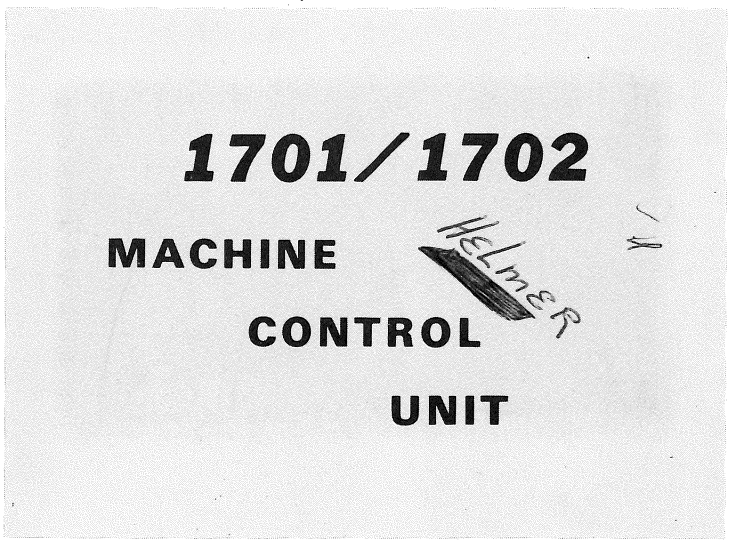
USERS MANUAL



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070-1072-00 1070

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year.

Any questions with respect to the warranty, mentioned above should be taken up with your Tektronix Field Engineer or Representative.

All requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type (or Part Number) and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

U.S.A. and foreign Tektronix products covered by U.S. and foreign patents and/or patents pending.

TABLE OF CONTENTS

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

Fig. 1-1. Tektronix 1701 Machine Control Unit

SECTION 1
CHARACTERISTICS

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The Tektronix 1701 and 1702 Machine Control Units are designed to translate digital data inputs into servo and switching signals for controlling motion and auxiliary functions of 2-axis (1701) and 3-axis (1702) machines. The basic Machine Control Units shown in the frontispiece consist of integrated logic circuitry on plug-in circuit cards, power supplies, an operator's control and readout panel, and a tape reader. Several options are available to adapt the 1701 and 1702 to special control requirements. The options available are listed at the rear of this section.

The characteristics that best illustrate the capabilities of the basic 1701 and 1702 Machine Control Units are as follows:

Standard Features

a. 3-Axis contouring control with linear interpolation (in the 1701, the third axis is limit-switch controlled only).

b. Absolute programming.

c. Closed loop servo system.

d. Resolution up to 0.0001 inch.[1]

e. Acceleration/Deceleration is automatically controlled (see Fig. 1-2).

f. Feedrates (0 to 240 inches per minute in 1-inch-per-minute increments) are programmed directly.

g. Positioning range is 0 to 99.9999 inches.[1] First quadrant absolute programming is used.

h. Full floating zero.

i. A CRT Interface is provided to drive a Tektronix Type 611 Display Unit. When connected to the Type 611, the 1701 and 1702 can output to the Type 611 storage CRT, and thus display the path of the tool before actual machining takes place. This feature permits checking tape and program validity quickly and inexpensively as opposed to cutting a piece of material. CRT resolution is 0.0256 inch.

j. Readout display of G, X, Y, Z, and F commands (G, X, Y, F, and M commands in the 1701) read from the tape or dial inputs, as well as the actual coordinate position attained by the controlled machine. The readout desired is selected by a front-panel switch.

k. Manual data input of commands (G, X, Y, F, and M in the 1701; G, X, Y, F, and Z in the 1702). The manual data input also permits presetting the X, Y and Z axes positions.

l. Auxiliary functions GØØ (positioning mode) and GØ1 (contouring mode) are standard in both the 1701 and 1702. In addition, M (miscellaneous) functions MØØ, MØ2, MØ3, MØ5, MØ8, M3Ø and M31 are standard in both units. MØØ, MØ2, and M3Ø are used internally only; the other M functions are accessible for external use.

m. Sequence number readouts from 0 to 999.

n. Adjustments are minimized. The 1701 and 1702 have only three adjustments per axis.

o. The cooling air keeps the cabinets under a slightly positive air pressure, reducing the possibility of foreign matter getting inside the cabinets.

Inputs

The data input to the 1701 and 1702 Machine Control Units can be either word-addressed EIA code from the tape reader, or manual input from front-panel switches. The 1701 and 1702 also require velocity and position feedback signals from the controlled device.

Outputs

The analog output voltages from X and Y (and Z in the 1702) axes are designed to drive servo amplifiers and have a maximum amplitude of +12 volts to −12 volts. In the 1701, the Z axis drive is +10 volts at 100 milliamperes

[1] **Accuracies given apply only to a standard 1701 or 1702 that is properly adjusted and operating within the temperature ranges specified by the manufacturer.**

Standard Accessories Included:

	Tektronix Part No.
1 1701/1702 User's Manual	070-1072-00
1 1701/1702 Maintenance Manual	070-1100-00
1 Remex Tape Reader Manual	062-1259-00
1 Mating Power Twistlock Connector	131-0170-00
1 Machine Interface Mating Connector	131-0239-00
3 Transducer Interface Mating Connectors	134-0049-00
1 Checkout Tape	062-1316-00

Optional Accessories:

Manual Timing Unit This is a manually controlled (push-button) timing unit for use in operational testing.	067-0631-00
Circuit Card Extender	670-1329-00

Tabulation of Design Characteristics

The following tables provide the reference information necessary when designing the 1701/1702 into a numerically-controlled machine system.

TABLE 1-1

MAJOR CHARACTERISTICS

Characteristic	Performance Limits
System Resolution	0.0001 inch
Linearity (Each Axis)	
Normal Mode	Within 0.0001 inch
Display Mode	Within 0.0256 inch
COMMAND Register Range	0 to +99.9999 inches each axis
Maximum Slide Departure	99.9999 inches each axis
POSITION Register Range	−99.9999 to +99.9999 inches each axis
Maximum Feed Rate	240 inches per minute
MANUAL DATA INPUT (MDI) Switches	6 Decimal digits, from 000000 to 99.9999
Floating Zero	Full Range
Acceleration/ Deceleration	Automatic (see Fig. 1-2)

TABLE 1-1 (cont)

Characteristic	Performance Limits
SEQUENCE NUMBER Readout	0 to 999
Basic Clock Rate	2 MHz, within 4%
Logic Type	TTL Series 74N logic and TTμL 9000 defined in terms of positive logic using the following definitions: Low Voltage Level = Logic 0 High Voltage Level = Logic 1
Input Power Requirements	95 V to 130 V or 190 V to 260 V, 60 Hz, 400 W.

TABLE 1-2

PHYSICAL CHARACTERISTICS

Characteristic	Description
Height	18.3 inches
Width	20.5 inches
Depth	20.5 inches
Weight	115 pounds
Finish	Vinyl painted, cast aluminum sides, anodized aluminum front panel, top cover is vinyl painted aluminum plate.
Mounting	Four 5/16 inch X 18 tapped holes in the bottom.

TABLE 1-3

ENVIRONMENTAL CHARACTERISTICS

Item	Requirement
Temperature (Ambient)	
Non-operating	−40°C to +60°C
Operating	+10°C to +45°C
During Calibration	+20°C to +30°C, 1/2 hour stabilization period required.
Humidity	To 95%

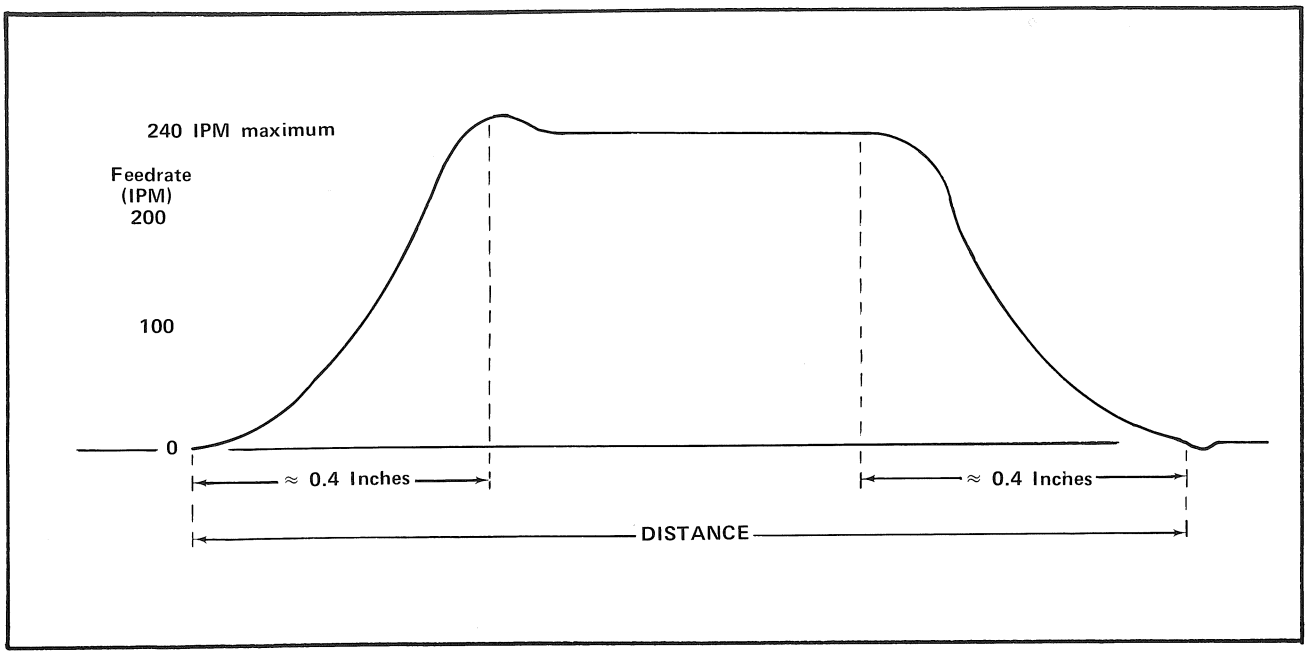

Fig. 1-2. Typical Acceleration/Deceleration curve of a 1701/1702 and machine system.

NOTE

If the 1701/1702 is to be operated in an extremely dirty or corrosive atmosphere, maintenance problems can be kept at a minimum by providing the 1701/1702 with a clean air supply piped to the air filter inlet.

No-Cost Options

Metric Operation. Provides calibration in metric units in place of English units.

ASCII Code. Permits the 1701 and 1702 to accept USASCII Code RS358 in place of EIA Code RS244.

Fast Feedrate. Provides feedrates of 255 inches-per-minute at 0.0002-inch resolution and 1000 inches-per-minute at 0.001 inch resolution.

Leading Zero Programming. This option changes the operation of the 1701 or 1702 so that leading zeros (in the axis commands) must be programmed, but trailing zeros are not required. This is for those installations where programming trailing zeros in the axis commands becomes much more of a chore than programming leading zeros.

Choice of Acceleration and Deceleration Characteristics. Permits the 1701/1702 to be used with a wide variety of servo systems.

Choice of Frequency Response. Permits the 1701/1702 to be properly matched to the servo system used.

Position Amplifier Output or Velocity Amplifier Output. This option also helps the customer to adapt the 1701/1702 to his needs.

Choice of Encoder Resolutions. Adapts the 1701/1702 to various encoder resolutions.

Additional Cost Options

S Functions. Provides spindle speed control. Spindle speed is programmed via two-digit codes.

T Functions. Provides programmed selection of tools. Tool selection is programmed via two-digit codes.

G80 Series. Provides a selection of repetitive operations such as drilling, boring, and tapping.

Circular Interpolation. Provides simplified data format for programming circular motion within a quadrant.

Feedrate Override. Gives the operator the ability to override (−75 to +20%) the programmed feedrate.

Jog Switch. Provides variable-feedrate manual control for set-up and maintenance.

M Function Decoding. The M Function outputs of the standard 1701 and 1702 are in the form of eighteen lines of M Function signals. The lines are numbered in base eight, and can be decoded into 79 (117_8) separate M functions.

NOTE

Options from the foregoing listing that are determined to be required in a particular installation should be specified when ordering a 1701 or 1702.

NOTES

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The standard models of the Tektronix 1701 and 1702 Machine Control Units differ as follows:

The 1702 is a 3-axis machine control with linear interpolation for all three axes. The 1701 is a 2-axis machine control with linear interpolation for two axes and limit switch control for a third axis.

The following operating procedure is written around the 1701, but it applies as well to the 1702, taking into account the differences listed above.

The 1701 causes the controlled machine to position work pieces or tools in longitudinal (X) and transverse (Y) directions. Through the use of the programmable M (miscellaneous) functions, the 1701 can also be programmed to command miscellaneous machine functions such as stopping axis motion, starting coolant, rotating the table, and rewinding the tape to the start of the program. The number of controlled machine functions and the manner in which they are controlled depend upon the operating mode selected.

Modes of Operation

The 1701 can be operated in Tape Auto, Tape Single Block, Dial Input, and Manual modes.

Tape Modes (Tape Auto and Single Block). In the tape modes, all commands are read into the 1701 from standard eight channel, one-inch wide tape (see Fig. 2-1) that is perforated in binary-coded-decimal machine language as specified by EIA standard classifications. The tape reading speed is 300 characters per second.

In the Tape Auto mode, the 1701 proceeds through the program on the tape until the program is completed, a tape or sync error is encountered, or the operator interrupts the program. In the Single Block mode, the 1701 executes the commands on one block of tape, then waits until directed to operate on the next block of tape. To enter either of these modes of operation, press the appropriate pushbutton switch (TAPE AUTO or SINGLE BLOCK). Once the operating mode is selected, pressing the CYCLE START pushbutton executes the program.

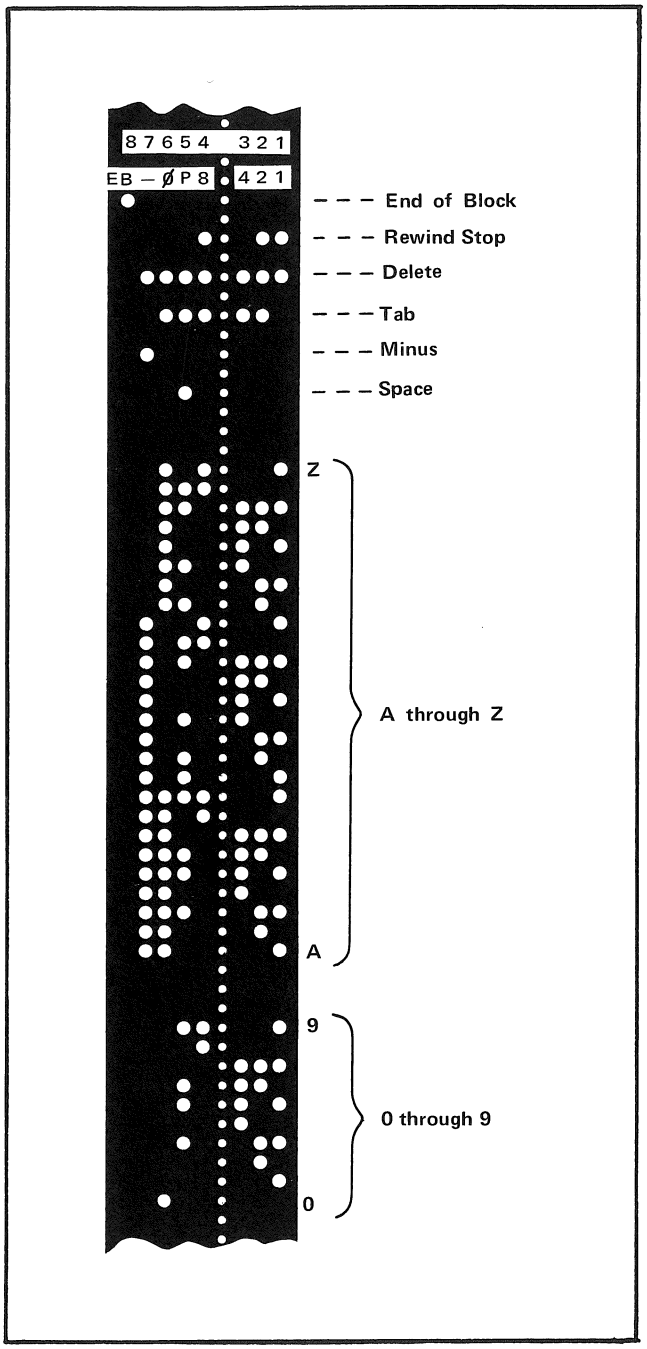

Fig. 2-1. EIA Standard Coding as used in the 1701/1702. The tape used is eight channel, 1 inch wide.

Dial Input Mode. In the Dial Input mode, the machine is positioned and operated by entering the commands into

the control with the Manual Data Input (MDI) lever switches. The command words for each axis are set on the lever switches, then entered into their respective command registers by first pressing the appropriate command register pushbutton switch, then pressing the ENTER pushbutton. When the ENTER switch is pressed, the command is displayed on the console readout, permitting the entered command to be checked before it is executed. Once the command words for the axes and feedrate have been entered, the G and M functions are selected by setting the front-panel switches. When the program block is complete, it is executed by pressing the CYCLE START switch. In this type of operation, the program is executed block by block as the blocks are built up by switch settings.

Manual Mode. In the Manual Mode, the operator can position either of the machine slides to a precise location by means of the machine handwheels or jog control. Precise positioning is obtained by watching the position readout for the axis being moved.

FUNCTION OF CONTROLS AND INDICATORS

DATA DISPLAY (See Fig. 1-1)

Provides digital readout of the G functions, M functions, Feedrate, and the contents of the Command and Position registers as selected by the COMMAND and POSITION pushbutton switches. Indicates the commands entered into the command registers, or the position of the controlled machine.

COMMAND

These pushbuttons select the command register whose contents are to be displayed on the DATA DISPLAY lamps. Once the register is selected, new command data can be entered manually by means of the DIAL INPUT, MANUAL DATA INPUT, and ENTER switches.

POSITION

These pushbuttons select the position register whose contents are to be displayed on the DATA DISPLAY lamps. Once the register is selected, the position data in the register can be modified manually by means of the DIAL INPUT, MANUAL DATA INPUT and ENTER switches.

MANUAL DATA INPUT

These six multi-position lever switches provide the means of manually setting up the desired numerical value for command, Feedrate, G function or M functions.

ENTER

This pushbutton enters into the selected register the command or position data set into the MANUAL DATA INPUT switches.

SEQUENCE NUMBER

Reads out the sequence number being read by the Tape Reader.

READ ERROR

This pushbutton lights (red) whenever an invalid reading from the tape reader has been detected. Push to cancel the indicator, then back the tape up to the word before the word in which the error occurred.

SYNC ERROR

This indicator lights (red) whenever the controlled machine is for some reason unable to comply with the commands. Procedures for correcting sync errors are given later in this section.

POWER FAULT

This lamp lights (red) whenever the power supply is unable to deliver the proper voltage (line voltage either high or low, or trouble in the power supply proper). Turning off the equipment power automatically unlatches the protective devices. After a 5-second wait, turn the power back on to renew operation.

RESET

In combination with CYCLE START, this pushbutton resets all registers to zero and clears the 1701. The control unit is automatically reset each time the power is turned on.

CYCLE START

This pushbutton executes the operation or sequence of operations that have been selected. CYCLE STOP interrupts the cycle.

CRT DISPLAY

When the 1701 is used in conjunction with a display unit, this pushbutton permits axis movements to be graphically displayed for checking program validity.

TAPE AUTO

When this pushbutton and CYCLE START are pressed, the 1701 will proceed automatically through programs punched on the tape.

SINGLE BLOCK

Pressing this pushbutton, then pressing CYCLE START, causes the 1701 to read and execute the commands in a single block of tape. This permits the operator to step through the program block-by-block.

DIAL INPUT

This pushbutton provides for operation similar to that of SINGLE BLOCK, except data is entered into the registers via the MANUAL DATA INPUT switches instead of the tape reader.

MANUAL

Pressing this pushbutton permits conventional manual control of the controlled machine.

END OF BLOCK

This lamp indicates that the reader has completed transferring the data in one block of tape into the 1701.

PROGRAM STOP

This lamp lights whenever the tape reader reads the program stop code.

IN POSITION

Indicates that the controlled machine has reached the commanded position.

EXTERNAL CONNECTORS (See Fig. 2-2)

J401

This connector makes the necessary connections to the X axis transducer.

J411

This connector makes the necessary connections to the Y axis transducer.

J421 (1702 only)

This connector makes the necessary connections to the Z axis transducer.

J461, J471, and J481

These BNC connectors supply X axis, Y axis, and Z axis signals respectively to the display unit (Tektronix Type 611).

J431

This connector makes the necessary connections to the Machine Interface Unit.

FIRST TIME OPERATION

Manual Mode

Turn on the equipment. Since the 1701 relies on the controlled machine for its power source, this means that the power switch for the controlled machine must be turned on.

CAUTION

Wait until you have read these operating instructions before you press the CYCLE START pushbutton.

1. Press the front-panel MANUAL pushbutton switch.

2. Using the JOG control or machine handwheels, slowly jog the controlled machine to the lower limit of the Y axis.

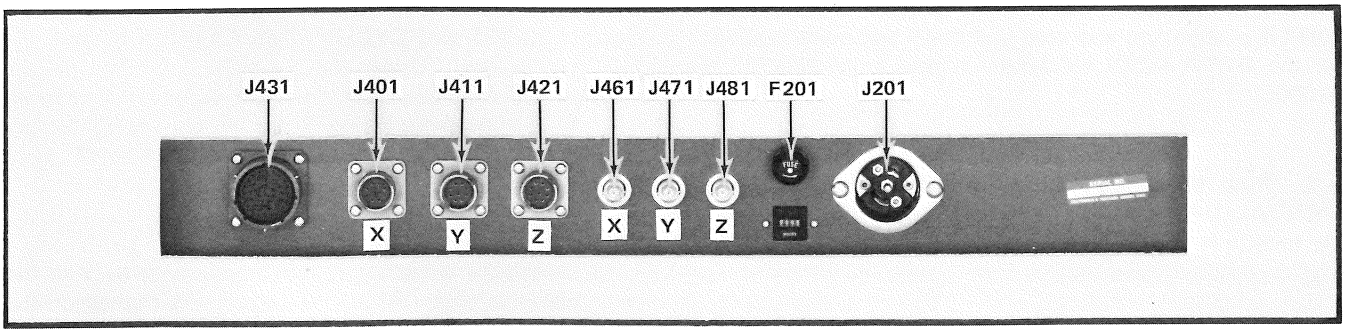

Fig. 2-2. 1701 and 1702 rear-panel connector identification.

3. Repeat for the X axis.

4. Press the X POSITION pushbutton and note the reading on the DATA DISPLAY readout. Repeat for the Y POSITION pushbutton.

5. Clear the control by pressing the RESET and CYCLE START pushbuttons. Note that the reading of the DATA DISPLAY readout changes to all zeros for both X and Y axis. The floating zero is now set at the X and Y lower limits.

6. Using the JOG control or the machine handwheels, move both axes of the machine one inch away from the lower limits. Press the X POSITION pushbutton, then the Y POSITION pushbutton and note that the DATA DISPLAY lamps read 010000 in each case.

7. Clear the control by pressing the RESET and CYCLE START pushbuttons. Note that the DATA DISPLAY changes to 000000 for each axis. The floating zero is now at a point one inch away from the lower limit of each axis. This is the way in which the floating zero is established. Jog to the desired position in each axis, then clear the control to set the position registers to zero. Do not clear the control until it is necessary to establish a new zero point, or to correct a sync error.

Semi-Automatic Mode (Dial Input)

With the floating zero established at a point one inch from the lower limit of each axis, proceed as follows:

1. Press the DIAL INPUT pushbutton. Press the X COMMAND pushbutton, then set the MANUAL DATA INPUT switches to 010000. Press the ENTER pushbutton and note that the X command readout on the DATA DISPLAY lamps changes from 000000 to 010000.

2. With the MANUAL DATA INPUT switches set to 010000, press the Y COMMAND pushbutton. Press the ENTER pushbutton and note that the Y command readout on the DATA DISPLAY lamps changes from 000000 to 010000.

3. Press the F COMMAND pushbutton. Change the MANUAL DATA INPUT switches to 000010 (ten inches per minute feedrate). Press the ENTER pushbutton.

4. Press the Y POSITION pushbutton, then press the CYCLE START. Note that the position readout counts from zero to 010000 as the Y axis moves one inch at a feedrate of 10 inches per minute. When the Y axis has moved to the commanded position, the IN POSITION lamp will light. Press the X POSITION pushbutton and note that the X axis has also moved to the commanded position (010000 or one inch from the zero position). When the IN POSITION lamp is lighted, command and position readouts should display the same numbers.

5. Again press the X COMMAND pushbutton. Set the MANUAL DATA INPUT switches to 100000 (10 inches). Press the ENTER pushbutton. Repeat for the Y axis. Press the F COMMAND pushbutton. Set the MANUAL DATA INPUT switches to the maximum feedrate given for the controlled machine. (The standard 1701/1702 can control feedrates up to 240 inches per minute, but very few numerically controlled machine systems are capable of this feedrate.)

6. Press the CYCLE START pushbutton. If the controlled machine is incapable of moving at the maximum feedrate specified, the SYNC ERROR lamp will light and the machine will stop.

NOTE

In most cases a sync error can be cleared by pressing CYCLE STOP, then pressing the proper mode switch (TAPE AUTO, SINGLE BLOCK, or DIAL INPUT) to put the 1701 back into the proper mode. In case of a position or feedback error, see steps 8a and 8b below.

7. With the sync error cleared, reset the feedrate to a little less than the feedrate arrived at in Step 5 above. Press CYCLE START and the controlled machine should move to the coordinates given in Step 5. Steps 5, 6, and 7 provide a means of checking the actual feedrate capabilities of the system as well as being a familiarization routine for the new operator.

8a. If the sync error lamp lights as a result of position or feedback error, use the Jog control or machine handwheels to bring the controlled machine back to the last reference point or operation known to be good. Clear the control by pressing RESET and CYCLE START. Press the DIAL INPUT pushbutton. Using the MANUAL DATA INPUT switches and the POSITION pushbuttons, enter the coordinates of the reference point. Enter the commands for the next move or operation. Press the CYCLE START pushbutton.

8b. Manually bring the controlled machine back to the zero reference point. When the machine is aligned on the zero reference, press the RESET and CYCLE START pushbuttons. Select the desired mode. Re-start the program by pressing the CYCLE START pushbutton.

TAPE MODE OPERATION (TAPE AUTO and SINGLE BLOCK)

General

The 1701 Machine Control Unit is a two-axis contouring control with linear interpolation. Commands on the tape that direct machine slide movements to a precise location are planned in accordance with a two-axis coordinate system. Coordinates are given as absolute dimensions with a positive value relative to the zero point. The longitudinal travel of the carriage defines the X axis. The cross travel defines the Y axis.

Generally, the floating zero is set to correspond to the point from which all dimensions originate on the part print or programmers layout sheet. The zero point may be placed outside the actual part, but must lie within the machine slide area. Since only positive X and Y values may be programmed, the zero point must be positioned such that the programmed points do not result in a negative X or Y value. Correct coordinate planning is easier if the programmer thinks in terms of the tool moving in relation to the zero point on a fixed work piece. Thus, with reference to the zero point, all points to the right will have positive X values and all points away from the operator will have positive Y values. The full floating zero is coordinated with the slide travel by picking a setup point common to both axes. (It is good practice to reference the setup point to the part fixture locating surfaces.)

The setup position is defined by the programmer. The operator manually adjusts the machine to the defined zero point.

Loading the Tape Reader

Loading and operation of the tape reader is covered in detail in the Tape Reader instruction manual. Basically, the tape reader loading operation is as follows:

a. Pull down on the LOAD lever (see Fig. 1-1).

b. Insert the leader portion of the tape between the pinch roller and the capstan with the sprocket holes on the side of the tape nearest the front panel.

c. Push the LOAD lever to its upper position. The tape is now loaded.

Operation

Turn the tape reader on. Set the floating zero point manually as previously explained. With a properly prepared tape loaded into the tape reader, press either the TAPE AUTO or SINGLE BLOCK pushbuttons, then press CYCLE START. Do not press the CRT DISPLAY pushbutton while the program is being executed.

NOTE

If a sync error occurs when operating in one of the tape input modes, press CYCLE STOP, then press the desired mode switch (TAPE AUTO or SINGLE BLOCK). Press the CYCLE START pushbutton and operation should continue. If the foregoing procedure will not correct the situation, manually re-position the controlled machine to the last previous reference point. Back the tape up to the block preceding the reference block. Clear the control by pressing RESET and CYCLE START. Dial the coordinates of the reference point (if other than zero) into the position registers. Select the desired mode and press CYCLE START.

Tape Terminology

The following terminology applies to punched tape used in tape-controlled machines.

Character. A character is a set of punched holes that represents a letter, a digit, a punctuation mark, a mathematical symbol, etc.

Row. A row is a path of holes perpendicular to the edge of the tape where the holes for one character are located.

Channel. A channel is a path parallel to the edge of the tape that can contain a hole or no hole, depending on the characters. There are eight channels on the tape used in the 1701.

Word. A word is a combination of characters that represents an axis command, a sequence number, or a function, etc. In the 1701, the first character in each word must be a letter address code; for example:

N∅49 X143172 Y∅3∅∅∅∅ M∅5

The first word is the sequence number, the next two words are axis commands, and the last word is a miscellaneous function command.

Block. A block is a combination of words that represents one complete sequence of commands. In the 1701, block length is variable, since the block needs to contain only those command words that have changes from the previous block. If only one axis or function is changed from the previous block, then the block can consist of only one word.

TEKTRONIX, INC.
MODELS 1701 AND 1702 PROGRAMMING MANUSCRIPT

SEQ NO N	PREP FUNC. G	AXIS X	AXIS Y	Z (1702 ONLY)	MISC FUNC. M	FEED RATE F

070-1102-00

Fig. 2-3. Programming worksheet for the 1701/1702.

Tape Format

The 1701 uses word address tape format. In this system, the letter part of the word gates the word into the proper register.[1] The word order within the block does not affect the operation of the 1701; however, words are normally entered on the programming manuscript[2] (see Fig. 2-3) in the following manner:

N3 G2 X2.4 Y2.4 F3 M2 EOB

In the foregoing block, the letters constitute the address part of the words. The N3 indicates a 3-digit sequence number (e.g. N3ØØ); it is necessary to program leading zeros as well as trailing zeros. Use of the sequence number is optional, the 1701/1702 will accept tape without sequence numbers. The G2 is a 2-digit preparatory function code. The X2.4 is a positive, 6-digit X-axis coordinate in inches, with two places to the left of the decimal point and four places to the right (the 1701 interprets axis commands as being expressed in multiples of one ten-thousandth of an inch). Do not punch the decimal point or minus sign (negative numbers are not acceptable).

NOTE

Leading zeros before the significant figures need not be programmed in axis and feedrate commands. The sequence number and all function codes require leading zeros.

The Y2.4 follows the same rules as the X2.4 as explained in the preceding paragraph. The F3 is a 3-digit feedrate function code expressed in inches per minute (leading zeros are understood). The M2 is a 2-digit miscellaneous function code (e.g. MØ2, M99). EOB is the end-of-block code; in the EIA code, this is the only legal hole ever to appear on the tape in channel 8.

Punching the Tape

It is assumed that the program tape for the 1701 will be punched on a Friden Flexowriter Ⓡ or similar machine. Any coding (such as punched identifiers) in the leader prior to the first EOB will be ignored. If an error is punched into the tape, back the tape up and overpunch the error with the delete code. EOB is an exception to the foregoing. If EOB is inadvertently punched, delete all the tape between the erroneous EOB and the previous EOB (punching the delete code over an EOB results in a parity error). Do not feed blank tape anywhere within the program, as this will cause a parity error. If the tape feed key is accidentally pressed and blank tape is fed within the program blocks, overpunch the blank tape with the delete code.

When punching the tape, the following rules must be observed:

a. Rewind stop. This code must occur before the first block of tape. Its purpose is to stop the tape reader when the tape reader is automatically rewinding. This is punched when the Stop Code key on the Flexowriter is pressed.

b. EOB. An end-of-block code must precede the first block immediately after the rewind stop code. The EOB tells the 1701 that everything that has gone before is finished, and the next block of tape can be read. Thus, it follows that every block must be terminated with an EOB (carriage return) code.

c. Sequence Number. The letter N followed by three digits in any combination can be used as a reference designation for block or sequence locations.

d. Letter Address. A single-letter address must precede each word.

e. Repetitive Words. Need not be re-entered (except MØØ, MØ2, and M3Ø). Remember that the GØ1 mode can be used only if direction changes are less than 30 degrees. If a direction change of 30 degrees or more is to be made, GØØ should be punched in the block preceding the block in which the abrupt direction change is to be made.

f. Decimal points. Decimal points must NOT appear on the tape. The 1701 interprets axis commands as being expressed in multiples of one ten-thousandth (0.0001) as previously explained.

g. Plus Signs. Need not be programmed.

h. Minus Signs. Must NOT occur.

i. Leading Zeros. Need not be programmed. However, if an axis position command is zero, a zero must be programmed (XØ, YØ) since the 1701 does not interpret the absence of a number as zero.[3]

[1] **The letter-address feature permits the operator to enter the TAB code and other annotations into the tape. So long as the entries are not preceded by one of the address letters, the information will be ignored by the 1701/1702.**

[2] **Blank 1701/1702 programming manuscript worksheets as shown in Fig. 2-3 can be ordered from Tektronix, Inc. in pads of 100. Order by Tektronix Part No. 070-1102-00.**

[3] **Trailing zeros can be omitted in the axis commands if the no-cost leading zero option is selected. In j above, the 1.1 would be programmed XØ11 if the control has the leading zero option installed.**

j. Trailing Zeros. Must be programmed (e.g., 1.1 is programmed as X11ØØØ).[3]

k. Feed Rates. Feed rates from 1 to 240 inches per minute are directly programmable by entering "F" followed by the appropriate feedrate (e.g. F111).

l. Programmed Stop (MØØ). The programmed stop occurs after any motions programmed in the block in which the MØØ is punched are completed.

m. Rewind Stop—End of Program (M3Ø). This function is identical with MØØ except that automatic tape rewind is also performed.

n. Positioning Mode (GØØ). This is the normal operating mode of the 1701. Under this mode, the machine fully decelerates to the programmed coordinate.

o. Contouring Mode (GØ1). Under this mode, acceleration and deceleration are supressed and the next block of tape is read before the programmed point is actually reached. This allows rapid response to cutting curved paths without buffer storage. Whenever the program calls for a direction change of 30 degrees or more, GØØ should be punched in the block preceding the block in which the abrupt direction change occurs. The GØØ enables the deceleration circuitry and prevents overshoot.

The two listed preparatory functions (GØØ and GØ1) are the only G functions included in the standard 1701. Additional G functions are available on special order.

NOTE

Only one G function can be programmed in any one block.

1701/1702 Short-Form Operating Procedure

Operating Mode							
MANUAL	Use Jog Control or machine handwheels.. Set machine to desired zero reference point. Set zero by pressing RESET & CYCLE START						
DIAL INPUT	Press DIAL INPUT	Enter first X coordinate on MANUAL DATA INPUT Switches	Press ENTER pushbutton	Enter Y, Z, G, F, and M commands as desired. Press ENTER after each.	Press CYCLE START	When machine cycle is completed, enter next coordinates	Press CYCLE START
SINGLE BLOCK		Load tape, turn on Tape Reader	Press SINGLE BLOCK and CYCLE START	Check that machine goes to commanded coordinates.	Press CYCLE START		
TAPE AUTO		Load tape, turn on Tape Reader	Press TAPE AUTO and CYCLE START	If machine stops on programmed stop, take action called for (tool change, etc.)	Press CYCLE START		
CRT DISPLAY	Load tape, turn on Tape Reader. Press CRT DISPLAY and CYCLE START.						

NOTE: Pressing RESET and CYCLE START in sequence clears all the registers and sets the floating zero. If a sync error occurs, press CYCLE STOP, the mode switch for the desired mode, then CYCLE START. If a feedback error occurs, go back to reference block or position, dial in position if different than zero, then start the tape in the block before the reference block. Do not change modes while the controlled machine is moving.

NOTES

SECTION 3
CODING

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section describes the coding requirements for the standard 1701 and 1702 Machine Control Units as well as the coding requirements for the various options available. The options available include fixed cycles for repetitive drilling, boring, and tapping operations; circular interpolation; vector feedrate; control for a rotary positioning fourth axis; and decreased resolution with increased feedrates.

Tape Format

The standard tape format is binary-coded-decimal, variable block, word address; punched on 8-channel, 1-inch wide tape (see Fig. 2-1). The format conforms with EIA Standard RS-274 except for feedrates, which are programmed directly. ASCII coding as listed in EIA Standard RS-358 is available as an option.

Block Format

The first block must be preceded by an EOB (carriage return) code. Any coding such as punched identifiers in the leader prior to the first EOB code will be ignored. A standard rewind stop code must occur prior to the EOB preceding the first block of tape if automatic tape rewind is used.

Command words in the form shown in the following text are punched in each block. With the exception of EOB, which must be the last item in the block, the words may be entered in any order. In general, words that have not changed since the previous block (repetitive words) need not be re-entered.

Typical Block Format. N3 G2 X+2.4 Y+2.4 Z+2.4 B+3.3 M2 T2 S2 F3 R+2.3 EOB

Note that all the words within the block have a single-letter address character before the digits. The letter portion of the word routes the word to the proper register and must always be punched. Translation of the block is as follows:

N3 =	A 3-digit sequence number.
G2 =	A 2-digit preparatory function command. Leading zeros must be programmed.
X+2.4 =	A positive, 6-digit X-axis coordinate in inches with two places to the left of the decimal point and four places to the right. Leading zeros before the significant figures need not be programmed, but trailing zeros must always be programmed.[1] Do not punch the decimal point or minus sign (negative numbers are not acceptable).
Y+2.4 =	Y-axis coordinate. The same rules as those listed for the X-axis apply.
Z+2.4 =	Z-axis coordinate. The same rules as those listed for the X-axis apply.
M2 =	A 2-digit miscellaneous function command. Leading zeros must be programmed.
T2 =	A 2-digit tool selection command. (Optional) Leading zeros must be programmed.
S2 =	A 2-digit spindle speed command. (Optional) Leading zeros must be programmed.
F3 =	A 3-digit feedrate command. Leading zeros must be programmed.
R+2.3 =	A positive, 5-digit rapid traverse coordinate for fixed cycles. Decimal point and sign rules listed for the X-axis apply (Optional on the 1702 only)
EOB =	End of block (carriage return).

[1] **An option provides for leading zero programming.**

NOTE

A programmed coordinate of 00.0000 inch must contain at least one zero with the letter address code (e.g. XØ). Plus signs need not be programmed. Minus signs are not allowed.

Miscellaneous Functions

A Miscellaneous Function register is provided in standard units. Only one M function may be programmed in any one block. Except for MØØ, MØ2, and M3Ø, M functions need not be repeated. The miscellaneous functions used internally in the 1701 and 1702 are as follows:

MØØ	Programmed Stop
MØ2	End of Program
MØ3	Spindle On
MØ5	Spindle Off
MØ8	Coolant On
MØ9	Coolant Off
M3Ø	Tape Rewind, End of Tape
M31	Interlock By-pass

All other miscellaneous functions may be assigned by the machine tool builder. A decoder unit to decode and interface 117_8 (79_{10}) M function output signal lines is available as an option.

Preparatory Functions

Preparatory functions (G codes) are modal, i.e., are maintained until cancelled. G codes used within the 1701 and 1702 are as follows:

GØØ =	Automatic Acceleration/Deceleration
GØ1 =	Inhibit Deceleration (see NOTE below)
GØ2 =	Arc CW (Circular interpolation option only)
GØ3 =	Arc CCW (Circular interpolation option only)

NOTE

The GØ1 code is used for linear interpolation of curved surfaces. Under this mode, full deceleration is inhibited so the next block of tape is read before the programmed point is actually reached. Therefore, GØØ must be punched in the block preceding the block in which a direction change of 30 degrees or more occurs.

The G8Ø-series of fixed cycles, available as an option to the 1702 only, is defined later in this section.

Typical Program

Figure 3-1 shows the tool paths for a typical part. The program print-out (given in Table 3-1) shows the coding used to punch the tape that is read by the 1701 or 1702 to produce the tool paths shown. Each line of type represents one block of tape. The explanations of the more significant blocks follow Table 3-1.

TABLE 3-1

```
n001g00x36000y147000f240
n002x120000y162000
n003x204000y135000
n004y105000
n005y21000
n006x183000
n007x162000
n008x141000
n009x120000
n010x99000
n011x78000
n012x57000
n013x36000
n014x84000y63000
n015x93000y54000
n016x129000
n017x138000y63000
n018y117000
n019x129000y126000
n020x93000
n021x84000y117000
n022x0y0m06
n023x90000y117000m00
n024x90013y117277g01f10
n025x90051y117551
n026x90115y117821
n027x90203y118084
n028x90315y118337
n029x90449y118579
n030x90606y118808
n031x90783y119021
n032x90979y119217
n033x91192y119394
n034x91421y119551
n035x91663y119685
n036x91916y119797
n037x92179y119885
n038x92449y119949
n039x92723y119987
n040x93000y120000
n041x129000y120000
n042x129277y119987
```

TABLE 3-1 (cont)

```
n043x129551y119949
n044x129821y119885
n045x130084y119797
n046x130337y119685
n047x130579y119551
n048x130808y119394
n049x131021y119217
n050x131217y119021
n051x131394y118808
n052x131551y118579
n053x131685y118337
n054x131797y118084
n055x131885y117821
n056x131949y117551
n057x131987y117277
n058x132000y117000
n059y63000
n060x131987y62723
n061x131949y62449
n062x131885y62179
n063x131797y61916
n064x131685y61663
n065x131551y61421
n066x131394y61192
n067x131217y60979
n068x131021y60783
n069x130808y60606
n070x130579y60449
n071x130337y60315
n072x130084y60203
n073x129821y60115
n074x129551y60051
n075x129277y60013
n076x129000y60000
n077x93000
n078x92723y60013
n079x92449y60051
n080x92179y60115
n081x91916y60203
n082x91663y60315
n083x91421y60449
n084x91192y60606
n085x90979y60783
n086x90783y60979
n087x90606y61192
n088x90449y61421
n089x90315y61663
n090x90203y61916
n091x90115y62179
n092x90051y62449
n093x90013y62723
n094x90000y63000
n095y117000m00
n096g00x30000y15000f240m00
n097g01y60000f10
n098x30792y60010
n099x31583y60042
n100x32374y60094
n101x33162y60167
n102x33949y60261
n103x34732y60376
n104x35512y60511
n105x36289y60667
n106x37061y60843
n107x37828y61039
n108x38590y61256
n109x39346y61493
n110x40095y61750
n111x40837y62026
n112x41572y62322
n113x42298y62637
n114x43017y62971
n115x43725y63324
n116x44425y63696
n117x45114y64085
n118x45793y64493
n119x46461y64919
n120x47117y65363
n121x47761y65823
n122x48393y66300
n123x49013y66794
n124x49619y67304
n125x50211y67830
n126x50789y68371
n127x51353y68927
n128x51902y69498
n129x52435y70084
n130x52953y70683
n131x53455y71295
n132x53941y71921
n133x54409y72559
n134x54861y73210
n135x55296y73872
n136x55713y74545
n137x56112y75229
n138x56493y75924
n139x56855y76628
n140x57199y77341
n141x57523y78064
n142x57829y78794
n143x58115y79533
n144x58381y80279
n145x58628y81031
n146x58855y81790
n147x59061y82555
n148x59248y83324
n149x59414y84099
n150x59559y84877
n151x59684y85659
n152x59789y86444
```

TABLE 3-1 (cont)

```
n153x59872y87232
n154x59935y88021
n155x59976y88812
n156x59997y89604
n157y90396
n158x59976y91188
n159x59935y91979
n160x59872y92768
n161x59789y93556
n162x59684y94341
n163x59559y95123
n164x59414y95901
n165x59248y96676
n166x59061y97445
n167x58855y98210
n168x58628y98969
n169x58381y99721
n170x58115y100467
n171x57829y101206
n172x57523y101936
n173x57199y102659
n174x56855y103372
n175x56493y104076
n176x56112y104771
n177x55713y105455
n178x55296y106128
n179x54861y106790
n180x54409y107441
n181x53941y108079
n182x53455y108705
n183x52953y109317
n184x52435y109916
n185x51902y110502
n186x51353y111073
n187x50789y111629
n188x50211y112170
n189x49619y112696
n190x49013y113206
n191x48393y113700
n192x47761y114177
n193x47117y114637
n194x46461y115081
n195x45793y115507
n196x45114y115915
n197x44425y116304
n198x43725y116676
n199x43017y117029
n200x42298y117363
n201x41572y117678
n202x40837y117974
n203x40095y118250
n204x39346y118507
n205x38590y118744
n206x37828y118961
n207x37061y119157
n208x36289y119333
n209x35512y119489
n210x34732y119624
n211x33948y119739
n212x33162y119833
n213x32374y119906
n214x31583y119958
n215x30792y119990
n216x30000y120000
n217y150000
n218x120000y168000
n219x210000y138000
n220y102000
n221x168552y83478
n222x168225y83320
n223x167908y83142
n224x167603y82946
n225x167310y82731
n226x167030y82499
n227x166765y82250
n228x166516y81986
n229x166283y81708
n230x166067y81415
n231x165869y81110
n232x165690y80794
n233x165531y80468
n234x165392y80132
n235x165273y79789
n236x165175y79439
n237x165099y79084
n238x165044y78725
n239x165011y78363
n240x165000y78000
n241y52000
n242x165015y51582
n243x165058y51166
n244x165131y50755
n245x165232y50349
n246x165361y49951
n247x165517y49563
n248x165700y49187
n249x165909y48825
n250x166142y48478
n251x166399y48148
n252x166679y47837
n253x166979y47547
n254x167299y47277
n255x167637y47031
n256x167991y46809
n257x168360y46612
n258x168742y46441
n259x169134y46297
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n263x30000
n264g00x0y0f240m30
```

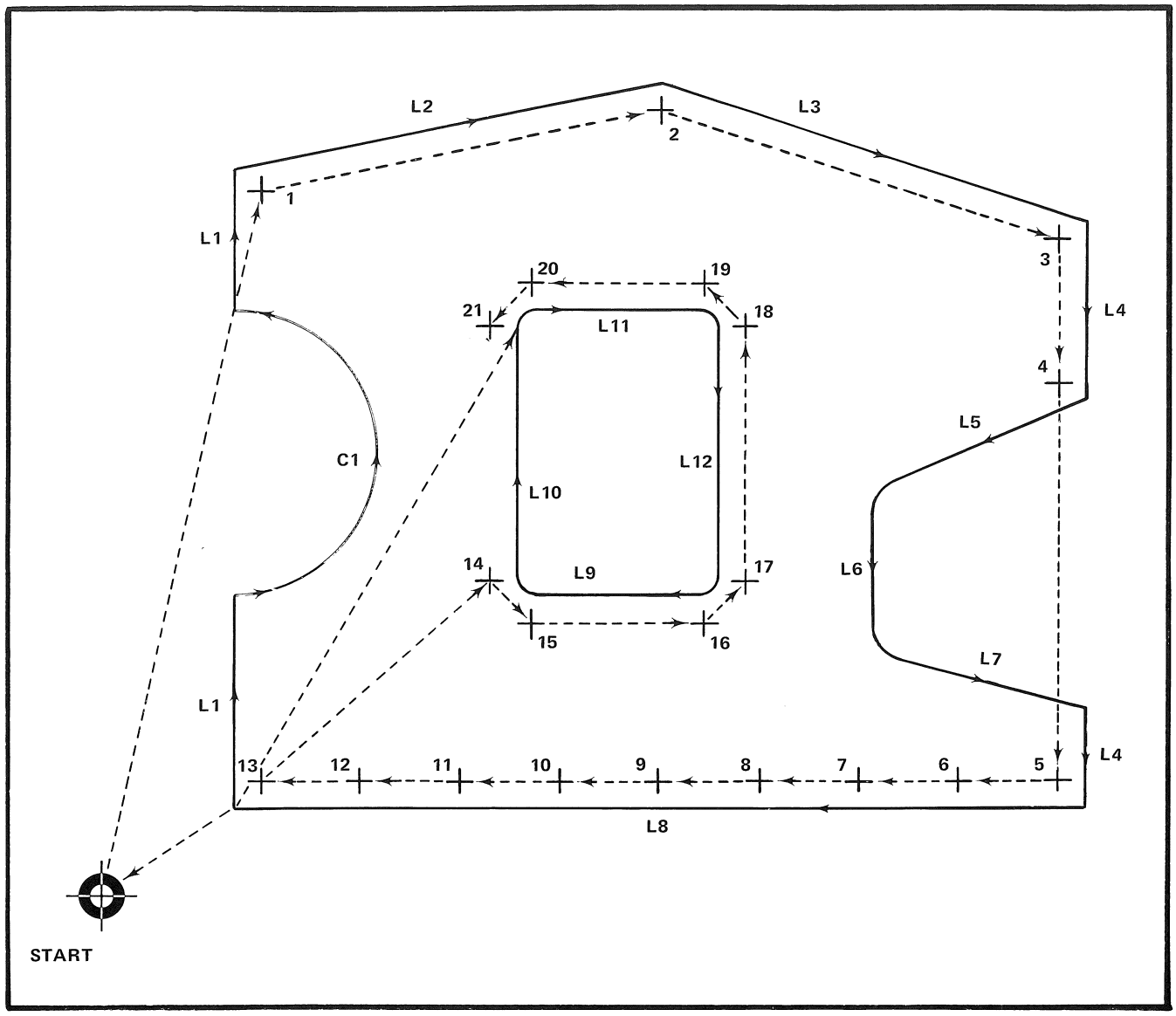

Fig. 3-1. Drawing of typical part turned out by numerically controlled machines. The coding required for reproducing this part is given in Table 3-1.

Block 1. This block and all subsequent blocks are identified by sequence number coding NØØ1 through N264 respectively. The GØØ code prepares the control to move in point-to-point mode. The F240 code establishes feedrate at 240 inches per minute (IPM). In this block, the tool will move to position 1 on the drawing at X = 36 inches, Y = 14.7 inches and drill a hole.

Blocks 2 through 21. The tool moves to positions 2 through 21 at 240 IPM and drills a hole at each location.

Block 22. Move to starting point and stop. The MØ6 code signifies tool change.

Block 23. Move to a point at the center pattern (X = 9.0 inches, Y = 11.7 inches) and stop to allow for lowering tool to cutting position.

Block 24. Start motion along center pattern. The GØ1 code establishes contouring mode at F10 = 10 IPM.

Blocks 25 through 95. Produce center pattern. Note the points used for linear interpolation for the radii. At block 95, the MØØ code causes the machine to stop for tool retraction.

Block 96. Move to the lower left hand corner at 240 IPM and stop for tool insertion.

Blocks 97 through 263. Produce peripheral pattern under GØ1, contouring mode, at 10 IPM in a clockwise direction. Note the coordinate values to produce the circular cuts, under linear interpolation in blocks 98 through 216, 221 through 240, and 241 through 260.

Block 264. Return to Ø, Ø at 240 IPM, stop and rewind the tape to the start (M3Ø).

Coding For Options

G8Ø Series of Fixed Cycles. The following group of fixed cycles can be provided for repetitive drilling, boring, and tapping operations. It is available for the 1702 only.

G8Ø =	Cancel all fixed cycles (G81 through G89)
G81 =	Drill: Position to X and Y; spindle CW; rapid to R; feed to Z; rapid to R.
G82 =	Counterbore: Position to X and Y; spindle CW; rapid to R; feed to Z; dwell; rapid to R.
G83 =	Available for assignment.
G84 =	Tap: Position to X and Y; spindle CW; rapid to R; feed to Z; spindle CCW; feed to R.
G85 =	Bore: Position to X and Y; spindle CW; rapid to R; feed to Z; feed to R.
G86 =	Bore-keylock: Position to X and Y; spindle CW; rapid to R; feed to Z; spindle stop; rapid to R.
G87 =	Available or assignment.
G88 =	Available for assignment.
G89 =	Bore-face: Position to X and Y; spindle CW; rapid to R; feed to Z; dwell; feed to R.

When a word in the series from G81 through G89 is used, the block in which it occurs should also contain the R and Z (rapid and feed dimensions) words necessary for the operation. This block must be preceded by a block containing the necessary X and Y words to position the work or tool to the coordinates at which the G function is to take place. The blocks following the block in which the G function appears need to contain only new information, such as coordinate changes, etc.

Circular Interpolation (Option). A circular interpolator that can generate arcs up to 90° from a single command block is available as an option for both the 1701 and 1702. When equipped with this option, the control is placed in circular interpolation mode by programming a GØ2 code (arc clockwise) or GØ3 code (arc counterclockwise). The G function code is followed by the arc center specified in values of I, J, and K; then the final point of the arc in values of X, Y, and Z. All values are absolute coorindates. The plane of operation is established by programming any two of the three axes (XY, YZ, ZX; the Control Units cannot handle arc functions in three dimensions simultaneously). Programming the actual feed rate desired (FØØ1 through F240) in the block establishes the feedrate for the arc.

NOTE

If the arc extends through more than one quadrant, then a program block is required for the segment of arc in each quadrant.

Optional Feedrates and Resolution. Optional resolutions of 0.0002 inch and 0.001 inch allow feedrates of 255 IPM and 1000 IPM feedrates respectively. Format for axis-motion words for both options remains at +2.4. For the 0.001 inch resolution option, the feedrate word format becomes F3, i.e. FØØ1 through F999.

Vector Feedrate (Option). Vector feedrates can be provided to simplify feedrate coding for linear interpolation. With this option, the standard feedrate coding is replaced by coding the actual feedrate desired, with the letter address F and three digits (ØØ1 through 999), which represents the actual vector feedrate in IPM in one IPM steps.

SECTION 4
SERVICING

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This servicing procedure contains only those items that the operator should be able to perform without inadvertently introducing real troubles into the equipment. Detailed maintenance procedures are given in the Maintenance Manual for the 1701/1702.

WARNING

The line voltage input and the supply for the readout lamps exceed 100 volts, and are therefore considered to be dangerous. Do not put hands or tools inside the cabinet unless the danger points have been identified, or adequate safety precautions have been taken. See Fig. 4-1 and Fig. 4-2.

Opening the Equipment Cabinet

The only tool required to open up the cabinet is a screwdriver with a 1/4 inch blade. The panels at the rear of the instrument have a quick release screw fastener at each side and a knurled fastener (which must be turned) in the center. The front-panel beneath the tape reader has a quick-release screw fastener in the center.

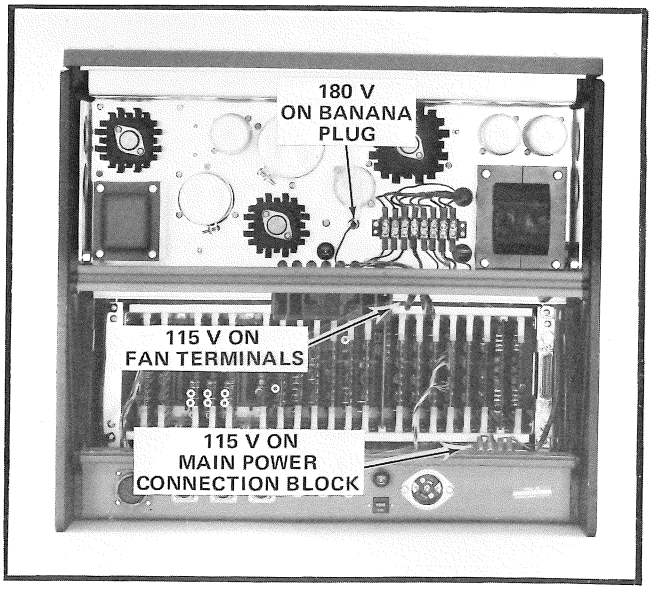

Fig. 4-1. Location of dangerous-voltage points.

Removing the Tape Reader

To remove the Tape Reader, it is necessary to first unplug the interconnecting cables that attach to the back of the Tape Reader. See Fig. 4-2. To obtain access to the cable plugs, first turn off the power, then remove the top panel at the rear of the 1701/1702. Next, unlatch the quick-release screw fastener at the top center of the power supply chassis. Swing the power supply chassis out and down. The Tape Reader interconnecting cables and fuse can now be reached.

Changing the Tape Reader Fuse

Get at the fuse as described in the preceding paragraph.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, and lubrication. Preventive maintenance is generally more economical than corrective maintenance, since it can usually be done at a time convenient to the user. The preventive maintenance schedule established for the instrument should be based on the amount of use and the environment in which the instrument is used. Maintenance procedures for the tape reader are given in the tape reader instruction manual.

Cleaning

Clean the air filter as often as operating conditions require. If it is found that the air filter gets loaded with dirt every few days, or if the instrument is used in a corrosive atmosphere, it is desirable to pipe a supply of clean dry air directly to the air filter inlet.

Maintenance problems can be kept at a minimum if dirt and corrosive vapors can be kept out of the equipment. Dirt on the components acts as a thermal insulating blanket (preventing efficient heat dissipation) and may provide electrical conducting paths. Corrosive vapors usually attack switch contacts first, then the plug-in circuit card connectors, and finally the etched circuitry where it is vulnerable. The fan keeps the cabinet slightly pressurized, helping to keep foreign matter out of the cabinet, but if the air filter gets dirt laden, or if the atmosphere is corrosive, trouble will eventually result.

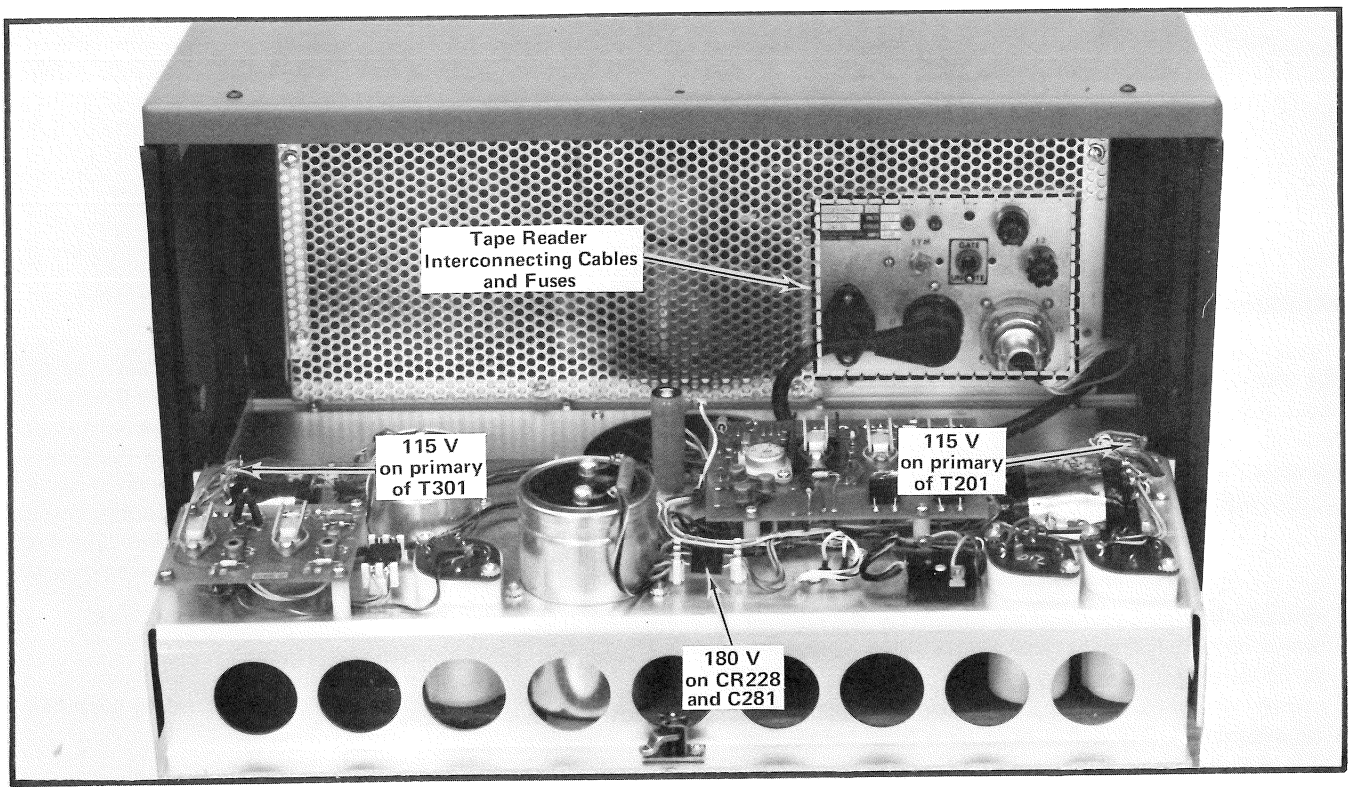

Fig. 4-2. Top-rear view showing power supply chassis and Tape Reader interconnecting cables.

Clean the instrument by loosening accumulated dust with a dry, soft paint brush of 1/2 or 1 inch size. Remove the loosened dirt with a vacuum cleaner. The nozzle on the vacuum cleaner hose should be a narrow plastic nozzle, such as those used for cleaning steam radiators. Hardened dirt and grease can be removed with a cotton-tipped swab or a soft cloth dampened with water and a mild detergent solution (such as Kelite or Spray White). Abrasive cleaners should not be used.

CAUTION

Since the 1701 and 1702 are generally used in an environment where there are conductive metal chips or abrasive materials about, do not use compressed air for cleaning these instruments. Be careful not to short connectors when cleaning the wire-wrap connector board. Do not permit water to get inside controls or shaft bushings. Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Some chemicals to avoid are benzene, toluene, Xylene, and acetone.

Visual Inspection

After a thorough cleaning, the instrument should be carefully inspected for such defects as damaged parts, frayed cables, loose connections, and dirty circuit card contacts. (Use a non-abrasive pencil eraser to polish any corrosion or dirt off the circuit card contacts.) The remedy for most visible defects is obvious; however, if heat-damaged parts are discovered, the cause of overheating should be determined before the damaged parts are replaced, otherwise the damage may be repeated.

Lubrication

The tape reader should be lubricated in accordance with the instructions given in the tape reader instruction manual.

Integrated Circuit and Transistor Checks

The integrated circuits and transistors in the 1701/1702 are soldered in place and should be removed only by authorized maintenance personnel in the course of corrective maintenance. The circuits within the instrument provide the only satisfactory check on transistor and integrated circuit performance.

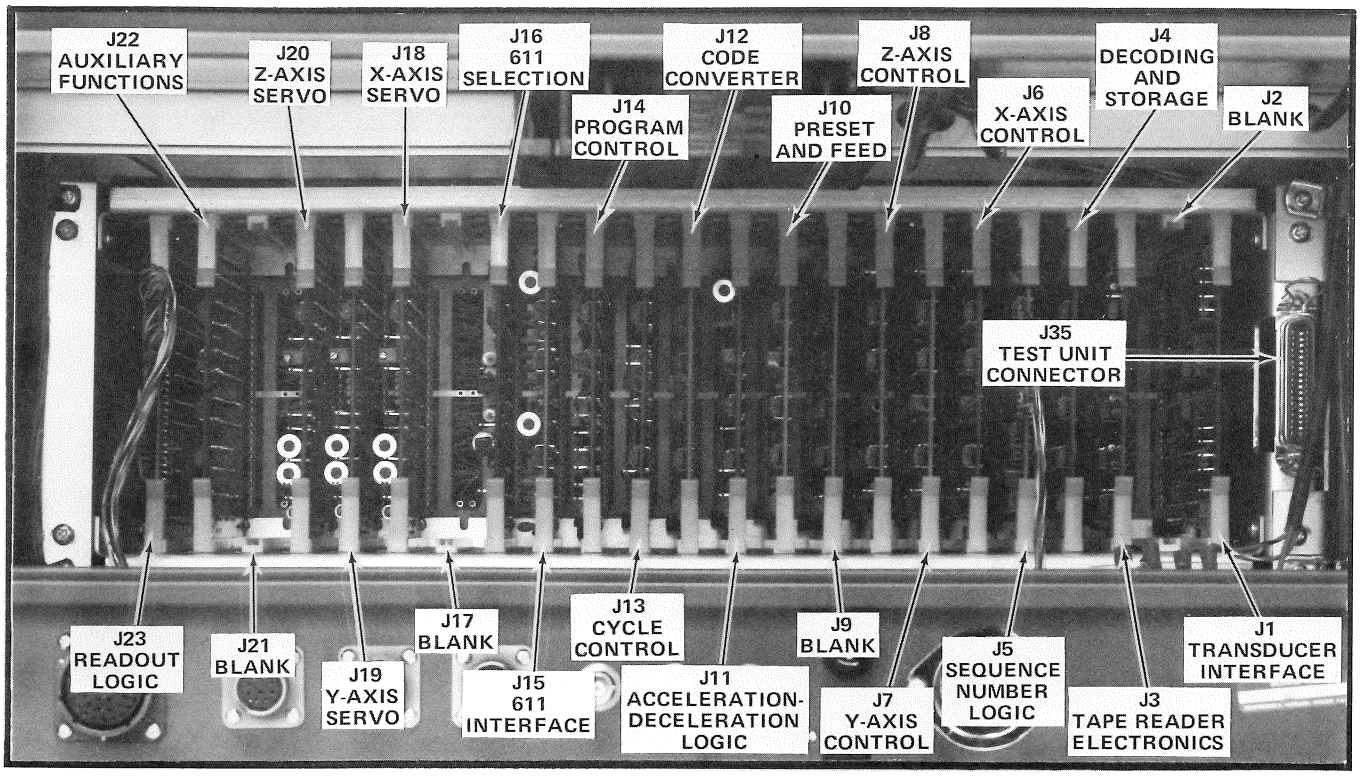

Fig. 4-3. 1702 rear view showing circuit card locations.

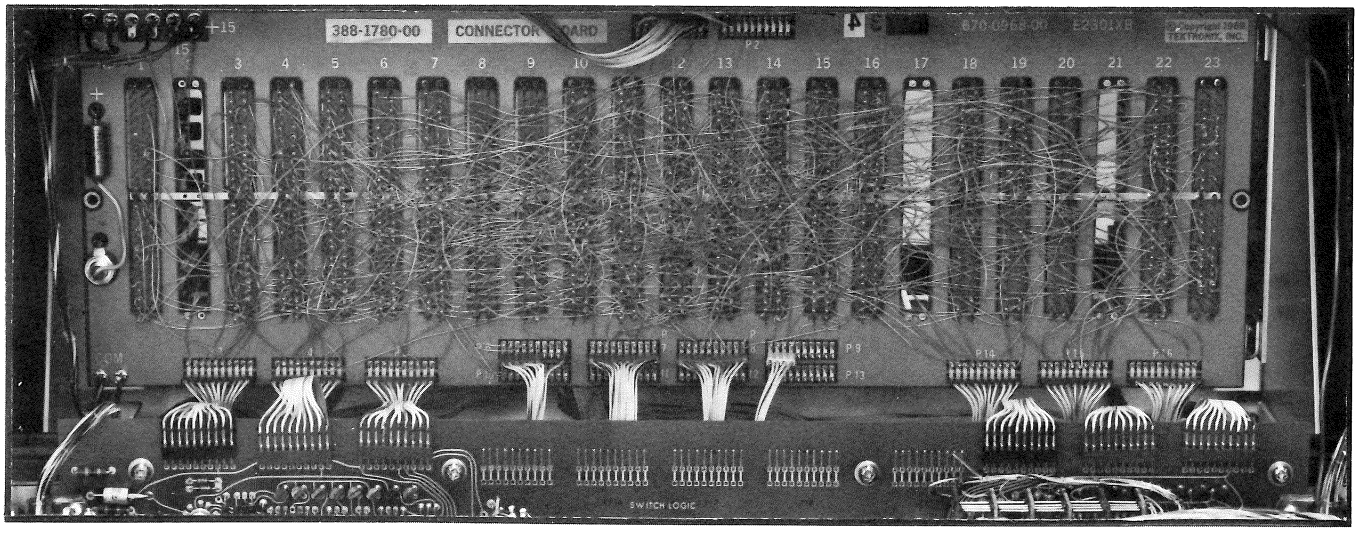

Fig. 4-4. Front interior view showing wire-wrap connection board.

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

TEXT CORRECTION

Section 2 Operating Instructions

Page 2-4 Semi-Automatic Mode (Dial Input)

CHANGE: the last sentence of the NOTE (after step 6) to read:

In case of a position or feedback error, see step 8a or 8b below.