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DRILL USER'S MANUAL

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PREFACE

This document presents instructions for the use of the DRILL Program. This software was developed to provide the printed wiring board designer with a convenient method for converting data contained in an Interactive Computer Graphics System (IGDS) design file to production of a paper tape for driving an Excellon MK-III numerically-controlled drilling machine.

It is assumed that the reader is familiar with the IGDS and RSX-11D systems; therefore, no attempt has been made to describe either system unless a part of the system is peculiar to DRILL Program operation.

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1. INTRODUCTION

The DRILL Program was developed to provide the printed wiring board (PWB) designer with a convenient method for converting data contained in an IGDS design file to the production of a paper tape for driving a numerically-controlled drilling machine. This capability, along with the artwork generation software, fully automates the translation of IGDS-created designs to the PWB production. For the DRILL software, the user is obliged to use standard IGDS cell names to uniquely identify the position and size of the holes required in the board. Aside from this requirement, no other special considerations are necessary.

Specifications for the paper-tape format were obtained from Excellon Automation, the MK-III equipment manufacturer. The MK-III will accept either the "EIA" (EIA RS-244) or the "ASCII" (EIA RS-358) paper-tape format for inputting control commands. Since the EIA format is more common, it was chosen for the DRILL software to improve the chances of compatibility with other manufacturer's drill machines.

2. OPERATING INSTRUCTIONS

This section contains instructions for DRILL Program input preparation, operation, and output.

2.1 IGDS Cell File Conventions

In order for the DRILL software to be able to recognize those IGDS design elements which represent drill locations, special cell names must be used. A convention has been adopted in which the user places "DRIL" in the first four positions of a six-character cell name to signal the DRILL Program of the presence of a hole. The last two characters in the name are selected by the designer to define different hole diameters; for example, the name DRILØ1 would represent holes of one diameter, while DRIL-A, DRILXY, etc., would represent holes of different diameters.

2.2 Pre-Execution Considerations

The DRILL Program is task built to utilize the initiating terminal as the paper-tape output device. If the computer facility has a high-speed paper-tape punch (HSP), the user is required to reassign a logical unit number of the DRILL Program to the HSP (see Section 2.3 for details). If an HSP is not available, the device most likely to be capable of punching tape (e. g., a TTY) is the system console. This configuration poses a problem if other users are on the system at the time the DRILL Program is running, since system messages (dismounts, errors, etc.) may be output and interspersed with the desired output. If the user is confident that no other output will be sent to the system console while the DRILL Program is running, no special action is required. If, however, there is no assurance of that; it is advisable to redirect all system console pseudodevices to an unused graphics terminal (see Section 2.3 for details).

2.3 Execution Instructions

This section presents the sequence of RSX-11 commands and DRILL Program responses to queries that are required to produce a paper tape. The conventions followed in this presentation are the same as those used in RSX-11D documentation in that: capital letters represent required input, and lower-case letters represent user-determined input; underlined entries represent system or program-generated text, while text that is not underlined represents user input.

In addition to the "permissible responses to prompts from the DRILL Program" that are shown below, it is allowable to respond with a control Z for any one of them. The effect, with one exception, is for the program to back up and reissue the preceding query. (The exception is that the control

Z will cause program termination if it is issued in response to the first query. This feature is useful in allowing the operator to correct mistakes i in data already entered.)

    <u>MCR</u> HEL [1, 1]

    <u>MCR</u> INS DRILL/UIC[1, 1]

  *<u>MCR</u> REA DRILL 4 PP:

 **<u>MCR</u> RED TTn: = CL:

 **<u>MCR</u> RED TTn: = CO:

 **<u>MCR</u> RED TTn: = MO;

    <u>MCR</u> RUN DRILL

<u>ENTER DESIGN FILE NAME</u> - User Response

Permissible User Response: dev:[g, u]filename. ext;ver

Effect: Subject file is opened for input.

<u>ENTER DESIGN SCALE FACTOR (UORS/INCH)</u> - User Response

Permissible User Response: n, an integer to specify scale factor

<div align="center">OR</div>

Blank to utilize scale factor in IGDS file.

Effect: Scale factor is set as indicated and the following messages are output.

<u>SCALE FACTOR IS n UORS/IN</u>

<u>Note:</u>

* Required only for installation with HSP.

** Required only if an alternate terminal (TTn:) is to be temporarily used as system console (see discussion, Section 2. 2).

<u>READY PUNCH AND TYPE A RETURN TO GO</u>

> User Response: Simply type a return if scale factor is satisfactory.

> Effect: Processing commences: the paper tape is punched and the following table is output to the terminal.

<u>***DRILL ORDER***</u>

<u>DRILL NAME NO. OF STROKES</u>

<u>DRILnn</u>

<u>   m </u>

    .

    .

    .

<u>DRILL -- STOP</u>

2.4   <u>Description of Output</u>

The paper tape which is output by the program is illustrated in Figure 2-1. All data for each drill size is consecutively output on the tape, thereby minimizing the number of machine stops for drill changes. In order to reduce the volume of tape produced, trailing zeros are suppressed and consecutive drill strokes with identical X or Y coordinates will not have the X or Y data present. Both of these measures are compatible with Excellon controller software and are believed to be compatible on an industry-wide basis.

PAPER TAPE FORMAT

1.   LEADER (36 inches)

2.   FEED (4 inches)

3.   REWIND STOP CODE

4.   CARRIAGE RETURN (EOB)

5.   T01

6.   XnnnYmmm   (n and m per IGDS Design File)

        (Repetition of X and Y as above as required to specify
        locations of all holes with first drill)

7.   T02

        (Repetition of items 5 and 6 for remaining drill sizes)

8.   M00

9.   CARRIAGE RETURN (EOB)

10.   TRAILER (36 inches)

NOTE: See Appendix A for explanation of paper-tape codes.
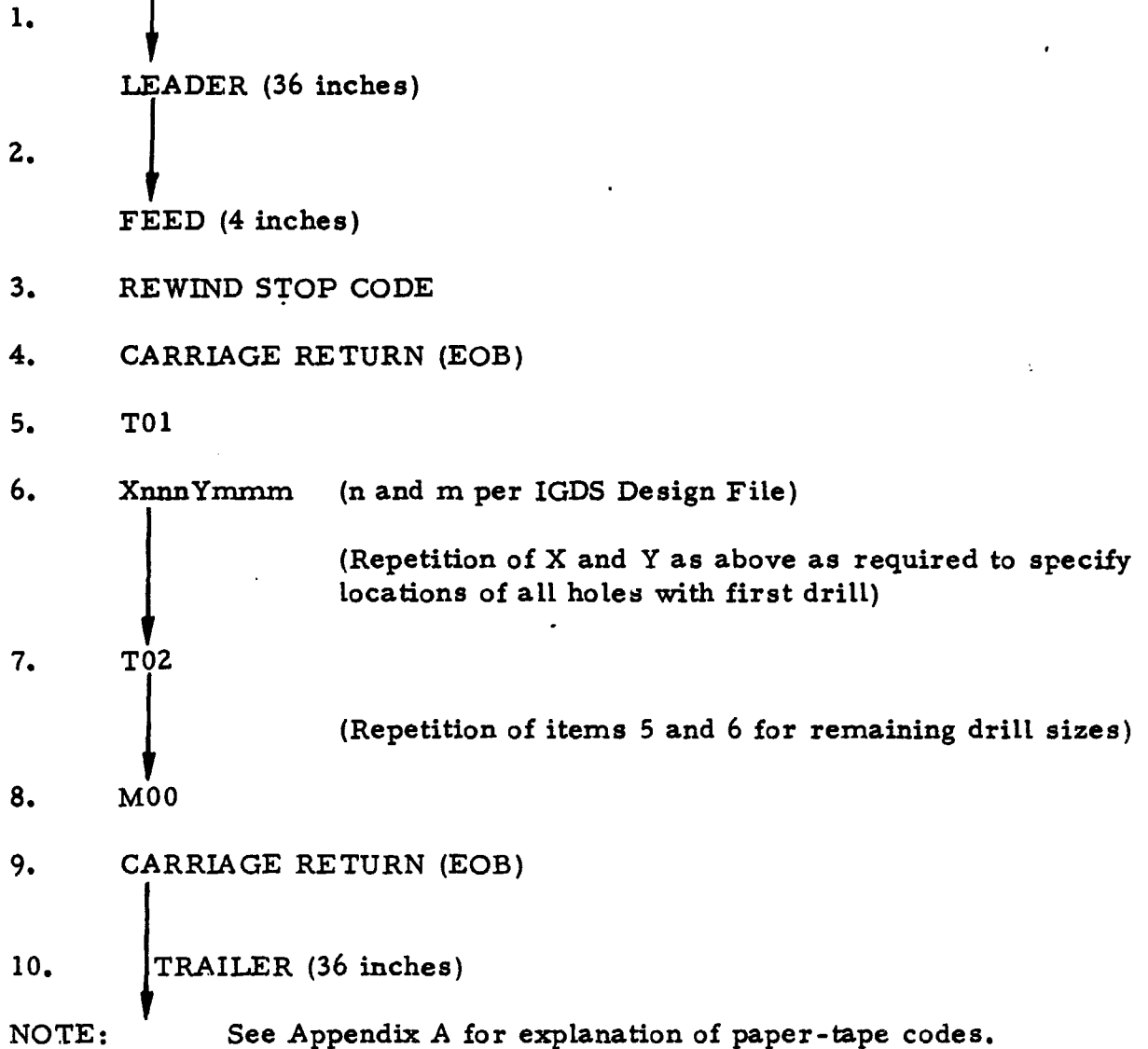
Figure 2-1
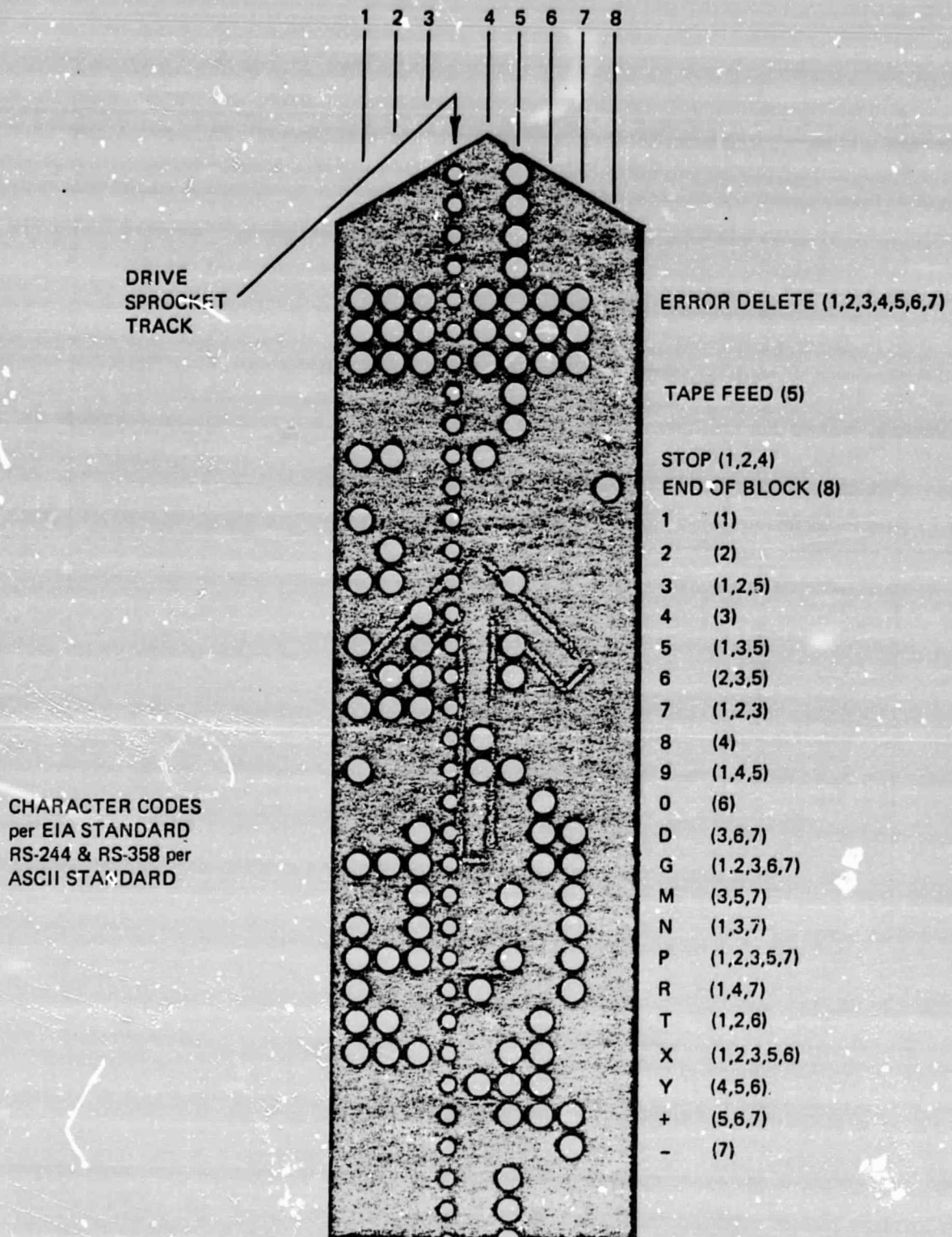
APPENDIX A

EXCELLON MK-III PROGRAMMING INFORMATION

Figure 5-2. Tape Character Codes

5.2.2.1 Feed Holes

Feed holes can be placed anywhere within a tape, with one important rule to remember: Prior to reading tape data, feed holes will be accepted indefinitely by the computer; after reading the tape data, the 51st consecutive feed hole will be interpreted as a program stop command. Tape reading will cease. The machine will then move to the park position. The length, therefore, of feed holes within a tape must never exceed five consecutive inches. There is no limit to the total length of feed holes within a tape, provided no more than five consecutive inches occur at any one time. On the other hand, when preparing an endless loop tape, the length of consecutive feed holes from the end of the tape data to the beginning of the tape data (in the splice area) must always exceed five inches for proper tape operation.

5.2.2.2 Error Delete Code

The error delete code punched over an existing row of holes causes the tape reader to disregard that row and advance to read the next row. The error delete codes can also function as tape feed information.

5.2.2.3 Stop Code

The stop code (EIA-tracks 1, 2 and 4 or ASCII-tracks 1, 3, 6 and 8) will cause a rewinding tape to stop.

5.2.2.4 Parity Checks

The control checks parity. A lack of parity will cause reader to stop and the data error lamp to illuminate. The block containing the data error will be visible in the read-head portion of the reader. A parity failure usually is indicative of worn, damaged or dirty tape.
In general, the program follows EIA Standard RS-273, dated January 1963.

5.3 PROGRAM COMMANDS

5.3.1 Sequence Number

Sequence number consists of the character N followed by, up to four digits. A sequence number of 9999 is the largest accomodated. The sequence number (if used) must precede all other information in a block.

5.3.2 Dimension Commands

The dimension command consists of the appropriate letter address (X or Y), proper directional sign (absence of a sign will be interpreted by the control as a plus) and up to six digits. Unless omitted, the X axis command precedes the Y. Location of any point can be defined by the combination of an X and a Y dimension command giving the distance and direction in each axis from zero (or in the case of incremental programming, from previous hole).

For dimension commands in inches, decimal point is assumed to follow the second digit. For millimeter commands the decimal point follows the fourth digit.

A drill stroke is initiated every time a block of dimensional information is read. Exceptions to this are; a program stop command is read in the same block, machine is in "no drill mode" is responding to step-and-repeat offset information, or an M09 command is used.

The dimension command normally begins the block of information (or in the use of sequence numbers, immediately follows the sequence number). Exceptions to this rule will be subsequently described in this section.

5.3.3 Miscellaneous Commands

Each miscellaneous command consists of the letter M followed by 2 digits. These commands and their purpose are listed in *Table 5-2*. A miscellaneous command can appear in a block by itself, precede, or follow the dimension command.

For proper placement, refer to the programming examples subsequently described in this section.

5.3.4 Stored Pattern Commands

Each stored pattern command consists of the character G followed by 2 digits. The command and pattern functions are listed in *Table 5-2*. The stored pattern appears in a block by itself.

5.3.5 Absolute/Incremental Command

A G90 command references all dimensional commands to a common zero (datum) line (absolute), whereas G91 (incremental) refers each dimension to the previously drilled hole. The functions are further detailed in *Table 5-2*.

TABLE 5-2. PROGRAM COMMAND DIRECTORY

MISCELLANEOUS COMMANDS	
COMMAND	**PURPOSE**
M00	Program stop command M00 prevents execution for the next block of information after the commands in the previous block or in the block containing M00 have been completed. If M00 is included in a block of coordinate information, no drill cycle will be initiated. When M00 is read, the computer will indicate program completion and the worktable will move to the park position.
M01	Used only with automatic step-and-repeat. An M01 indicates completion of the hole pattern to be stepped and repeated. M01 also advances the pattern counter. M01 constitutes a complete block of information.
M02	Used only with automatic step-and-repeat. Each offset is preceded by an M02. M02 appears in the same block as the offset itself. M02 also advances the offset counter. An unlimited number of offsets can be programmed. M02 = M00 in a non-step-and-repeat program (M00 is preferred).
M04	No-drill command. Used only with step-and-repeat. M04 constitutes a complete block of information.
M08	Used only with automatic step-and-repeat. An M08 command is programmed in a block by itself following step-and-repeat offsets. M08 clears the position registers, the M04 con. and and the offset counter. When an M08 is read and the pattern counter do not agree, the next pattern will be drilled. If the two counters agree at the time M08 is read, the program stop circuit will be actuated, terminating the program. At the same time, the pattern counter will be reset to zero.
M09	When this command (M09) is used alone, program will be stc ꞏ ꞏed for inspection purposes. If used in the same block with coordinate information, the worktable will move to that location and stop but drill stroke will be prevented. Example: M09X01Y01.
M30	Same as M00 program stop command with the added function of rewinding tape to program start. Indicates completion of a sequence in conjunction with M31.
M31	A properly programmed M31 signals the computer to continue separate drill sequences linked by M30 commands. M31 saves time in a step-and-repeat program by permitting all same-size holes to be drilled prior to drill size change. M31 constitutes a complete block of information.

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TABLE 5-2. PROGRAM COMMAND DIRECTORY (cont.)

MISCELLANEOUS COMMANDS (Cont.)	
COMMAND	**PURPOSE**
M80	X-inversion command M80 in a step-and-repeat program causes the drilling machine to interpret subsequent X dimension commands as reversed in direction, so that the basic hole pattern is "flipped" about the Y-axis as a mirror image pattern. The M80 command follows coordinate information in the offset block to be mirror imaged.
M90	Y-inversion command M90 causes Y direction commands to be interpreted as reversed in direction, to drill mirror image pattern symmetrical about the X-axis. The M90 command follows coordinate information in the block to be mirror-imaged.
G92	A G92 command preceding coordinate information (G92 appears in the same block as coordinate information) establishes location defined by the coordinate information as a working (floating) zero in relation to the machine home position. Any working (floating) zero previously established (manually or via a previous G92 command) is automatically elimenated.

STORED PATTERN COMMANDS	
COMMAND	**PURPOSE**
G81	The G81 command calls for the 14 pin dual-in-line intergrated circuit package hole pattern. A G81 constitutes a complete block of information.
G82	The G82 command calls for the 16 pin dual-in-line intergrated circuit package hole pattern. A G82 constitutes a complete block of information.
G83	The G83 command calls for the circular 8 pin plug-in L-package hole pattern and constitutes a complete block of information.

TABLE 5-2. PROGRAM COMMAND DIRECTORY (cont.)

ALTERABLE STORED PATTERN COMMANDS	
COMMAND	**PURPOSE**
G84	The G84 command is an alterable stored pattern command permitting holes 1/4 in. (6.4 mm) dia. and larger to be made via a series of interconnecting 1/8 in. (3.18 mm) dia. holes drilled around the periphery.
G85	The G85 command is an alterable stored pattern command which permits slots to be made via a series of closely spaced drilled holes.
ABSOLUTE/INCREMENTAL COMMANDS	
COMMAND	**PURPOSE**
G90	A G90 command preceding coordinate information will cause the computer to interpret information from the tape as absolute data (all holes referenced to the same zero or datum line). The computer normal operating mode is in this manner. The G90 command can be omitted. A G90 command constitutes a complete block of information.
G91	A G91 command preceding coordinate information will cause the computer to interpret coordinate data incrementally with each hole dimensioned from the previous one. A G91 command constitutes a complete block of information.

5.3.6 Repeat Pattern Commands

Each repeat pattern command consists of the proper character address and 2 digits. Character address used to repeat a single hole is character R. To repeat a stored pattern, character P is used. The 2 digits represent the number of times to repeat a particular hole or stored pattern. Unless sequence numbers are used, repeat pattern commands precedes all other information in the block calling for a repeat. If sequenc₂ numbers are used, the repeat pattern commands follow the sequence number.

5.3.7 Tool Select Commands

Each tool select command causes drill changer equipped machines to automatically change drill size. This command will cause a machine not so-equipped, to stop at the appropriate time to allow manual drill change. The control will accept 6 different commands for each of 6 possible tool selections. They are as follows:

$$T01,T10,T1,D01,D10,D1 = \text{Tool No. 1}$$
$$T02,T20,T2,D02,D20,D2 = \text{Tool No. 2}$$
$$T03,T30,T3,D03,D30,D3 = \text{Tool No. 3}$$
$$T04,T40,T4,D04,D40,D4 = \text{Tool No. 4}$$
$$T05,T50,T5,D05,D50,D5 = \text{Tool No. 5}$$
$$T06,T60,T6,D06,D60,D6 = \text{Tool No. 6}$$

The tool select command can constitute a complete block of information. In this case, all coordinate data following this block will be drilled with the new drill size. The tool select command can also be included in the same block with the first hole wherein the new drill size is defined (either preceding or following the coordinate data).

5.3.8 Feed And Speed Commands

The drilling machine described in this manual can be supplied with an option that allows spindle feed and speed to be included in the part program tape. Characters used for this purpose are F and S followed by 3 digits signifying the feed and speed desired.
Feed rate is programmed in inches per minute (ipm). Each digit represents a 1 ipm increment (F125 represents a spindle feed rate of 125 inches/minute).
Spindle speed is programmed in revolutions per minute (RPM). Each digit represents 100 RPM increments (S585 represents a spindle RPM of 58,500).

5.4 PROGRAMMING EXAMPLES

The examples of drilling programs described have been simplified for clarity, but are otherwise valid. The following general assumptions apply to the illustrations and instructions.

a. The printouts shown in the illustrations are a printout of the drilling tape that would be obtained if the tape were run through a printout device (except as noted in Paragraph b).

b. Rewind stop codes do not provide an alphanumeric printout. The words "stop code" will appear in the location for which a stop code is required.

c. Each line of the printout is assumed to be followed with an end-of-block (EOB) character. On most printout devices, the EOB character activates the carriage return function — hence, a new line in the printout.

d. In the illustrations, work zero locations are circled for identification and arrows point positive (+) axes directions.

e. The figure "0" in the printouts is a numeral not a letter.

f. For simplicity, holes are assumed to be at the nominal location. For instance, a hole is considered to be exactly at X=00.2000 inch rather than at X=00.2004 inch or 00.1997 inch.

g. For clarity, printouts shown in the programming illustrations with all dimension commands shortened.

5.4.1 Example Of Basic Hole Pattern Without Auto Rewind

Figure 5-3 depicts a basic program for a single pattern of holes to be drilled without automatic tape rewind capability. Program the tape in the following manner.

a. Punch approximately 24 inches (610 mm) of leader (tape feed) on the tape.

b. Follow the tape leader with the X and Y coordinates of the holes to be drilled. The X axis information should precede the Y axis. Each block of information (an X and Y coordinate for one hole) must be followed by an EOB character. Holes will be drilled in the same sequence as punched on the tape.

c. After the last block of coordinate information, enter a final block containing a program stop command (letter M and two zeros). The final block also requires an EOB character after the stop command.

d. Punch approximately 24 inches of leader at the end of the tape. The 24 inch leader at each end of the tape provides ample length for using reader reels.

NOTE

Sequence numbers are included on Figure 5-3 (example) to indicate proper placement. Sequence numbers may be added to any example shown in this manual.
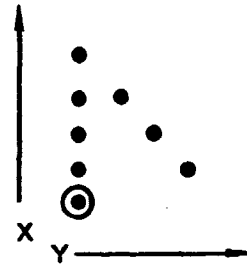
Figure 5-3. Basic Hole Pattern Without Auto Rewind

5.4.2 Example Of Basic Hole Pattern With Auto Rewind

The example in *Figure 5-4* uses a basic hole pattern identical to that of *Figure 5-3* except that the program take advantage of the automatic tape rewind capability. Program as follows:

a. Run approximately 24 inches (610 mm) of tape feed.
b. Program rewind stop code (tape tracks 1,2, and 4).
c. Follow rewind stop code with EOB character.
d. Enter all blocks of the hole pattern coordinates.
e. After the last block of coordinate information for the basic hole pattern has been programmed, enter the automatic tape rewind command M30 followed by an EOB code. Note that the M30 command replaces the M00 of the previous example.
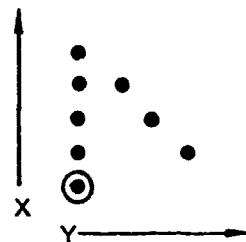f. Punch 24 inches of feed holes and the tape for this example is complete.

Figure 5-4. Basic Hole Pattern With Auto Rewind

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