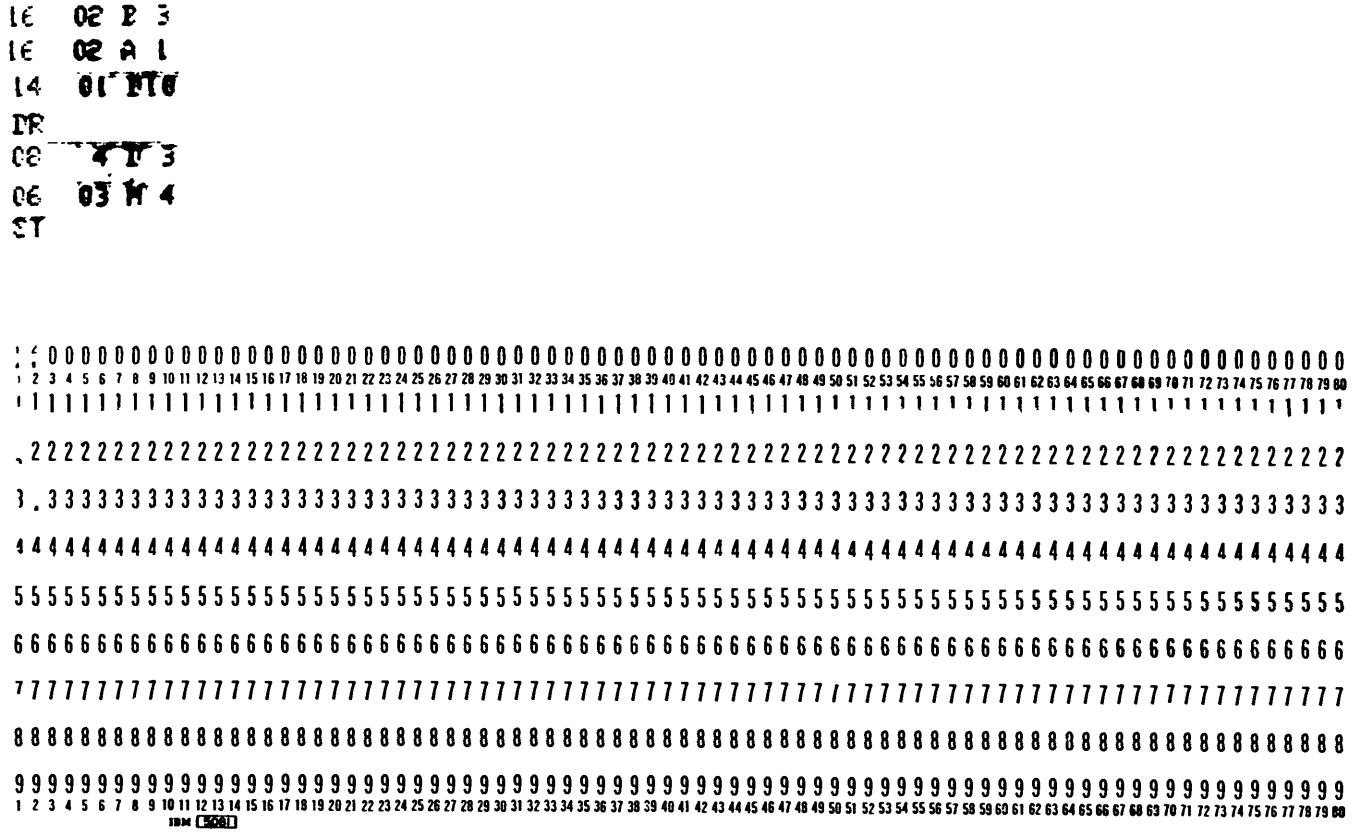


FIGURE 10

```
14   02 A12
14   01 C 2
DS
14   02 G 1
14   02 F 2
DS
14   02 E 3
14   01 G 4
14   01 F 5
DR
ST
```

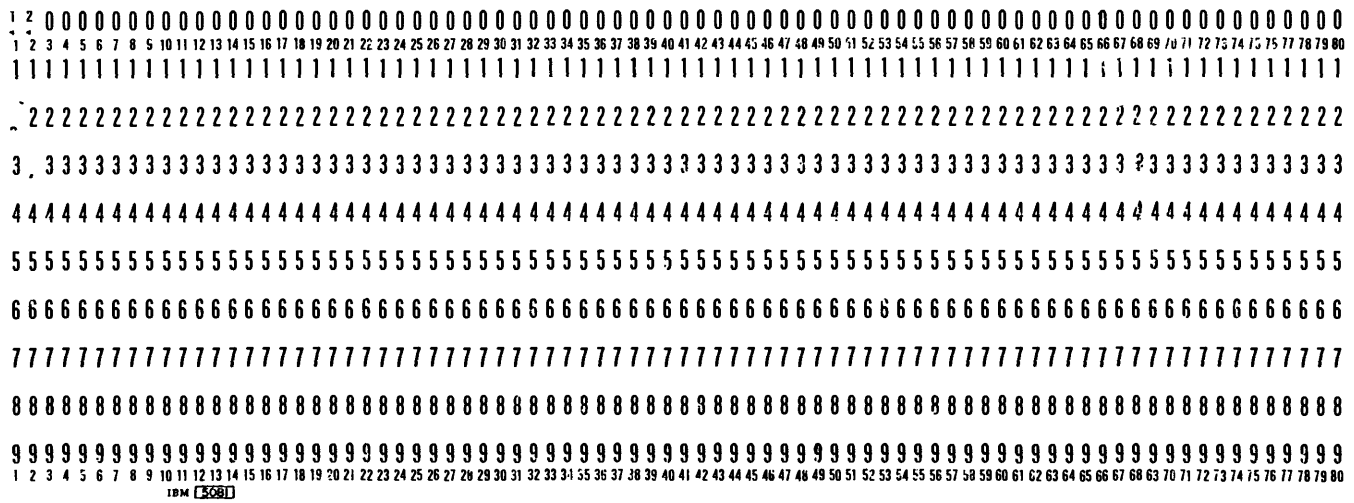


FIGURE 11

```
 WIRELIST='PRINT';
 PINLIST='PUNCH';
 DWG='WIRELIST '    REV'AB';
 PROJECT="PROJ. NO.';
 DES='  THIS SPACE IS FOR    BOARD DESCRIPTION';
 VERSION='01-720812';
 TITLE='XXX-0000-000'  BDATE='720812';
DD
```

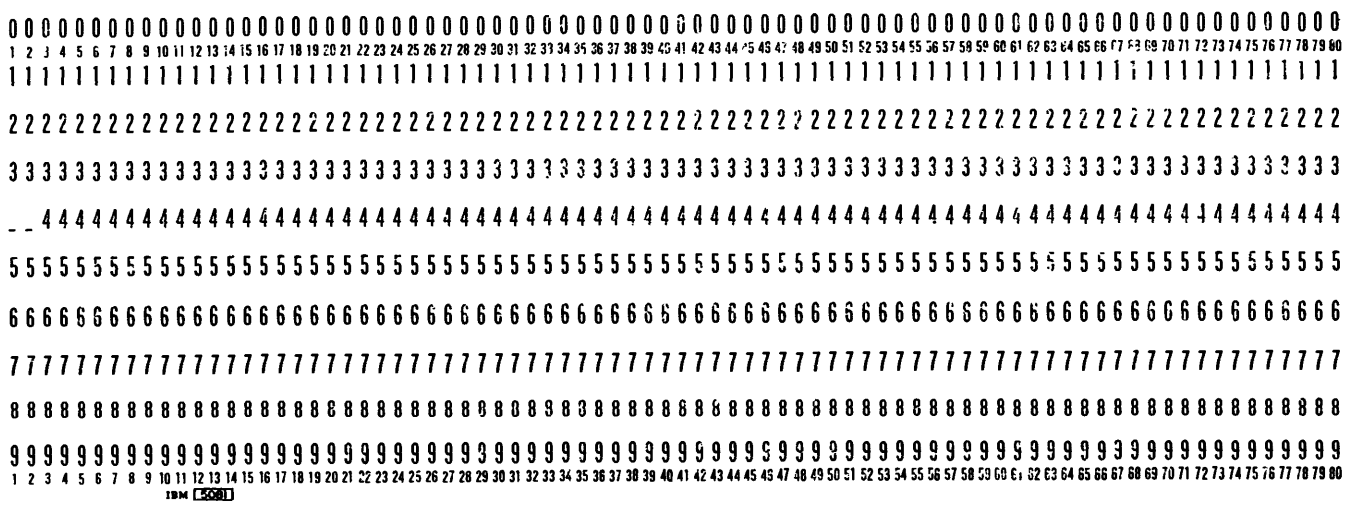


FIGURE 12

TITLE PAGE INFORMATION FOR WIRE WRAP PROGRAM

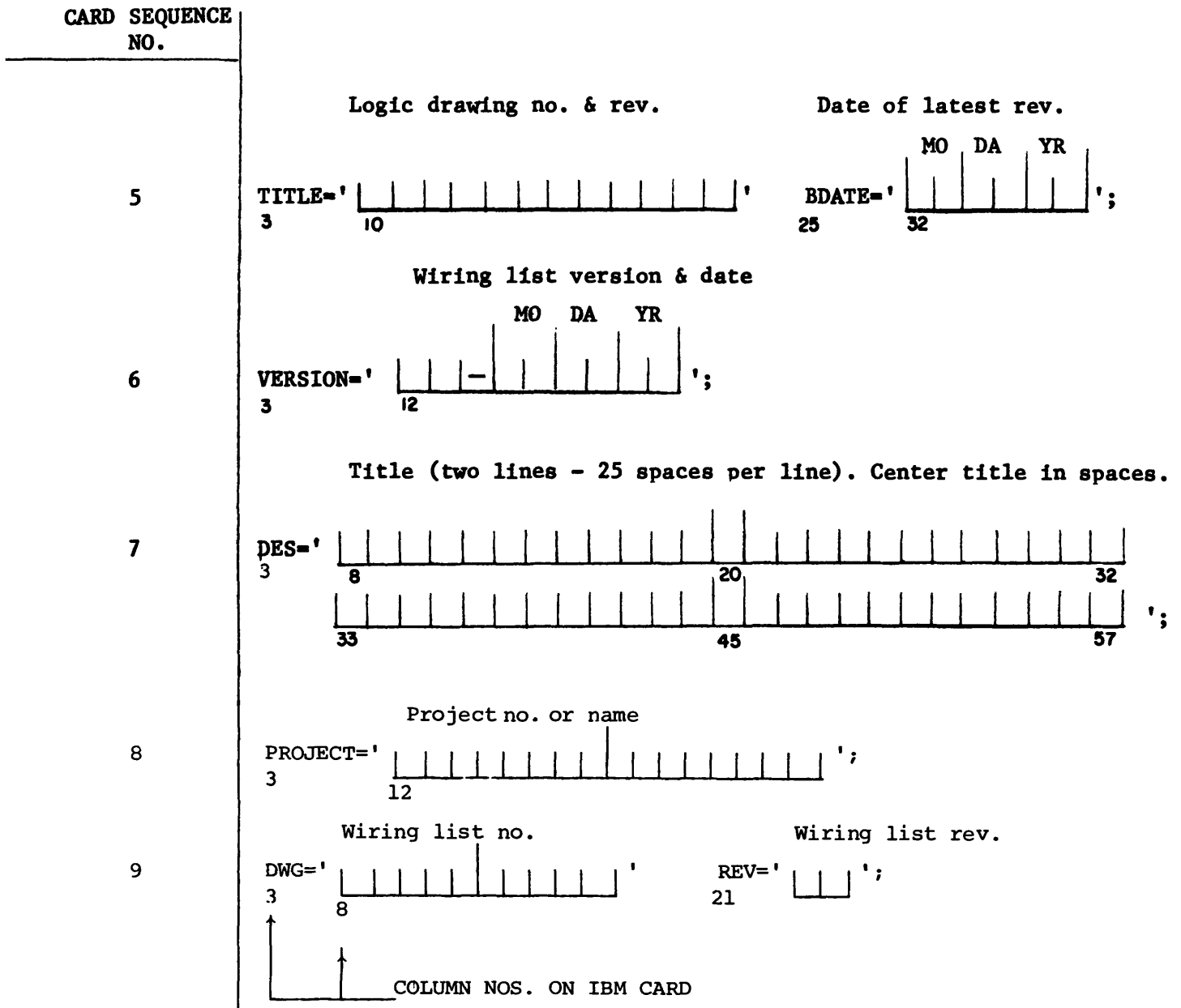


FIGURE 13

C. CARD Program

The CARD program produces the data cards used by the WIREWRAP Program. The input cards to this program have three fields (Figure 5b). Card columns one and two are the type field, this tells the program what type IC coordinate system to use (i.e. what IC chip, see the first part of the report for an explanation of the IC coordinate systems). Card columns eleven and twelve specify what IC row to punch; and card column twenty specifies how many cards to punch for each IC pin. The program will then punch cards for all the pins for the IC row in the coordinate system specified.

Figure 5b shows the input format for connector pins and power pins. Connector pins are specified by a blank type field and IC row field. Power pins are specified by PP in the type field and an IC row field; this will punch cards for all the power pins on the row, in the fourteen pin coordinate system.

D. CRT Input

1. General Information

As an alternative to organizing punched cards produced by the CARD program, the data can be entered and edited on a CRT, then stored on disk for use by the Wirewrap program. The CRT is controlled by a general purpose editing program called PANDORA. This program is written and maintained by the Computer Division, and a brief write up on the commands used by PANDORA is included as an appendix to this report. Also see Appendix B for general instructions for entering Wirewrap Data through CRT terminal. The data is entered on the CRT in a format described below, then, by running a separate program called CONVERT, it is converted to card images in the in the format described in Section B and fed directly to the WIREWRAP Program.

The data is stored on disk in a partitioned data set (PDS) under the catalogued name ELECTR.WIREWRAP.PANDORA. A partitioned data set is composed of a number of small data sets called members, and is referenced by a name of up to eight characters. All data entered through the CRT is given a name and becomes a member in the partitioned data set. PANDORA was written to edit partitioned data sets; and all members can be accessed then edited, updated, deleted, or submitted directly into the job stream of the 360. The general procedure is for a user to enter his data under a

name particular to his project; then to submit it, and other members that contain the JCL needed to run the CONVERT program and then the WIREWRAP program.

2. CRT DATA Format

A different data format is used with the CRT so as to make the most efficient use of the CRT as an input medium. Data sets accessed by PANDORA are made up of card images, 80 columns long, with columns 73 to 80 used for sequence numbers; these card images will be referred to as lines. In general, there is no format. All data items (i.e. IC types, pin positions, instructions) must be separated by at least one space; but there are no restrictions on where or how many can be entered on a line, only that a data word cannot be continued from one line to another.

The first three lines of the member are input data for the CONVERT program. Line one is INPUT DISP PUNCH (or NOPUNCH); this specifies to the program whether or not to punch the card images that are fed to the WIREWRAP program. The type of IC used on each row can be defined before the data is actually entered. Line 2 must have DEFINE ROW TYPE; and line 3 must have 11 numbers representing the type of IC used on each row. The CONVERT program will, simply by checking which row the IC is on, automatically assign the proper type to the pin. In the case of mixing IC types on a row, the row type can be overridden by entering the proper IC type followed by a space immediately preceding the pin data.

The next 6 lines (4 to 11) must contain DD and the title page information just as it would appear on cards (Figure 12). The data is now entered in free format; remembering that spaces are used exclusively to separate data words; the data words described in Section B are replaced as shown in Figure 6.

3. Operation of the CRT

The conventions for using the CRT in general, and PANDORA in particular are described here; a description of PANDORA's functions appears in Appendix C. All finished messages are transmitted to the computer by actuation of the CTRL key and D key simultaneously or the EOT key. The user may type a meassage, backspace, retype, etc. but nothing is transmitted until

EOT is typed. Once a message has been transmitted it is important NOT to type anything until the computer sends back a ready signal (i.e. a "ready" light flashes, or cursor jumps to next line). Failure to observe this rule could cause PANDORA to fail and the last message transmitted to be lost.

4. PDS Members

A number of members that exist on the partitioned data set, are the actual source programs, and the job control language needed to run these programs. Other members are called utilities, used for maintaining the PDS. The utilities are PRINT, PUNCH.

PRINT and PUNCH are utilities that will print or punch members that immediately follow them (see Figure 16). It is suggested that once a user enters a data member into the PDS, runs it and plans no further changes, that he punch out the member, then scratch it from the PDS to conserve space.

CONVERT and WIREWRAP are the members that contain the actual job control language to run both the CONVERT and WIREWRAP programs. The job is submitted as shown in Figure 14a and 14b.

5. CRT Output

It is possible to submit WIREWRAP from a CRT terminal and to receive the output of the program at that terminal. This option can be used for preliminary runs of a set of data to screen for errors. The output from WIREWRAP is stored in certain members of the PDS. The output from the CONVERT step of the program is stored in one of six members called OUTCON1 to OUTCON6, similarly the PINLIST output from WIREWRAP is stored in one of six members called OUTPIN1 to OUTPIN6, and the members for storing the ICLIST output are called OUTIC1 to OUTIC6. The WIREWRAP program with CRT terminal output is submitted by using the members CRTCON and CRTWRAP1 to CRTWRAP6 (to get output members 1 to 6) as shown in Figure 14c. Care should be taken when using the CRT output option that the output members chosen are not the same as the members used by another WIREWRAP job; since subsequent running of WIREWRAP using the same output members will wipe out the output of any previous job and display the output of the latest run. Contact Gene Runion for assignment of output members.

To submit WIREWRAP Program

a) When data is stored in member labeled XXXXXXXX

```
SUBMIT CONVERT,XXXXXXXX,WIREWRAP
```

b) When data is in workspace

```
SUBMIT CONVERT,*,WIREWRAP
```

c) and get output stored in output members in PDS

```
SUBMIT CRTCON3,XXXXXXXX,CRTWRAP3
```

(output will be stored in OUTCON3, OUTPIN3, and OUTIC3)

FIGURE 14

TABLE 2

Display = Indicates display visible on CRT screen

CTL D = Indicates two key board keys that are to be pushed simultaneously

Upper case words are words that are displayed on CRT screen and/or typed in on keyboard.

NOTE: After typing CRT D, wait until Ready signal before resuming typing.

A. To Obtain Example:

1. Display: LOGON PLEASE
2. TYPE: WIREWRAP
3. CTL D
4. Display: a. WORKSPACE NOT CLEAR b. WORKSPACE CLEAR
   a. Type: CLR
      CTL D
      Type: GET EXAMPLE
      CTL D
   b. Type: GET EXAMPLE
      CTL D
5. Display: MEMBER NOW IN WORKSPACE
6. Type: L 1
7. CTL D
8. See example now displayed on CRT screen.

B. To Enter New Data:

1. Type: CLR
2. CTL D
3. Display: WORKSPACE CLEAR
4. Type: ENTER XXXXXXXX (XXXXXXXX is drawing number, first character must be a letter, max. of 8 characters)
5. CTL D
6. Display: 1. (User prompted with line 1, is ready to input the first line of 11 lines of instructions. Each line is to followed by CTL D.)

6. (cont.)

Type on line:

1. INPUT DISP PUNCH or NOPUNCH (Tells program whether or not to punch input data cards)
2. DEFINE ROW TYPE (This and line 3 define the type of IC package i.e. number of pins, used for each row.)
3. XX XX XX XX XX XX XX XX XX XX XX (eleven sets of two digit numbers, program has provisions for mixed types in a row but each row must still be defined initially, all eleven rows must be defined even if all are not used)
4. DD
5. TITLE='XXXXXXXXXXXX' (logic drawing no. and rev., 12 characters max)

   BDATE='XXXXXX'; (date of latest rev., 6 characters max)
6. VERSION='XXXXXXXXX'; (wiring list version and date, 9 characters max)
7. DES='XXX ··· XXX'; (board title or circuit description, 50 characters max)
8. PROJECT='XX-XX'; (16 characters max. for project no. or name)
9. DWG='XXXXXXXXXX' REV='XX'; (for wiring list no. and wiring list rev.)
10. PINLIST='NOPUNCH'; or 'PUNCH'; (Tells program whether or not to punch a set of cards for automatic wirewrapping)
11. WIRELIST='PRINT'; or 'NOPRINT'; (Tells program whether or not to print IC list)

7. Enter data (see example or write up). Each line is to be followed by CTL D
8. After completing the last line of data, hit ESC (escape) key.
9. CTL D
10. Type: SAVE
11. CTL D
12. Type: SUBMIT CONVERT,XXXXXXXX,WIREWRAP
13. CTL D (lines 12 and 13 submit the data to the computer, XXXXXXXX is the drawing number (members name) under which the data was entered.)

Correspondence between Card and CRT data format:

CARD INPUT		CRT INPUT
ST		→ S
ST	EXACT	→ SE
ST	GRAPH	→ SG
DD		→ DD
DR		→ DR
DS		→ DS
14 1 D5		→ 1D5 (if Row 1 is defined type 14)
		→ 14 1D5 (if not)

FIGURE 15

To submit a member to be printed or punched

```
SUBMIT      PRINT,(MEMBER'S NAME)
SUBMIT      PUNCH,(MEMBER'S NAME)
```

FIGURE 16

To submit CONVERT and WIREWRAP Programs

```
SUBMIT      CONVERT,(MEMBER'S NAME),WIREWRAP
```

FIGURE 17

E. WIREWRAP Program

The WIREWRAP program is broken up into eleven subprograms or procedures. The main procedure is called WIREWRAP, it is the controlling section of the program and it calls the other procedures. The WIREWRAP procedure reads in one set of connections and how it is to be processed. The data is then processed by calling the various procedures that it needs and printed out and a new set of connections is read in, and soon. The program is terminated when the last set of connections is read in and an end of file condition is raised.

The STPRINT procedure sets up the program for each board to be processed. It is called whenever a DD card is read in (for an explanation of the types of cards mentioned here, see Section C); it reads in the board data and program options, resets the counters, and prints the title page for PINLIST. The PRINT procedure is called after each set of connections is processed. It produces the wiring instructions from the ordered set of pins that is sent to it. It converts distances from board units to inches, chooses a color for the wiring path (BR, O, Y, GR, B, V, PR, G, W), alternates wiring levels on the board, it prints the PIN LIST, and will punch the connections if specified.

The CONVERT procedure converts the input pin listing from IC notation to board notation (see the first part of this report for an explanation of the different notations used). The CONVERT procedure is called while the data is being read in; each pin is converted and stored, then the converted set of pins is processed when the next ST card is read in. The DISTANCE procedure calculates and stores the pythagorean distance, in board units, between two pins that are sent to it. The POWERPIN procedure converts the input pin listing from IC notation to board notation and connects each pin to the nearest power pin. A VCC or GND in the instruction field indicates whether the power pin will be voltage or ground, and the program chooses the nearest power pin according to tables which are stored in the program.

The ORDER procedure chooses the shortest unbroken chain wiring path for a set of pins that is sent to it. The method is to choose a starting pin, then pick out the closest pin to it, then it picks out the closest remaining pin to that one, and so on. When it has chosen a wiring path in this way it picks another starting pin and chooses another wiring path. After cycling through all possible starting pins, it selects the shortest wiring path and returns it to the main procedure.

The DRIVER procedure is not available in this version of the program.

The SDRIVE procedure will take tow or three defined subgroups of pins and connect them to a specified drive pin. (The input format for this procedure is explained in Section C.) The procedure then sends each of the subgroups to the ORDER procedure to choose the shortest wiring path; and then they are connected to the drive pin by choosing the shortest distance between each subgroup and the drive pin. This procedure is essentially the same as the DRIVER procedure, except that the person who is running the program must choose the subgroups instead of letting the program do it.

The GRAPHIT procedure will take an ordered set of pins produced by one of the wiring procedures mentioned above and prodcue CalComp plots of the wiring paths. Whenever GRAPH is specified in the instruction field of a ST card, the ordered pin list will be sent to the GRAPHIT procedure after exiting from the PRINT procedure. The GRAPHIT procedure will first plot out an array representing all the pins on the WIREWRAP board, and then it will "connect the dots" to illustrate the wiring path choosen.

The WIRELIST procedure prints the IC List, when specified. It is a cross-reference list of all the pins used on the board, in IC ROW-POS-PIN order. After each pin, all pins it connected FROM, and all pins it is connected TO are listed; FROM being all pins below and to the right, and TO being all pins above and to the left with respect to the pin in question. Since the WIRELIST procedure operates on all pins on a particular board, and the WIREWRAP program only operates on one wiring path at a time, when the IC List is specified all the wiring paths are stored on disk, and the WIRELIST procedure starts as a separate job step after the WIREWRAP program is finished. This means that for a complete cross reference listing all the

pins for a board must be processed in one run of the WIREWRAP program and cannot be added during later runs; although more than one board may be cross-referenced during any one run of the WIREWRAP program.

CARD MNEMONICS

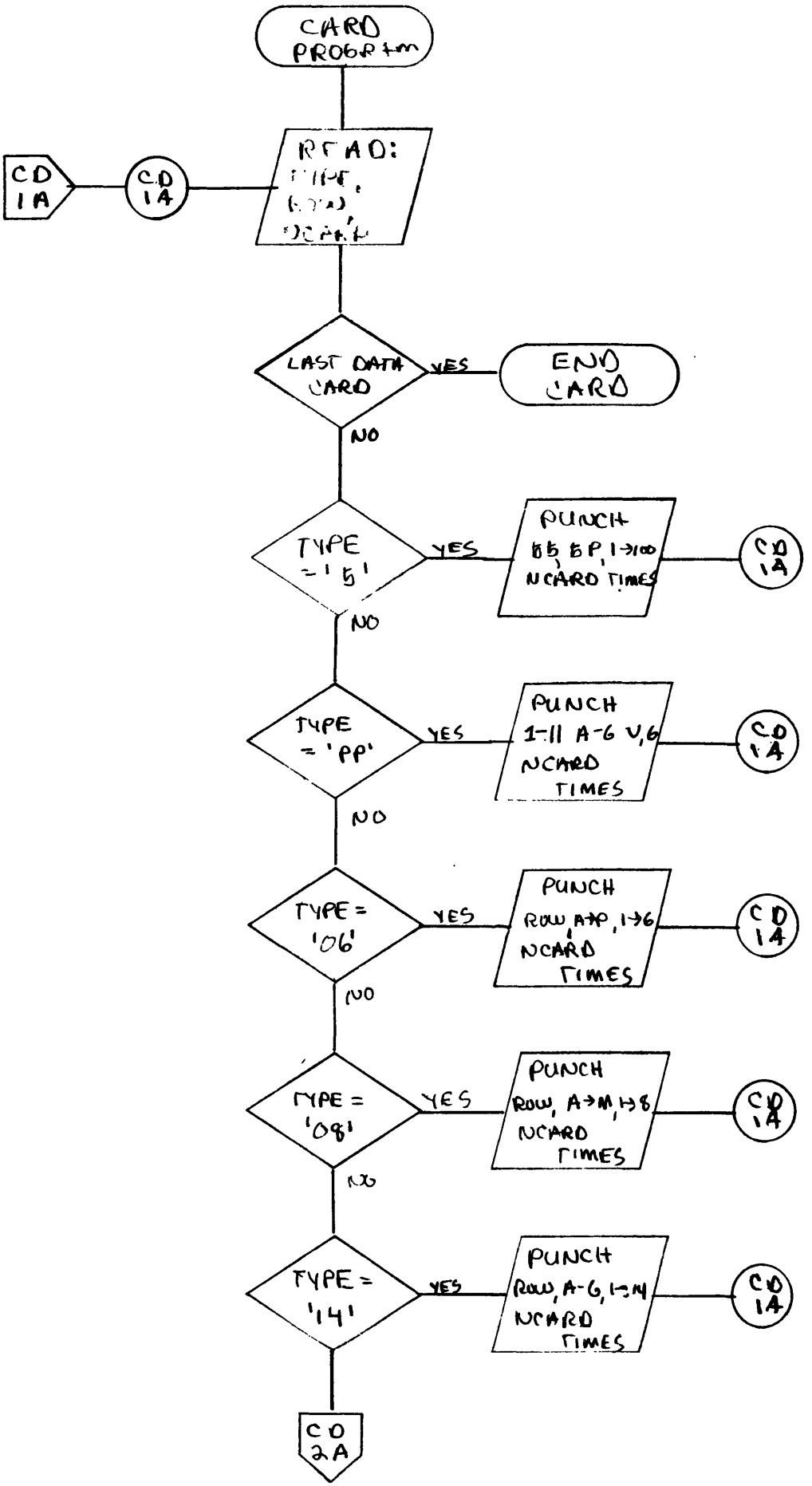
TYPE FIELD	CARD NAME
ST	Start Card
DR	Drive Pin Card
DS	Drive Subgroup Card
DD	Data Definition
PP	Power Pin Data
P	Connector Pin Data
06	6 Pin Chip Data
08	8 Pin Chip Data
14	14 Pin Chip Data
16	16 Pin Chip Data
18	18 Pin Chip Data
20	20 Pin Chip Data
24	24 Pin Chip Data
28	28 Pin Chip Data
40	40 Pin Chip Data
68	Insert 6 Pin Chip in 8 Pin Chip Slot
46	Insert 4 Pin Chip in 16 Pin Chip Slot
88	Refers to Pin

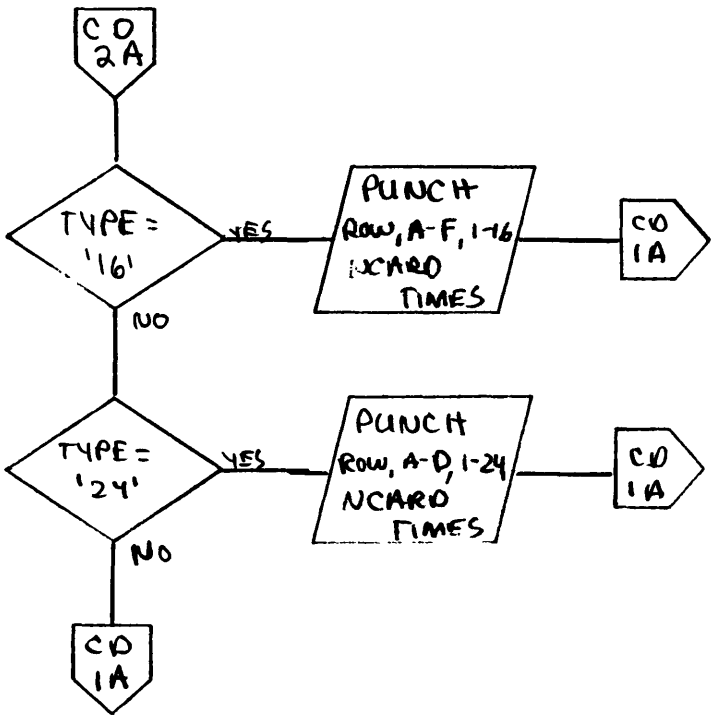
INSTRUCTION FORMATS ON START CARDS

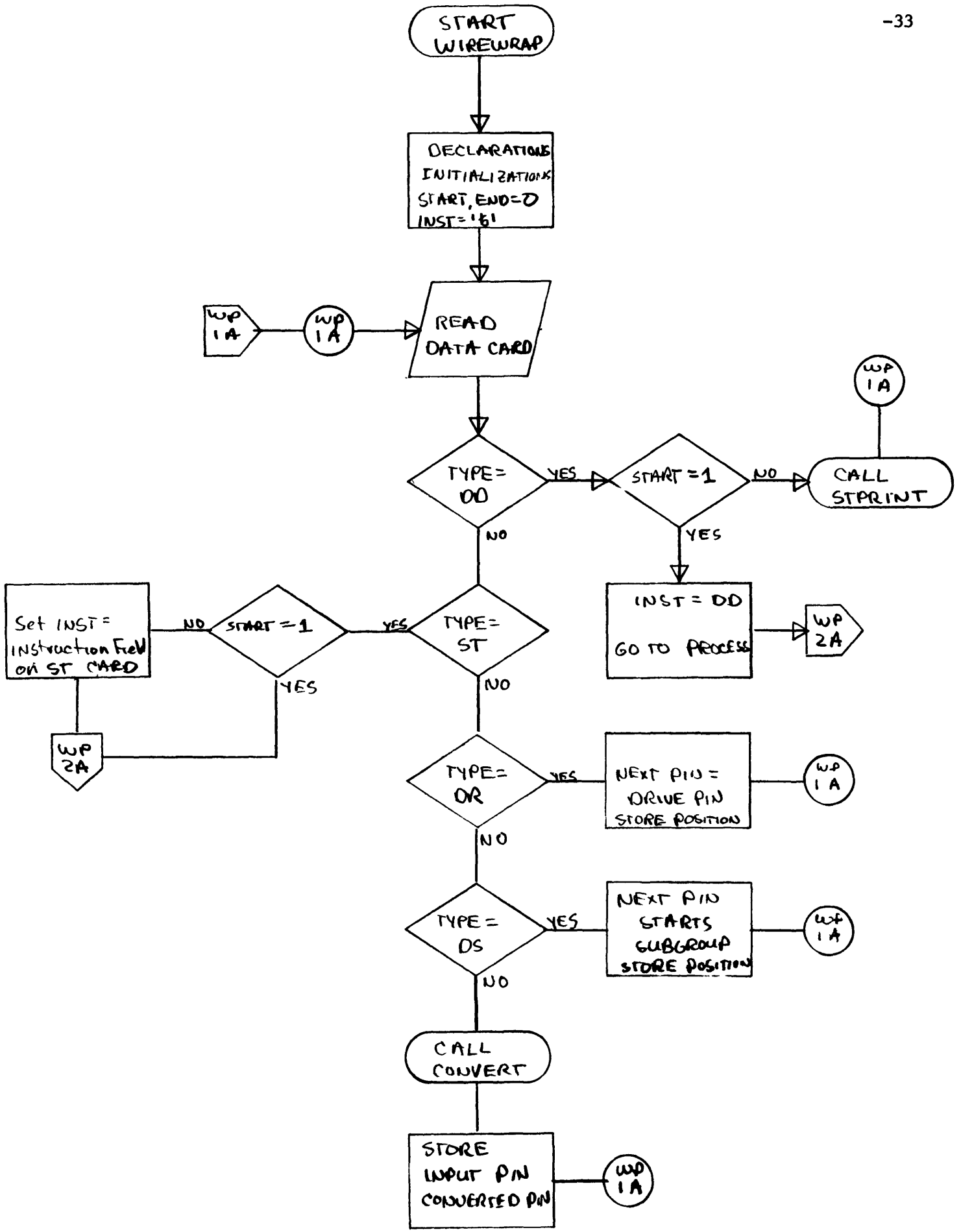
ST	blank	-	Picks out shortest wiring path
ST	EXACT	-	Wiring path is order that pins were read in
ST	GRAPH	-	CalComp plot of wiring path
ST	VCC	-	Connect following pins to nearest power pin
ST	GND	-	Connect following pins to nearest ground pin

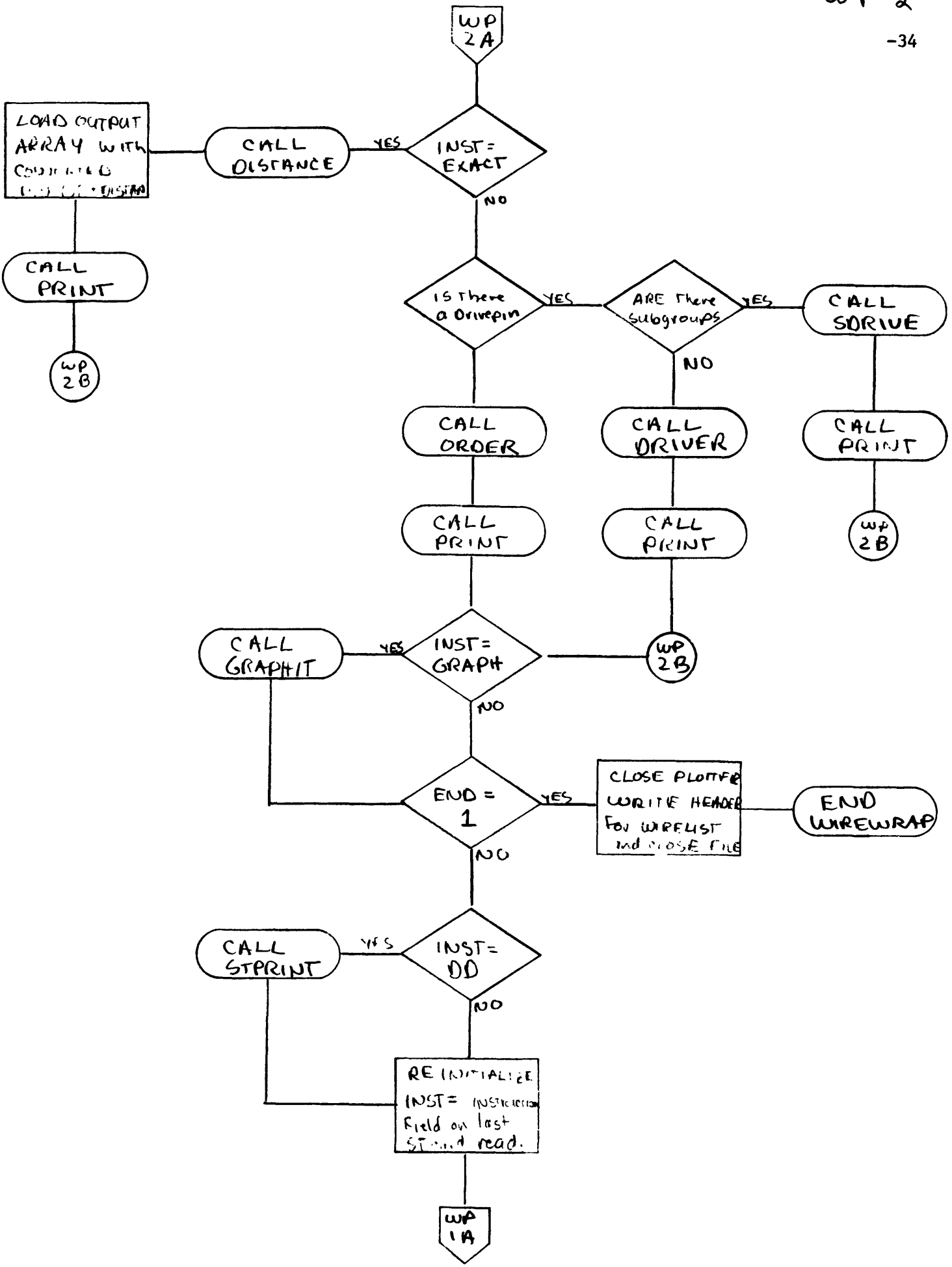
APPENDIX A

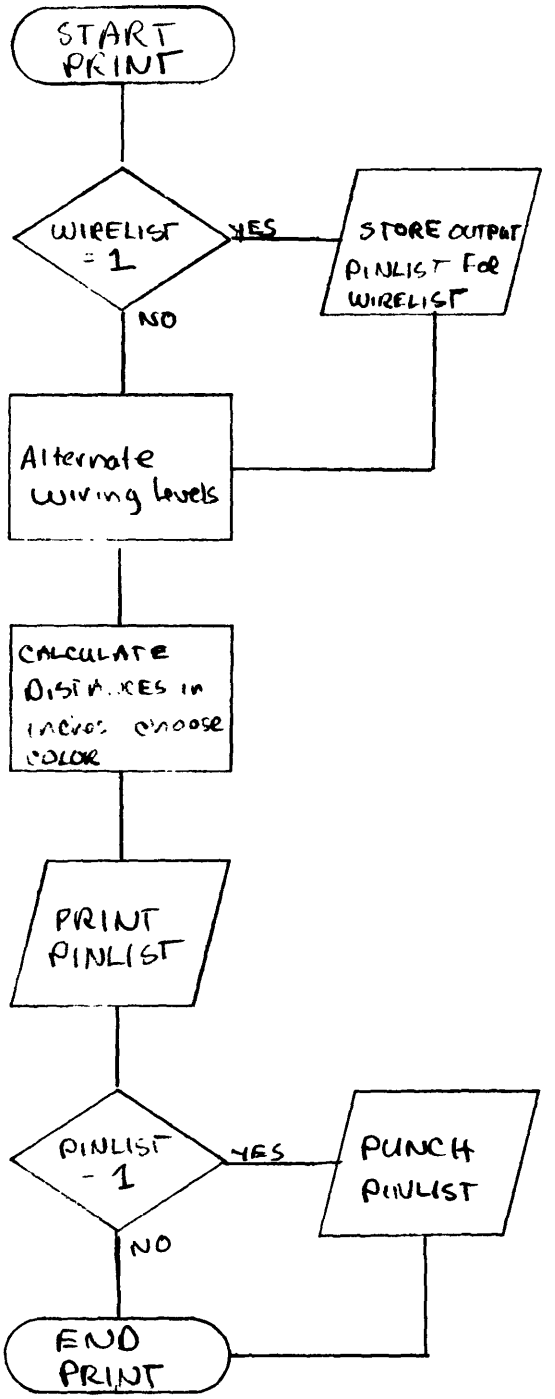
FLOW CHARTS FOR CARD AND WIREWRAP PROGRAM

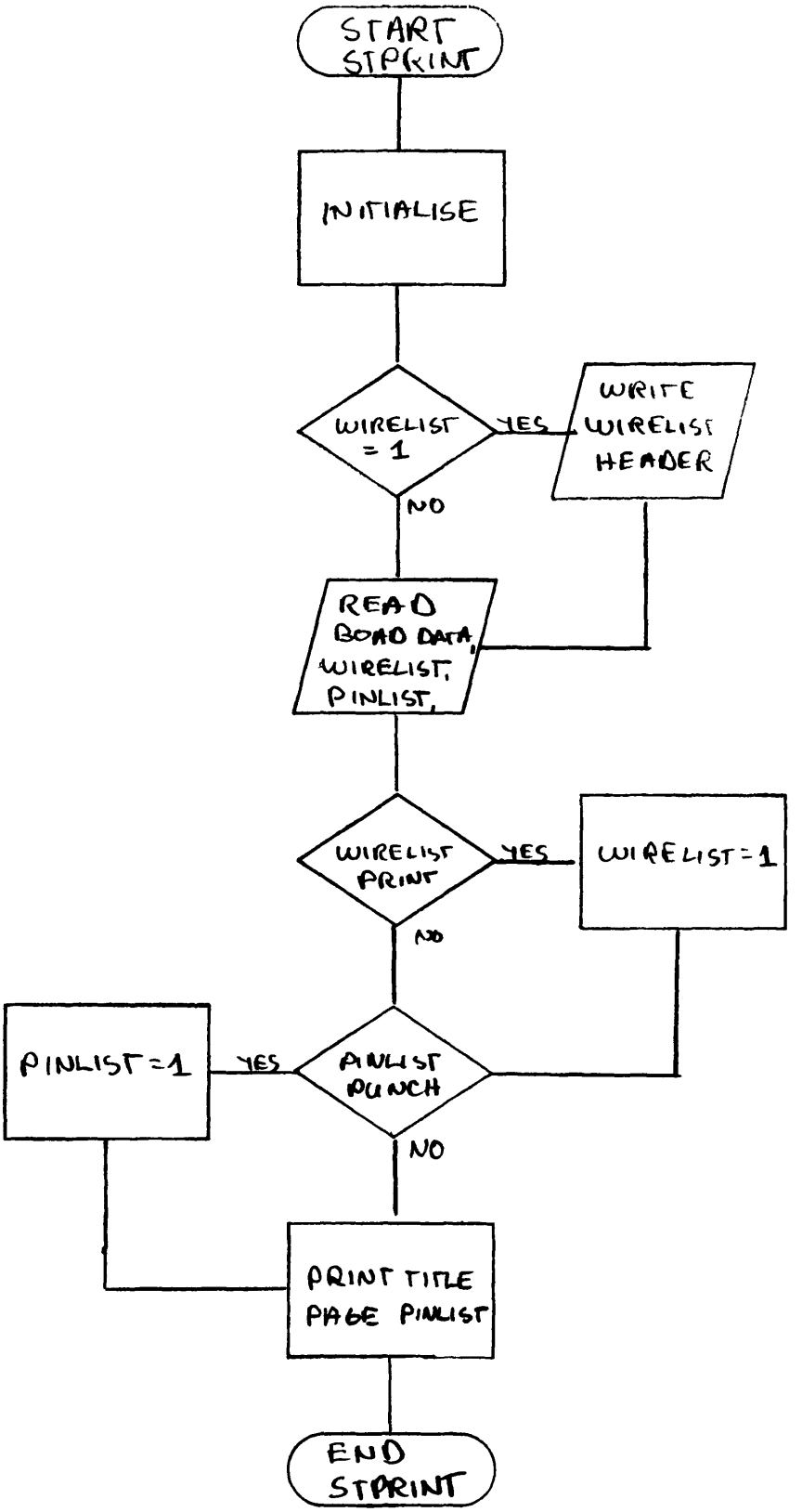

CARD PROGRAM
READ:
TYPE,
NCARD
LAST DATA CARD
YES
END CARD
NO
TYPE = '5'
YES
PUNCH
BB, BP, 1→100
NCARD TIMES
C D 1A
NO
TYPE = 'PP'
YES
PUNCH
1-11 A-G V,6
NCARD TIMES
NO
TYPE = '06'
YES
PUNCH
ROW, A→P, 1→6
NCARD TIMES
NO
TYPE = '08'
YES
PUNCH
ROW, A→M, 1→8
NCARD TIMES
NO
TYPE = '14'
YES
PUNCH
ROW, A-G, 1→14
NCARD TIMES
C O 2A

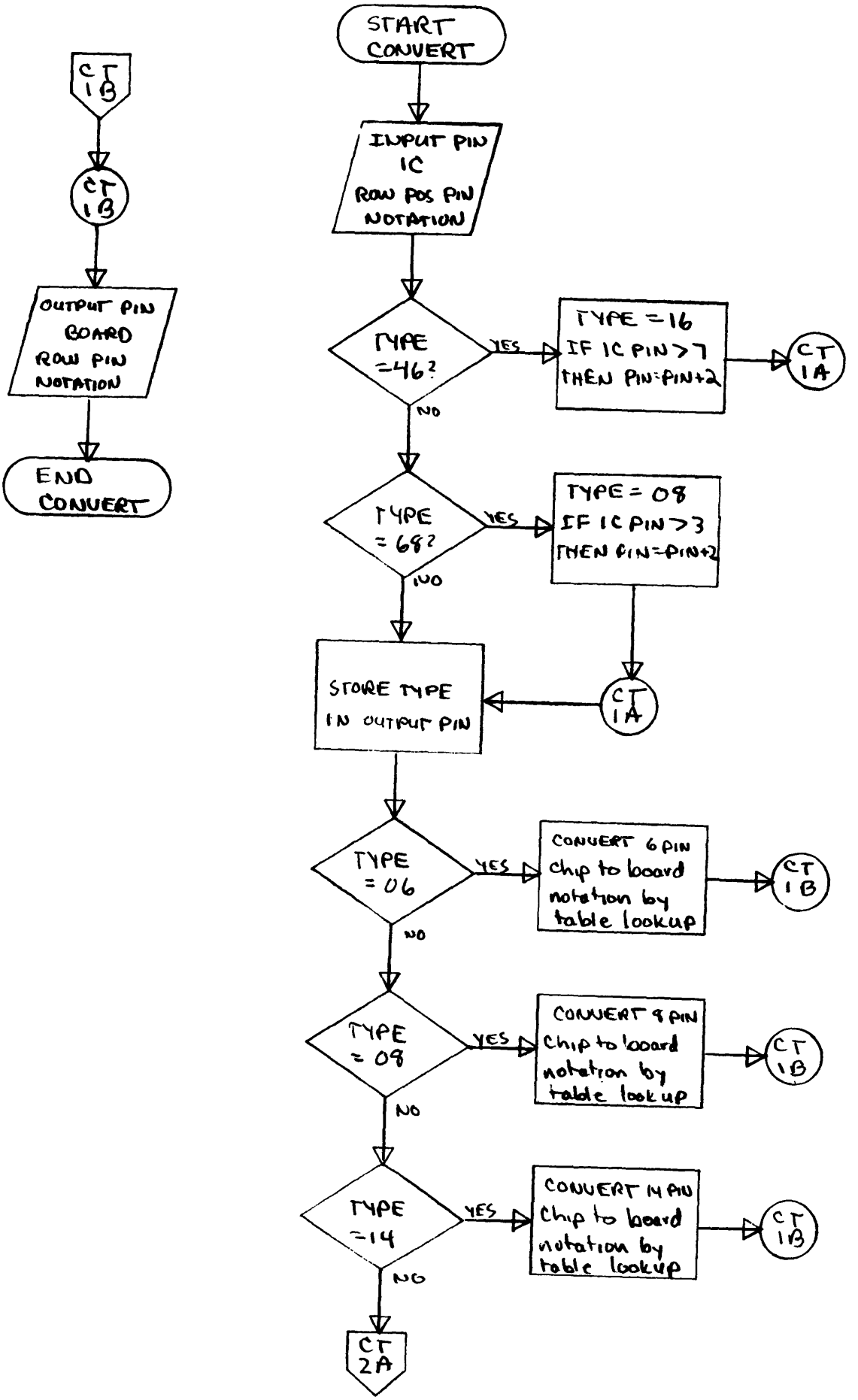

CO 2A
TYPE = '16'
YES
PUNCH ROW, A-F, 1-16 NCARD TIMES
CO 1A
NO
TYPE = '24'
YES
PUNCH ROW, A-D, 1-24 NCARD TIMES
CO 1A
NO
CO 1A

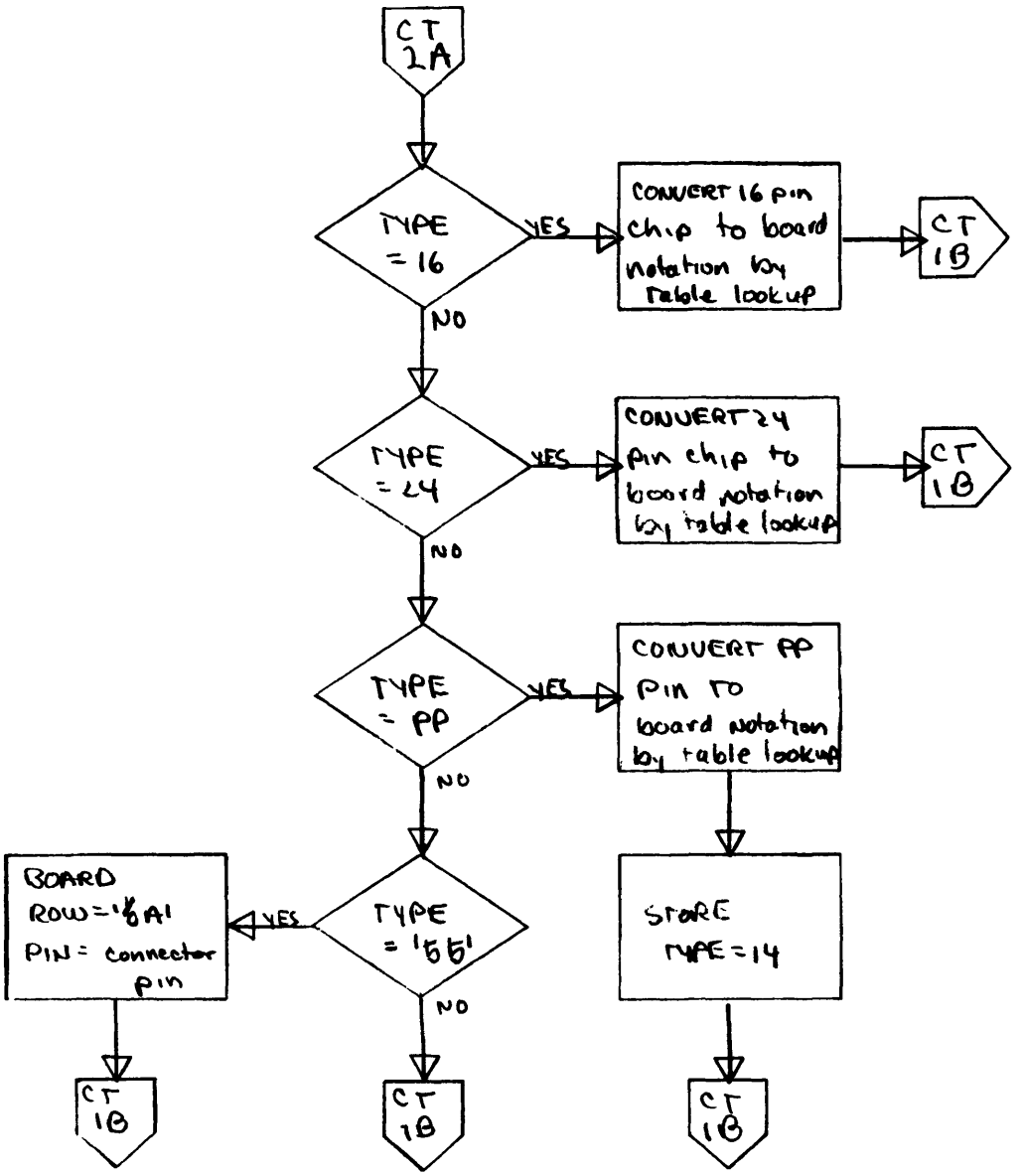

START WIREWRAP
DECLARATIONS INITIALIZATIONS START, END=0 INST='61'
WP 1A
WP 1A
READ DATA CARD
TYPE= DD
YES
START =1
NO
CALL STPRINT
WP 1A
NO
YES
INST = DD
GO TO PROCESS
WP 2A
TYPE= ST
NO
START =1
YES
NO
Set INST = INSTruction FieW on ST CARD
WP 2A
YES
TYPE= OR
YES
NEXT PIN = DRIVE PIN STORE POSITION
WP 1A
NO
TYPE = DS
YES
NEXT PIN STARTS SUBGROUP STORE POSITION
WP 1A
NO
CALL CONVERT
STORE INPUT PIN CONVERTED PIN
WP 1A

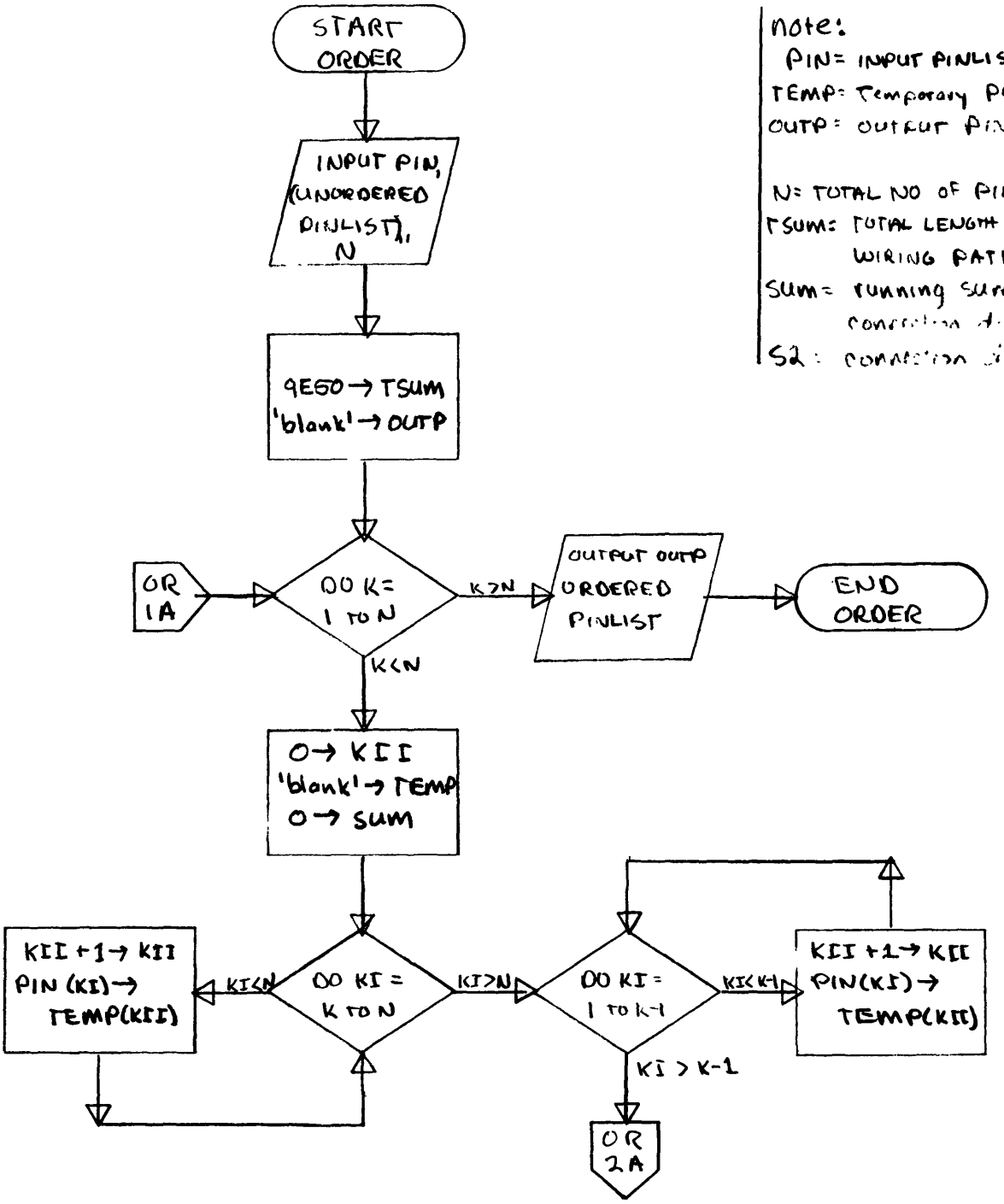

WP 2A
LOAD OUTPUT ARRAY WITH
CALL DISTANCE
YES
INST = EXACT
NO
CALL PRINT
WP 2B
IS There a Drivepin
YES
ARE There Subgroups
YES
CALL SDRIVE
NO
CALL ORDER
CALL DRIVER
CALL PRINT
CALL PRINT
CALL PRINT
WP 2B
CALL GRAPHIT
YES
INST = GRAPH
WP 2B
NO
END = 1
YES
CLOSE PLOTTER
WRITE HEADER
FOR WIRELIST
END WIREWRAP
NO
CALL STPRINT
YES
INST = DD
NO
RE INITIALIZE
INST = INSTRUCTION
Field on last
read.
WP 1A


START PRINT
WIRELIST = 1
YES
STORE OUTPUT PINLIST FOR WIRELIST
NO
Alternate wiring levels
CALCULATE DISTANCES in inches choose color
PRINT PINLIST
PINLIST = 1
YES
PUNCH PINLIST
NO
END PRINT


START
STPRINT
INITIALISE
WIRELIST
= 1
YES
WRITE
WIRELIST
HEADER
NO
READ
BOARD DATA,
WIRELIST,
PINLIST,
WIRELIST
PRINT
YES
WIRELIST=1
NO
PINLIST=1
YES
PINLIST
PUNCH
NO
PRINT TITLE
PAGE PINLIST
END
STPRINT

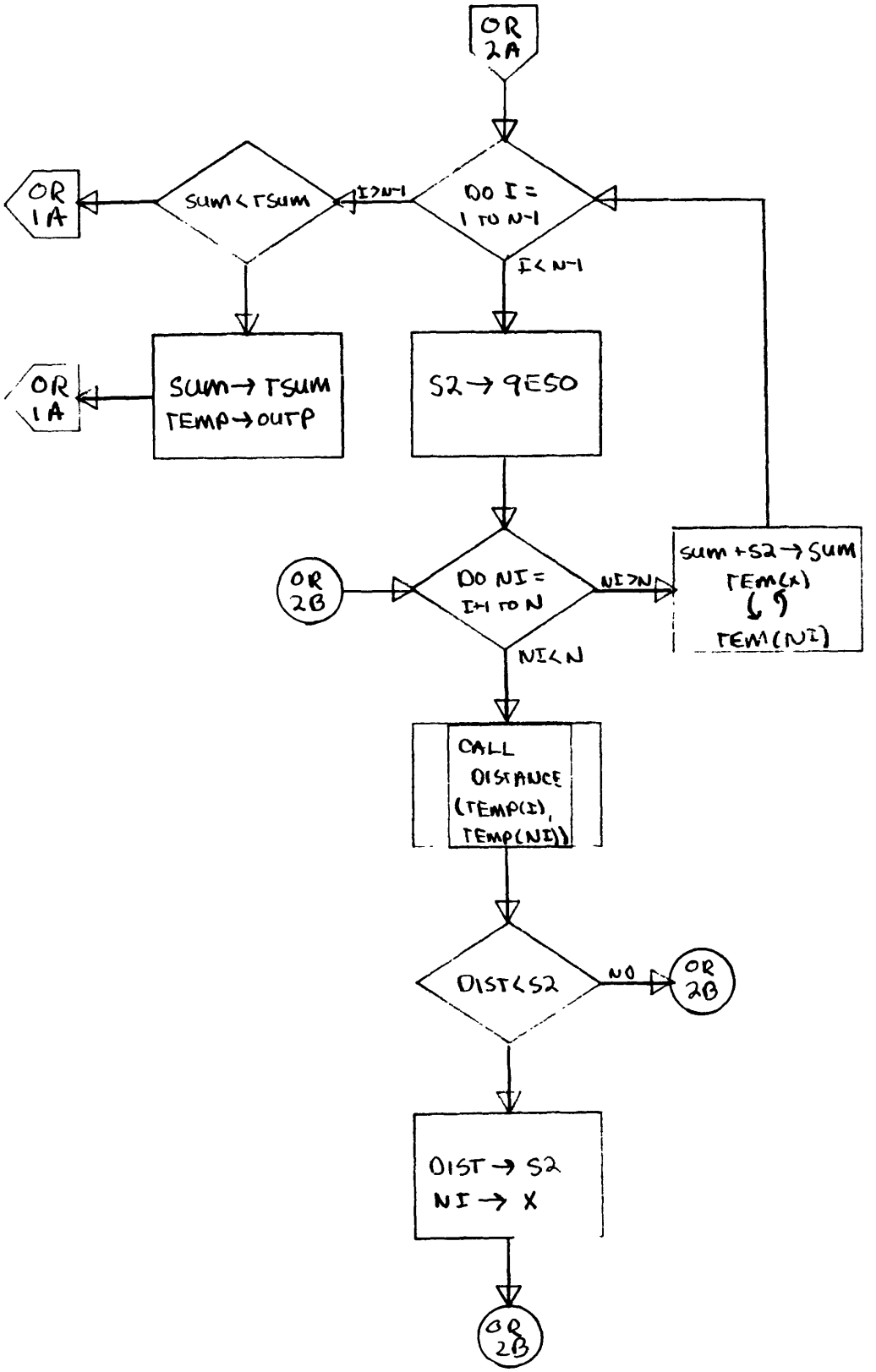

START CONVERT
INPUT PIN IC ROW POS PIN NOTATION
TYPE =46?
YES
TYPE =16
IF IC PIN >7
THEN PIN=PIN+2
CT 1A
NO
TYPE =68?
YES
TYPE = 08
IF IC PIN >3
THEN PIN=PIN+2
NO
STORE TYPE IN OUTPUT PIN
CT 1A
TYPE =06
YES
CONVERT 6 PIN chip to board notation by table lookup
CT 1B
NO
TYPE =08
YES
CONVERT 8 PIN chip to board notation by table lookup
CT 1B
NO
TYPE =14
YES
CONVERT 14 PIN chip to board notation by table lookup
CT 1B
NO
CT 2A
CT 1B
CT 1B
OUTPUT PIN BOARD ROW PIN NOTATION
END CONVERT

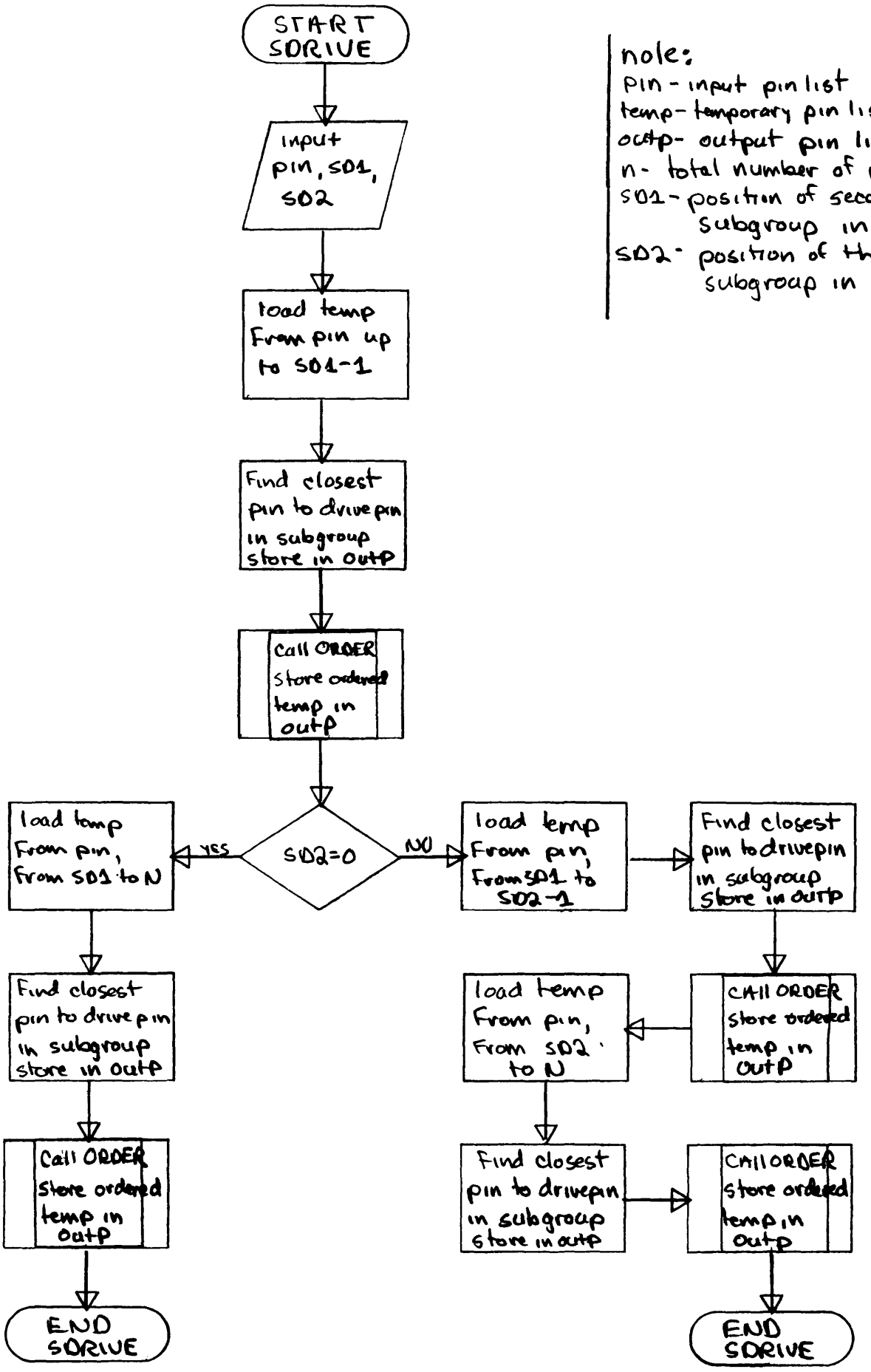

CT 2A
TYPE = 16
YES
CONVERT 16 pin chip to board notation by table lookup
CT 1B
NO
TYPE = 24
YES
CONVERT 24 pin chip to board notation by table lookup
CT 1B
NO
TYPE = PP
YES
CONVERT PP pin to board notation by table lookup
NO
TYPE = '55'
YES
BOARD ROW = '&A1 PIN = connector pin
STORE TYPE = 14
CT 1B
CT 1B
CT 1B

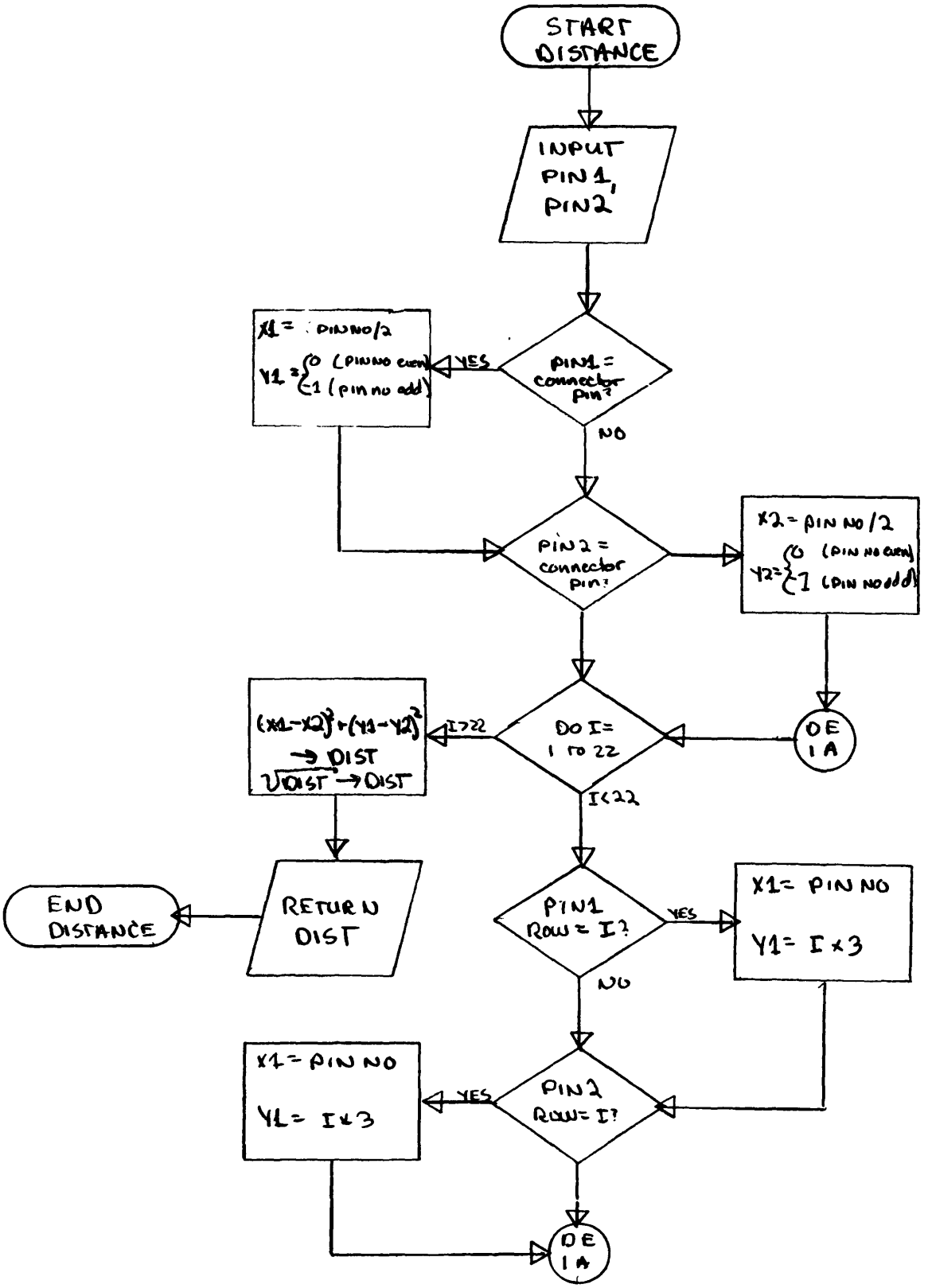


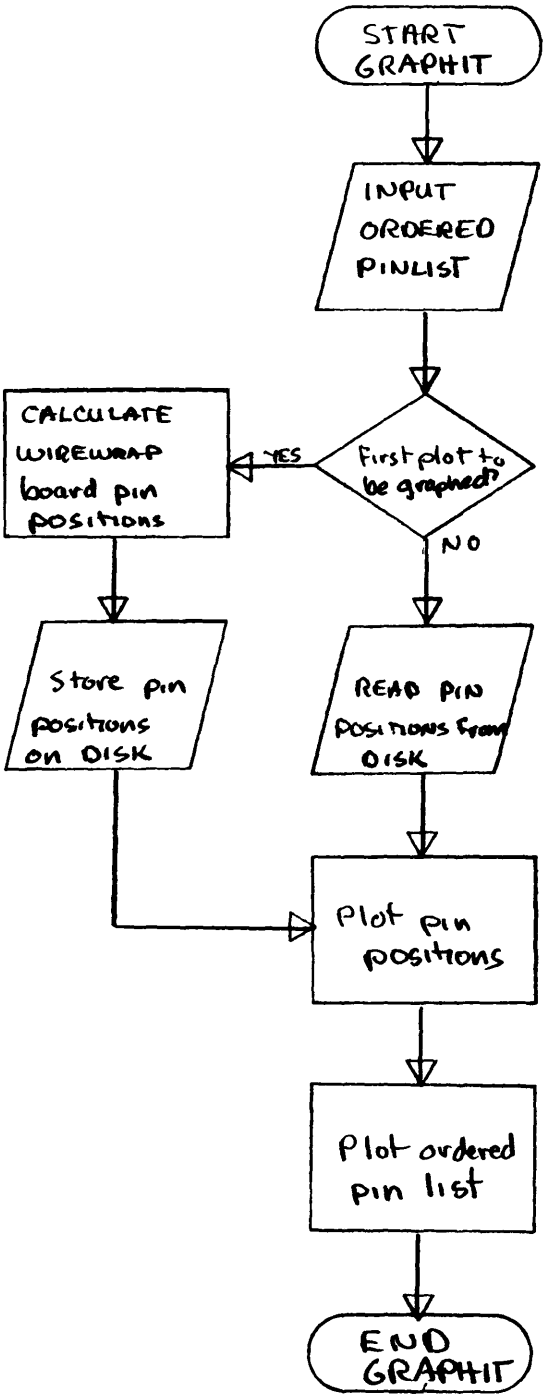
note:
PIN= INPUT PINLIST
TEMP= Temporary PINLIST
OUTP= OUTPUT PINLIST

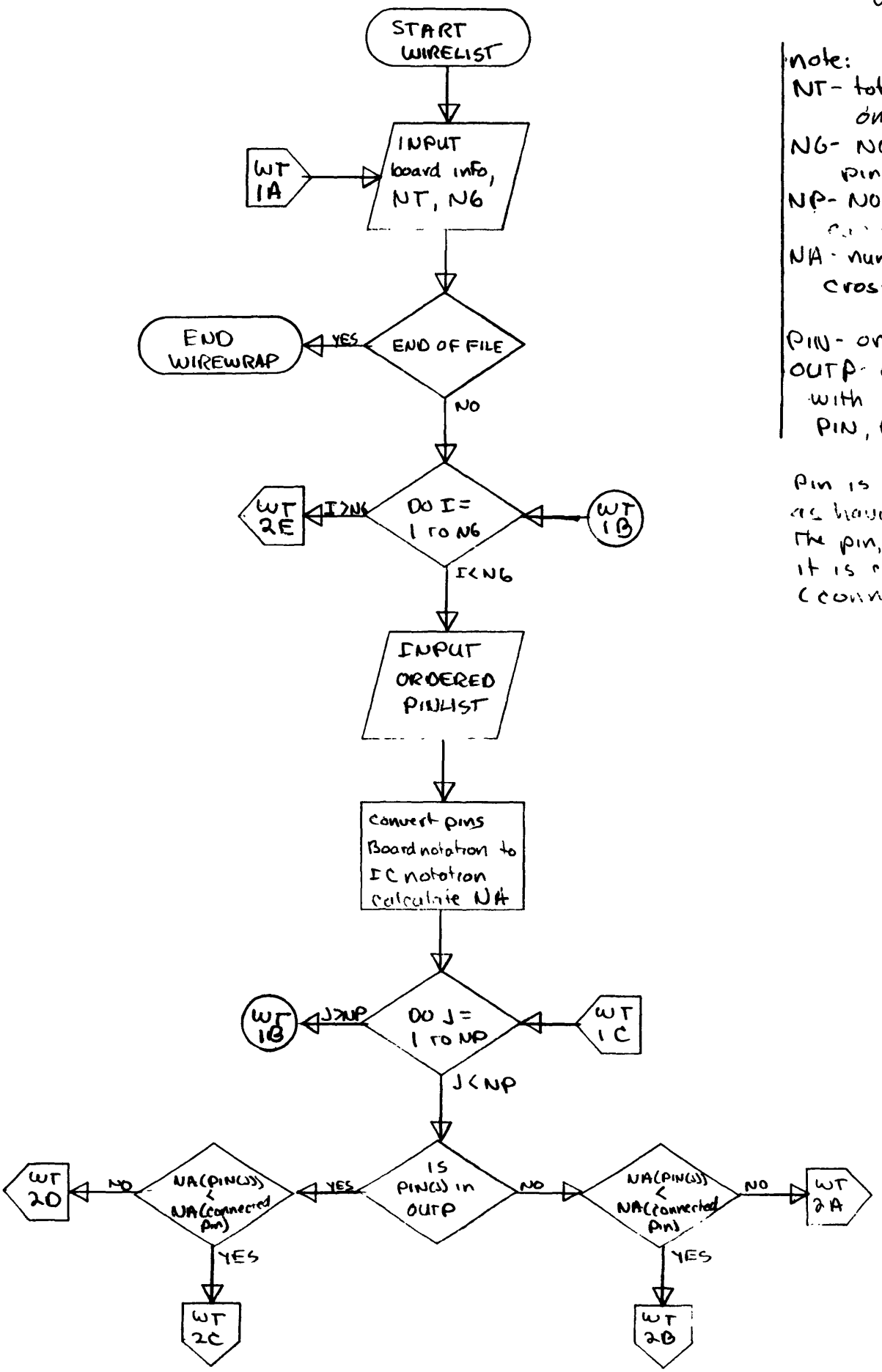
N= TOTAL NO OF PINS
TSUM= TOTAL LENGTH OF WIRING PATH
SUM= running sum of
S2 :


OR 2A
DO I = 1 TO N-1
I>N-1
SUM < TSUM
OR 1A
I < N-1
SUM → TSUM
TEMP → OUTP
OR 1A
S2 → 9ESO
OR 2B
DO NI = I+1 TO N
NI>N
SUM + S2 → SUM
TEM(X)
TEM(NI)
NI < N
CALL DISTANCE (TEMP(I), TEMP(NI))
DIST < S2
NO
OR 2B
DIST → S2
NI → X
OR 2B


START SDRIVE
input pin, SD1, SD2
load temp From pin up to SD1-1
Find closest pin to drivepin in subgroup store in outp
Call ORDER Store ordered temp in outp
SD2=0
YES
NO
load temp From pin, From SD1 to N
Find closest pin to drivepin in subgroup store in outp
Call ORDER Store ordered temp in outp
END SDRIVE
load temp From pin, From SD1 to SD2-1
Find closest pin to drivepin in subgroup store in outp
Call ORDER Store ordered temp in outp
END SDRIVE
note:
pin - input pin list
temp - temporary pin list
outp - output pin list
n - total number of pins
SD1 - position of second subgroup in pin
SD2 - position of third subgroup in pin


START DISTANCE
INPUT PIN1, PIN2
PIN1 = connector pin?
YES
X1 = PIN NO/2
Y1 = 0 (PIN NO even) -1 (PIN NO odd)
NO
PIN2 = connector pin?
X2 = PIN NO/2
Y2 = 0 (PIN NO even) -1 (PIN NO odd)
DO I= 1 TO 22
OE 1A
I>22
(X1-X2)²+(Y1-Y2)² → DIST
√DIST → DIST
I<22
PIN1 ROW = I?
YES
X1= PIN NO
Y1= I×3
NO
PIN2 ROW= I?
YES
X1= PIN NO
Y1= I×3
OE 1A
RETURN DIST
END DISTANCE

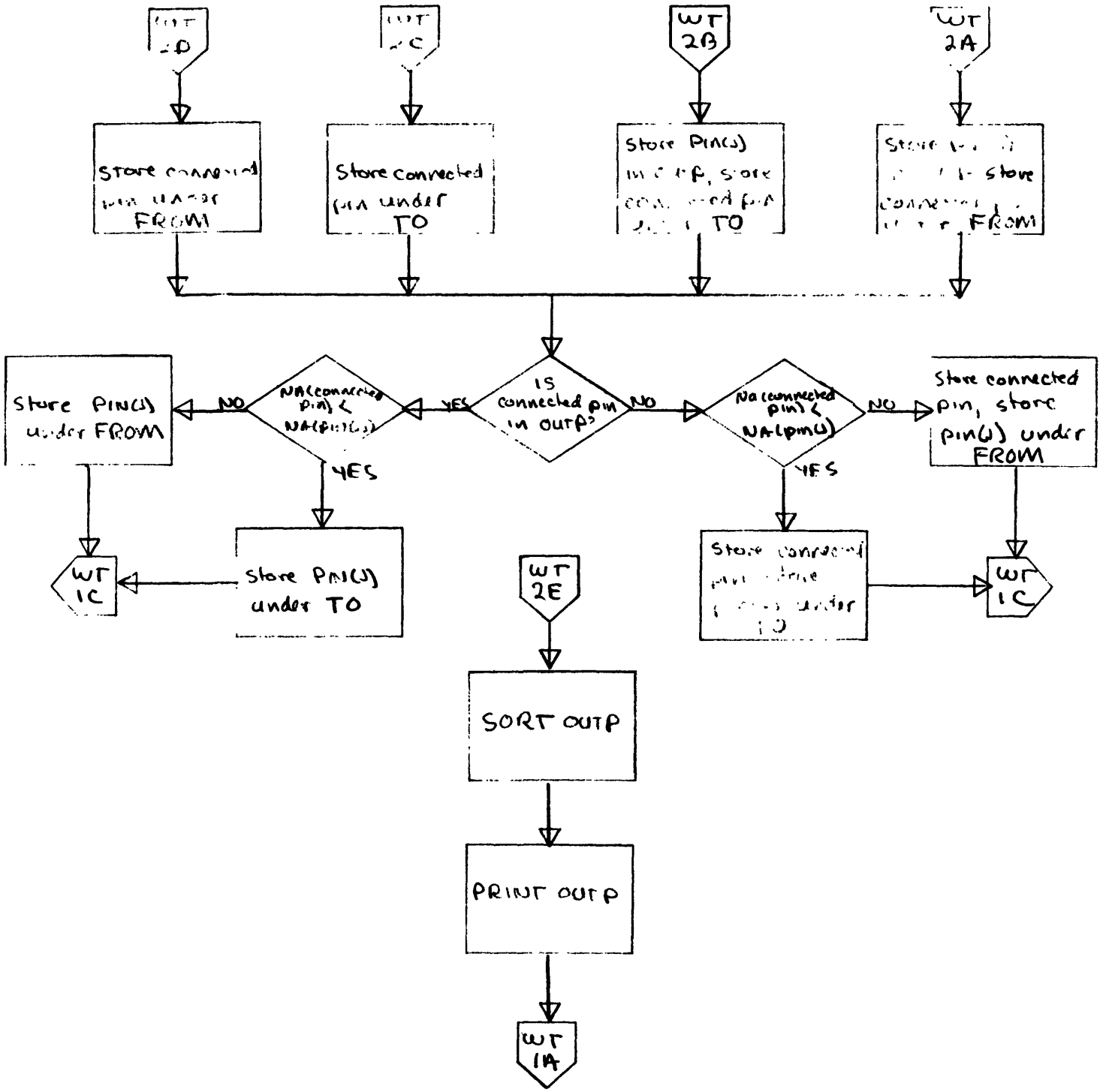

START GRAPHIT
INPUT ORDERED PINLIST
First plot to be graphed?
YES
NO
CALCULATE WIREWRAP board pin positions
Store pin positions on DISK
READ PIN POSITIONS from DISK
Plot pin positions
Plot ordered pin list
END GRAPHIT



note:
NT - total no. of pins on a board
NG - NO of ordered pinlists on a board
NP - NO of pins in [illegible] pinlist
NA - number used to cross-reference pins

PIN - ordered pinlist
OUTP - output pinlist with three columns PIN, FROM, TO.

Pin is referred to as having two terms the pin, and the pin it is connected to (connected pin)


WT 2B
WT 2A
Store PIN(J)
Store connected
FROM
TO
IS connected pin in OUTP?
YES
NO
Store PIN(J) under FROM
Store connected pin, store PIN(J) under FROM
Store PIN(J) under TO
WT 1C
WT 2E
SORT OUTP
PRINT OUTP
WT 1A

APPENDIX B

WIRE WRAP

GENERAL INSTRUCTIONS FOR ENTERING WIRE WRAP DATA THROUGH CRT TERMINAL

C. Broadwell

G. Runion

October 16, 1974

Revised November 7, 1975 (G.R.)

INTRODUCTION

The following general instructions were written specifically for entering wirewrap data through the CRT Terminal and does not attempt to cover the complete description of the Pandora Text-Editing and Job Entry System, nor does it attempt to explain the workings of the Wirewrap program. Internal Report No. 19, "Pandora," describes the full use of the Pandora system, and Internal Report No. explains the Wirewrap program in detail.

The wirewrap user should first familiarize himself with the wirewrap board before attempting to do a CRT wire list. To help become familiar with the wirewrap board study Figures 3 & 4, which show the various IC and discrete spacings and the nomenclature used with the wirewrap board. Although the wirewrap board has much flexibility in accepting various types of chips, the guidelines set forth in Figure 3 and in the following pages must be adhered to when using the wirewrap program.

The terminal at Ivy Road is connected to the IBM 360 Computer via telephone link. The Ivy Road user should first turn on the CRT terminal and place the terminal in remote operation mode by depressing the REMOTE key located in the upper center of keyboard. The Ivy Road user must then establish the phone link which is accomplished by pushing the talk button on the phone and then dialing 295-1202. The IBM 360 Computer should answer the phone on the first ring after which a tone should be heard. As soon as the tone is heard push the red button on the phone marked DATA, at which time the phone receiver can be placed back into the phone cradle. If the computer or PANDORA Program is not operational the phone will not be answered in which case the user may check with the computer operations people to find out when the computer will be back in operation. If a busy signal is received the computer operator must be called and asked to reset the phone modem for Ivy Road.

The Ivy Road user should terminate the use of the terminal with LOGOFF, BYE or one of the other appropriate PANDORA commands. When the user properly terminates the use of the terminal both the Ivy Road and Edgemont Road phone modems will be automatically reset and will be ready for the next user.

The Edgemont Road user does not have to bother with the phone link since the CRT terminals at Edgemont Road are located near the computer.

LIST OF TERMS USED IN THE FOLLOWING PROCEDURE

Display = Indicates information visible on CRT screen

CTRL D = Indicates two keyboard keys that are to be pushed simultaneously

EOT = Special single key on some keyboards that duplicates the function of CTRL D

WORK SPACE = Scratch pad memory used by the CRT terminal. Each terminal has its own work space.

UPPER CASE WORDS = Words that are displayed on CRT screen and/or words to be typed in on keyboard

PDS = Partitioned Data Set which is a disk library made up of members

MEMBER = The name under which your set of data (wirewrap data or a program) is listed in the PDS. The name may be a drawing number, board title, or whatever the user decides as long as the name is not longer than 8 characters, of which the first must be a letter and there cannot be any spaces or punctuation. Be sure that you do not duplicate an existing name!

PROCEDURE

Display: LOGON PLEASE

Type: WIREWRAP

CTRL D

Display: (a) THE WORK SPACE CONTAINS XXXXXXXX DATE TIME

(b) THE WORK SPACE IS EMPTY

If (a) above -

Type: CLR

CTRL D

If (b) above -

Proceed with next step.

Type: ENTER XXXXXXXX (XXXXXXXX is a drawing number, first character must be a letter, max. of 8 characters. This is the number or name that your data will be listed under in the PDS. Be certain that the name you choose is not already in existence in the PDS.)

CTRL D

Display: 1 (You are now ready to input the first 11 lines of instructions. Each line is to be followed by CTRL D or EOT which will prompt you with the next line number.)

(For an actual example of the following, see Pg. 11.)

Type on line:

1 INPUT DISP NOPUNCH or PUNCH (Instructs program whether or not to punch input data cards, which are compatible with the card shark program.

2 DEFINE ROW TYPE (This and line 3 define the type of IC packages, i.e. number of pins, used for each row).

3 XX XX XX XX XX XX XX XX XX XX XX
(Eleven sets of 2 digit nos., program has provisions for mixed types in a row but each row must still be defined initially, all eleven rows must be defined even if all are not used. See Figure 3 for correct row numbers for IC's with .6 inch lead spacing.)

4 DD

5 TITLE='XXXXXXXXXXXX' BDATE='XXXXXX';
(Title - 12 characters max. - for logic drawing no. and rev.
Date - 6 characters - for the date of latest logic drawing rev.)

6 VERSION='XX-XXXXXX'; (Wiring list version and date)

7 DES='XXX...XXX'; (Board title or circuit description, 50 characters max. Computer prints out description on two lines of 25 characters each; however, the description is entered on one CRT line.)

8 PROJECT='XX-XX'; (16 characters max. for project no. or name.)

9 DWG='XXXXXXXXXX' REV='XX'; (for wiring list no. and wiring list rev.)

10 PINLIST='NOPUNCH'; or 'PUNCH'; (Tells program whether or not to punch a set of cards for automatic wirewrapping.)

11 WIRELIST='PRINT'; or 'NOPRINT'; (Tells program whether or not to print the IC list.)

The above eleven lines must be as shown. (See Figure 2)

12 You are now ready to start entering data on this line from your logic drawing. Lines 13 through 23 are examples of various types of input.

The following is a list of various start commands that can be used:

S — Start Command - The computer will generate the shortest wiring list path between the input data points following "S". 30 points max.

SGND — Start Ground List Command - The computer will generate a wiring list for all IC ground pins entered. The PC ground pins need not be entered because they are stored in the program. A max. of 30 IC points may be entered with each SGND command. This command will wire each individual IC pin listed to a PC ground pin; therefore, to avoid too many wraps on the PC ground pins do not use this command to ground IC inputs.

SVCC — Start Power List Command - The computer will generate a wiring list for all IC power pins entered. The PC power pins need not be entered because they are stored in the program. A max. of 30 IC points may be entered with each SVCC command. This command will wire each individual IC pin listed to a PC power pin; therefore, to avoid too many wraps on the PC power pins do not use this command to connect IC inputs VCC.

SG — Start Graph Command - Same as the start command but will also generate a CalComp plot of the wiring path.

SE — Start Exact Command - The computer will generate a wiring list in the same order that the input data is entered after "SE".

SDR — Start Drive Command - This can be used for a driver driving many loads. This command will insure a separate wire from the drive point to a max. of 3 groups of inputs for which the computer will generate the shortest wiring list path for each group. The user must divide the inputs into 3 groups (max.). The first group of inputs would consist of SDR, the driver point, then followed by the input points of the first group. The other 1 or 2 group(s) are described next under "DS".

DS — Drive Continue Command - This command must precede the input data of the other 1 or 2 group(s) described above. The drive point need not be repeated.

13 S 1AV 1A16 S 1AG 1A8 S 1B16 1BV S 1B8 1BG

→ Indicates a wire wrap board ground pin that IC 1A pin 8 should be connected to.

→ Indicates a wire wrap board power pin (VCC) that IC 1A pin 16 should be connected to.

14 SVCC 1A16 1B16 1C16 1D16 1E16 1F16 2A14 4A10

→ This is an alternative method that is easier than the above example to connect the listed IC pins to the wire wrap board VCC plane.

15 SGND 1A8 1B8 1C8 1E8 1F8 2A7 4A9

→ Same as above except that the listed IC pins will be connected to the ground plane.

16 S 11B1 1D6 5D4 3E10 P21 S 3G3 1D5 10C6

→ No spaces allowed

→ Must be one or more spaces

17 SE 5A12 1A15 1A12 1B15 1C15

→ Indicates that the following listed points will be wired in the same order as they are listed.

18 SDR 4C12 3D11 3A11 4B13 DS 7D5 9D5 7D3 DS 4G11 5F11 6D10 4F11

→ Indicates the 2nd & 3rd groups of inputs

→ Indicates that 4C12 is a drive point which will have 3 separate wires feeding 3 groups of inputs.

19 SGND 3A7 3B7 6 3P3 4A8 4C8

→ Indicates that IC 3P is a 6 pin IC in a 6 pin position but in an IC row that has been defined on CRT line No. 3 as something other than a 6 pin row.

20 S 2L4 68 2M3 2F4 1A15 S 1A2 10C2 3E2 4F1 S 11C2 9B3

→ Indicates that IC 2M is a 6 pin IC in an 8 pin position and that IC row 2 has been defined as an 8 pin IC row.

21 S 46 4E7 4F8 5A10 S 1D9 3D5 S 3D4 5E6

→ Indicates that IC 4E is a 14 pin IC in a 16 pin position and that IC row 4 has been defined as a 16 pin IC row.

22 S 6F7 28 7C25 7B12 9C14 10A8 6D12 28 7C20

→ Possible row numbers for IC's with .6 inch lead spacing are: 1, 3, 4, 6, 7, 9, 10. See Figure 3

→ Indicates that IC 7C is a 28 pin IC in an IC row that has been defined on CRT line No. 3 as something other than a 28 pin IC row.

23 S 9AV 40 26A39 88 T21 S 6C5 7D8 5 G2

→ Indicates wirewrap pin No. 21 in wirewrap pin row "T".

→ Indicates that T21 is a wirewrap pin location and not an IC. This feature accommodates the use of discrete components.

If the above line is the last line of data to be entered --

CTRL D

Display: 24 (which is just the next line)

Using the cursor control (the arrow pointing to the left) move the cursor one or more spaces to the left.

CTRL D

Display: CURSOR MOVED OFF RECORD
END INSERTION OR ENTRY

Type: SAVE

CTRL D

Display: MEMBER XXXXXXXX ADDED TO PDS
PDS HAS ----------TRK.

IMPORTANT! Be sure you receive this message. Get assistance if necessary.

Type: SUBMIT CONVERT,XXXXXXXX,WIREWRAP
(XXXXXXXX is the drawing number that was entered at the beginning.)

Display: YOUR JOB HAS BEEN SUBMITTED

Type: BYE

Display: LOGON PLEASE

ADDITIONAL KEYBOARD COMMAND FUNCTIONS AND EXAMPLES

(For a complete list of commands one should refer to PANDORA's instructions)

CTRL D or EOT	Sends instruction or completed line to computer. CTRL D represents 2 separate keyboard keys that must be pushed simultaneously. EOT is a special single key found on some keyboards that duplicates the function of CTRL D. Either may be used.

If the user is being prompted by sequence numbers and he wishes to perform one of the following functions, the user must first backspace cursor to the left and push CTRL D keys simultaneouly or the EOT key. The line on which the cursor is backspaced or moved off record will not be recorded by the computer.

BYE	Will clear the work space and will then LOGOFF
C 12	Makes line 12 (in the work space only) available for changes. If change(s) are to be entered in the PDS the SAVE command must be executed before clearing work space or before logging off.
CLR	Clears the work space
D 10	Will delete line 10 of the member in the work space
D 10, 20	Will delete line 10 through 20 of the member in the work space
DWS	Will display the member's name that is in the work space and the date and time that it was saved.
ENTER	Will begin prompting the user with the next sequence number of a member already in the work space.
ENTER XXXXXXXX	Will start a new set of data
GET XXXXXXXX	Will transfer the named member from the PDS into the work space if the word space is clear.

I 7.01	Will provide an additional line for entering data between lines 7 & 8.
L 1	Will list lines - of a member in the work space - starting with line 1 until the CRT screen is filled.
L	To continue the listing of the lines of a member in the work space as per the previous listing instructions.
L 50,6	Will list a total of 6 lines beginning with line 50.
LISTPDS	The names of all members in the PDS are displayed.
LOGOFF	Signals computer that user is finished, and then the computer will put terminal in standby mode for next user.
NULL COMMAND	CTRL D or EOT
REPLACE XXXXXXXX	Enables user to take a member from the PDS and make changes to it in the work space and enter it back into the PDS under a new name (XXXXXXXX) and still retain the old member in the PDS under its original name. This command may also be used to change a member's name.
SAVE	Contents of work space member is transferred to the PDS. If the contents of the work space (member) is not saved it will be lost!!!
SCRATCH XXXXXXXX	The named member is scratched from the PDS
SEND	Permits CRT user to send message to computer console Example: SEND PLEASE.HANG.UP.PHONE.
SEQ	Will renumber all lines. Useful after insertions have been made.
SUBMIT CONVERT,XXXXXXXX,WIREWRAP	Submits the named member (XXXXXXXX) to be processed by the wirewrap program.
SUBMIT CONVERTI,XXXXXXXX,WIREWRAP	Same as above except that "Ivy" will be printed on the print out so that the print out will be routed to Ivy Rd. building.

SUBMIT CONVERT,*,WIREWRAP	Submits what is in work space as data to be processed by the wirewrap program.
SUBMIT CONVERTI,*,WIREWRAP	Same as above except that "Ivy" will be printed on the print out so that the print out will be routed to Ivy Rd. building.
SUBMIT PRINT,XXXXXXXX	Prints what is in the PDS under that name. (The name of the print out is "Print Electr").
SUBMIT PRINTI,XXXXXXXX	Same as above except that "Ivy" will be printed on the print out so that the print out will be routed to Ivy Rd. building.
SUBMIT PRINT,*	Prints what is in the work space. (The name of the print out is "Print Electr").
SUBMIT PRINTI,*	Same as above except that "Ivy" will be printed on the print out so that the print out will be routed to Ivy Rd. building.
SUBMIT PUNCH,XXXXXXXX	Punches cards for what is in the PDS under that name. With the use of the utility program - ADDTO - these cards can be used to read the data on the cards back into the PDS in case it is erased or scratched from the PDS. If the user does not plan on using the stored data frequently but wishes to save it, it is suggested that he does so on cards instead of tying up disk space.
SUBMIT CRTCONI,XXXXXXXX,CRTWRAP↓ (or *) ↓ 6	Submits the named data to be processed by the wirewrap program; however, the output is written onto disk in the PDS instead of being printed out on paper. In this way the user does not have to wait for the paper output to see if his data is in correct form and that the program will run with his data. There are six disk areas (1-6) set aside for this purpose. The user should first check with the Digital Lab to see which of the 6 areas he should use; otherwise, the user may destroy good output belonging to someone else. These six disk areas are intended to be a preliminary output check and are not to be used as a permanent record.

To display the various outputs:

GET OUTCON1 ↓ 6	The Convert output
GET OUTPIN1 ↓ 6	The Pin List output
GET OUTIC1 ↓ 6	The IC List output

Since the user has no way to tell when his output is ready, he should just wait a reasonable length of time and check to see if his output is in the PDS.

INSERTION AND DELETION OF CHARACTER SPACES

KEYS THAT MUST BE PUSHED SIMULTANEOUSLY	FUNCTION
SHIFT IC	Insert one character space at cursor position
SHIFT IC REPEAT	Insert character spaces to the right of cursor until keys are released
SHIFT DC	Delete one character space at cursor position
SHIFT DC REPEAT	Delete character spaces to the right of cursor position until keys are released

EXAMPLE OF INPUT DATA AND COMPUTER OUTPUTS

The next several pages consist of an example. First there is an example of what information would be seen on the CRT screen as the input instruction and data are entered through the CRT keyboard. Next there is a copy of the computer print out of the Pin List. Following the Pin List is a copy of a CalComp plot of a group of connections in the example. Last there is a copy of the computer output of the IC list for the input data in the example.

Below is an example of wirewrap instructions and data as would be seen on the CRT screen as the data is entered into a CRT terminal:

```
LOGON PLEASE

WIREWRAP
ENTER EXAMPLE


 1   INPUT DISP NOPUNCH
 2   DEFINE RCK TYPE
 3   06 C8 14 16 20 14 24 14 40 16 14
 4   DD
 5   TITLE='DRAWING NO.'     BDATE='081974';
 6   VERSION='01-081974';
 7   DES='EXAMPLE OF WIRE WRAP DATA      FROM CRT TERMINAL     ';
 8   PROJECT='PROJECT NO.';
 9   DWG='WIRING NO.'  REV='A8';
10   PINLIST='NOPUNCH';
11   WIRELIST='PRINT';
12   SGND 1A3 183 1C3 1D3 1E3 1F3 1G3 1H3 1J3 1K3 1L3 1M3 1N1 1P3
13   2A4 284 2C4 2E4 2F4 2G4 2H4 2J4 2K4 2L4 68 2M3
14   SGND 3A7 3B7 3C7 3D7 3E7 3F7 6 3P3 4A8 4B8 4C8 4D8
15   46 4E7 4F8 5A10 5B10 5C10 5D10 5E10 6A7 6B7 6C7 6E7
16   SGND 6F7 7A12 7B12 7C12 7D12 28 9C14 10A8 11A7
17   11B7 SVCC 1A6 1B6 1C6 1D6 1C6 2A8 2B8 2C8 2D8 2E8 2F8 2G8 2H8
18   2J8 2K8 2L8 3A14 3B14 3C14 3D14 3E14 3F14 6 3P6 7A24
19   28  9C28 S 9AV  9A40 88 T21 S 9AG  9A19  9A20
20   SG 1F2 11D13 1DC4 88 D54 68 D55 5D19 2C6 3E5  6E13 68 2A1 46 +D5
21   P6 S 3C4 4E4 S 5E15 5E1 5D1 5D16 S 5B3 9A38 9A1 28  9C26
22     SDR 3F12 88 F48 3G12 3G10 46 4E11 DS 9A6 11B8 10C15 10C13
23   5C17 5B1 5C5 DS 68 2M5 1P5 1N5 88 B26 P40 S P50 88 P50


SAVE

SUBMIT CONVERT,EXAMPLE,WIREWRAP

BYE
```

```
TITLE='D13500L22' BDATE='110574';
VERSION='00 111174';
DES=' EXCHANGE DATA GENERATOR       GO/NOGO STORAGE';
PROJECT='VLA';
DWG='A13500W22' REV=' ';
PINLIST='NOPUNCH';
WIRELIST='PRINT';



******* STEP HAS COMPLETED NORMALLY.  *******
```

PIN LIST

DRAWING NO. 081974

EXAMPLE OF WIRE WRAP DATA

FROM CRT TERMINAL

VERSION 01-081974

10/09/74

NRAO PROJECT NO.

DWG= WIRING NO. REV= AB

DRAWING NO. PAGE 1

INPUT ST	GND	FROM	TO	LENGTH	COLOR	COUNT
6	1 A 3	C 3	B 7 G	3.0	C	1
6	1 B 3	C11	B15 G	3.0	C	2
6	1 C 3	C19	B23 G	3.0	C	3
6	1 D 3	C27	B31 G	3.0	C	4
6	1 E 3	C35	B39 G	3.0	C	5
6	1 F 3	C43	B47 G	3.0	C	6
6	1 G 3	C49	B55 G	3.5	C	7
6	1 H 3	E 5	D 7 G	3.0	C	8
6	1 J 3	E14	D15 G	3.0	C	9
6	1 K 3	E27	D23 G	3.0	C	10
6	1 L 3	E36	D39 G	3.0	C	11
6	1 M 3	F45	D47 G	3.0	C	12
6	1 N 1	E53	D55 G	3.0	C	13
6	1 P 3	C 7	B 7 G	3.0	C	14
8	2 A 4	C15	B15 G	3.0	C	15
8	2 B 4	C23	B23 G	3.0	C	16
8	2 C 4	C31	B31 G	3.0	C	17
8	2 E 4	C39	B39 G	3.0	C	18
8	2 F 4	C47	B47 G	3.0	C	19
8	2 G 4	C55	B55 G	3.0	C	20
8	2 H 4	E 9	D 7 G	3.0	C	21
8	2 J 4	E23	D23 G	3.0	C	22
8	2 K 4	E32	D31 G	3.0	C	23
8	2 L 4	E41	D39 G	3.0	C	24
8	2 M 3	E50	D55 G	3.5	C	25

DRAWING NO. PAGE 2

INPUT ST	INPUT GND	FROM	TO	LENGTH	COLOR	COUNT
14	3 A 7	G 7	F 7 G	3.0	Y	26
14	3 B 7	G23	F23 G	3.0	Y	27
14	3 C 7	G39	F39 G	3.0	Y	28
14	3 D 7	G55	F55 G	3.0	Y	29
14	3 F 7	J18	H15 G	3.0	Y	30
14	3 F 7	J36	H39 G	3.0	Y	31
14	3 F 7	J54	H55 G	3.0	Y	32
6	3 P 3	L21	K23 G	3.0	Y	33
16	4 A 8	L43	K39 G	3.0	Y	34
16	4 B 8	N 7	M 7 G	3.0	Y	35
16	4 C 8	N23	M23 G	3.0	Y	36
16	4 D 8	G15	F15 G	3.0	Y	37
46	4 E 7	G31	F31 G	3.0	Y	38
16	4 F 8	G47	F47 G	3.0	Y	39
20	5 A1C	J 9	H 7 G	3.0	Y	40
20	5 B1C	J27	H23 G	3.0	Y	41
20	5 C1C	J44	H47 G	3.0	Y	42
20	5 D1C	L10	K 7 G	3.0	Y	43
20	5 E1C	L32	K31 G	3.0	Y	44
14	6 A 7	L54	K55 G	3.0	Y	45
14	6 B 7	N15	M15 G	3.0	Y	46
14	6 C 7	N39	M39 G	3.0	Y	47
14	6 E 7					

INPUT ST	INPUT GND	FROM	TO	LENGTH	COLOR	COUNT
14	6 F 7	N47	M47 G	3.0	GR	48
24	7 A12	S27	P33 G	3.5	GR	49
24	7 B12	S55	P55 G	3.5	GR	50
24	7 C12	X 9	W 7 G	3.0	GR	51
24	7 D12	Z15	Y15 G	3.0	GR	52
24	9 C14	S13	P 7 G	3.5	GR	53
16	10 A 8	S41	P39 G	3.5	GR	54
14	11 A 7	V46	W39 G	3.5	GR	55
14	11 B 7	Z 7	Y 7 G	3.0	GR	56

DRAWING NO. PAGE 3

INPUT	FROM	TO	LENGTH	COLOR	COUNT
ST VCC					
6 1 A 6	B 1	B 3 V	3.0	B	57
6 1 B 6	B 9	B11 V	3.0	B	58
6 1 C 6	B 9	B11 V	3.0	B	59
6 1 D 6	D 6	D 3 V	3.0	B	60
6 1 D 6	D15	D11 V	3.0	B	61
6 1 C 6	D24	D27 V	3.0	B	62
8 2 A 8	D33	D35 V	3.0	B	63
8 2 B 8	D42	D43 V	3.0	B	64
8 2 C 8	F 1	F 3 V	3.0	B	65
8 2 D 8	F17	F19 V	3.0	B	66
8 2 E 8	F33	F35 V	3.0	B	67
8 2 F 8	F53	F51 V	3.0	B	68
8 2 G 8	T33	W35 V	3.5	B	69
8 2 H 8	B 5	B 3 V	3.0	B	70
8 2 J 8	B13	B11 V	3.0	B	71
8 2 K 8	D 2	D 3 V	3.0	B	72
8 2 L 6	D11	D11 V	2.5	B	73
14 3 A14	D20	D19 V	3.0	B	74
14 3 B14	D29	D27 V	3.0	B	75
14 3 C14	D38	D35 V	3.0	B	76
14 3 C14	D47	D51 V	3.0	B	77
14 3 E14	F 9	F11 V	3.0	B	78
14 3 F14	F25	F27 V	3.0	B	79
6 3 P 6	F41	F43 V	3.0	B	80
24 7 A24	P 2	P 3 V	3.0	B	81
28 9 C28					

INPUT	FROM	TO	LENGTH	COLOR	COUNT
ST	T 1	U 3 V	3.0	V	82
PP 9 A V	U 3 V	T21	4.5	V	83
40 9 A40					
88 T21					

INPUT	FROM	TO	LENGTH	COLOR	COUNT
ST	U 7 G	V19	4.0	PR	84
PP 9 A G	V19	V20	3.0	PR	85
40 9 A19					
40 9 A20					

DRAWING NO. PAGE 4

INPUT ST		FROM	TO	LENGTH	COLOR	COUNT
6	1 F 2	X23	Y26	3.0	G	86
14	11 D13	L34	U55	3.0	G	87
16	10 C 4	M34	K35	3.5	G	88
68	U54	J33	G37	3.5	G	89
68	U55	C22	D13	3.5	G	90
20	5 D15	E 2	A 6	4.0	G	91
8	2 C 6	Y26	U54	6.0	G	92
14	3 F 5	U55	M34	5.5	G	93
14	6 E13	K35	J33	3.0	G	94
68	2 A 1	G37	C22	4.5	G	95
46	4 D 5	D13	E 2	4.0	G	96
	P 6					

INPUT ST		FROM	TO	LENGTH	COLOR	COUNT
		G20	J41	5.0	W	97
14	3 C 4					
16	4 E 4					

INPUT ST		FROM	TO	LENGTH	COLOR	COUNT
		K50	L45	3.5	BR	98
20	5 F15	K38	L34	3.0	BR	99
20	5 F 1	L45	K38	3.5	BR	100
20	5 C 1					
20	5 D16					

INPUT ST		FROM	TO	LENGTH	COLOR	COUNT
20	5 B 3	V 1	T 3	3.5	O	101
40	9 A38	L14	T35	5.5	C	102
40	9 A 1	T 3	L14	5.0	C	103
28	9 C26					

DRAWING NO. PAGE 5

INPUT	FROM	TO	LENGTH	COLOR	COUNT
ST	F43	F46	3.0	Y	104
DR	F51	F48	3.0	Y	105
14 3 F12	F43	L31	4.5	Y	106
20 F48	W21	Y15	3.5	Y	107
14 3 G12	V 6	L12	5.0	Y	108
14 3 G10	K26	L31	3.5	Y	109
46 4 F11	D52	B54	3.5	Y	110
DS	B50	B28	5.0	Y	111
40 5 A 6	F53	F51	3.0	Y	112
14 11 B 8	F48	H41	3.5	Y	113
16 10 C15	W23	W21	3.0	Y	114
16 10 C13	Y15	V 6	4.0	Y	115
20 5 C17	L12	K26	4.0	Y	116
20 5 B 1	F43	D52	4.0	Y	117
20 5 C 5	B54	B50	3.0	Y	118
DS	B28	A40	3.5	Y	119
68 2 M 5					
6 1 P 5					
6 1 N 5					
28 B28					
P40					

INPUT	FROM	TO	LENGTH	COLOR	COUNT
ST	P50	A50	7.5	GR	120
P50					
88 P50					

END OF FILE

INVENTORY

LENGTH	NUMBER
2.5	1
3.0	83
3.5	19
4.0	6
4.5	3
5.0	4
5.5	2
6.0	1
6.5	0
7.0	0
7.5	1
8.0	0
8.5	0
9.0	0
9.5	0
10.0	0
10.5	0
TOTAL	120

EXAMPLE OF CALCOMP OUTPUT

(Viewed from wiring side of board)

FROM	TO
X23	Y26
U54	U55
M34	K35
J33	G37
C22	D13
E 2	A 6
Y26	U54
U55	M34
K35	J33
G37	C22
D13	E 2

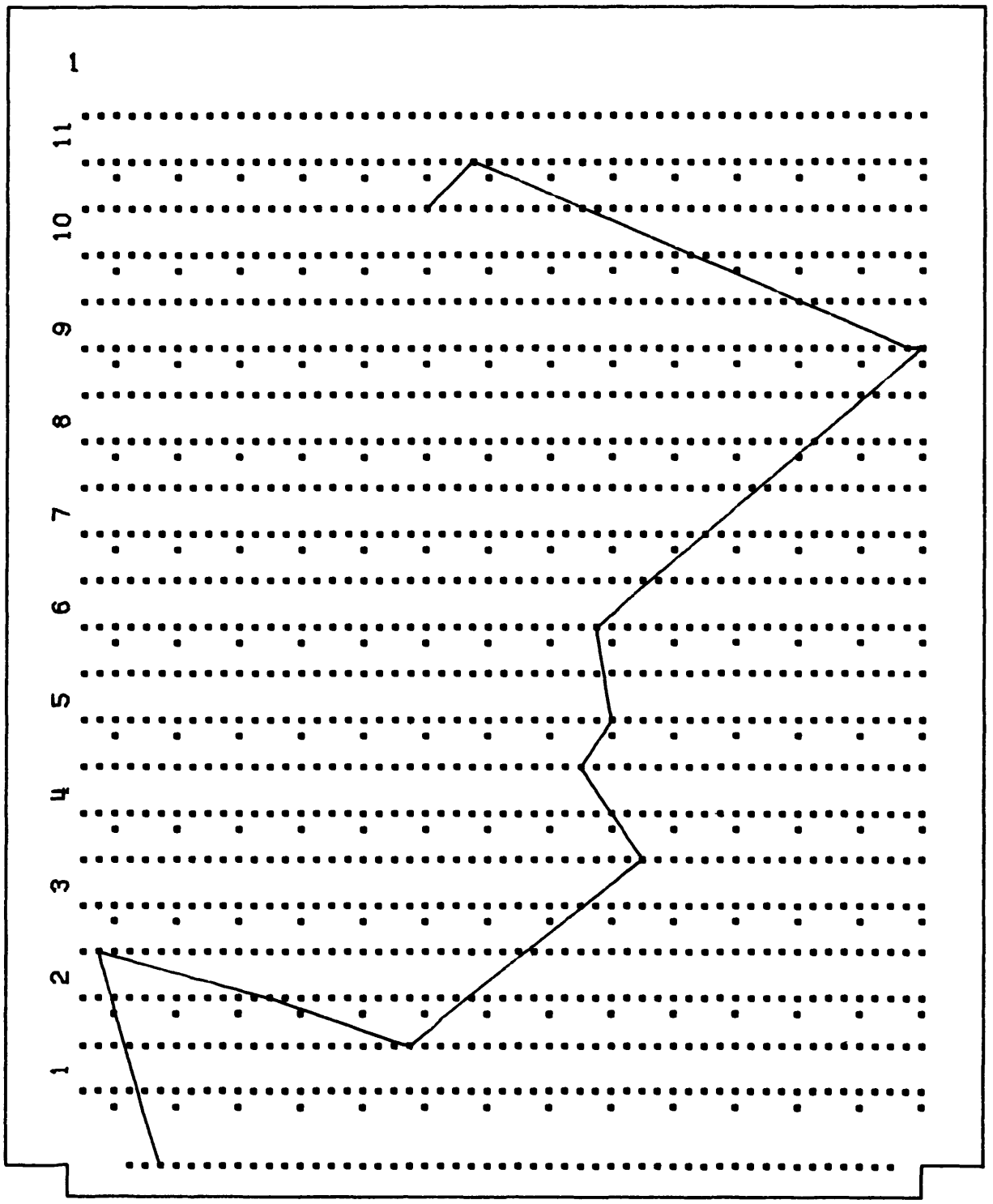


Figure 1

IC LIST

DRAWING NO. 081974

EXAMPLE OF WIRE WRAP DATA

FROM CRT TERMINAL

VERSION 01-081974

10/09/74

NRAO PROJECT NO.

DWG= WIRING NO. REV= AB

CONVERSION TABLE

IC CODE		IC PIN
11	G G	14
IC ROW	IC POS	

N PIN CHIP = IC CODE

2	=	A
4	=	B
6	=	C
8	=	D
10	=	E
12	=	F
14	=	G
16	=	H
18	=	J
20	=	K
22	=	L
24	=	M
26	=	N
28	=	P
30	=	R
32	=	S
34	=	T
36	=	U
38	=	V
40	=	W

DRAWING NO. PAGE 1 OF 7

PIN	FROM		TO		
P 6			2DA 1		
P40			B28		
P50			P5C		
1GA V			1CA 6	1CB 6	
1GA G			1CA 3	1CB 3	
1GB V			1CC 6	1CD 6	1CC 6
1GB G			1CC 3	1CD 3	
1GC G			1CE 3	1CF 3	
1GD G			1CG 3	1CH 3	
1GE G			1CJ 3	1CK 3	
1GF G			1CL 3	1CM 3	
1GG G			1CN 1	1CP 3	
1CA 3	1GA G				
1CA 6	1GA V				
1CB 3	1GA G				
1CB 6	1GA V				
1CC 3	1GB G				
1CC 6	1GB V	1GB V			
1CD 3	1GB G				
1CD 6	1GB V				
1CE 3	1CC G				
1CF 2			3GE 5	2DC 6	
1CF 3	1CC G				
1CG 3	1CD G				
1CH 3	1CD G				
1CJ 3	1GE G				
1CK 3	1GE G				
1CL 3	1GF G				
1CM 3	1GF G				
1CN 1	1GG G				

PIN	FROM		TO	
1CN 5	B28		1CP 5	
1CP 3	1GG G			
1CP 5	1CN 5		2DM 7	
2GA V			2DA 8	2DB 8
2GA G			2DA 4	2DB 4
2GB V			2DC 8	2DD 8
2GB G			2DC 4	
2GC V			2DE 8	
2GC G			2DE 4	
2GD V			2DF 8	2DG 8
2GD G			2DF 4	2DG 4
2GE V			2DH 8	2DJ 8
2GE G			2DH 4	2DJ 4
2GF V			2DK 8	
2GF G			2DK 4	
2GG V			2DL 8	
2GG G			2DL 4	2DM 3
2DA 1	P 8		2DC 6	
2DA 4	2GA G			
2DA 8	2GA V			
2DB 4	2GA G			
2DB 8	2GA V			
2DC 4	2GB G			
2DC 6	1CF 2	2DA 1		
2DC 8	2GB V			
2DD 8	2GB V			
2DE 4	2GC G			
2DE 8	2GC V			
2DF 4	2GD G			
2DF 8	2GD V			
2DG 4	2GD G			
2DG 8	2GD V			
2DH 4	2GE G			
2DH 8	2GE V			

DRAWING NO. PAGE 3 OF 7

PIN	FROM	TO
2DJ 4	2GE G	
2DJ 8	2GE V	
2DK 4	2GF G	
2DK 8	2GF V	
2DL 4	2GG G	
2DL 8	2GG V	
2DM 3	2GG G	
2DM 7	1CP 5	3GF12
3GA V		3GA14
3GA G		3GA 7
3GB V		3GB14
3GB G		3GB 7
3GC V		3GC14
3GC G		3GC 7
3GD V		3GD14
3GD G		3GD 7
3GE V		3GE14
3GE G		3GE 7
3GF V		3GF14
3GF G		3GF 7
3GG V		3CP 6
3GG G		3CP 3
3GA 7	3GA G	
3GA14	3GA V	
3GB 7	3GB G	
3GB14	3GB V	
3GC 4		4HE 4
3GC 7	3GC G	
3GC14	3GC V	
3GD 7	3GD G	
3GD14	3GD V	
3GE 5	1CF 2	4HD 5
3GE 7	3GE G	
3GE14	3GE V	

PIN	FROM	TO
3GF 7	3GF G	
3GF12	2DM 7	F48 5KC 9
3GF14	3GF V	
3GG10		3GG12
3GG12	3GG10	F48
3CP 3	3GG G	
3CP 6	3GG V	
4GA G		4HA 8
4GB G		4HB 8
4GC G		4HC 8
4GE G		4HD 8
4GF G		4HE 7
4GG G		4HF 8
4HA 8	4GA G	
4HB 8	4GB G	
4HC 8	4GC G	
4HD 5	3GE 5	5KD19
4HD 8	4GE G	
4HE 4	3GC 4	
4HE 7	4GF G	
4HE13	F48	
4HF 8	4GC G	
5GA G		5KA10
5GC G		5KB10
5GD G		5KC10
5GE G		5KD10
5GG G		5KE10
5KA10	5GA G	

PIN	FROM		TO	
5KB 1			9WA 6	5KC17
5KB 3			9WA38	9PC26
5KB1C	5GC G			
5KC 9	3GF12		5KC17	
5KC1C	5GC G			
5KC17	5KB 1	5KC 9		
5KD 1			5KD16	
5KD1C	5GE G			
5KD16	5KD 1		5KE 1	
5KD19	4HD 5		6GE13	
5KE 1	5KD16		5KE15	
5KE1C	5GG G			
5KE15	5KE 1			
6GA G			6GA 7	
6GB G			6GB 7	
6GC G			6GC 7	
6GE G			6GE 7	
6GF G			6GF 7	
6GA 7	6GA G			
6GB 7	6GB G			
6GC 7	6GC G			
6GE 7	6GE G			
6GE13	5KD19		U55	
6GF 7	6GF G			
7GA V			7MA24	
7GA G			7MA12	
7GE G			7MB12	7MC12
7GG G			7MD12	
7MA12	7GA G			
7MA24	7GA V			

PIN	FROM		TO
7MB12	7GE G		
7MC12	7GE G		
7MD12	7GG G		
9GA V	T21		9WA40
9GA G			9WA19
9WA 1			9WA38
9WA 6	5KB 1		11GB 8
9WA19	9GA G		9WA20
9WA20	9WA19		
9WA38	9WA 1	5KB 3	
9WA40	9GA V		
9PC14			10GE G
9PC26	5KB 3		
9PC28			10GE V
10GA G			10HA 8
10GE V	9PC28		
10GE G	9PC14		
10HA 8	10GA G		
10HC 4			11GD13
10HC13			10HC15
10HC15	10HC13		11GB 8
11GA G			11GA 7
11GB G			11GB 7
11GA 7	11GA G		
11GB 7	11GB G		
11GB 8	10HC15	9WA 6	
11GD13	10HC 4	U54	

DRAWING NO. PAGE 7 OF 7

PIN	FROM		TO
B28	P40		1CA 5
F48	5GF12	3GG12	4HE13
P5C	P50		
T21			9GA V
U54	U55		11GD13
U55	6GE13		U54

FORMS AND TABLES

The next several pages are various forms, layouts and conversion tables that the user of the NRAO wire wrap boards might find useful. Additional copies of any of the forms, layouts or tables may be obtained from the CV Digital Lab.

GUIDE FOR ENTERING PROGRAM INSTRUCTIONS AND TITLE PAGE INFORMATION

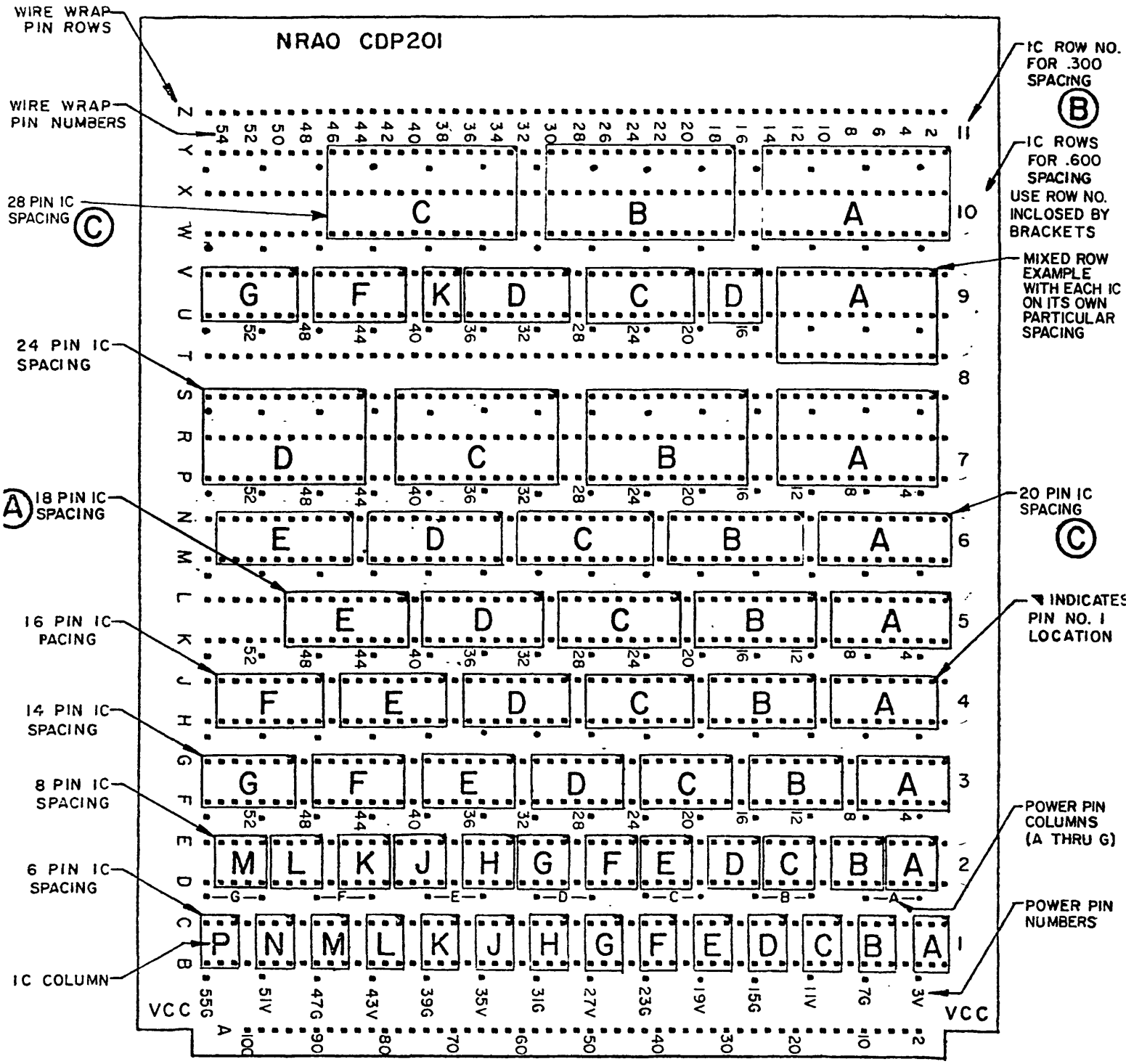
TYPE:

ENTER |_|_|_|_|_|_|_|_|

CRT LINE NO.	TYPE ON CRT LINE NO.:
1	INPUT DISP NOPUNCH or PUNCH
2	DEFINE ROW TYPE
3	1 2 3 4 5 6 7 8 9 10 11
4	DD
5	Logic drawing no. & rev. TITLE='_____' Date of latest rev. BDATE='MO DA YR';
6	Wiring list version & date VERSION='___-MO DA YR';
7	50 spaces available for description - 1 CRT line - the computer will print des. on 2 lines with 25 (max) characters per line. User may center his des. DES='_____';
8	Project no. or name PROJECT='_____';
9	Wiring list no. DWG='_____' Wiring list rev. REV='___';
10	PINLIST='NOPUNCH'; or 'PUNCH'
11	WIRELIST='PRINT'; or 'NOPRINT'

Lines 5 through 9 contain information for the title page.

Figure 2



NOTES:

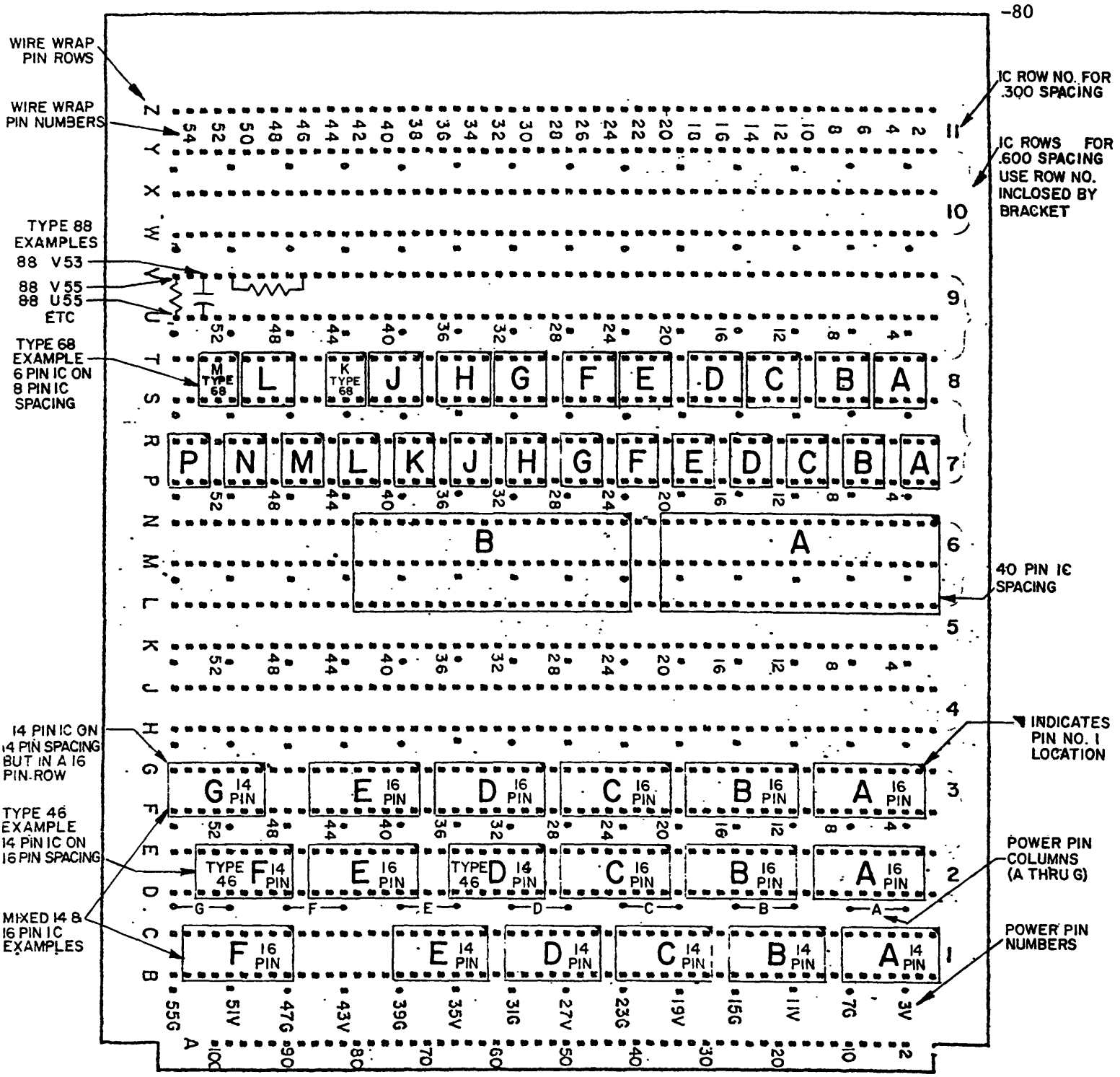
1. COMPONENT SIDE OF BOARD SHOWN
2. THE CDP202 BOARD HAS ONLY 5 IC ROWS AVAILABLE INSTEAD OF THE 11 IC ROWS SHOWN.
3. Vcc PLANE I/O CONNECTIONS: 2, 4, 98, 100
4. GND PLANE I/O CONNECTIONS: 1, 3, 27, 28*, 49, 50*, 73, 74*, 97, 99
5. 6 & 14 PIN ICs ARE ON SAME SPACING
6. 8 & 16 PIN ICs ARE ON SAME SPACING

* GND BUS CONNECTIONS ONLY.
NO P.C. CONNECTIONS ON W.W. BOARD

A	ADDED 9-25-73 JE
B	.300 WAS .030 .600 WAS .060 1-17-74 JE
C	ADDED 9-19-74 SSR
D	CHANGED .600 SPACING NOTATION 10-10-74 SSR

WIRE WRAP BOARD IC LAYOUT (SHEET 1 OF 2)

FIGURE 3



SEE NOTES ON SHEET 1 (FIGURE 3).

WIRE WRAP BOARD IC LAYOUT (SHEET 2 OF 2)

FIGURE 4

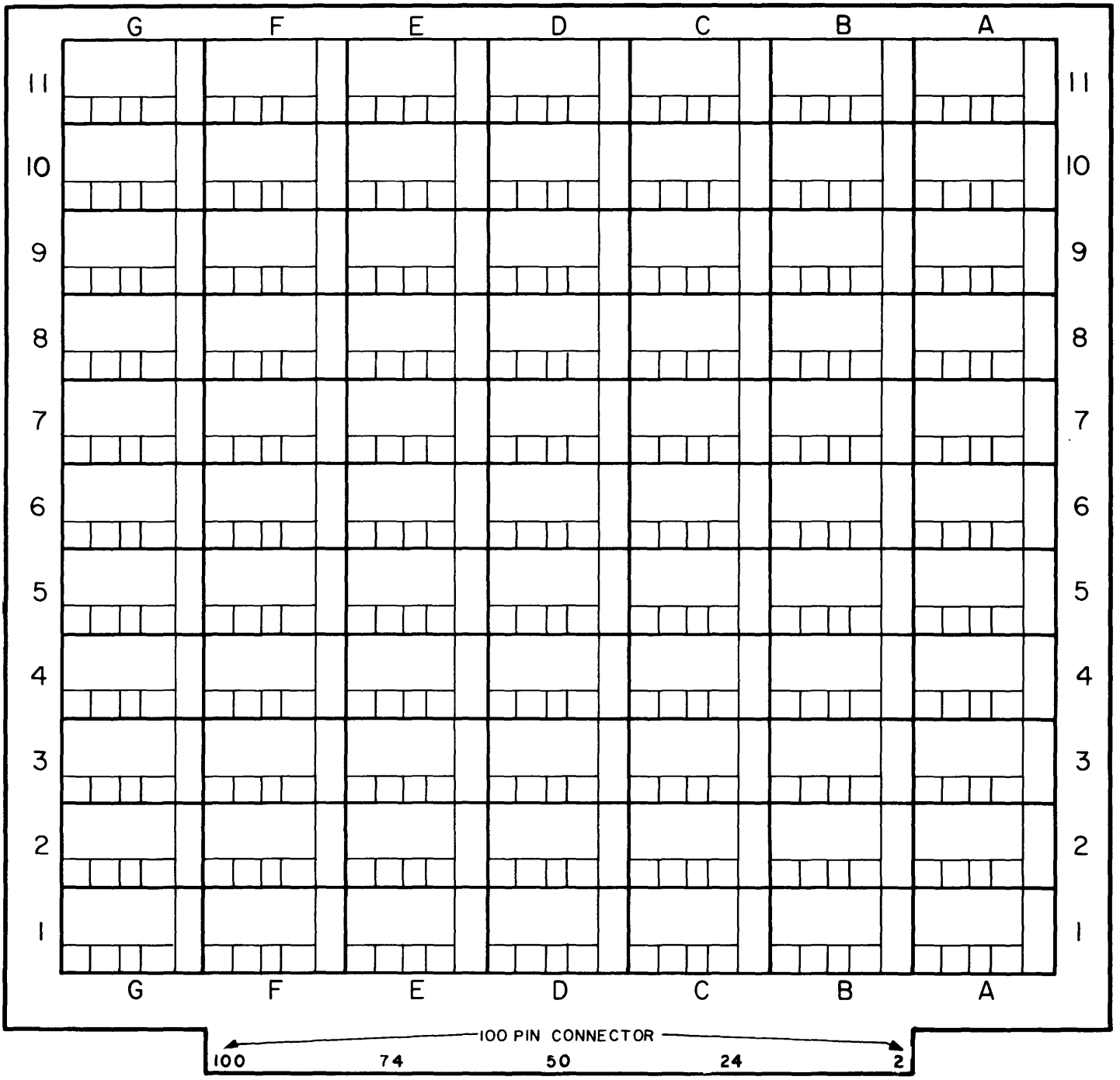
WIRE WRAP BOARD COMPONENT LOCATION -2

NRAO

BY _____

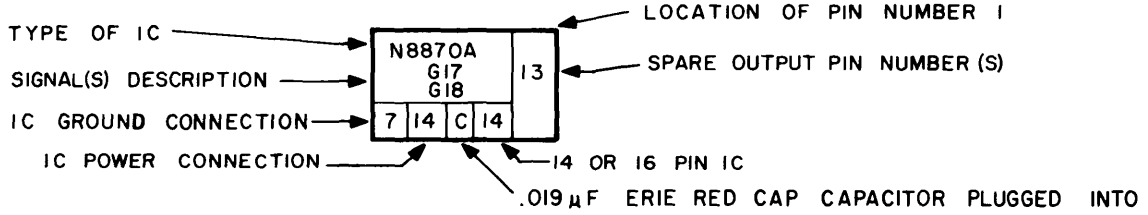
LOCATION

DATE _____



NOTES:

1. SAMPLE BOX



2. TOP VIEW, COMPONENT SIDE OF BOARD
3. **THIS COLUMN NOT AVAILABLE**
4. **VCC** CONNECTOR PINS: P2, 4, 98, 100 – GND. CONNECTOR PINS: P 1, 3, 27, 49, 73, 97, 99

TABLE 1

NRAO

Wire Wrap Printed Circuit Board
Wire List Power Conversion Chart

November 9, 1972

Rev. A Added 18 Pin
Rev. B Added 20 & 28 Pin

6 PIN IC			8 PIN IC			14 PIN IC		
IC Column	Power Pin Column		IC Column	Power Pin Column		IC Column	Power Pin Column	
A	AV	AG	A	AV	AG	A	AV	AG
B	AV	AG	B	AV	AG	B	BV	BG
C	BV	BG	C	BV	BG	C	CV	CG
D	BV	BG	D	BV	BG	D	DV	DG
E	CV	CG	E	CV	CG	E	EV	EG
F	CV	CG	F	DV	DG	F	FV	FG
G	DV	DG	G	DV	DG	G	GV	GG
H	DV	DG	H	EV	EG			
J	EV	EG	J	EV	EG			
K	EV	EG	K	FV	FG			
L	FV	FG	L	GV	GG			
M	FV	FG	M	GV	GG			
N	GV	GG						
P	GV	GG						

16 PIN IC		
IC Column	Power Pin Column	
A	AV	AG
B	BV	BG
C	CV	CG
D	EV	EG
E	FV	FG
F	GV	GG

24 PIN IC		
IC Column	Power Pin Column	
A	AV	AG
B	CV	CG
C	EV	EG
D	GV	GG

18 PIN IC		
IC Column	Power Pin Column	
A	AV	AG
B	BV	BG
C	CV	CG
D	EV	EG
E	FV	FG

28 PIN IC		
IC Column	Power Pin Column	
A	AV	AG
B	CV	CG
C	EV	EG

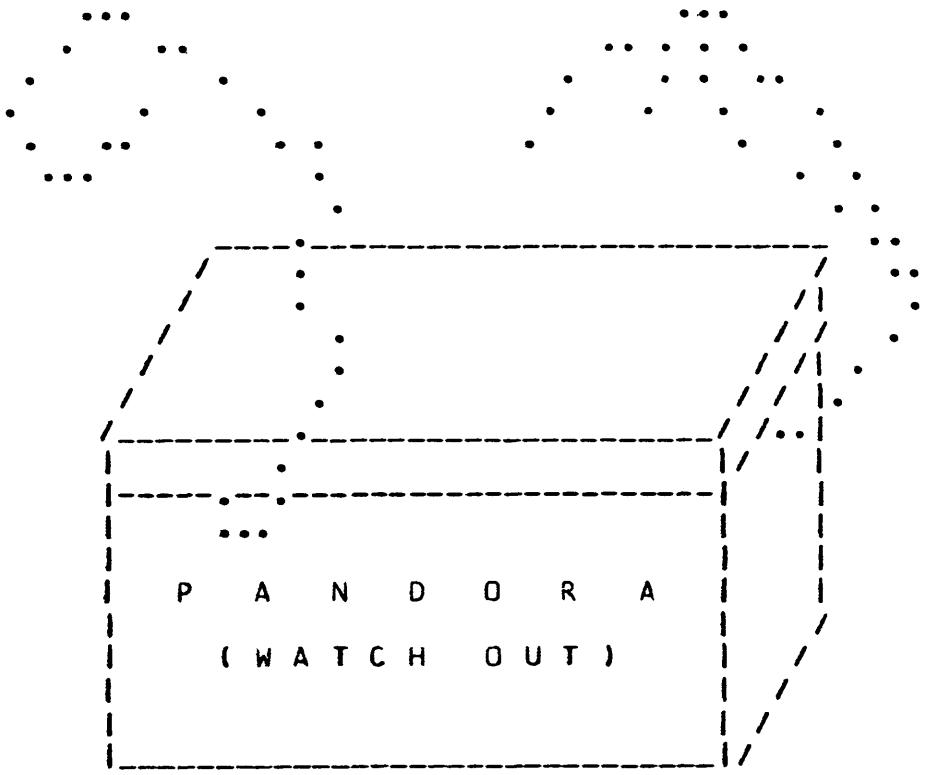
Power Pin Column		V Pin Number	G Pin Number
A	=	3V	7G
B	=	11V	15G
C	=	19V	23G
D	=	27V	31G
E	=	35V	39G
F	=	43V	47G
G	=	51V	55G

0.60" IC Row Spacing	Power Pin Row Used
1	B
3	H
4	H
6	P
7	P
9	W
10	W

20 PIN IC		
IC Column	Power Pin Column	
A	AV	AG
B	CV	CG
C	DV	DG
D	EV	EG
E	GV	GG

APPENDIX C

Copies of Computer Division Internal Report #19 can be obtained from the Computer Division.



BY AL BRAUN, DAVE EHNEBUSKE, AND JERRY HUDSON

COMPUTER DIVISION INTERNAL REPORT #19