altair Q70 Printer DOCUMENTATION

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INTRODUCTION

This documentation package describes the Altair Q70 printer system. The Q70 system includes the Q70 printer and the 88-Q70C Controller board for connecting the printer to an Altair 8800 series microcomputer.

The documentation package consists of three parts. The first part, the Operation Manual, describes the procedures for loading paper and ribbon cartridges, replacing printwheels, cleaning the printer and miscellaneous procedures. The second part, the Product/Interface Description Manual, is a detailed description of the electrical characteristics of the printer, including required signals, command sequences, etc. The final part of the package is the Q70 Printer Controller Manual which includes information on the Q70C controller board and on programming for the 8800 series microcomputers.

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Q70 PRINTER CONTROLLER MANUAL

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MOUNTING THE FORMS TRACTOR

Some printers come equipped with an optional forms tractor. This accessory is mounted through slots in the top of a special cover which is installed on tractor-feed printers. Tractor feed provides a more positive method of paper control. To mount the forms tractor, refer to Figure 7 and instructions below.

- The first step in installing the forms tractor is to remove the top printer cover.
- Then pull the paper bail forward, out of the way.
- With both thumbs, depress the two spring-loaded locking levers on the forms tractor and clamp the unit to the platen shaft.
- The right stanchion engages a groove on the platen's shaft, and the forms tractor will appear to be centered on the printer when this position is correct.
- Release the locking levers and check to make sure that they pop all the way out. The right-hand lever may not click into place on the first try, and it will then be necessary to rock the mechanism a little to obtain the proper engagement. When the forms tractor is fully locked in place, the right-hand locking lever will be just as far out as the left.
- Now adjust the forms tractor for the width of the paper to be used. First loosen the two drive sprocket clamping screws and slide each of the two drive sprockets to the outside of the tractor support rail.
- Lift the paper gates on the drive sprockets and insert a sheet of paper behind the platen. Rotate the platen knob transporting the paper through to the front.
- Pull the paper release lever all the way forward, disengaging the friction feed mechanism.
- Position the holes in the edge of the paper over the pins of the right-hand drive sprocket, and lower the right-hand paper gate.
- Tighten the right-hand drive sprocket clamping screw.
- Now slide the left hand drive sprocket over to engage the holes in the paper's left margin. Make sure that the upper edge of the paper is parallel to the tractor support rail, and lower the left-hand paper gate.
- Finally, adjust the position of the left-hand drive sprocket and tighten the left-hand clamping screw to hold it in place. **The paper must not be under any tension.** At the same time, however, the adjustment should not be so loose that the paper buckles upward at the center of the platen. Once the forms tractor has been adjusted for the width of paper to be used, no further adjustment will be necessary unless the clamp screws are disturbed.

- Move the paper bail toward the platen, letting it rest against the tractor frames.
- Now carefully insert the printer top cover under the tractor and snap it into position.

NOTE

Check to be sure that the paper release lever is forward when the tractor is in operation.

LOADING PAPER (TRACTOR FEED)

Printers equipped with a forms tractor are generally set up to draw fan-folded paper from a supply box which is located behind the printer. As the printed output emerges from the printer, it is deposited in an empty receiving box.

- Pull the paper bail forward, out of the way, and raise the paper gates on the tractor's drive sprockets.
- If your printer has a TOP-OF-FORM button on the front of the cover, you should press it momentarily to index the feed mechanism.
- Insert the edge of the paper behind the platen, as on a typewriter.
- Manually rotate the platen knob transporting the paper through to the front.
- Pull the paper release lever all the way forward, disengaging the friction feed mechanism.
- Draw the paper around the front of the platen and line it up so that the pins on the drive sprockets match up with the holes punched in the paper margins. Then close the paper gates.
- Check the adjustment of the drive sprockets. They must not be so far apart that they stretch the paper. If they are too close together, on the other hand, the paper will buckle upward at its center. See that the page is approximately centered. If necessary, loosen the clamp screws on the drive sprockets and re-position them accordingly.
- Finally, rotate the platen to position the paper at the top of the page, using the horizontal lines on the transparent card guide. If your printer has a TOP-OF-FORM button, you must de-clutch the platen at the right knob while you are positioning the paper vertically. This insures that the top-of-form point in the paper feed mechanism corresponds to the actual beginning of the page.
- Move the paper bail toward the platen, letting it rest against the tractor frames.

NOTE

Check to be sure that the paper release lever is in the forward position when the tractor is in operation.

CLEANING

GENERAL

About once a week you should check the printer and remove the paper fibres that tend to build up inside the printer. At the same time you should clean away any ink that has accumulated on the plastic card guide. And you should inspect the condition of the printwheel to see if it needs to be cleaned or replaced.

- Use a soft-bristle brush to dust the printwheel carriage assembly lightly.
- Follow up with a soft cloth, using this to wipe the carriage guide rails and to mop up the interior generally. Clean up any ink residue with a cloth moistened in FORMULA 409™ household cleaner. **Do not spray solvents directly into the interior of the printer.**
- Ink will accumulate on the plastic card guide, obscuring the operator's view of the printing area. The card guide may be cleaned with a soft, lint-free cloth moistened in FORMULA 409™. Use a clean cloth to avoid scratching the transparent surface.

PRINTWHEEL

The printwheel can become clogged with ink and paper fibres, particularly in those printers that use nylon ribbons. Cleaning will be necessary whenever there is a noticeable deterioration in the clarity of the printed output.

- Remove the printwheel.
- Dip a type cleaning brush (or a toothbrush) in FORMULA 409™, and brush away all traces of greasy residue embedded in the printing dies. **Protect your clothing from ink spatters during the cleaning operation.**
- When you are finished, wipe the printwheel dry with a clean, lint-free cloth and re-install it on the printer.

COVER

The printer's plastic cover can be cleaned when necessary with a cloth moistened in FORMULA 409™.

IF YOU HAVE TROUBLE

Reliable as the Sprint Series/Q-Series Printer is, it will need to be fixed sooner or later. All machines do. But before you call your service representative, there are a few points you should check, just to be sure that you really need his help.

- Is the printer's separate power supply turned on?
- Is the cover off? The Sprint Series/Q-Series printers with Qume covers will not function while their cover is removed.
- Is there paper in the machine? Some systems contain an interlock that prevents printing when the machine is out of paper.
- Is the ribbon cartridge empty? Certain machines have an optional detector that prevents printing when the printer is out of ribbon.
- Try turning the printer's power supply off for a moment, then on again. Once is enough. This resets the printer internally, and may clear the problem. If you find that you have to do this often, however, call your service representative anyway.
- Open the printer's snap-on cover and make sure the carriage guide rails are not blocked by something that has fallen into the machine.
- Press down firmly on the "C" button of the carriage locking lever to be sure that the carriage is locked in its operating position.
- If the print quality is poor, examine the printwheel to see if it is worn or dirty. Clean it or replace it as necessary.
- Look at the back of the printer to see if its two cables are attached properly. Cables are sometimes disconnected temporarily and then forgotten.

If the problem persists after a careful check of the printer, then go ahead and call your service representative. He will be glad to advise and assist you. It will be helpful if, when you call, you tell him the model number and the serial number of your machine. The identification tag is located inside the printer and is visible when the platen is removed.

CAUTION

Do not attempt to fix the machine yourself by lubricating any part of the printer mechanism, even if you feel sure that this will solve your problem. This service *MUST* be performed by an authorized representative who has the proper lubricants in his tool kit. The use of the wrong lubricants can damage the printer, and will void your warranty.

altair Q70 Product/Interface Description Manual

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SECTION 1

INTRODUCTION

This manual is designed as a familiarization guide for those who want to use the Sprint 3 Series printers in automatic data systems. The programmer has to know enough about the possibilities inherent in hardware to enable him to request options that may be helpful in his application, and to specify certain features in the hardware interface. At the same time, the logic designer must be sympathetic enough to the programmer s problems to enable him to suggest the most advantageous solution to the questions that arise. That is precisely where this manual can be helpful. In addition to providing a ready source of reference information, it describes the interface structure from both the hardware and software points of view. The situation we want to help you avoid is that where you later hear: "You could have done X, and saved Y dollars per systems," or "cut Z seconds from your mean terminal response time." Your best defense is a sound understanding of the printer and its interface requirements.

The Sprint 3 Series High-Speed Character Printer is a high-performance, low cost character printer designed for use in automatic data systems. Its light weight and compact design, its ease of operation, and its dependability are important features in any application that calls for a printer of intermediate output capacity. The printer provides a full 96-character set, which includes upper and lower case alphabetics, numerics, and a variety of special purpose symbols. A number of optional type styles are available, on printwheels that are easily interchangeable by operators in the field.

On typical sequential text, the S3/35 printer can print at rates up to 35 characters per second for average English text. The S3/55 can attain print speeds as high as 55 characters per second. However, the usefulness of these devices is not restricted to line-sequential printing. Both the vertical and horizontal location of each character printed are fully programmable, with four degrees of freedom. And a unique method of optical control permits extremely accurate character placement. These features make the Sprint 3 Series printers suitable for plotting, and for applications where it is more convenient to randomize output than it is to format data in the conventional left-to-right and top-to-bottom manner. These printers provide for quad-directional positioning, within 1/120th of an inch horizontally and within 1/48th of an inch vertically. Horizontal displacements up to 13.1 inches (26.2 inches on the WideTrack model) and vertical displacements up to 21.3 inches may be programmed by each external command.

Control interface is fully TTL-compatible. The printer uses a 13-bit weighted data bus and three strobe lines for its basic control functions. Data on the bus at any given instant may represent a vertical displacement of the paper mechanism, a horizontal displacement of the carriage, or an ASCII code which identifies the character to be printed. Three strobe lines ($\overline{\text{PAPER FEED STROBE}}$, $\overline{\text{CARRIAGE STROBE}}$, and $\overline{\text{CHARACTER STROBE}}$) distinguish the operation to be performed and initiate the appropriate action.

The ribbon lift function is also controlled externally. Other interface lines serve to enable and initialize the printer and to indicate the printer's internal status. Optional circuitry within the printer monitors paper and ribbon continuously, and indicates whenever the supply of either is exhausted.

Perhaps the most significant feature of the printer is its mechanical simplicity. Mechanical functions have been replaced with electrical functions wherever possible, and the remaining inertia of the mechanaism has been minimized through the use of light-weight, low-moment components. By minimizing the number of moving parts and by carefully optimizing the mechanical details, the designers have produced an exceptionally fast, quiet, and reliable serial printer. Mean time between failures exceeds 1,000 hours, and plug-in serviceability permits on-site repair with an absolute minimum of down time.

With their respective printing rates of 35, 45, and 55 characters per second, the Model S3/35, S3/45, and S3/55 High-Speed Character Printers offer the systems designer an alternative, both to the slow speed that is typical of serial devices like the teletype and automatic electric typewriter and to the inevitable expense of very high-speed devices such as the line printer. In addition, the Sprint 3 Series printers have an advantage not shared by either of the traditional approaches to hard copy generation: print quality which rivals that of the very best office typewriters, including the ability to space proportionally. These basic characteristics, together with low cost, make the Sprint 3 Series printers ideal for use both in smaller systems that are "I/O bound", and in larger systems that call for a flexible terminal printer with a highly readable output.

The new Qume Sprint Micro 3 Series of printers incorporates a completely new electronics package that includes a true MOS microcomputer, sharply cutting the number of electronic components and connections and increasing product reliability. The package also provides self-testing capability and self-compensating circuit boards that can be replaced without the need for adjustments.

The Sprint Micro 3 Printers have a built-in self test feature to ensure proper operation and simplify service. The microprocessor can conduct a checkout of itself and other printer functions. The status of each can then be instantly displayed on Qume s palm size option, the Micro 3 Activity Monitor.

SECTION 2

SPECIFICATIONS

PRINT SPEED:	Qume printer speed varies according to the sequence of characters being printed and whether the various capabilities of the printer (high speed electronic tab, printing right to left, etc.) are used properly. Speeds shown below are for average English text on one line, with electronic tab over spaces between words, and are shown in characters per second (cps).

Sprint Micro 3/35:	35 cps
Sprint Micro 3/45:	45 cps
Sprint Micro 3/55:	55 cps
Sprint Micro 3/X30:	30 cps (metallized wheel)
Sprint Micro 3/X40:	40 cps (metallized wheel)
Sprint Micro 3/WideTrack:	40 cps

PRINT:	Full characters of electric typewriter quality, printed serially: variable intensity ballistic hammer automatically adjusts to one of six intensities according to character size.
FORMS:	Single sheets and continuous forms, with or without sprocket holes. The Sprint Micro 3 printers maximum forms width is 15 inches (38.1 cm). WideTrack maximum forms width: 28 inches (71.1 cm).
FONT:	96 CHARACTER POSITIONS ON "daisy" printwheel: Wide variety of standard font styles in 10 and 12 pitch and proportional spacing.
FORMAT:	<u>Horizontal</u>: Sprint Micro 3: 132 columns at 10 characters per inch; 158 columns at 12 characters per inch; left or right. Electronic tabbing and carriage return up to 13.1 inches (33.3 cm). <u>Vertical</u>: Spacing in increments of 1/48th of an inch, up or down: slew rate at 5 inches (12.7 cm) per second. WideTrack slew rate: 5 inches (10.2 cm) per second.
PLOTTING:	Resolution of 5760 points per square inch.
PAPER FEED:	Pressure Platen: pin feed platens, forms tractor, optional.
RIBBON:	Easy to handle cartridge with multi-strike carbon, single strike carbon, or fabric ribbon.
PRINTWHEEL:	Easily operator changeable.
OPERATOR CONTROLS:	Horizontal forms positioning; vertical forms positioning; forms thickness; ribbon advance.

TEMPERATURE: Operating 50 to 105 degrees F (10 to 40 degrees C).
Storage -40 to 170 degrees F (-40 to 76 degrees C).

HUMIDITY: Operating 10% to 90% RH (no condensation).
Storage 2% to 98% RH (no condensation).

PHYSICAL: <u>Sprint Micro 3</u>

Weight:	28 pounds (12.7 kg)
Width:	23.63 inches (60 cm)
Height:	7.11 inches (18 cm)
Depth:	13.5 inches (34.3 cm)

<u>WideTrack</u>

Weight:	37.2 pounds (16.9 kg)
Width:	36.5 inches (92.8 cm)
Height:	7.11 inches (18 cm)
Depth:	13.5 inches (34.3 cm)

DATA INPUT: 13-bit parallel TTL levels plus control lines.

POWER REQUIREMENTS: (For All Sprint Micro 3 Models).

+ 5	VDC	± 3%	3.5 amps DC
+15	VDC	± 10%	4.5 amps average (14 amps peak 20 ms max.)
-15	VDC	± 10%	4.5 amps average (14 amps peak 20 ms max.)

SECTION 3

FUNCTIONAL OPERATION

3.1 MECHANICAL FUNCTIONS

Both the systems analyst and the interface designer will find their jobs a little easier if they understand a bit about the mechanical functions of the printer, in addition to understanding its logical functions, or the way that it responds to electrical commands. This makes it easier to visualize the exact effect of a given series of commands, and thus, makes it easier to specify the hardware interface and the controlling program that are most conducive to an efficient and responsive system. We therefore suggest that anyone contemplating an application become at least somewhat familiar with the printer s mechanical design, rather than viewing it strictly as a functional "black box".

In their mechanical operation the Sprint 3 Series Printers resemble an office typewriter. There has to be a way of selecting the character to be printed, and some means of positioning the paper under the printing die (or of positioning the die over the paper). With the die in the proper relative position, printing is accomplished by striking the die so that it contacts a ribbon that is impregnated with ink. The ribbon in turn contacts the paper, transferring the die's image to the paper surface. The exhausted section of the ribbon is advanced just prior to each impression, ensuring a clear image every time that the die is struck. Because these functions are much the same as those performed in a typewriter, the operation of the printer is somewhat similar to the operation of certain high-speed typewriters and teleprinters.

A typewriter-style platen roller feeds paper and positions the paper vertically in front of the printing die. In the standard version of the printer, paper is held in place by the pressure of spring-loaded pinch rollers mounted underneath the platen itself. Rubber surfaces on the platen and on the feed rollers restrain the paper, in a mechanism known as friction feed.

Rotation of the platen moves the paper vertically. This is done manually during the loading of the paper using the knobs provided on either end of the platen. Once the paper has been loaded, however, paper feed is commanded automatically by the controlling device. External commands act on the printer s electronics, to position a control motor within the printer. The motor then drives the platen through a gear train to move the paper in multiples of a basic 1/48th of an inch increment.

An optional version of the Sprint 3 Series Printer provides independent left and right paper feed mechanisms. This printer contains two platens, mounted on a common axial shaft, so that each may be rotated without affecting the position of the other. The right hand platen is driven by the standard paper feed mechanism, while the left is driven by a functionally similar mechanism which is installed on the left side of the printer chassis. Independent feed mechanisms are convenient in certain specialized applications where complementary split forms must be prepared simultaneously.

Pin feed is available optionally, in order to allow the use of continuous forms. In the pin feed arrangement sprockets are mounted on either side of the platen, and the teeth on these engage pre-punched holes in the paper margins. This prevents the paper from slipping on the platen, as occasionally happens with friction feed machines, especially where multiple copies are being prepared. Slippage is seldom serious enough to be a problem where the printer is being used to prepare short forms and single pages, but, cumulative slippage can become significant in situations where the printer must operate unattended for long periods of time. In those applications, and in applications that require precise control of vertical print position, the pin feed option has obvious advantages.

The principle disadvantage with pin feed is that the width of the forms used is dictated by the distance between the platen s opposing sprockets. In many applications this is perfectly acceptable, but, greater flexibility may be obtained with the adjustable forms tractor, which is also offered as an option. Installation of this convenient accessory is accomplished easily in the field, without tools, and the tractor may likewise be removed at any time. No other modification is necessary than the snap-on installation of a slotted top cover, which replaces the printer s standard plastic cover.

As in pin-feed, the form is positioned by means of perforations in its margins. Positioning is accomplished, however, by the teeth on two flexible belts, which are driven indirectly by a gear on the platen shaft. Spacing between the two drive belts is adjustable to accommodate any size form, including the 11 X 15 inch fan-folded sheet that is standard in many EDP installations. The increment of paper advance is still 1/48th of an inch, just as it is with the friction feed system. A dual forms tractor is also available, for use on printers equipped with the split platen option.

The dies used to print the characters are molded into a light-weight plastic disc, called the printwheel. Ninety-six spokes emerge radially from the hub of this disc and the tip of each carries the relief image of an alphanumeric character. The printwheel rotates in a vertical plane which is also parallel to the horizontal axis of the platen, and is positioned so that the character on the uppermost spoke (12 o clock) is in the proper position to strike the platen squarely. Printing is then accomplished by an electromagnetically operated printhammer mounted behind the 12 o clock printwheel position. A current pulse applied to the printhammer causes it to strike the uppermost spoke, and the flex in the spoke permits the die to contact paper and platen, through an intervening ribbon.

Character selection is thus determined by the angular position of the printwheel at the instant that the printhammer is activated. External commands act on the printer s electronics, to position a motor which in turn positions the printwheel. Each succeeding command causes the printwheel to adopt a new angular position. The printhammer is tripped automatically as soon as the printwheel has found the position commanded by the controlling device and the carriage and the paper feed are at rest.

Printwheels are furnished in 96-character fonts. The durable plastic printwheel is designed to withstand several millions of individual impressions, while maintaining a high standard of clarity and definition in the printed output. Replacing a worn printwheel or installing a special font takes the operator only a few moments. Interchangeable printwheels are available in a variety of optional styles. Consult the latest Supplies Price List for samples of the type fonts currently offered.

The printwheel and printhammer are mounted on a mechanical assembly known as the carriage. Also mounted on this assembly is the ribbon cartridge, the mechanism that lifts the ribbon into printing position, and the ribbon drive motor. The carriage assembly travels the width of the chassis on two rails which parallel the axis of the platen. The location of the carriage on its guide rails thus determines the horizontal positioning of the character to be printed. External commands position a drive motor which in turn operates through a cable and pulley arrangement to position the carriage itself. This straight-forward mechanical system permits extremely fast and precise positioning of the printed character. The basic increment of horizontal motion is 1/120th of an inch.

Three interchangeable ribbon cartridges enable the user to choose the kind of ribbon that represents the most advantageous compromise between economy of operation and print quality. Cartridge styles include:

(1) single-strike carbon

(2) multi-strike carbon

(3) continuous re-usable nylon

The ribbon cartridge clips into place on the carriage. An external command operates an electromagnet which is also mounted on the carriage, to lift the loop of the ribbon into printing position. This permits the controlling device to drop the ribbon when it has finished sending its message, so that the operator can view the printed result.

Ribbon is advanced incrementally during each cycle of the printwheel just prior to the firing of the printhammer. A small motor mounted on the carriage performs this function to ensure a clear image each time that a character is struck. Ribbon advance is an automatic function of the printer. Unlike those functions previously discussed, it is not under direct program control. The increment of advance, however, is automatically programed. Programmed ribbon advance enables the printer to make the most economical use of the ribbon, permitting an increment of advance that is proportional to the width of the last character printed and the width of the next character to be printed. In a typical text printing application, this means that ribbon expenditures will be reduced by approximately 30%.

3.2 STATUS AND CONTROL

The printer uses a thirteen-bit weighted data bus and three strobe lines for its basic control functions: paper feed, carriage movement, and character printing. Digital data on the bus at a particular instant may represent a vertical displacement of the paper feed, a horizontal displacement of the carriage, or an ASCII code which identifies the character to be printed. Three strobe lines (PAPER FEED RIGHT STROBE, CARRIAGE STROBE, and CHARACTER STROBE) distinguish the operation to be performed and initiate the appropriate action.

The ribbon lift function is also programmed externally, by a single "TWO STATE" command line. Other interface lines serve to initialize and enable the printer to indicate the printer's internal status. Certain optional status and control functions may also be provided in addition to the standard functions associated with the printer.

3.2.1 ENABLING FUNCTIONS

The printer's enabling functions consist of the PRINTER SELECT command line and the PRINTER READY status line. All other command lines will be inhibited, and all status lines will be false, until an active low enabling level is applied to the PRINTER SELECT command line.

PRINTER READY will be true whenever the proper supply voltages are available to the printer, and when the printer has succeeded in initializing itself properly, following the application of power. Once energized, PRINTER READY remains true until disabled by internal malfunction or by an external power supply failure. The PRINTER READY signal is gated by the PRINTER SELECT line.

Initialization is performed automatically when the printer first senses the application of power. This generates a complete internal reset of the printer's control logic and positions the carriage at its extreme left limit of travel and spins the printwheel to locate the index pulse and syncronizes the control circuitry.

3.2.2 EXCEPTION FUNCTIONS

The printer's exception functions cover unusual operating conditions. They consist of the $\overline{\text{CHECK}}$ status line and the $\overline{\text{RESTORE}}$ command line. $\overline{\text{CHECK}}$ is the principle indicator of error status and will be true whenever any of the following exceptional conditions exist:

(a) power supply voltages out of tolerance

(b) a carriage command is received that the printer is unable to complete

(c) a printwheel command is received that the printer is unable to complete

Either of these will cause the $\overline{\text{CHECK}}$ flag to be set, simultaneously inhibiting all other command lines except $\overline{\text{RESTORE}}$.

The $\overline{\text{RESTORE}}$ command line furnishes the means of resetting a $\overline{\text{CHECK}}$ condition that is due to some transient cause, such as a power fluctuation or an illegal carriage command. $\overline{\text{RESTORE}}$ will not be effective, however, in clearing a $\overline{\text{CHECK}}$ condition that is the result of a permanent malfunction. A $\overline{\text{RESTORE}}$ command may be issued by the controlling device any time that the $\overline{\text{PRINTER SELECT}}$ line is enabled. This command causes initialization of the printer as described in 3.2.1.

Programmable $\overline{\text{TOP OF FORM}}$ ($\overline{\text{TOF}}$) is offered as an option. This option enables the user to program 1 of 16 form increments by the generation of a special ASCII Form Feed (FF) code coincidental with a $\overline{\text{CHARACTER STROBE}}$. After the form length has been programed the action command to execute $\overline{\text{TOF}}$ is initiated by the $\overline{\text{TOP OF FORM}}$ line.

An optional status line, $\overline{\text{COVER INTERLOCK}}$, indicates whether the printer's cover is in place and inhibits further operation when false.

Two other optional status lines, $\overline{\text{PAPER OUT}}$ and $\overline{\text{RIBBON OUT}}$, indicates that the printer is out of paper or out of ribbon.

3.2.3 PAPER FEED FUNCTIONS

A paper feed instruction is executed by testing the INPUT BUFFER READY status line (previously called PAPER FEED RIGHT READY) and using the PAPER FEED MAIN STROBE. A true level on the INPUT BUFFER READY line indicates that the buffer is clear and can accept an instruction. Any command strobe arriving at the time the INPUT BUFFER READY line is false will be ignored.

Paper feed is initiated by placing a binary command word on the printer's input data bus and by activating the PAPER FEED MAIN STROBE line. The command word indicates the direction of movement and the relative displacement in multiples of 1/48th of an inch as follows:

D2048	Not used
D1024	Direction ("0" = Advance "1" = Retard)
D512	
D256	
D128	
D64	
D32	
D16	
D8	
D4	
D2	
D1	
D1/2	Not used

The printer's INPUT BUFFER READY line will be inhibited within 250 to 950 nanoseconds of the strobe, and will remain false for 20 to 800 usecs.

Paper feed is also protected by an automatic interlock which prevents paper motion while a previous character print cycle is in progress. Any command arriving during a current print cycle will be stored internally, and its execution will be deferred until completion of the preceding character command.

NOTE

Paper cannot be reversed when the optional forms tractor is in place. Installation of this accessory calls for disabling the standard paper feed mechanism. Reversing the paper motion under these circumstances will cause paper to wrinkle and pile up at the front of the platen.

3.2.4 CARRIAGE FUNCTIONS

A carriage instruction is executed by testing the INPUT BUFFER READY status line (previously called CARRIAGE READY) and using the CARRIAGE STROBE line. A true level on the INPUT BUFFER READY line indicates that the buffer is clear and can accept another instruction. Any carriage command arriving at the time the INPUT BUFFER READY line is false will be ignored.

Carriage motion is initiated by placing a binary command word on the printer's input data bus, and by activating the CARRIAGE STROBE line. The command word indicates the direction of movement and the relative displacement in multiples of 1/60th of an inch.

D2048	(In the WideTrack model D2048 equals 1024 steps of 1/60th of an inch.)
D1024	Direction ("0" = Right "1" = Left)
D512	
D256	
D128	
D64	
D32	
D16	
D8	
D4	
D2	
D1	
D1/2	Allows 1/120th of an inch motion

The printer's INPUT BUFFER READY line will be inhibited within 250 to 950 nanoseconds of the strobe, and will remain false for 20 to 800 usecs.

Carriage motion is also protected by an automatic interlock which prevents carriage movement while a previous character print cycle is in progress. Any command arriving during a current print cycle will be stored internally, and its execution will be deferred until completion of the preceding character command.

3.2.5 CHARACTER PRINTING FUNCTIONS

The character instruction is executed by testing the INPUT BUFFER READY status line (previously called CHARACTER READY) and using the CHARACTER STROBE line. A true level on the INPUT BUFFER READY line indicates that the printer's INPUT BUFFER is clear, and that it can therefore accept another command. Any character command originating during the time this line is false will be ignored.

Printing is initiated by placing a binary command word on the printer's input data bus, and by activating the CHARACTER STROBE line. The command word indicates the character to be printed, in modified ASCII format as follows:

D2048	Not used
D1024	Not used
D512	Not used
D256	Not used
D128	Not used
D64	
D32	
D16	
D8	
D4	
D2	
D1	
D1/2	Not used

The printer's INPUT BUFFER READY status line will be inhibited within 250 to 950 nanoseconds of the strobe, and will remain false for 20 to 800 usecs.

Character printing is also protected by an automatic logical interlock that permits positioning of the printwheel but delays firing of the printhammer while a paper feed or a carriage motion is in progress. Any command arriving during a cycle of the paper feed logic or the carriage logic will cause the printwheel to re-position itself. The firing of the printhammer, however, will be deferred until completion of the other commands in progress.

When the micro processor comes to a character instruction the printer will automatically begin advancing the ribbon. The ribbon will be advanced a proportional amount determined by the width of the last character printed, and the width of the next character to be printed. (See Table 5-4.)

3.2.6.RIBBON LIFT FUNCTION

The ribbon lift function consists of a single RIBBON LIFT command line. A true condition on this line causes the ribbon to be raised into printing position, while a false condition drops the ribbon. Raising or lowering of the ribbon may be performed without the preliminary testing of a status line, and the action requires a nominal 30 milliseconds in each case.

The ribbon lift function is protected by an automatic internal interlock which prevents the raising or lowering of the ribbon while a character print cycle is in progress. A corresponding interlock in the character printing logic prevents firing of the printhammer while the ribbon is in motion.

SECTION 4

INSTALLATION

INSTALLATION

The following paragraphs outline procedures for installing the printer.

4.1 POWER CONNECTIONS

The printer requires three power supply voltages, as listed in Table 4-1. Seperate modular power supplies having the required characteristics may be used.

TABLE 4-1

POWER REQUIRED

SUPPLY/TOLERANCE	CURRENT REQUIRED
+15 VDC ± 10%	4.5 amps avg/14 amp peaks - 20 msec max.
-15 VDC ± 10%	4.5 amps avg/14 amp peaks - 20 msec max.
+ 5 VDC ± 3%	3.5 amps

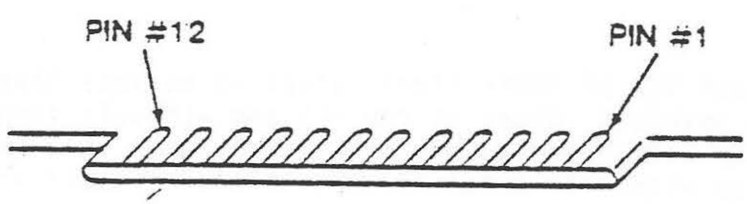
All voltages must reach 90% of their final values in no less than 4 msecs and no more 100 msecs. The absolute values of the +15 and -15 volt input must not differ by more than 2.0 volts during their rise or fall. The +5 volt input must reach 90% of its final value within 50 msecs of the +15 and -15 volt input.

All power connections are made through a single connector (Molex #09-01-1121-1), which attaches to a corresponding connector (see Figure 4-1) on the left side of the printer, viewed from the rear. Pin allocations on the power connector are given in Table 4-2. Note that separate lines for high and low current supply distributions must be provided for all three supplies to prevent noise from being coupled from the carriage and printwheel motor drive circuits into the signal processing circuits. It is suggested that the recommended wire sizes (see Table 4-2) be used for installation. For proper noise isolation, the +5 V logic supply return path must be isolated from the +15 V and -15 V supply ground return paths in the power supply and the power cable.

TABLE 4-2

POWER CONNECTOR

POWER	PIN	WIRE SIZE
+15V High Current	3,4	2x18 AWG
+15V Low Current	6	1x18 AWG
-15V High Current	1,2	2x18 AWG
-15V Low Current	5	1x18 AWG
+ 5V Logic Current	7,8	2x18 AWG
+ 5V Power Current	12	1x18 AWG
Ground	9, 10, 11	3x18 AWG (or 7/32" tinned copper braid)



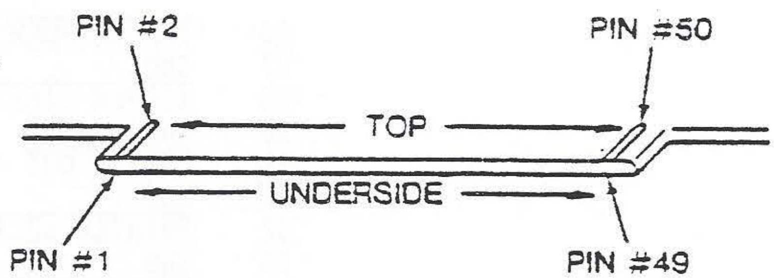
As Viewed From Rear of Printer

FIGURE 4-1

POWER CONNECTOR (J2) ORIENTATION

4.2 CONTROL

Control interface is provided through a dual 25-pin edge card connector (0.1" contact centers). Recommended connector is 3M #3415-0000. This mates with J1 (right side of the printer, as viewed from the rear). Recommended cable is 3M #3365, a 50-conductor ribbon type cable which has a 100 ohm characteristic impedance. Allocations on the control connector are given in the accompanying Table 4-3.

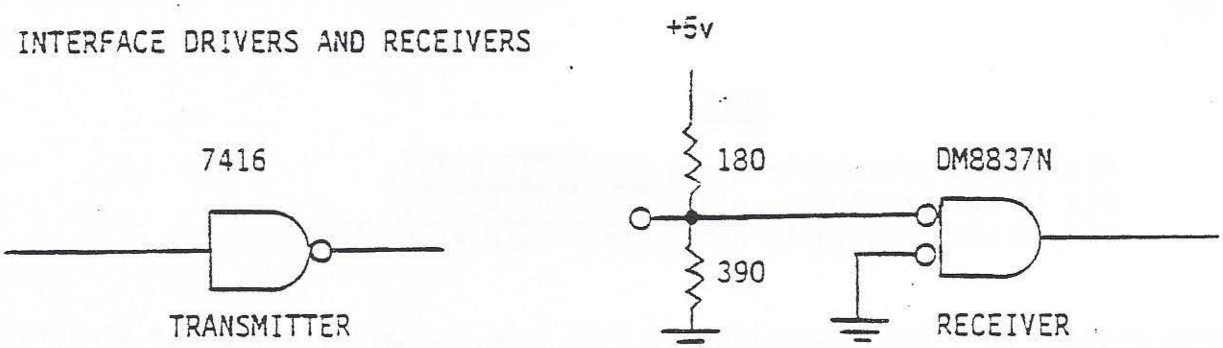


As Viewed From Rear Of Printer

FIGURE 4-2

CONTROL CONNECTOR (J1) ORIENTATION

INTERFACE DRIVERS AND RECEIVERS



All input/output signals are active low.
Logic 1: ≤ 0.4v Logic: 0: ≥ 2.4v
Data 1/2 thru 2048 have 1K pull-up
resistor and are received by 74412's.

TABLE 4-3

INTERFACE SIGNALS AND PIN ASSIGNMENTS

Connector: 3M #3415-0000

PIN	SIGNAL NAME	PIN	SIGNAL NAME
1	GND	26	TOP OF FORM (OPT)
2	DATA 1/2	27	GND
3	DATA 1	28	RIBBON LIFT COMMAND
4	DATA 2	29	GND
5	DATA 4	30	RIBBON OUT (OPT)
6	DATA 8	31	GND
7	DATA 16	32	PRINTER SELECT
8	DATA 32	33	GND
9	DATA 64	34	COVER INTERLOCK (OPT)
10	DATA 128	35	GND
11	DATA 256	36	GND
12	DATA 512	37	CHECK
13	DATA 1024	38	GND
14	DATA 2048 (OPT)	39	INPUT BUFFER READY
15	GND	40	GND
16	RESTORE	41	INPUT BUFFER READY
17	GND	42	GND
18	CHARACTER STROBE	43	INPUT BUFFER READY
19	GND	44	GND
20	CARRIAGE STROBE	45	(Not used)
21	GND	46	GND
22	PAPER FEED MAIN STROBE	47	PRINTER READY
23	GND	48	GND
24	PAPER FEED AUXILIARY STROBE (OPT)	49	PAPER OUT (OPT)
25	GND	50	GND

NOTE

Pin 39 was previously named CHARACTER READY.
Pin 41 was previously named CARRIAGE READY.
Pin 43 was previously named PAPER FEED RIGHT READY.

These three signals have been consolidated (but gate isolated) and occur simultaneously. Only one of these INPUT BUFFER READY lines needs to be tested prior to each CHARACTER, CARRIAGE or PAPER FEED STROBE.

4.3 INITIAL PERFORMANCE CHECK

The ideal performance check is to install the printer in the system with which it will be used, and execute a suitable exercise routine.

An alternate check may be performed by grounding pin 2 of the 40 pin test point strip on P.C.B. #2. The printer should be powered down when securing a jumper between ground and pin 2. In this test the printer relies on a diagnostic test stored in its own micro processor memory. This test may be monitored and controlled by the Sprint Micro 3 Activity Monitor (part #80740). For further explanation of this test and Activity Monitor refer to, Sprint Micro 3 Maintenance Manual, chapter VI.

The diagnostic test performs the following:

(1) ROM test.

(2) I/O lines.

(3) Executes a restore.

(4) Carriage moves 114 times back and forth in diminishing movements.

(5) Printwheel moves 96 times clockwise and counter clockwise.

(6) Executes various combinations of forward and reverse paper feeds.

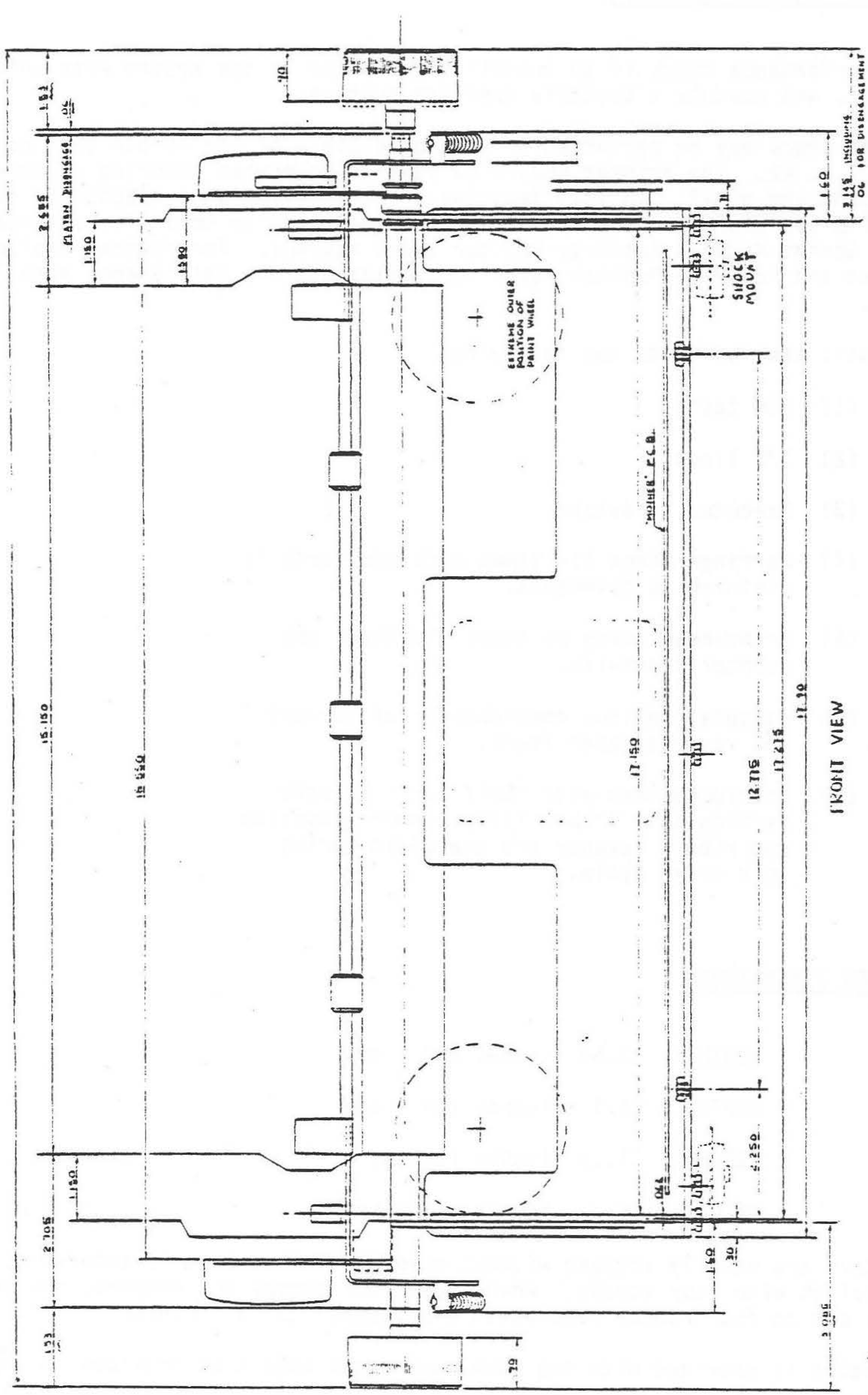
(7) Concludes test with "Self Test" printed vertically. Ribbon lift, hammer actuation and ribbon advance are exercised during this print cycle.

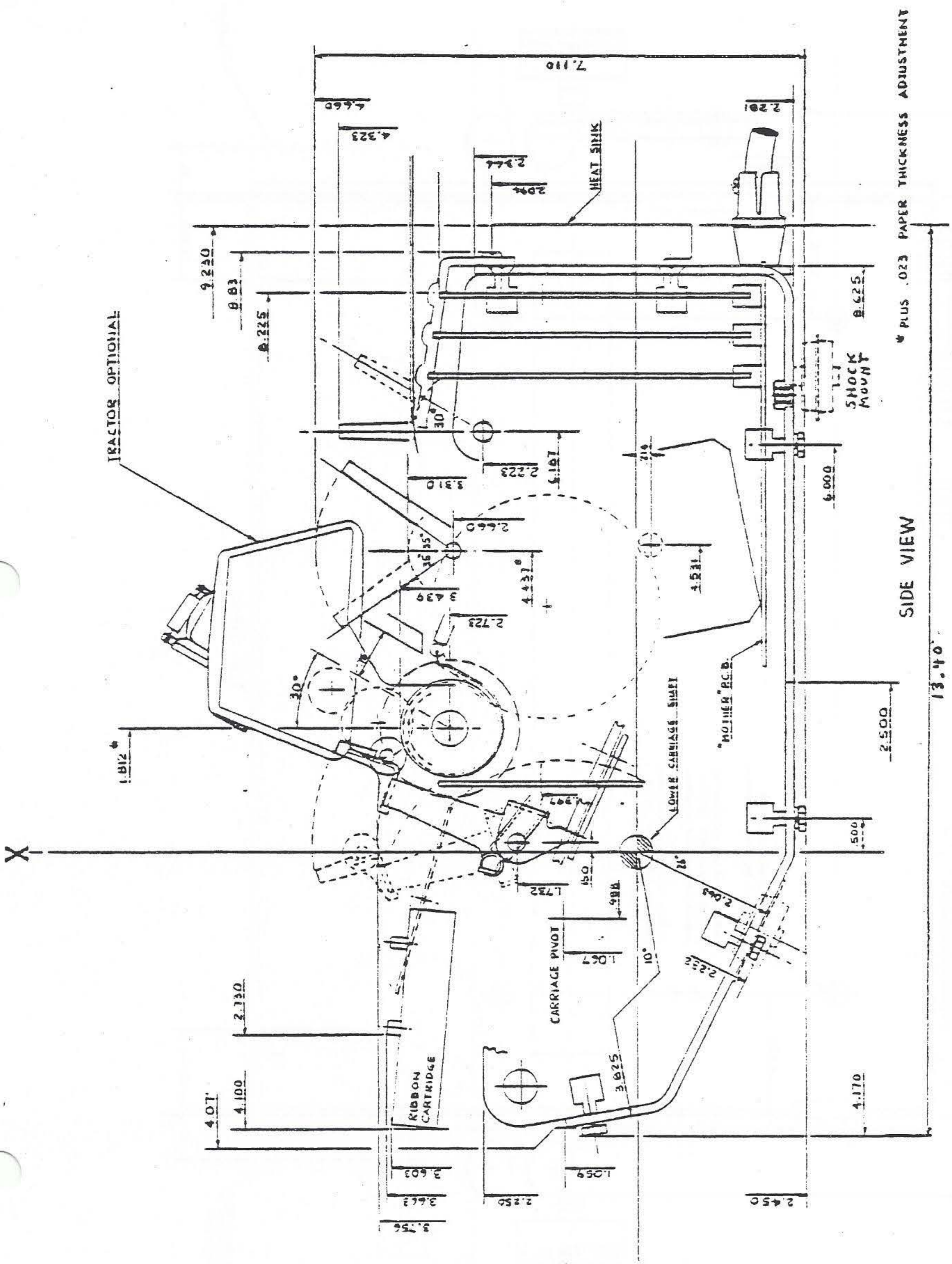
4.4 PRINTER DIMENSIONS

WIDTH	23.63	inches (59.8 cm)
DEPTH	13.5	inches (34.3 cm)
HEIGHT	7.11	inches (18 cm)
WEIGHT	26	pounds (11.8 kg)

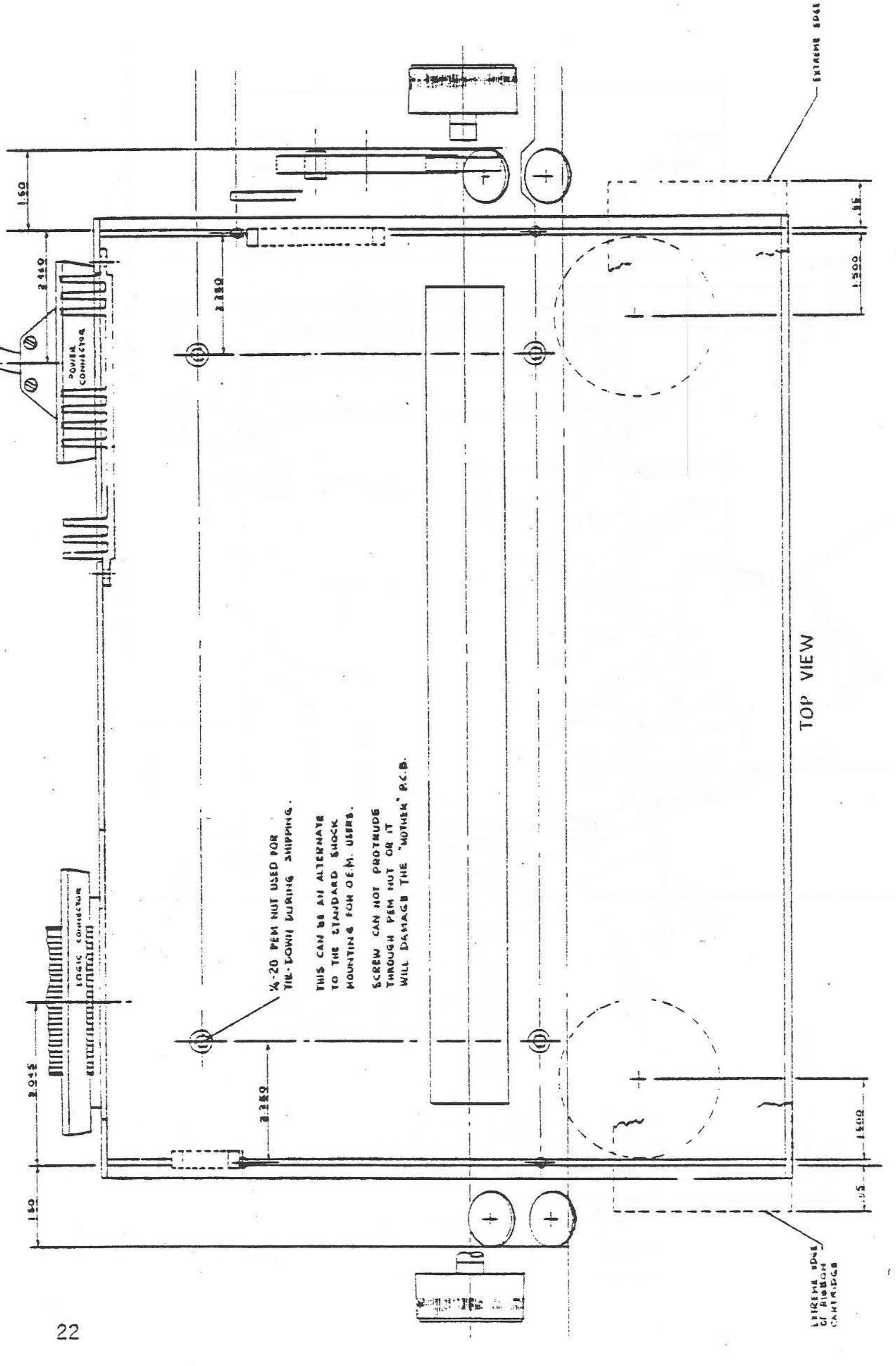
Qume printers are usually shipped without covers. The printer is secured to a shipping pallet with four screws. When these four screws are removed, the printer will sit on four rubber feet which are secured to the printer.

Shock mounting is provided with the Qume covers and should be provided in any other covers that will be used. Four holes are provided in the printer base plate for the shock mounts.


FRONT VIEW
EXTREME OUTER POSITION OF PRINT WHEEL
SHOCK MOUNT
'MOTHER' P.C.B.
PLATEN DISENGAGE
INCLUDES .06 FOR DISENGAGEMENT
15.150
17.150
12.716



SIDE VIEW
TRACTOR OPTIONAL
HEAT SINK
SHOCK MOUNT
"MOTHER" P.C.B.
LOWER CARRIAGE SHAFT
CARRIAGE PIVOT
RIBBON CARTRIDGE
X
* PLUS .023 PAPER THICKNESS ADJUSTMENT
7.110
4.660
4.323
2.344
2.094
2.281
9.230
8.83
8.225
8.625
3.310
2.223
6.187
2.660
4.437
3.439
2.723
4.531
6.000
1.812 *
2.500
13.40
.500
1.732
.150
.988
1.067
2.065
2.222
3.825
2.730
4.100
4.07
4.170
3.603
3.663
3.756
2.250
1.059
2.450
30°
35°
10°


TOP VIEW
POWER CONNECTOR
LOGIC CONNECTOR
1/4-20 PEM NUT USED FOR TIE-DOWN DURING SHIPPING.
THIS CAN BE AN ALTERNATE TO THE STANDARD SHOCK MOUNTING FOR O.E.M. USERS.
SCREW CAN NOT PROTRUDE THROUGH PEM NUT OR IT WILL DAMAGE THE 'MOTHER' P.C.B.
EXTREME EDGE OF RIBBON CARTRIDGE

SECTION 5

INTERFACING

The term interface, while it is often understood to mean the controller hardware, realy refers to the combination of hardware and software provisions that establish the logical scheme enabling the processor to control the printer. It is at this point where the cordination of skills involved in putting together a system can become most critical, for the programmer is usually unaware of at least some of the hardware possibilities and the hardware designer on his part is correspondingly unaware of the programmer's needs and limitations. It is up to the system designer to bridge this gap.

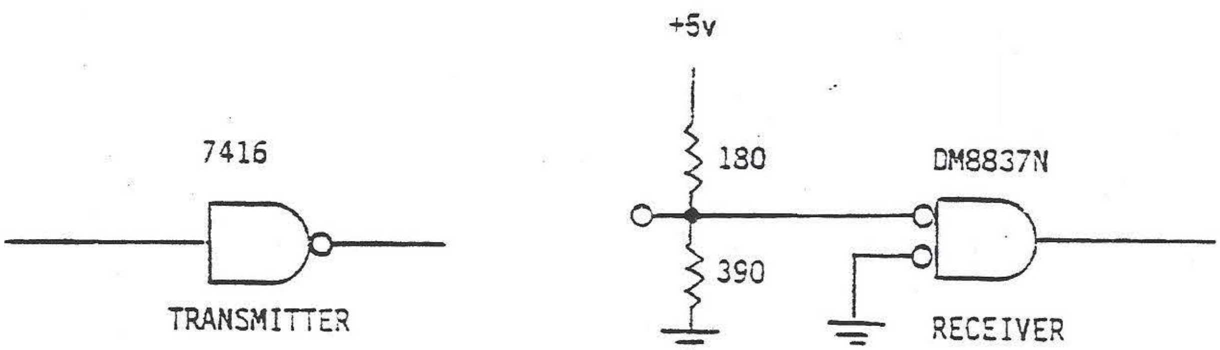
I/O design is a specialized branch of the more comprehensive art of systems design, involving an intimate knowledge of the peripheral's characteristics, the processor's requirements, the intermediary logic, and the overriding constraints of the system specifications. It would not only be unwise to attempt to cover this discipline, which is largely a matter of informed intuition, it would be impossible as well. What we can do is to show by detail and by example how the printer works, and thereby suggest answers to some of the more common questions that arise in the course of interface design. Hopefully this will enable the designer to specify those interface features that permit him to achieve the most economical and efficient configuration consistent with the basic requirements of his system.

TABLE 5-1

INTERFACE SIGNALS AND PIN ASSIGNMENTS
Connector: 3M #3415-0000

PIN	SIGNAL NAME	PIN	SIGNAL NAME
1	GND	26	TOP OF FORM (OPT)
2	DATA 1/2	27	GND
3	DATA 1	28	RIBBON LIFT COMMAND
4	DATA 2	29	GND
5	DATA 4	30	RIBBON OUT (OPT)
6	DATA 8	31	GND
7	DATA 16	32	PRINTER SELECT
8	DATA 32	33	GND
9	DATA 64	34	COVER INTERLOCK (OPT)
10	DATA 128	35	GND
11	DATA 256	36	GND
12	DATA 512	37	CHECK
13	DATA 1024	38	GND
14	DATA 2048 (OPT)	39	INPUT BUFFER READY
15	GND	40	GND
16	RESTORE	41	INPUT BUFFER READY
17	GND	42	GND
18	CHARACTER STROBE	43	INPUT BUFFER READY
19	GND	44	GND
20	CARRIAGE STROBE	45	(Not used)
21	GND	46	GND
22	PAPER FEED MAIN STROBE	47	PRINTER READY
23	GND	48	GND
24	PAPER FEED AUXILARY STROBE (OPT)	49	PAPER OUT (OPT)
25	GND	50	GND

INTERFACE DRIVERS AND RECEIVERS



All input/output signals are active low.
 Logic 1: ≤ 0.4 Volts Logic 0: ≥ 2.4 Volts

5.1 DATA AND CONTROL CONNECTIONS

Input control and data signals are connected to the printer through J1 (right side of chassis viewed from the rear). The connector consists of a dual 25-pin edge card connector (0.1 inch contact centers). Recommended connector is 3M #3415-0000. Recommended interconnecting cable is 3M #3365, 50-conductor ribbon. Pin assignments on the control connector are given in Table 5-1 and shown in Figure 4-2.

5.1.1 BASIC SIGNAL INPUTS

PRINTER SELECT LINE (Pin 32)

This signal is used to select the printer for operation, and enables the input and output lines in the interface. All interface lines are disabled until the select line is low.

RESTORE (Pin 16)

This signal initiates a restore sequence, normally following a printer malfunction r power failure which causes a "check" condition (see Basic Signal Outputs). The restore sequence consists of positioning the carriage at the leftmost position, synchronizing the printwheel, and resetting the carriage, printwheel, and interface logic. The internal "check" circuits are also reset.

DATA LINES (Pins 2 - 14)

These thirteen lines contain binary-coded information representing an ASCII character, a carriage movement command, or a paper feed command.

When representing an ASCII character, only the low-order seven lines (D1-D64) are used; the remaining lines are ignored. Refer to Table 5-2 for a cross-reference between printwheel addresses and ASCII inputs.

When representing a carriage movement command, the eleven low-order bits designate the distance the carriage is to be moved in multiples of 1/60th of an inch. The D-1/2 bit indicates 1/2 times 1/60th, or 1/120th of an inch. A value of six is required for one character at 10 characters/inch. The high-order bit (1024) determines the direction of carriage travel. If this bit is a logic "0" the carriage travels to the right; if a logic "1" the carriage travels to the left. D2048 bit is used in the WideTrack model to represent 1024 steps.

When representing a paper feed command, the ten low-order bits designate the number of vertical position increments to be moved, in multiples of 1/48th of an inch. The igh-order bit (1024) determines the direction of paper movement; a logic "0" moves the paper upward, and a logic "1" moves the paper downward.

CHARACTER STROBE (Pin 18)

When this signal is pulled low with valid character data on the data lines, the character data will be transferred into the input buffer register. Timing is shown in Figure 5-1.

CARRIAGE STROBE (Pin 20)

This signal enters carriage movement data into the input buffer when pulled low.

RIBBON LIFT COMMAND (Pin 28)

This signal raises and lowers the ribbon. If the level on this line is high (false), the ribbon will drop to the lower position; if the level is low (true), the ribbon will be raised to the printing position

PAPER FEED MAIN STROBE (Pin 22)

When pulled low this signal enters paper movement data into the input buffer in operations where a single platen is used, or enters righthand platen movement data when the split platen option is installed

PAPER FEED AUXILARY STROBE (Pin 24)

When pulled low this signal enters left platen paper movement data when the split platen option is installed.

TOP OF FORM COMMAND (Pin 26) (Rom Version Only)

This signal advances the paper to its starting point at the Top of Form. There is sixteen programmable lengths of form feed available. The length of form to be used should be programmed prior to applying the TOF strobe by initiating a character st-robe co-incidental with the ASCII FF code with data bits D128, D256, D512 and D1024 determining the length of feed. See Table 5-1A. If FF code is not used, the Top Of Form increment will automatically be set at eleven inches.

Character Strobe	D1	0
ASCII FF Code	D2	0
	D4	1
	D8	1
	D16	0
	D32	0
	D64	0
	* D128	A
	* D256	B
	* D512	C
	* D1024	D

TABLE 5-2

TOP-OF-FORM

DATA BITS OF FF COMMAND				FORM LENGTH (INCHES)
D1024	D512	D256	D128	
0	0	0	0	11 Note 2
0	0	0	1	3
0	0	1	0	3.5
0	0	1	1	4
0	1	0	0	5
0	1	0	1	5.5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	8.5
1	0	1	0	9
1	0	1	1	10
1	1	0	0	11-2/3 (70 lines)
1	1	0	1	12
1	1	1	0	14
1	1	1	1	17

Notes:

1. Other data bits in command are (D64 to D1): 0001100.
2. Eleven inches is the default value after a Restore command.

TABLE 5-3

ASCII CODE

CHAR-ACTER	ASCII BINARY CODE	ASCII HEX CODE	DECIMAL PRINTWHEEL ADDRESS	RELATIVE HAMMER FORCE	RIBBON ADVANCE
A	1000001	41	022	5	4
B	1000010	42	016	5	4
C	1000011	43	020	4	3
D	1000100	44	044	5	4
E	1000101	45	030	4	3
F	1000110	46	018	4	3
G	1000111	47	048	5	4
H	1001000	48	034	5	4
I	1001001	49	040	4	3
J	1001010	4A	058	5	3
K	1001011	4B	056	5	4
L	1001100	4C	042	4	3
M	1001101	4D	012	6	4
N	1001110	4E	038	5	4
O	1001111	4F	036	5	4
P	1010000	50	052	4	3
Q	1010001	51	054	5	4
R	1010010	52	026	5	4
S	1010011	53	028	4	3
T	1010100	54	032	4	4
U	1010101	55	046	5	4
V	1010110	56	060	4	4
W	1010111	57	008	6	4
X	1011000	58	064	5	3
Y	1011001	59	050	4	4
Z	1011010	5A	014	4	4
a	1100001	61	168	4	4
b	1100010	62	156	4	3
c	1100011	63	158	4	3
d	1100100	64	152	4	3
e	1100101	65	166	3	3
f	1100110	66	178	3	3
g	1100111	67	148	4	3
h	1101000	68	174	4	3
i	1101001	69	170	3	3
j	1101010	6A	144	3	3
k	1101011	6B	186	4	3
l	1101100	6C	154	3	3
m	1101101	6D	142	6	4
n	1101110	6E	164	4	3
o	1101111	6F	160	4	3
p	1110000	70	180	4	4
q	1110001	71	184	4	4
r	1110010	72	162	4	3
s	1110011	73	176	4	3
t	1110100	74	172	4	3
u	1110101	75	182	4	3
v	1110110	76	146	3	4
w	1110111	77	000	5	4

TABLE 5-3

ASCII CODE *(continued)*

CHAR-ACTER	ASCII BINARY CODE	ASCII HEX CODE	DECIMAL PRINTWHEEL ADDRESS	RELATIVE HAMMER FORCE	RIBBON ADVANCE
x	1111000	78	150	4	3
y	1111001	79	188	4	4
z	1111010	7A	190	4	3
0	0110000	30	074	4	3
1	0110001	31	066	3	3
2	0110010	32	068	4	3
3	0110011	33	070	4	3
4	0110100	34	072	4	3
5	0110101	35	076	4	3
6	0110110	36	078	4	3
7	0110111	37	080	4	3
8	0111000	38	082	4	3
9	0111001	39	084	4	3
¢	0100000	20	004	4	3
!	0100001	21	136	3	2
"	0100010	22	140	2	3
#	0100011	23	092	4	3
$	0100100	24	088	5	3
%	0100101	25	094	6	4
&	0100110	26	138	5	4
'	0100111	27	108	2	2
(	0101000	28	120	4	2
)	0101001	29	116	4	2
*	0101010	2A	122	3	3
+	0101011	2B	090	3	3
,	0101100	2C	006	1	2
-	0101101	2D	086	2	3
.	0101110	2E	010	1	2
/	0101111	2F	132	4	3
:	0111010	3A	024	1	2
;	0111011	3B	062	1	2
<	0111100	3C	114	3	3
=	0111101	3D	096	3	3
>	0111110	3E	100	3	3
?	0111111	3F	130	3	3
@	1000000	40	124	6	4
[	1011011	5B	106	4	2
\	1011100	5C	126	4	4
]	1011101	5D	102	4	2
^	1011110	5E	128	2	3
_	1011111	5F	110	1	5
`	1100000	60	112	2	2
{	1111011	7B	098	4	3
|	1111100	7C	118	4	2
}	1111101	7D	134	4	3
~	1111110	7E	104	3	3
-	1111111	7F	002	2	3

NOTE: The character set shown in the preceding pages is that of the Prestige Elite 12 character set. The character faces will change with different fonts; however, the ASCII code relationship to the printwheel address location will always remain constant.

TABLE 5-4

HAMMER INTENSITY

HAMMER INTENSITY	HAMMER "ON" TIME (ms)
1	1.60
2	1.70
3	1.85
4	2.00
5	2.25
6	2.50

TABLE 5-5

PROPORTIONAL RIBBON ADVANCE

(RIBBON MOTOR STEPS)

CURRENT CHARACTER WIDTH	LAST CHARACTER WIDTH (Ribbon Motor Steps)			
(Ribbon Motor Steps)	5	4	3	2
5	5	4	4	3
4	4	4	3	3
3	4	3	3	3
2	3	3	3	2

5.1.2 BASIC SIGNAL OUTPUTS

These signals indicate the status of internal printer functions, and can be used by the external processor as flags for initiating data and control inputs.

PRINTER READY (Pin 47)

This signal indicates that the printer is ready to accept data and control inputs.

INPUT BUFFER READY (Pin 39) Previously called CHARACTER READY.
INPUT BUFFER READY (Pin 41) Previously called CARRIAGE READY.
INPUT BUFFER READY (Pin 43) Previously called PAPER FEED RIGHT READY.

These signals indicate that the printer is ready to accept an input command. These three signals have been consolidated (but gate isolated) and occur simultaneously. The INPUT BUFFER READY line must be tested before every character, carriage, and paper feed command. The input commands are stored in a single command hardware buffer and transferred to a 15 command, software controlled, first in /first out buffer.

(Pin 45) (Not used)

CHECK (Pin 37)

This signal indicates that one or more printer malfunctions has occurred:

1. the carriage has been commanded to move, but no movement has been detected; or

2. the printwheel has been commanded to move, but, no movement has been detected; or

3. the power supplies have failed.

Under these circumstances, the CHECK signal will be true and no input commands will be accepted until the check condition has been cleared by clearing the malfunction and initiating a "restore" sequence.

PAPER OUT (Pin 49)

This signal indicates that the printer is out of paper. In printers not equipped with the paper out option, this line will always indicate a "paper available" condition.

RIBBON OUT (Pin 30)

This signal indicates that the printer is out of ribbon. In printers not equipped with the ribbon out option, this line will always indicate a "ribbon available" condition.

COVER INTERLOCK (Pin 34)

This signal indicates that the printers top cover is in place. In printers not equipped with the cover interlock, this line will always indicate the cover is in place.

5.2 TIMING CONSIDERATIONS

The timing diagram shown in Figure 5-1 illustrates the relationships between the data lines, the strobe input, and the internal ready line. The illustration shown is for a character input, but, the carriage and paper feed command timing is the same.

TYPICAL CHARACTER COMMAND SEQUENCE

The commands that are sent to the printer will be executed in order of receipt. A carriage motion and paper feed may be executed simultaneously. The character command inhibits any paper or carriage motion during the second portion of its execution cycle. The print cycle is divided into two parts:

1) Motion of the printwheel

2) Firing the printhammer

Hammer firing will be executed only when the printwheel, carriage, and paper feed are all at rest. During the hammer firing cycle, and execution of printwheel rotation, carriage movement and paper feed is deferred until completion of the hammer firing cycle. There is no restriction on overlapping printwheel motion, carriage movement, and paper feed.

A carriage strobe followed by a character strobe will cause both the carriage and printwheel to move. Printing will occur when both the carriage and the printwheel are stopped. This is termed a space before print sequence.

TIMING

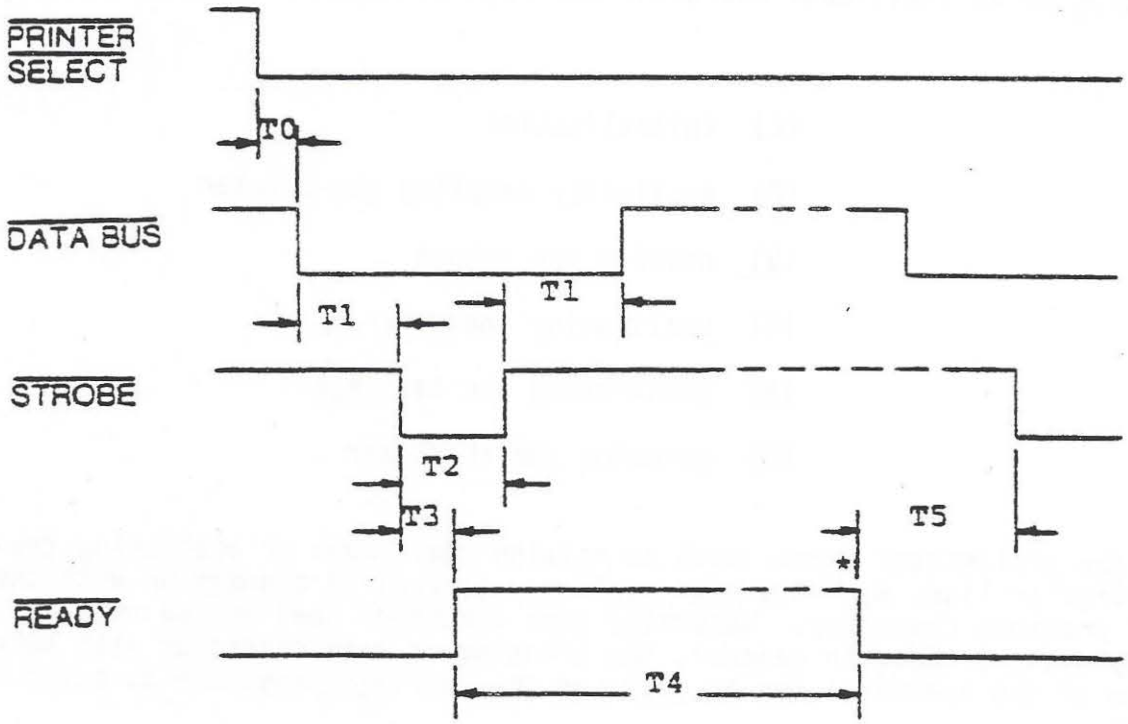


FIGURE 5-1

CONTROL TIMING

T0 >	0 ns
T1 >	200 ns
T2 >	750 ns
250 ns < T3 <	950 ns
T4 >	20 usec
T5 >	000 ns

*Any STROBE arriving during the time that the INPUT BUFFER READY line is false (≥ 2.4 Volts) will be ignored.

The INPUT BUFFER READY lines will go false for 20 to 800 usec upon receipt of any strobe. If the input buffer is full, INPUT BUFFER READY lines will remain false until completion of the command being executed. Commands are executed in order of receipt.

The Sprint 3 printers have a sixteen command input buffer. The character, carriage and paper feed commands are stored in a single-command hardware buffer and transferred to a 15 command software-controlled first in/first out buffer.

5.3 THE PRINTER AND ITS REQUIREMENTS

The printing of an individual character can require several distinct steps, including:

(1) initialization

(2) explicitly enabling the printer

(3) raising the ribbon

(4) positioning the paper

(5) positioning the carriage

(6) printing the character

Some of the preliminary steps, such as raising the ribbon or postioning the paper on a particular line, may have been performed already in connection with the printing of a previous character. Naturally such functions need not be repeated with every impression. But, in general, the printing of each character will necessitate a minimum of two commands: one to position the carriage, and, one to print the actual character.

Those accustomed to working with the teletype printer may have a little trouble at first in adjusting to the carriage functions in the Sprint 3 Series Printer. In the teletype printer the advance of the carriage is automatic. The printer advances one standard pica space each time it receives a character from its controlling device. The Sprint 3 Series Printer on the other hand requires an explicit command before the carriage can be advanced. This means that every command to print a character must be preceded or followed by a command which re-positions the carriage. Any time that the programmer forgets to do this he risks overprinting existing text.

By the same token, there is no counterpart of the ASCII "space" character included in the Sprint 3 Series Printer's command lexicon. The printer simply does not recognize such a command. This confers certain benefits, such as the freedom to program fine increments of motion and the ability to move bidirectionally to any point on a given line using a single carriage command. However, it also imposes upon the programmer an unaccustomed responsibility, that of determining the most suitable multiple of the printer's basic 1/120th of an inch horizontal increment and commanding that movement explicitly. This may be a simple matter of establishing a conventional interval of spacing between characters and then ensuring that each character command is preceded or followed by that interval. Or the programmer may create more elaborate effects by using values drawn from a base-relative table in memory, as in proportional spacing. The programmer can stretch the spaces between words, to produce right-justified margins. And if speed is vital, the bi-directional positioning feature enables the right-to-left printing of alternate lines, saving the time required to return to the left margin at the end of every line.

It is customary with the teletype to precede a transmission with a "carriage return" character, resetting the teletype's carriage at its left hand margin. This simple convention synchronizes the printer with the controlling program, which cannot otherwise assume that it presently knows the position of the carriage. The printer, however, does not have such a function and does not recognize the "CR" control character. Synchronization is obtained instead by initializing the printer with a RESTORE command. Initialization not only moves the carriage to a predetermined position at the left extreme of travel, it also performs internal housekeeping functions, such as, synchronizing the printwheel and resetting the printer's control logic. Turning on power to the printer of course initializes the printer automatically. But, unless the external conditions are well known and can therefore be assumed safely, it is a good idea to RESTORE the carriage explicity upon entering the first subroutine that is dedicated to the printer.

A RESTORE command, however, must not be treated as if it were the equivalent of the teletype's "carriage return". Since conditions are unknown at the moment of initialization, this command is designed to produce a low-velocity motion of the carriage. That is, it will take the carriage appreciably longer to reach the left-hand margin as part of initialization than it would have taken to reach the same point had it been moved there by an explicit carriage command. Any program that habitually uses the RESTORE command as a substitute for "carriage return" will be needlessly slow.

But, the carriage cannot be commanded to a particular point unless its present position is known, and this imposes an additional responsibility on the controlling device. The controller must maintain a status register which tracks the location of the carriage. This will be reset to zero at the time of initialization, and increased or decreased thereafter by the amount of displacement implicit in any subsequent carriage command. There are several possibilities. Maintaining a current space count can be one of the automatic functions assigned to the hardware interface, in which case the program need only interrogate a special status port in order to determine the carriage position. But, in many applications, the designer will be unwilling to incur the expense of the additional hardware, and space count will therefore be relegated to the realm of software functions. Fortunately this is a relatively simple matter of establishing a dedicated register or memory location and ensuring that it is updated faithfully.

The accurate return of the carriage is not the only reason for maintaining a space count. It also serves as a protection against illegal or out-of-range commands. Since all programmed carriage motions are relative to the present carriage position it is possible to issue a command that the printer cannot execute. If the carriage is one inch from the left hand margin, for example, and the printer receives a command to move the carriage nine inches to the left it will attempt to perform the instruction, causing it to collide at full speed with one of the rubber deceleration stops. This is not damaging to the printer, which is designed to withstand that eventuality, but, it does set the check flag and prevent the printer from responding to any further commands. In most systems, a CHECK condition will cause a jump to an exception routine designed to analyze the failure. And once this has been determined, the flag can only be reset by a simple RESTORE command. Identifying and clearing the condition, however, requires a significant amount of time, and any program that frequently issues out-of-range commands will therefore be inefficient. In some cases it will be inoperable. Thus designers may want to specify a programmed test, based upon the present status of the space counter.

Character printing is actually a complex of functions governed by a single CHARACTER STROBE line. Printing requires positioning the printwheel, advancing the ribbon, and tripping the printhammer. All of these functions are handled automatically by the printer's control logic, but, in programming the output you should be aware of the effect that the carriage interlock has on the printing cycle.

Both paper feed and carriage motion are protected by logical interlocks that delay the execution of a command until the printwheel's cycle is finished. This prevents relative motion while the printing die is in contact with the paper, and so avoids tearing of the paper or blurring of the image. The printwheel is protected by complementary interlock which delays the firing of the printhammer until any paper movement or carriage motion is completed.

These interlocks permit the controller to issue a paper feed command, a carriage motion command, and a printwheel command in rapid succession, and then turn to other business without the risk of command interference. It also means that the three commands can be given in any desired sequence: space before print,; space after print; and so on. Note, however, that all the possible sequences are not strictly equivalent.

Paper feed and carriage motion cannot begin until any character cycle in progress has finished. The printwheel cycle, however, can be overlapped with paper and carriage movements. Specifically, the printwheel itself can be re-positioned during the paper feed and carriage cycles. Only the actual firing of the printhammer must wait until all other motions have ceased. The printer's micro processor will overlap command executions.

As in the case of "space" and "carriage return", there is no couterpart in the printer of the teletype's "line feed" function. Like the other teletype control characters, the printer just ignores it. Whenever it is necessary to move paper, the program must determine the appropriate feed interval, translate it to a multiple of the basic 1/48th of an inch vertical feed increment, and command the motion explicitly. Movements up to 21.3 inches (1024/48") in either direction can be programmed by a single PFM STROBE, subject only to the restriction that the optional forms tractor cannot be reversed more than 1/3rd of an inch.

Like the carriage command, the paper feed command is a relative displacement. Thus in some systems it will be necessary to establish loading procedures that ensure the ability of the printer to place its characters with absolute vertical accuracy. But the need for this can vary widely. The simplest case one can visualize is that where the printer draws its paper from a continuous supply roll, just as in a teletype installation.

Since there is no top or bottom to such a form, the question of absolute vertical position is just about meaningless, and there is no need to worry about keying the print to a particular line on the form. It will be sufficient to precede your transmission with a paper feed command that is the physical equivalent of several "line feed" characters on the teletype, thus, ensuring a fresh print area and a space that separates the beginning of the new message from the end of the last.

Unfortunately, not all cases are that simple. Suppose that you have in mind an application where the printer serves as an output terminal in a forms processing system. There is no way for the controlling program to know the real position of the form, and it must therefore assume that the terminal operator has positioned the form in accordance with a pre-arranged convention. This is a matter of establishing standard operating procedures, rather than a problem in control programming, but, the system designer has to be aware of it nevertheless and has to allow for it in his specifications. By referring to the specification the programer should be able to determine whether the form will initially be centered on the platen and positioned at the upper edge of the paper, for example, or the same form will be positioned so that the carriage is in immediate printing position on the first line.

Yet another possibility is that where the printer draws paper from a continuous, but, segmented supply, like the familiar fanfolded form. In a case like this, it may be necessary periodically to move the paper to the top of the next page, and it will therefore be necessary to keep track of the absolute vertical position of the paper. Here again, the designer has a couple of options. One is to maintain a status register in memory, updating this register each time the paper is advanced or retarded. Or just as with the carriage status, this can be specified as an automatic hardware interface function. In the latter event the program need only query a specified port in order to determine line status.

In both cases, however, it will be necessary to coordinate operator procedures with program function. The status register will have to be zeroed at the time paper is loaded, and the operator will have to position the form at a predetermined vertical point. Thereafter, it will be possible at any point in the program to determine line status, to calculate the distance to the desired line on the next page, and to construct a command word that will effect the desired relative displacement of paper.

If such re-positioning of the paper is called for often, however, it may be to your advantage simply to specify the top-of-form option. This feature enables you to advance the paper feed to the top of the next page by means of a separate command, without incurring the processing overhead involved in maintaining continuous line status. Naturally, it will still be necessary to establish operating procedures that synchronize the mechanical top-of-form point with the actual top of a page. It must be stressed too, that the forms tractor is highly desirable for maintaining accurate vertical positioning in applications where the printer must operate unattended for prolonged periods. In most multiple copy applications, it is essential.

Programming the ribbon lift function is straight forward. The ribbon may be raised or dropped at any time, without the preliminary testing of a status line. This function is protected by an internal logic interlock that delays the raising or lowering of the ribbon until any character printing cycle in progress has been completed. And a complementary interlock in the printwheel logic inhibits the firing of the printhammer until all ribbon motion has ceased. Ribbon lift should occur prior to print command. If sent simultaneously, whichever the interface receives first will be taken first. Therefore, if the character is received first the ribbon lift will be detoured until after the character is printed.

It is also significant that the user realize that when the ribbon is lowered the printwheel will go to address 000, which properly positions a blank area on the 94 character printwheel. This enables the operator to view the last character printed. During the time the printwheel is rotating to this position, the INPUT BUFFER READY line is false. If a character is strobed during this time it will be lost. Proper monitoring of the INPUT BUFFER READY line will eliminate this improper operation.

The important thing to remember is that any ribbon lift function, whether it involves raising or lowering, takes an average of 30 milliseconds, and that during this interval no character may be printed. It is therefore, apparent that raising the ribbon for every impression will limit your print speed to less than 15 characters per second. Obviously then, the thing to do is to raise the ribbon at the beginning of a message and to hold it until the transmission is completed. Keep in mind too, that the only reason for having a programmed ribbon drop function is to enhance operator visibility. If this criteria is not vital, you might consider an interface specification that calls for keeping the RIBBON LIFT command line enabled continuously, and save the overhead involved in keeping track of this function.

A similar consideration applies to the PRINTER SELECT, which is used to enable all the printer's status and control functions generally. This function permits convenient selection and disabling of the printer at the system console level, but, is superfluous from the programming point of view. Perhaps the most unfortunate consequence of requiring explicit enabling is that the ribbon will drop automatically every time the printer is de-selected, even though the RIBBON LIFT is maintained continuously. This will naturally limit the printer's response, in essentailly the same way as the ribbon lift function previously discussed. It will therefore be advantageous to enable the PRINTER SELECT line continuously during a transmission, rather than seperately for each character, just as it was with the ribbon lift function. And in those cases where there is no compelling need for an explicit select, it will be wise to enable the PRINTER SELECT line continuously in your hardware interface.

5.4 THE PROCESSOR

The nature of the interface is also determined by the controlling device, and there are many different processors. They vary widely according to their characteristic word length, their instruction sets, their cycle timing, and their method of handling input and output transactions. All these considerations have a bearing both on the hardware interface and on the one hand to give completely general guidelines, and, impractical on the other hand to try to anticipate all the different possibilities.

But we can make a few fairly safe assumptions about the nature of the processor, and thus come up with a hypothetical "average" processor. We can then show how the characteristics of this typical processor determine the bare minimum hardware interface, and use that interface to demonstrate the techniques of output programming by a simple illustrative example.

Processors are classified generally by their characteristic word length, or the number of bits that they can handle in parrallel. Word lengths in common usage are 8 bits, 12 bits, 16 bits, 24 bits, 32 bits, and up.

Processors with word lengths in excess of 32 bits tend to be used in applications requiring the capacity to process extremely large volumes of data. These applications usually resort to very high speed output devices such as line printers and will probably not involve direct processor control of a character printer.

Eight-bit and twelve-bit processors, on the other hand, tend to be unsuitable for problems involving the manipulation of alphabetic strings and are used far more frequently in control application. While inventive programming and interface can overcome some of the problems, it is usually easier to buy a processor with more hospitable characteristics. The sixteen-bit parallel processor has proved to be extremely popular choice with designers of small systems, and we feel that our printer is more likely to be used with this kind of processor than with any other. We therefore choose it as our typical CPU, hastening to add that processors of another kind would be just as suitable, given a different programming technique.

Even among processors with the same characteristic word length there can be considerable variation in instruction sets, which affects the kind of manipulations that the CPU can perform. In general, however, it is safe to say that most of these processors can do pretty much the same tricks. Some simply require a little more roundabout approach than others, making them more or less efficient than their counterparts. Our printer does not require very exotic manipulations. Logical masking, shifting, and carry bit branching are available on all the popular sixteen-bit minis.

There are important and irreconcilable differences, however, in the way that different CPU's handle their I/O (input/output), but, here again we can make some reasonable assumptions. Most processors begin an output transaction by sending out an I/O address early in the cycle. This is transmitted on a multiline bus to the peripherals, to identify and select the objective device. Sometime later in the cycle, after sending out the address, the CPU precharges the lines of a second bus with the data contents of a designated internal register. This bus is the data bus, and its lines typically correspond one-for-one to the 16 digits stored in the output register. Then, after data on the bus has had a chance to "settle", the processor keys the transfer by activating an output strobe, causing the object peripheral to record the data.

We will assume further that the timing of this output cycle permits direct compatibility with the printer. That is, we assume that the output strobe has a pulse width in excess of 750 nanoseconds, and that the interval between pre-charging of the data lines and the leading edge of the strobe (data setup time) exceeds the printer's minmum requirements. And finally, we assume that the interval between the trailing edge of the strobe and release of the date bus (data hold time) is greater than the allowable minimum. These realistic assumptions simplify the hardware interface, by reducing the number of intermediate functions we have to provide.

5.5 THE BASIC HARDWARE INTERFACE

Given the printer's requirements and the characteristics of the processors, we can define the requirements of a minimum basic interface. The logical block of such an interface is shown in the accompanying figure.

The principle interface function is device selection, and to that end the controller contains an address decoder. This section receives its input from the processor's address bus and produces an output whenever it recognizes the logical address assigned to the printer. Address decoding is a simple coincidence function.

The output of the address decoder is used by two secondary coincidence sections, to distinguish between input and output processor functions. An output strobe naturally indicates that the processor has placed a command to the printer on its data bus, while an input strobe indicates that the processor expects to receive status information from the printer on the same data bus. Simultaneous outputs from the address decoder and on the processor's $\overline{\text{OUTPUT STROBE}}$ line therefore enable the gating of commands to the printer. Outputs from the address decoder and on the $\overline{\text{INPUT STROBE}}$ line concur to gate status information on the printer's five principal status lines through to the processor's I/O data bus.

Observe how the 16 data lines from the processor are distributed among the various interface functions, since this is instrumental in determining the distribution of functions in the 16-bit command field. Note that the processor's 2^0 - 2^{12} data lines are linked directly to the D1/2 - D2048 inputs of the printer. As a result these digits in the processor's output register correspond to the lines of the printer's thirteen-bit command bus.

Notice too, that the 2^{15} data line from the CPU is applied to the input of a latch, where it is registered and saved by the coincidence of an output from the command section. This bit will therefore be used to control the ribbon lift function.

With lines 2^0 - 2^{12} and 2^{15} already assigned to specific functions, only the 2^{13} and 2^{14} lines remain available to convey control strobe information to the printer. Fortunately there are just four strobe functions in the standard printer: $\overline{\text{RESTORE}}$, $\overline{\text{PAPER MAIN STROBE}}$, $\overline{\text{CARRIAGE}}$, and $\overline{\text{CHARACTER}}$. This makes it convenient to encode the identity of the strobe in the 2^{13} and 2^{14} digits of the processor's output register, and expand this to a one-of-four output by decoding in the interface:

2^{14}	2^{13}	STROBE I.D.
0	0	RESTORE
0	1	PFR STROBE
1	0	CARR STROBE
1	1	CHAR STROBE

To summarize then, our output field looks like this:

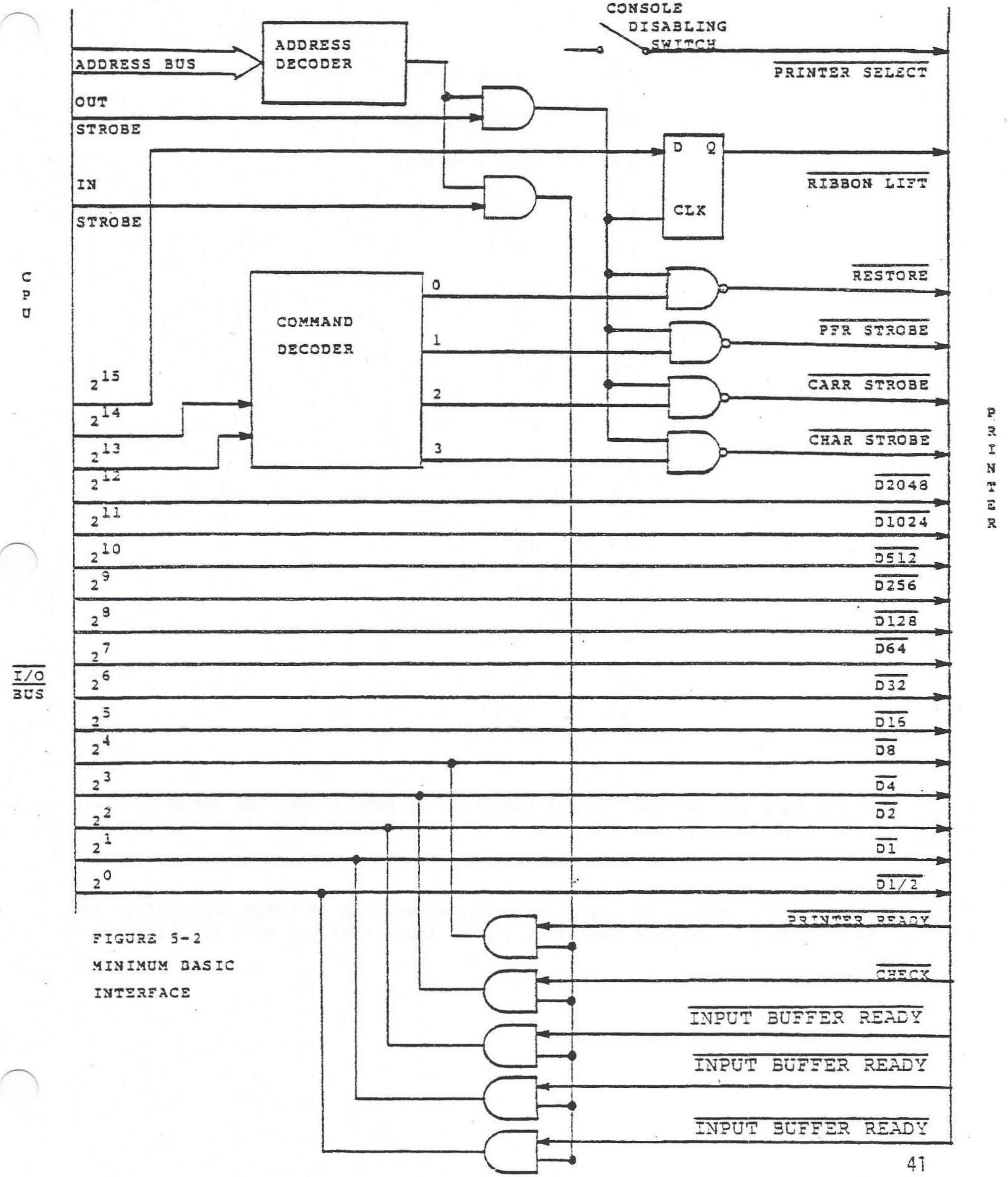


FIGURE 5-2
MINIMUM BASIC
INTERFACE

2^{15}	RIBBON LIFT
2^{14}	COMMAND STROBE
2^{13}	COMMAND STROBE
2^{12}	D2048
2^{11}	D1024
2^{10}	D512
2^{9}	D256
2^{8}	D128
2^{7}	D64
2^{6}	D32
2^{5}	D16
2^{4}	D8
2^{3}	D4
2^{2}	D2
2^{1}	D1
2^{0}	D1/2

In order to initiate any desired control function, we simply load the three significant fields with the appropriate data and transmit the entire 16-bit word to the interface.

To test the printer's status, on the other hand, we execute an input transaction addressing the interface. The data deposited in the input register will be distributed as follows:

2^{15}	
2^{14}	
2^{13}	
2^{12}	
2^{11}	
2^{10}	
2^{9}	
2^{8}	
2^{7}	
2^{6}	
2^{5}	
2^{4}	$\overline{\text{PRINTER READY}}$
2^{3}	$\overline{\text{CHECK}}$
2^{2}	$\overline{\text{INPUT BUFFER READY}}$
2^{1}	$\overline{\text{INPUT BUFFER READY}}$
2^{0}	$\overline{\text{INPUT BUFFER READY}}$

It is then a simple matter to execute a programmed right shift through the carry, and to branch based on a conditional test.

The last significant feature of this interface is a console switch which permits the operator to select or disable the printer, as might be convenient during the loading of paper for example. It presumes, of course, that there is no compelling reason for direct controller enabling of the printer. This switch connects through the interface directly to the $\overline{\text{PRINTER SELECT}}$ command line.

As we said earlier, this is a <u>bare minimum</u> hardware interface. It exploits the full capability of the standard printer, permits the crudest form of test-loop I/O, and does not do much more. In particular, it completely ignores the advantages to be gained through the judicious use of priority interrupts which permit other processing activities to be interleaved with the output function.

It also ignores a number of more exotic functions that can be performed automatically by a hardware interface, including:

(1) command buffering and strobing

(2) maintaining carriage pointer

(3) maintaining line pointers

(4) generating automatic standard spacing

(5) generating automatic proportional spacing

That is not its purpose, however. The specification of more elaborate interfaces, which in turn involves careful consideration of the cost-effectiveness equation, is the creative province of the system designer. What we can do using the basic interface is to show by example how the printer may be programmed to do a typical printing task.

5.6 PROGRAMMING THE INTERFACE

As an illustrative exercise we can set ourselves a simple printing task: using standard pica spacing throughout, print the heading "QUME" centered six lines down from the top of an operator-loaded 8-1/2" x 11" form, skip three standard lines and print "The" beginning at a margin one inch from the left hand edge of the page.

The operator first de-selects the printer, by disabling it with the console switch. He then loads the form into the printer, centering it against the printer's paper centering scale and positioning it so that the top edge is aligned with marks inscribed on the plastic card quide. When ready to print he flips the disabling switch back to its normal operating position, signalling the printer to begin.

While the operator is in the process of loading paper, the processor can be idling in a loop which tests one of the INPUT BUFFER READY lines. This line will be false, until the PRINTER SELECT is explicitly enabled via the console switch. The processor reads in status through its interface, shifts right once to get the INPUT BUFFER READY bit into the carry position, and executes a test of the carry, branching back to the start of the loop if the status bit is false. When the bit finally goes true, the processor exits the test loop to begin its printing routine.

The first step is to initialize the printer. This requires loading "00" into bits 2^{13} and 2^{14} of the disignated output register and executing an output which addresses the interface. In conventional symbology, the output word looks like this:

XOOXXXXXXXXXXXXX

The X's are "don't care" bits for the purpose of this command, meaning that they have no effect on the end result.

When initialization is complete, the carriage will have come to rest at the left limit. We accordingly test the $\overline{\text{INPUT BUFFER READY}}$ line to determine when the printer is ready to receive its first command. The processor will idle in a test loop, executing an input which addresses the interface. It then shifts the input field right one place through the carry and exits this loop when the carry bit is true.

Paper feed is generally the slowest of the printer's functions, and it is therefore wise to command this motion first.

Since we are presently at the top edge of the form, and since we wish to begin printing six standard lines below this, we must first determine how far to move the paper. Standard spacing calls for six lines per inch, so, we want to command a one inch upward motion of the paper. At the same time we shall take this opportunity to raise the ribbon into printing position. The output register must thus be pre-loaded with the following data word:

101X00000110000X

Where a "1" in the 2^{15} digit signifies ribbon lift, a "01" in the 2^{14} and 2^{13} digits signifies a paper feed strobe, the "0" in the 2^{11} digit signifies an upward paper motion, and the remaining digits indicate the relative increment of motion (48/48 inches). When this word is output to the interface, the paper feed mechanism will begin moving paper toward the desired position.

Routine positioning of the carriage requires prior testing of the $\overline{\text{INPUT BUFFER READY}}$ line. And, even though we tested this same line to determine when initialization was over, we now repeat the preface to determine when the printer has transferred the previous command from the input buffer to the command buffer. Having ascertained that the input buffer can receive our command, we load and output the following data word to the interface:

110X001100000110

The composition of this word is determined as follows. The 2^{15} digit signifies that the ribbon is lifted, the 2^{14} and 2^{13} digits signify a carriage motion, and the 2^{11} digit signifies a right movement of the carriage. The remaining digits indicate the increment of motion (774/120 inches).

Since we wish to center our four-character word, and since we are using a standard pica spacing of 10 characters per inch, we want to position the center of the first character exactly 0.15 inches to the left of page center. We also know that the carriage is presently at its left limit of travel, and that this point is approximately 6.6 inches to the left of the carriage center. And we therefore want to move the carriage 6.45 inches to the right, or 774/120 inches. This is how our initial carriage displacement was determined.

Having given the commands that will position the paper and carriage, we now issue our first character command. After testing the $\overline{\text{INPUT BUFFER READY}}$ status line by the usual input-shift-branch technique, we output the following command field to the interface:

111XXXXX1010001X

Once again the most significant bit signifies a raised ribbon. The 2^{14} and 2^{13} bits designate a $\overline{\text{CHARACTER STROBE}}$. And the 2^{1} through 2^{7} bits specify "Q".

We now idle in a test loop, repeatedly testing the $\overline{\text{INPUT BUFFER READY}}$ status line. By monitoring this line, we shall know immediately when the printer is ready to receive its next command.

When the $\overline{\text{INPUT BUFFER READY}}$ line again comes true, we issue the following carriage command. This carriage command will shift the carriage right by one tenth of an inch, then drop again into a test loop which samples the $\overline{\text{INPUT BUFFER READY}}$ status:

110X000000001100

When the $\overline{\text{INPUT BUFFER READY}}$ line comes true, we issue the following character command. This command will print a "U".

111XXXXX1010101X

When the input buffer is ready to accept the next instruction as indicated by the true state of the $\overline{\text{INPUT BUFFER READY}}$ line, we proceed to the next step.

Using the same technique of status testing followed by the commands, we print the next two characters, "M" and "E":

110X000000001100

111XXXXX1001101X

and

110X000000001100

111XXXXX1000101X

The hypothesis of our example now calls for skipping three standard lines and moving the carriage to the first space on a line which begins one inch from the left the page. The paper feed command is straightforward. After testing the INPUT BUFFER READY status line, we issue the following paper feed command:

101X00000011000X

thereby advancing the paper one-half inch.

The necessary carriage displacement is quickly calculated for the purpose of this simple example, and you will observe that we have chosen to save ourselves the overhead involved in maintaining a carriage pointer. We know that the carriage is presently 0.15 inches to the right of center on an 8-1/2" page. And we further know that we have to move it left to a point that is 1.05 inches to the right of the paper's left edge, in this way ensuring the specified one-inch margin. We therefore calculate that we shall have to move the carriage left 3.35 inches, and after testing the INPUT BUFFER READY line issue the following carriage command:

110X100110010010

Note the "1" in the 2^{11} digit which results in a left movement of the carriage.

Finally we test the INPUT BUFFER READY status line and print "T":

111XXXXX1010100X

Then, using the test loop technique to verify the $\overline{\text{INPUT BUFFER READY}}$ status line, we issue the commands that space and print the last two characters:

110X000000001100

111XXXXX1101000X

and

110X000000001100

111XXXXX1100101X

causing "h" and "e" respectively to be printed, and completing the requirements of our example.

5.7 EMERGENCY CONDITIONS

Various unusual conditions can arise in the course of printing. Some of these can detected and identified by a fairly simple sequence of tests, and if an alternative device is available for displaying instructions to the operator then it may be worth while to analyze the failure.

Most of the steps in our programming example involved test loops for verifying status. The seasoned programmer will quickly spot the fault in such a scheme, to wit if any status line fails through electrical malfunction the processor will be stalled in an endless loop from which it cannot exit. Moreover, it may take some time before the operator realizes that something is wrong and attempts a remedy.

To prevent this, any such loop should contain a safeguard, a provision for example that causes a jump to an exception routine whenever the accumulated number of iterations makes it reasonable to assume that the test line has no intention of coming true. Under these circumstances we would be justified in tentatively checking other status lines to see if something had gone wrong.

The printer's principle status line is the $\overline{\text{CHECK}}$ feature. If a test of this line shows that it is false, as we would normally expect it to be, then we can conclude that the failure of the printer to respond to interrogation is probably the result of internal malfunction.

A CHECK line which proves to be true, on the other hand, could indicate one of three abnormal conditions. The first informed reaction should be an attempt to reset the CHECK flag with the RESTORE line. If a subsequent test of the CHECK reveals that the condition has been cleared by this expedient, then the error condition was probably the result of an illegal or out-of-range command. However, it could also be due to a foreign object inadvertently dropped into the printer's mechanism.

If the CHECK condition is not cleared by the RESTORE command, the next logical step is to test the PRINTER READY status line.

But if both the CHECK and the PRINTER READY lines are true, then there are just two possibilities remaining. Either the operator has completely forgotten to turn on the printer's external power supply, or a legitimate malfunction exists.

altair Q70 Printer Controller Manual

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1. INTRODUCTION

The Altair Q70C Printer Controller board provides the interface between the Q70 Printer and Altair 8800 series microcomputers. It connects the twenty-nine printer signal lines to the eight data lines on the Altair data bus, providing the proper signals for the printer and buffering the computer bus from external disturbances.

The Q70C Controller also contains the address decoder circuitry, allowing the printer to be addressed at any one of thirty-two different I/O locations.

This manual describes the hardware of the Controller board and some examples of software for utilization with the 8800 series computers. Section 2 deals with the Q70C data and control registers. Section 3 details the Q70C software initialization procedure. Section 4 is an example of Assembly Language code needed to print characters on the Q70 printer, and Section 5 covers the use of interrupts. Section 6 is a review of the controller board circuit theory and the final section is a description of the connections between the Q70 printer and controller board.

For a more detailed description of the functions of the Q70 Printer, see the Q70 Printer/Interface Description Manual.

2. Q70C CONTROLLER DATA FLOW

Each of the four channels of the Q70C Printer Controller board has a pair of addresses. The even address is for the Control Register which holds information that determines the operation of the controller channel itself. The odd address is that of either the Data Register or the Data Direction Register, depending upon the state of the Control Register. The Data Register holds information that is to be passed between the computer and the printer. Table A shows the signals required by the Q70 Printer and the corresponding bits of the Data Registers.

Table A. Q70C Signals

ADDRESS	BIT	INPUT (I) OR OUTPUT (O)	FUNCTION
Ø61	Ø	O	Data Bit 1/2
ICJ, Section A	1	O	Data Bit 1
	2	O	Data Bit 2
	3	O	Data Bit 4
	4	O	Data Bit 8
	5	O	Data Bit 16
	6	O	Data Bit 32
	7	O	Data Bit 64
Ø63	Ø	O	Data Bit 128
	1	O	Data Bit 256
ICJ, Section B	2	= BF = DF = 7F O	Data Bit 512
	3	O	Data Bit 1024
	4	O	Data Bit 2048
	5	O	CHARACTER STROBE $DF
	6	O	CARRIAGE STROBE $ BF
	7	O	PAPER FEED MAIN STROBE $7F
Ø65	Ø	*NU	
	1	I	CHECK
ICK, Section A	2	I	PAPER OUT
	3	I	RIBBON OUT
	4	I	PRINTER READY
	5	I	INPUT BUFFER READY
	6	I	INPUT BUFFER READY
	7	I	INPUT BUFFER READY
Ø67	Ø	O	PRINTER SELECT
	1	O	RESTORE
ICK, Section B	2	O	RIBBON LIFT
	3	*NU	
	4	O	PAPER FEED AUX STROBE (Opt)
	5	O	TOP OF FORM
	6	*NU	
	7	O	COVER INTERLOCK (Opt)

*NU=Not Used

All signals are active LOW

The direction in which information flows through the interface is determined by the Data Direction Register (DDR). The DDR has 8 bits, one for each data line in the channel. Writing one into a DDR bit causes the corresponding data line to be considered an output to the printer. Conversely, a line is designated as an input by writing a zero into the corresponding DDR bit. In the Q70C Controller, three of the channels (24 lines) are outputs and one (8 lines) is an input channel.

The Control Register bits and their functions are shown in Table B.

Table B.

Control Register Bits	7	6	5	4	3	2	1	Ø
Function	Interrupt Request			C2 Control		DDR Control	C1 Control	

Access to the Data Direction Register is controlled by Control Register bit 2. When bit 2 is zero, the DDR is accessed by the odd address of the channel address pair. When Control Register bit 2 is on, the Data Register is accessed.

Bits 7 and 6 reflect the state of the two "handshake" lines, C1 and C2, respectively. Only the C1 line is used on the Q70C Controller board. It is used to request an interrupt from the computer each time the $\overline{\text{INPUT BUFFER READY}}$ line from the printer goes LOW. During the time the printer is unavailable for data transfer, the computer can be executing other tasks. When the printer is ready, the computer can interrupt its computations and send the information to be printed. The effect of an input pulse on the C1 line is controlled by Control Register, bits 1 and Ø. The use of interrupts in the operation of the Q70C Controller board is explained beginning on page 12.

3. INITIALIZATION PROCEDURE

Before the printer can be used, the Q70C Controller board must be initialized by setting the directions of the 32 data lines. The printer must be initialized by selecting it, resetting it and raising the ribbon into place for printing.

The Data Direction Registers are accessed by loading the Accumulator with zeros and sending them to the Control Registers. Assuming the controller board is addressed at Ø6Ø$_8$, use the following program to accomplish this (all numbers are octal):

```
XRA  A          ;LOAD ACCUMULATOR WITH 0
OUT  060        ;OUTPUT ZEROS
OUT  062        ;TO CONTROL
OUT  064        ;REGISTERS
OUT  066
```

To set the direction of the lines, the following instruction sequence is used:

```
XRA  A          ;PORT 065 DESIGNATED
OUT  065        ;AS INPUTS
CMA             ;LOAD ACCUMULATOR WITH ONES
OUT  061        ;PORT 061, 063, 067
OUT  063        ;DESIGNATED AS
OUT  067        ;OUTPUTS
```

Finally, the sequence below is used to allow access to the Data Registers:

```
MVI  A,44
OUT  060
OUT  062
OUT  064
OUT  066
```

If $\overline{\text{INPUT BUFFER READY}}$ interrupts are to be used, the output to port 064 is changed to initialize the CA1 line. (See Interrupts, p. 12, for more information.)

The Q70C Controller board is now ready to transfer information between the computer and the printer. First, the printer must be selected and reset. $\overline{\text{PRINTER SELECT}}$ and $\overline{\text{RESTORE}}$ are bits Ø and 1, respectively, of port 067. Since they are active LOW, the following instructions must be included:

```
MVI  A,0374 $FC ;ALL BITS ON EXCEPT 0 and 1
OUT  067        ;OUT TO DATA PORT
```

The data port is latched, and the RESTORE bit must be turned off before information can be transferred. The printer is selected and the ribbon lifted before printing begins. The following instructions are used to accomplish these actions.

```
    MVI   A,0372 $FA ;ALL BITS ON EXCEPT Ø AND 2
    OUT   067        ;OUT TO DATA PORT
```

Now the printer and controller board are ready for printing.

4. PRINTING PROCEDURE

Once the printer and controller have been initialized, data can be transferred to the printer. Commands to the printer are of three types: character printing, paper movement and carriage movement.

A character is printed by transmitting its ASCII character code to the printer coincident with a pulse on the CHARACTER STROBE line. The Q70 Printer prints characters from a 15 command input buffer. When the buffer is full, the INPUT BUFFER READY signal goes HIGH and further transfer from the controller to the printer is inhibited. Data must be presented on the data lines 200 nanoseconds before the CHARACTER STROBE is sent.

When the CARRIAGE STROBE is pulsed, the data lines specify the distance the carriage is to move. The carriage moves in increments of 1/120 inch. Since spacing is completely separate from character printing, the carriage is moved between characters by means of a carriage command.

A carriage return character is not recognized by the Q70 printer. To begin a new line, the carriage is moved to the left margin by a carriage command and the paper is moved to the new line by a paper feed command. When the PAPER FEED MAIN STROBE is pulsed, the data lines indicate the distance the paper is to be moved. The paper is moved in increments of 1/48 inch.

The Assembly Language instruction sequences for issuing these commands are shown in the programs which follow. These programs are taken from Altair BASIC version 4.1 line printer code.

The BASIC Q70 Printer driver has three main sections. One section outputs printable characters. Another generates spaces and other carriage movements. The third moves the paper between lines.

BASIC first pops the character to be printed off the stack and determines whether it is a tab, carriage return or line feed (ASCII code < 040_8); a space (ASCII code = 040_8) or a printable character (ASCII code > 040_8). It then calls the appropriate routine to generate the proper printer commands.

The space routine (QSPACE) takes advantage of the Q70 Printer's ability to move its carriage any given distance with a single command. The carriage is not actually moved until just before a character is to be printed. If multiple spaces precede a character, they are moved all at once, saving time and printer wear. Tabs are executed as a series of spaces, and carriage returns use a portion of the QSPACE routine in order to move the carriage to the left-hand margin.

The QSPACE routine is shown in Listing I. The most important labels are shown below:

LPTLEN	allowed length of the printing line in characters
QELN	routine that executes a carriage return/line feed sequence
LPTPOS	current position of the carriage in the line in characters
QMOV	distance the carriage is to move before next character is printed in increments of 1/120 inch
QUME1	addresses of the Q70C controller's
QUME2	first two data ports

NOTE: LPTPOS is in the Accumulator upon entry to this routine.

LISTING I

```
QSPACE:  INR   A          ;INCREMENT CHARACTER POS
         LXI   H,LPTLEN   ;CHECK FOR END OF LINE
         CMP   M          ;END?
         J2    QELN       ;YES, DO A CRLF, & RESET MOV CNTR
         STA   LPTPOS     ;NO, STORE NEW LPTPOS
         LXI   D,QINC     ;GET CHARACTER INCREMENT
         LHLD  QMOV       ;GET MOVE VALUE
         DAD   D          ;ADD INC TO MOVE
         SHLD  QMOV       ;STORE NEW MOVE VALUE
         JMP   ENDQME     ;FINISH UP WITH STACK
;MOVE THE CARRIAGE SUBROUTINE
QMOVE:   INR   A          ;INCREMENT CHARACTER POS
         STA   LPTPOS
         LXI   D,QINC     ;GET CHAR INC
         LHLD  QMOV       ;GET CURRENT MOVE DISTANCE
         DAD   D          ;ADD INC TO MOVE
         XCHG
         LHLD  QPOS       ;GET CURRENT Q POSITION
         DAD   D          ;ADD MOVE TO POSITION
         SHLD  QPOS       ;STORE NEW POSITION THEN MOVE
QBAK:    CALL  WAIT       ;WAIT FOR BUFFER READY
         MOV   A,E        ;SEND OUT MOVE CMD
         CMA              ;ACTIVE LOW DATA LINES
         OUT   QUME1
         MOV   A,D
         CMA
         OUT   QUME2
         XRI   0100       ;SET CARRIAGE STROBE BIT
         OUT   QUME2
         ORI   0100       ;RESET CARR STROBE
         OUT   QUME2
         LXI   H,0
         SHLD  QMOV       ;ZERO OUT MOVE COUNTER
         RET
```

The character printing routine (Listing II) uses part of the QSPACE routine to position the carriage before printing. The listing of the character printing routine is as follows. The most important labels are:

WAIT	a loop that tests the $\overline{\text{INPUT BUFFER READY}}$ line and waits until it goes LOW.
OUTCHR	the BASIC routine that calls this line printer code. This recursive call allows a part of Q70 printer code to call another part of the code to execute a command.
ENDQME	a routine that prepares the stack for exit from the line printer code.

LISTING II

```
LPIGO:  POP     PSW             ;STRAIGHTEN OUT STACK
        PUSH    H               ;GET SOME WORK ROOM
        PUSH    D
        PUSH    PSW
        CPI     040             ;IS THE CHAR A SPACE?
        LDA     LPTPOS          ;GET READY WITH CHAR POSITION
        JM      OTHER           ;NO, CHECK FOR CONTROL CHAR
        JZ      QSPACE          ;YES, GO DO A SPACE
        CALL    QMOVE           ;PRINTABLE CHAR, MOVE CARRIAGE
        POP     PSW             ;GET CHAR
        PUSH    PSW
        ADD     A               ;SHIFT CHAR LEFT ONE BIT
        CMA                     ;ACTIVE LOW DATA LINES
        OUT     QUME1           ;SEND TO PIO
        CALL    WAIT            ;READY TO GO?
        MVI     A,0337
        OUT     QUME2           ;SET CHARACTER STROBE
        ORI     040
        OUT     QUME2           ;RESET CHAR STROBE
        LDA     LPTPOS          ;GET CURRENT CHAR POSITION
        LXI     H,LPTLEN        ;GET ADDRESS OF LENHGT
        CMP     M               ;END OF CARRIAGE?
        JNZ     ENDQME          ;NO, JUST RETURN
QELN:   MVI     A,015           ;YES, FAKE A CARRIAGE RETURN
        OUTCHR                  ;DO THE LP
        JMP     QLF             ;NOW DO THE LP
```

The line feed routine is shown in Listing III. The most important label is:

QLINCM the line feed increment in units of 1/48 inch.

LISTING III

```
;LINE FEED OPERATION.  LINE FEEDS ARE NOT SKIPPED OVER AS SPACES
;ARE, BUT ARE DONE INDIVIDUALLY.  THIS IS TO PREVENT THE
;POSSIBILITY OF GIVING THE QUME AN ILLEGAL OUT OF RANGE PAPER
;FEED CMD.
QLF;     LXI    X,QLINCM        ;LOAD LINE INCREMENT(ACTIVE LOW)
         CALL   WAIT            ;READY TO GO?
         MOV    A,L             ;OK, SEND TO PIO
         CMA
         OUT    QUME1
         MOV    A,H
         CMA
         OUT    QUME2
         XRI    200             ;SET PAPER FEED STROBE
         OUT    QUME2
         ORI    200             ;RESET PAPER FEED STROBE
         OUT    QUME2
         JUMP   ENDQME          ;FINISH UP WITH STACK
```

5. PRINTER INTERRUPTS

The computer outputs information much faster than the Q70 Printer can print it. Therefore, the printer has a buffer which stores the data until the printer can catch up with it. When the buffer is full, more information cannot be accepted by the printer until space is made available in the buffer. The printer indicates this condition with the $\overline{\text{INPUT BUFFER READY}}$ signal which goes HIGH when the buffer is full. When the $\overline{\text{INPUT BUFFER READY}}$ signal goes LOW, the buffer is ready to accept new information.

There are two ways for the computer to monitor this signal. One way, used in Altair BASIC, is to periodically check the signal and to output information when it goes LOW. If the signal is HIGH, BASIC waits an interval and tests it again. This is a simple procedure but it has the disadvantage in some applications of dedicating all computer resources to printing operations. While printing is in progress, the computer cannot execute any other tasks.

The other way to monitor the $\overline{\text{INPUT BUFFER READY}}$ signal is to have the Q70C Controller request an interrupt when the signal goes LOW. During the time the signal is HIGH, the computer can process other tasks. When it goes LOW, however, the computer can interrupt its current operations and pick up the printing operation where it left off. Since the computer is considerably faster than the printer, this arrangement can result in a significant increase in throughput.

The $\overline{\text{INPUT BUFFER READY}}$ signal is applied to the CA1 input of IC F. If Control Register bit Ø in port A is set to one, then an active LOW input to CA1 causes an interrupt request signal to be generated at the $\overline{\text{IRQA}}$ output of IC F. This interrupt request signal can then be connected to the computer bus by means of jumpers and used to control the interrupt request input of the CPU.

To initialize the port for interrupts, the following instructions are executed after the directions of the ports have been set (see page 5):

```
MVI A,45
OUT 064
```

I/O address 064 (in this example) is the port A Control Register, of IC F. Writing a 1 in bit 2 of the Control Register allows access to the Data

Register instead of the Data Direction Register, while writing a 1 in bit Ø causes the $\overline{IRQA}$ output to go LOW when the $\overline{INPUT\ BUFFER\ READY}$ signal goes LOW. Note that before this arrangement can be used, an EI instruction must be executed to enable interrupts in the CPU.

The $\overline{IRQA}$ signal is brought out to jumper pad KA in the lower left-hand corner of the board. It is connected to the bus by installing one of the following jumpers:

a. If the Vector Interrupt board is in use, install the jumper from KA to one of the pads marked VI0 to 7, depending upon the priority level at which printer interrupts are to occur. See the VI/RTC board manual for further information.

b. If the Vector Interrupt board is not used, install the jumper between KA and $\overline{PINT}$. To install this jumper, use the following procedure:

1. Cut a length of wire equal to the distance between the desired printed circuit board pads plus approximately 1 inch.
2. Strip about 1/2 inch of insulation from each end of the wire and bend the bare ends at right angles to the wire.
3. Insert the ends into the desired holes on the printed circuit board and secure the jumper by spreading the leads apart from the back side of the board.
4. Turn the board over and solder the ends of the wire to the board. Clip off excess lead length. Make sure no solder bridges are left between conductors.

6. ELECTRICAL THEORY

Figure 1 is the schematic diagram of the Q70C Controller board.

The port section is selected by signals A1 and A0 and inputs RS0 and RS1 according to the following chart:

Table C Port Selection

A1	A0	Section	Register
0	0	A	Control
0	1		Data
1	0	B	Control
1	1		Data

In summary, the incoming address selects the Q70C board, a port, a section and a register. To write into or read from a register, the E pulse (pin 25 of ICs D and F) must be HIGH. The E pulse is the logical sum (OR) of PDBIN and $\overline{PWR}$. This produces one pulse per machine cycle and assures that data is read or written at the correct time.

6-1. Address Selection

Address signals A7 - A0 and their complements ($\overline{A7}$ - $\overline{A0}$) are buffered and applied to the address selection switch SW1. If the address matches that set in SW1, pin 8 of IC P goes LOW and pin 6 of IC L goes HIGH. The addresses selected by SW1 are shown in Table D. Bus signals SINP and SOUT indicate whether an IN or OUT instruction is being executed. In either case, pin 6 of IC G and the $\overline{CS2}$ inputs of the PIAs (ICs D and F) go LOW. This selects both I/O ports. Address signal A2 selects one of the ports through the CS1 input of IC F and CS0 of IC D. When A2 is Ø, port D is selected; if A2 is 1, port F is selected.

Table D. Q70C Address Selection Chart

Address (Octal)	Switch 1 Position 54321	Address (Octal)	Switch 1 Position 54321
000	00000	200	10000
010	00001	210	10001
020	00010	220	10010
030	00011	230	10011
040	00100	240	10100
050	00101	250	10101
060	00110	260	10110
070	00111	270	10111
100	01000	300	11000
110	01001	310	11001
120	01010	320	11010
130	01011	330	11011
140	01100	340	11100
150	01101	350	11101
160	01110	360	11110
170	01111	370	11111

NOTE: Switch OFF = 0
Switch ON = 1

7. CONNECTING THE PRINTER

The Q70C board is the interface between the Altair 8800 series computer and the Q70 printer. The Q70C board fits into one of the sockets on the motherboard and thus provides the printer's connection with the system bus. The Q70C board is, in turn, connected to the printer by two lengths of 50 conductor ribbon cable and the appropriate connectors. This section details the procedure for installing the Q70C board and cables.

Before removing the cover of the 8800 computer chassis, turn off system power and unplug the power cord from the wall socket. Remove the two screws at the top of the back panel that secure the cover. Remove the cover by sliding it back and lifting it off the chassis.

> **NOTE**
> Do not reapply power until the board and cables are installed and the chassis cover is replaced.

7-1. Cable Feed-Through Installation

The cable from the Q70C Controller board to the Q70 Printer is supplied in two sections as shown in Figure 2. One section runs from the Q70C board to the back panel and the other from the back panel to the printer. The feed-through connectors connect the two sections of cable.

The cable feed-through connectors are mounted in two of the rectangular cut-outs in the back panel of the 8800 series chassis. To mount each feed-through:

a. Insert the feed-through connector through the cut-out from the front.

b. Insert a 6-32x1/2" bolt through one of the bolt holes from the rear. Secure the bolt with a washer and a 6-32 nut. Repeat this procedure for the other bolt.

c. Tighten both nuts.

d. Repeat this procedure for the other feed-through.

7-2. Q70C Board Installation

Any socket on the motherboard can be used to install the Q70C board. Install the board according to the following procedure:

a. Orient the board so the card edge connector is down and the components are to the right as viewed from the front of the chassis.

b. Insert the card in the two card guides and slide it down to meet the socket on the mother board.

c. By applying pressure first on one end of the board and then on the other, mate the board securely with the socket. The top of the card should be nearly flush with the top of the card guides.

7-3. Cable Connections

A. Insert the 50-pin connector of the shorter section of cable into connector P6 so that the edge of the cable marked with the blue stripe is toward the front of the chassis. Insert the connectors on the other end into the back panel feed-through connectors as shown in Figure 3.

B. Insert the smaller two connectors on the longer cable section into the back panel feed-through connectors. The edge with the blue stripe must correspond with the striped edge of the internal cable so that the conductors of the two cables match. Insert the other connector into the socket on the Q70 Printer so that the lowest numbered pins on the connector are toward the center of the printer. (The numbers are embossed in the end of the connector.)

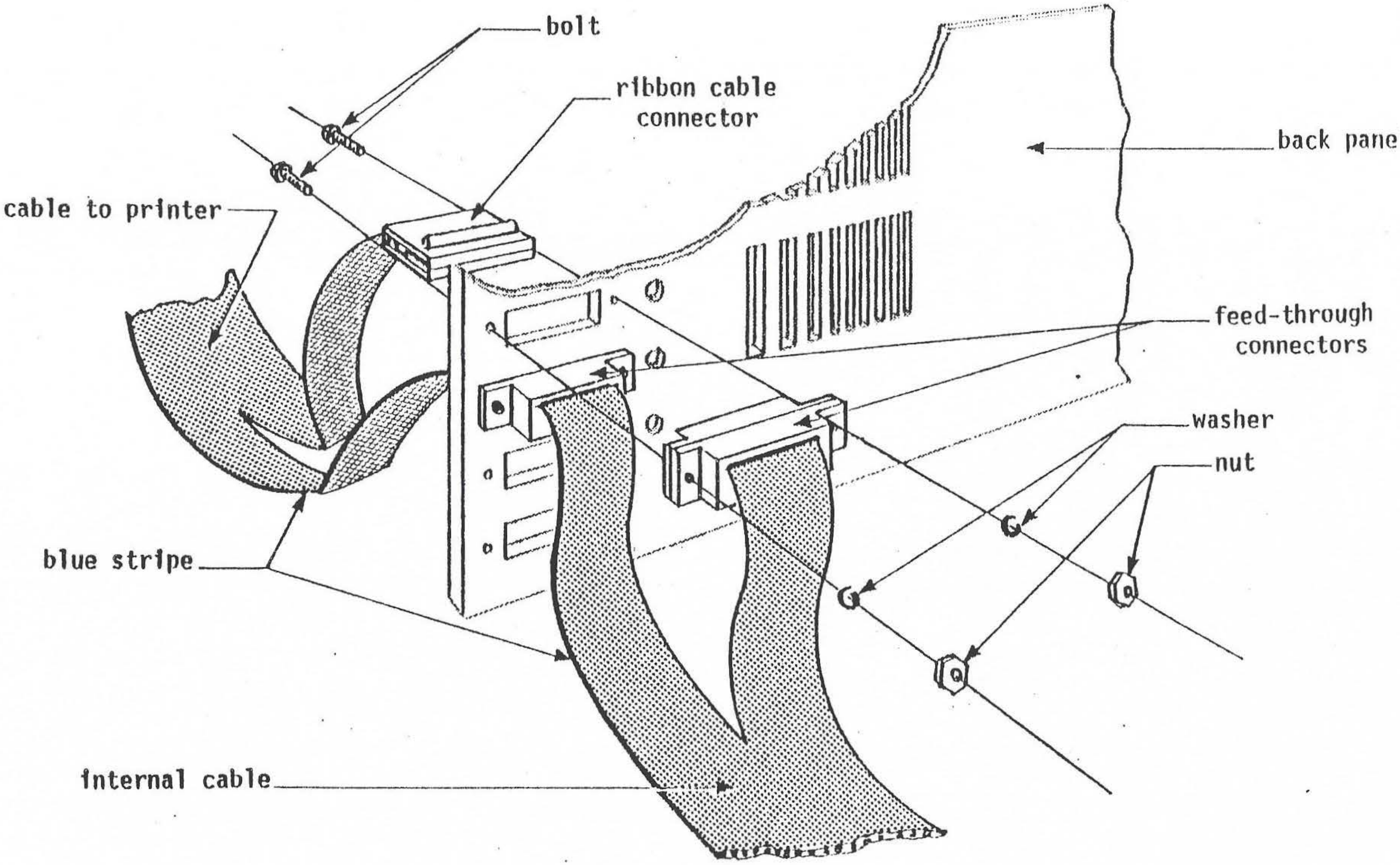

Figure 3.
C[illegible] and Connectors