SPEX

Instructions

CD2A-B

Compudrive

Contents

1 INTRODUCTION

The SPEX COMPUDRIVE (CD2A) hands you total keyboard control over your spectrometer/recorder drive system. Not only does it repeat scan over the spectral regions you define, while the stripchart recorder tracks faithfully along, but it also outputs the spectrometer position and scan status, at the same time accepting trigger inputs, so you can easily tie it into a dialog with your detector electronics or computer.

As you might expect, the key to CD2's power is flexibility. Drive your spectrometer manually, or slew automatically with a SET command. CD2's translator/drive gives you a step resolution decidedly finer than previously available. Scan continuously, or in bursts, or even latch data acquisition into your system with those external triggers to begin scans, or govern the length of the dwell between burst increments. All the while, CD2A updates its LED display so you know at a glance just where the spectrometer happens to be, no matter if you change gratings, spectral order, or swap a wavenumber for a wavelength spectrometer. A few keystroke modifications of CD2's configuration table are all you need before you're on your way taking data. Scan, start, end, rate, repetitions, delay between repetitions, recorder scale, and marker frequency are all programmable. Close and open a shutter for laser-Raman PMT protection or tell an external device to flick a filter in and out of the beam at certain points in the scan. And if you do make a mistake, CD2's error detection pinpoints its source.

Once CD2 is out of its crate and hooked to your spectrometer as explained in Section 2, you can start operating immediately by following the step by step get-acquainted instructions in Section 3. Section 4 details CD2's configuration table, while error codes are listed in Section 5.

Or you can link CD2A to your computer for two-way communication by following the instructions in Section 3.4.13.

2 UNPACKING AND INSTALLATION

Unwrap your CD2 and save the packing material for possible future use or for inspection by the carrier should you uncover any damage. Carefully inspect both drive unit and keyboard console for any damage. If you find any, notify the carrier immediately.

Position the drive unit near the spectrometer and the keyboard console in a convenient location where airflow to its rear panel is not restricted. Unfold the wire kick-stand on the floor of the console if you wish.

Connect the short, D-shell cable between MONO OUTPUT on the drive unit and the receptacle on the rear of your spectrometer. Now run the long ribbon cable between the CONTROL INPUT connector on the translator drive and MONO DRIVE on the rear panel of the CD2 console.

Connect RECORDER, REMOTE, BCD OUT, and TRIGGER cables as needed (Fig 1B). Pin assignments are listed in Section 6, Specifications.

Before attaching power cable, check to be sure that the 115/230 VAC switches on the rear of *both* drive unit and keyboard console are set to the proper line voltage and that the corresponding fuses are installed. Power cables may then be installed.

NOTE: The drive unit must always be turned on *before* the keyboard console to avoid self-diagnostics errors.

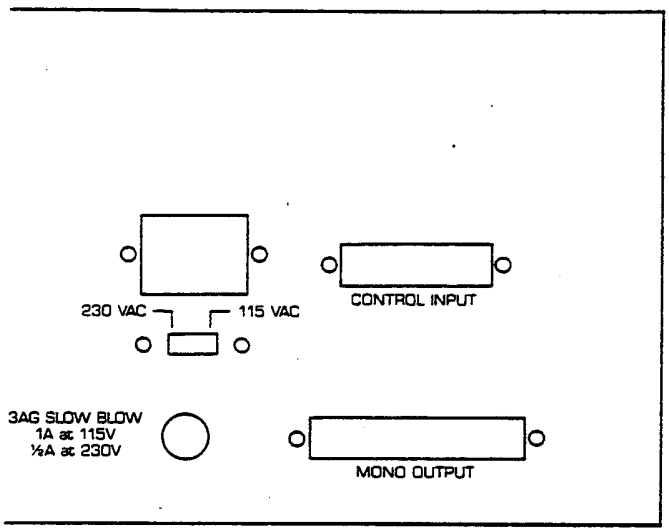


Fig 1A
Drive Unit

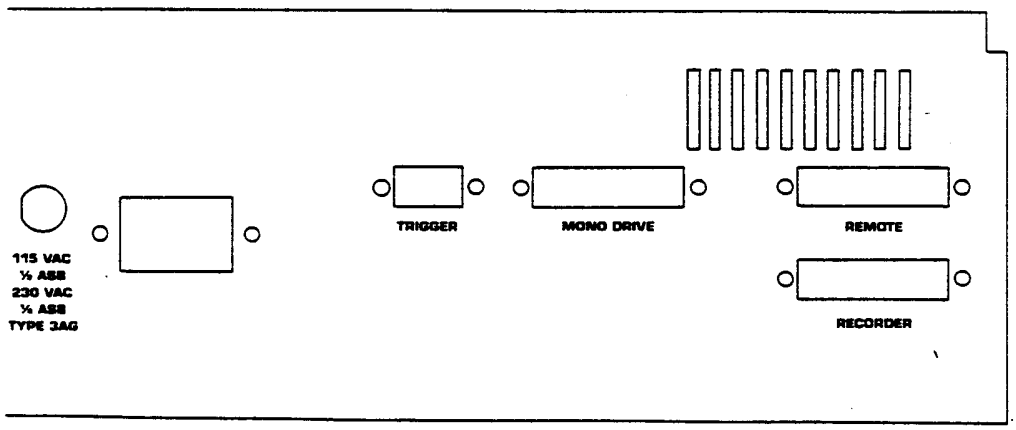


Fig 1B
CD2A Console Rear Panel

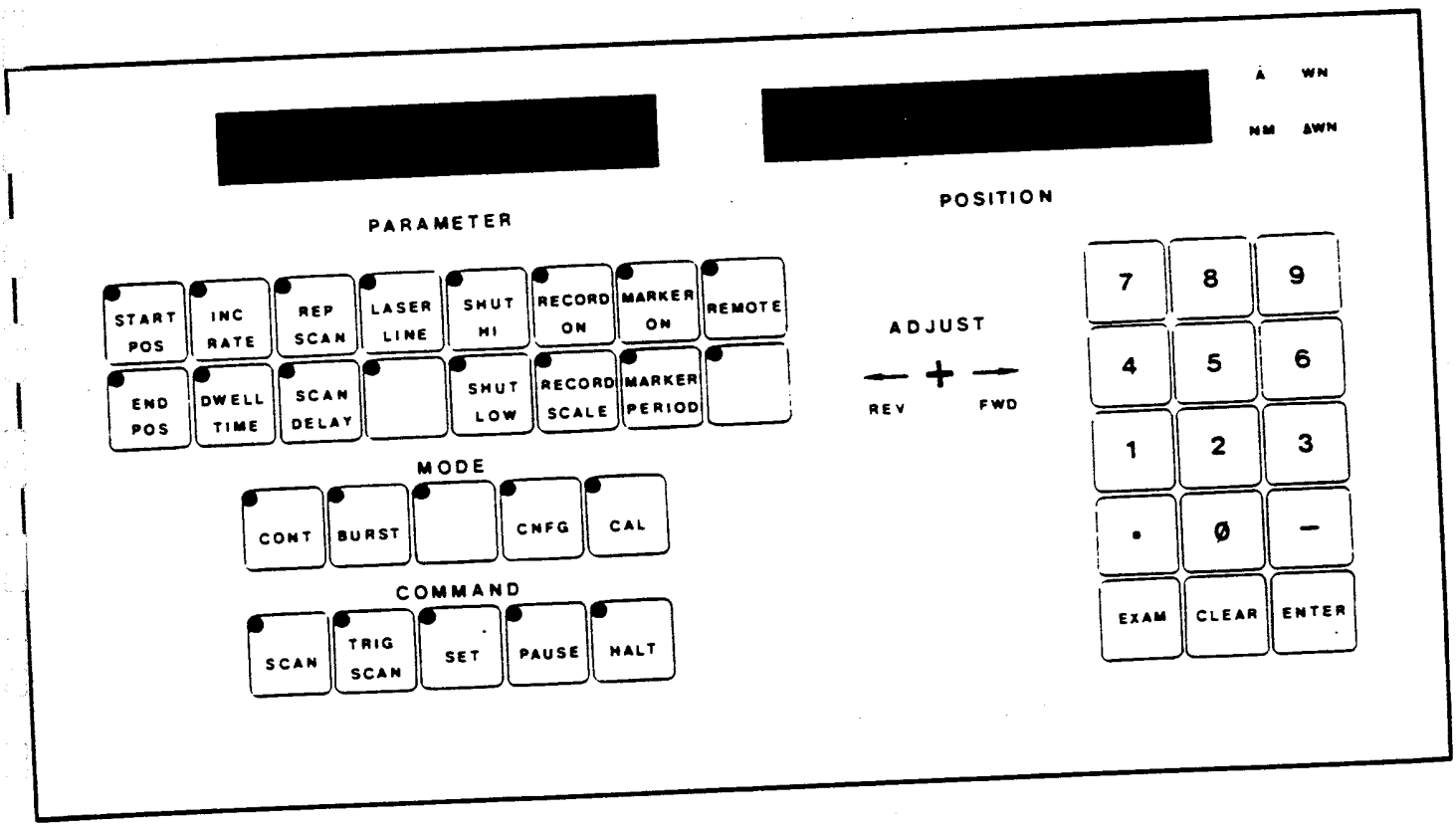


Fig 2
CD2 COMPUDRIVE Keyboard and Display

3 OPERATION

3.1 Keyboard

CD2A's keyboard is shown in Fig 2. The power switch is in the upper, right-hand corner of the console and it should be in the off position for now. Note that there are two LED displays for up to eight digits of data, messages, and error codes. The one labelled PARAMETER shows each entry as it is made and can also display the contents of various parameter buffers as explained further on. POSITION keeps track of where in the spectrum your spectrometer happens to be sitting. Once calibrated, it will faithfully follow all spectrometer movements, constantly updating in angstroms, nanometers, wavenumbers, or delta wavenumbers (as indicated by the lit dimension – A, NM, WN, ΔWN –, depending on the configuration, Section 5) even if you change gratings or spectral orders. Immediately beneath the PARAMETER display you'll find the keys that give you access to the operational parameters stored in memory and enable output to peripheral devices. Note that each key has an LED in its upper, left-hand corner. Pressing any one of these keys will light its LED and, if it happens to be a parameter key, the associated value will appear in the PARAMETER display. These values can be altered by entries from the bank of keys on the right, which includes the digits 0 through 9, a decimal point, a negative sign, and three other keys (EXAM, CLEAR, ENTER). All changes in parameter values must be locked into CD2's memory by pressing the ENTER key.

The MODE keys select the type of scanning you will be doing (continuous or burst), let you recalibrate your spectrometer, or give you access to CD2's configuration elements that define the type of system the CD2 expects to control; that is, the kind of recorder, spectrometer, what gratings are mounted, and so on.

The bottom set of keys (COMMAND) control the movements of the spectrometer. You can scan with a cycle determined completely by keyboard entries, or one based on outside trigger signals, set the spectrometer to a particular spectral position, pause at the end of the current scan in a multi-scan sequence, or just halt all operations and bring CD2 to a dead stop.

Finally, a toggle switch (ADJUST) gives you touch control over spectrometer position so you can home in on a peak.

The functions of individual keys are detailed starting with Section 3.3.

3.2 Start-Up

Once your CD2A has been installed as detailed in Section 2, begin by turning the stepper drive power on. The rocker switch will light when power is supplied. Turn on your recorder (if attached), then push CD2's power switch to the ON position. Immediately CD2 signals with a beep and a row of 8's in the display which reverts to a row of dashes. This is the beginning of an internal diagnostic check which polls the various circuits in CD2's network for reports on their general well-being. Any symptoms of failure are instantly identified by numerical error codes on the CD2A's PARAMETER display. Often, these errors are as simple as turning on the CD2A console before the stepper drive unit (Error 26). In such cases, once the trouble is rectified (turn the translator drive on), the error display condition can be removed with the CLEAR key and normal operation restored. Complete error codes are listed in Section 5.

Routinely, the self-diagnostics will be completed without a hitch. CD2 then removes the backlash from your spectrometer drive and signals with a beep. Cr—— (Counter reading) appears on the PARAMETER display. Before you go any further, you must load in the spectral position of your spectrometer as defined by the mechanical counter on the side panel of the instrument (in nm, A, or cm^{-1} — *not* Δcm^{-1}, see Section 3.5.3. if necessary). Do this by pressing the corresponding sequence of keys on the numerical pad, including decimal point when necessary. Note that the numbers appear in the PARAMETER display, but when you press ENTER to lock them in, the spectral position is transferred to the POSITION display. It will remain there throughout CD2A's operation, and be constantly updated as the monochromator is scanned, either automatically or manually with the ADJUST toggle. Be sure that the POSITION units (A, NM, WN, ΔWM) agree with the units of your spectrometer. ALL PARAMETERS MUST BE LOCKED INTO MEMORY WITH THE ENTER KEY.

Error messages for misentries result in an identifying code number. They can be cleared, in most cases, by pressing the CLEAR key. Refer to Section 5 when you get into trouble.

For CD2's configured in wavenumbers, the next PARAMETER display will be LL—— (Laser Line). A non-zero number entered at this time automatically changes the POSITION units from WN to ΔWN (ΔWN = LL – WN). Enter a zero, and CD2 stays in wavenumber units. Should your spectrometer also be equipped with a shutter to protect the PMT, your SHUTTER HI and LO values should be set to define the protection window, or portion of scan range blocked from the PMT. Set shutter values by pressing SHUT LO. (Note the LED on the key lights to show you which value is being displayed.) Key in the desired limit for the shutter (– 50, for example), and press ENTER. Repeat with SHUT HI (50, for example). The region between the limits (– 50 to 50 ΔWN) is blanked out by the shutter. (SHUTTER HI/LO may also be used with any CD2 system, regardless of scanning units, to control external devices, such as filters or sample changer, see Section 3.4.3.)

You can go on to tell it to scan, set, or do any of the operations outlined in the sections to follow, if you prefer. On the other hand, it would probably be better to run through the sequence of commands described below to manually adjust the spectrometer, do a set to a

particular position, and maybe even run a scan so you can get a quick feel for CD2's operation.

Place a fingertip on the ADJUST toggle, moving it back and forth while noting the POSITION display as it updates to match the spectrometer movements. Remember that you can't expect the POSITION to be accurate unless you are moving in a scan direction. After movements in a non-scan direction, at least ten (and as many as 50) units reverse into a scan direction are required to remove backlash depending on the spectrometer drive. All SPEX spectrometers scan from high to low wavenumber, low to high wavelength, etc.

Press SET. CD2 responds with POS——(Position) in the PARAMETER display. Key in the spectral position you'd like your spectrometer to locate. When ENTER is pressed, the spectrometer slews to that destination, complete with backlash removal if approaching from a non-scan direction.

Run a quick scan by pressing START POS, and entering the beginning of the scan. Repeat with END POS and INC/RATE. This last entry, in the CONTinuous mode tells CD2 how fast to scan. Try loading in 1.0 for 1 unit/sec. Press REP SCAN and enter in a 2 to repeat the scan, then a 5 into SCAN DELAY to idle for five seconds between scans. If you'd like to record the output from your detector during the scan, enter a 10 (10 scan units/recorder unit) into RECORD SCALE, then press RECORDER ON to enable the recorder drive. Now select CONT in the MODE key bank, then SCAN. CD2 will automatically slew to the START POS, taking out the backlash if need be, before scanning at one unit/sec as the recorder tracks along with the spectrometer.

On reaching the END POS, CD2 pauses for five seconds before restarting the scan sequence. It then halts, waiting for the next command. Note that the display shows how many scans have been run out of the total requested (e.g. 001 002).

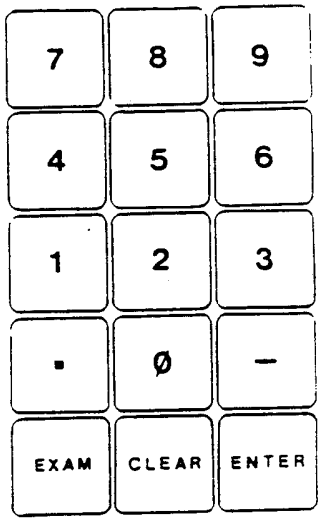
These scans were simple continuous movements of the spectrometer at a constant speed or rate. CD2 also scans in a discontinuous or BURST mode in which the spectrometer slews for a selected INCrement, DWELLS at that position for a selected length of time, before slewing to the next position in the scan, one increment away.

In addition, a continuous scan may be triggered externally (TRIG SCAN key) to start on a given signal, or the length of all the dwells in a BURST scan can be set by such a trigger. With our DPC2, this can lead to BURST scanning where data is taken only while the spectrometer is stationary (Section 3.10).

All the above features and other functions of the CD2, such as STATUS LINE output, changing spectral order, etc. are detailed in the following sections.

3.3 Numerical-entry Key Group

Located on the right side of the CD2 control panel, these keys include the numbers 0 through 9, a decimal point, a negative sign, and three operations (EXAM, CLEAR, ENTER) defined below.



The top 12 keys load their labels into the PARAMETER display to specify scan parameters or to alter CD2's configuration (Section 4). The displayed values are not locked into memory until the ENTER key is pressed. Then the value is loaded into the parameter that is identified by a lit LED on its key and confirmed to the operator by a beep.

3.3.1 EXAM

The EXAM key is a way to recall the present parameter value (for the key with a lit LED) after the display has been CLEARed or written over, but ENTER has not been pressed. For instance, pushing START POS may bring a 400 into the display. Pressing CLEAR or a sequence of numbers in an attempt to alter the START value will removed 400 from the display. But if ENTER has not been pressed, EXAM will load 400 back into the display, since that remains the real scan START value.

3.3.2 CLEAR

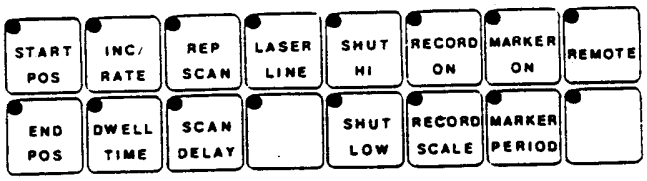
This key merely blanks the display so new parameter values can be entered. It has no effect on the parameter value unless ENTER is pressed after it. In that case the parameter value becomes zero.

3.3.3 ENTER

You'll probably resort to this key more than any other for it tells CD2 to accept the displayed data as a parameter value for the key identified by a lit LED. No numerical value will be trapped by CD2's memory until ENTER is pressed.

3.4 Parameter Key Group

This group of keys determines which parameter will be displayed or altered after ENTER is pressed. During operations, hitting a particular key displays the parameter associated with it and lights the LED to identify which parameter is being displayed.



This group also includes the keys for turning the recorder, marker, and peripheral data link on and off.

All scan parameters should be entered *before* a scan is requested to avoid errors (Section 5).

3.4.1. START POS

Press this key when you want to tell the CD2 where scans begin. Load in the value, in units matching the POSITION display, from the numerical-entry keys, then lock in with ENTER.

3.4.2 END POS

Press this key to tell the CD2 where scans end. Load in the value, in units matching those in the POSITION display, from the numerical-entry keys, then lock in with ENTER.

3.4.3 INC/RATE

The meaning of the INC/RATE parameter key hinges on the mode of scanning you choose: Continuous or Burst.

For Burst scanning, in which the spectrometer slews over a spectral division or increment, then dwells there for a selected time (Section 3.4.4), or until an external trigger is received, set the distance between dwell points by loading in your increment in POSITION display units. The smallest logical increment is one motor step, the reciprocal of element 6 in the configuration table, Section 4. Choose your value by pressing the selected sequence of numerical keys, then ENTER.

For Continuous scanning, press this key to define the RATE, or speed, of your scan in POSITION display units/sec: (START-END)/RATE = total time of scanning. Normally continuous scans are not ramped; that is, the spectrometer begins stepping at the choosen rate immediately on leaving the START position. There is no gradual acceleration and so the inertia of the spectrometer drive sets a limit on the ultimate speed of a normal continuous scan. Because of this, CD2's maximum rate for unramped scanning is set by configuration element 9 (start speed of spectrometer/100 or 10 for LSD) and element 6 (motor steps/unit, see Section 4). So the maximum continuous scan rate for your spectrometer will be (element 9 x 100)/(element 6). CD2 will, of course, scan at rates higher than this. In fact, it will scan as fast as element 10 (maximum speed of spectrometer/1000 or 100 LSD) allows, and this upper limit is determined by (element A x 1000)/(element 6). However, these faster scans will be ramped, and the recorder will not be allowed to follow in a coupled mode.

For example, if your element 9 was set to 40 and element 6 to 400, your maximum unramped scanning rate would be 10 units/sec. If you entered a value greater than this into INC/RATE and requested a CONTinuous scan, the scan would still be performed but CD2 beeps and displays HI SPEED in the PARAMETER Display to let you know that normal scanning has been overridden. Now the spectrometer accelerates up to the specified speed on a ramp, then back down again to reach the end.

When a RATE greater than the maximum speed of the spectrometer is entered, requests for scans will result in an ERROR 86 and the RATE LED will light.

3.4.4 DWELL TIME

For Burst mode scanning where the pause after each increment is *not* to depend on an external trigger, but instead is set by CD2's own clock, press this key to select your parameter. Enter in a number between 0.01 and 600 seconds, then press ENTER. During scanning the spectrometer will be stationary that long between slew increments. DWELL TIME has no meaning when you select a continuous or triggered scan.

3.4.5 REP SCAN

With this key you tell CD2 how many times to repeat the scan over the region defined by the other parameters. Key in a number between 1 and 999, then press ENTER.

Pressing the REP SCAN key during scans will display two numbers on the PARAMETER LEDs. The one on the left is the number of scans that have been completed, while the number on the right is the total number of scans that have been requested.

3.4.6 SCAN DELAY

Press this key to postpone the beginning of each scan repetition. The CD2 will wait at the end of each scan while this delay runs out. Key in a number (between 0.01 and 600 seconds, or zero) and press ENTER.

SCAN DELAY does not function when a TRIGGER SCAN has been selected.

3.4.7 LASER LINE

For Raman systems, this key allows you to work in delta wave-numbers defined as ΔWN = Laser Line − WN.

A non-zero entry into this parameter automatically alters all wavenumber scan parameters, including START POS, END POS and SHUTTER HI/LO to their delta wavenumber equivalents. The spectrometer POSITION is also changed as evidenced by lighting of the ΔWN symbol.

A zero entry into this parameter preserves (or restores) the wavenumber format of the instrument.

For wavelength-drive instruments, pressing LASER LINE will simply be ignored.

Press the proper sequence of numerical keys (e.g. 19435), then ENTER.

3.4.8 SHUT HI/LO

With a Raman system, these keys define a region blocked from your PMT by a mechanical shutter. On any CD2 system you can alternatively control an external device that may, for example, insert and remove a filter when scanning through a certain spectral region.

In any event, press either key to define when the shutter output begins (LO) and ends (HI). Key in the desired numbers in units that match those in the POSITION display, then lock in with an ENTER command.

NOTE: If HI = LO, the shutter is always open.

For instance, you may have installed that shutter to block out a region to either side of the laser line and prevent accidental blinding of your phototube. Entering −25 into SHUTTER LO and 20 into SHUTTER HI will then prevent any light in the region from 25 delta wavenumbers on the anti-Stokes side, to 20 on the Stokes from reaching the exit port of your spectrometer. In the defined region, pin 9 in the MOTOR CONTROL connector is grounded. Pin locations and outputs for shutter control are listed in Section 6. (Note that for wavenumber units SHUT LO is a larger number than SHUT HI, since that corresponds to the scan direction.)

3.4.9 RECORD ON

This key enables or disables the drive circuitry which couples the recorder to the monochromator. Pressing a lit key disables and turns off the LED. Pressing an unlit key enables and lights the LED. The recorder cannot be turned on till a RECORDER SCALE is entered (Section 3.4.10).

Note that the first scan after start up automatically removes one recorder unit of backlash from the chart drive. Be sure there is enough excess paper in your recorder to allow for this.

If no recorder appears in the configuration table (Section 4), pressing RECORD ON will be ignored.

3.4.10 RECORD SCALE

Press this key to set the number of scan units that will be plotted as one unit of chart paper (e.g. 10A/in., 5WN/cm, etc.). Follow the proper sequence of keys (maximum five digits, including decimal point) with an ENTER command.

In the Burst mode, you need only make sure the SCALE is not zero. However, in the Continuous mode you must always keep the SCALE large enough to allow the recorder to follow. This means that (RATE/SCALE) x RECORDER STEPS/RECORDER UNITS (see configuration element 7) must be less than or equal to the maximum recorder speed, element 8. For a SPEX recorder this simply means the number in RATE should never be more than about 1.5 times that in RECORD SCALE. Invalid RECORD SCALEs result in an ERROR 90 ($\leq$0 valve), 91 (no continuous scan rate entered), 92 invalid; (e.g. too fast).

3.4.11 MARKER ON

This key enables or disables the circuitry which sends a pulse to your recorder at constant intervals to scale the wavelength or wavenumber axis of the charted data. Pressing an unlit key enables and lights the key's LED. The marker cannot be turned on unless a MARKER PERIOD (Section 3.4.12) has been entered.

If no marker appears in the configuration table (Section 4), this key is ignored.

3.4.12 MARKER PERIOD

Press this key when you want to select the number of spectrometer units between signal pulses to your marker. Follow the proper integer number (maximum 3 digits) with an ENTER command.

In the Continuous mode, MARKER PERIOD/RATE must be greater than or equal to one. In the Burst mode, MARKER PERIOD must be an integer multiple of the increment. When a scan is requested, invalid entries give an error 8D ($\leq$0), 8E (no increment/rate entered), 8F (out of range).

3.4.13 REMOTE — RS232

The RS232 remote provides a communications port for OUTPUTTING data to a user device (such as a datalogger, printer, or computer) and RECEIVING data and commands from a computer. (See Tech Note #66 at the rear of this manual for an example.)

The RS232 port supplies information on spectrometer position and certain operational conditions described in following paragraphs. Also, Parameters and Commands may be inserted into the CD2 through the RS232 port.

NOMENCLATURE: (The following symbols are used in this section)

< . . >: ASCII Control Character
<CR>: Carriage Return (ASCII 13)
< LF >: Linefeed (ASCII 10)
[. .]: Optional Characters (as per configuration)

3.4.13.1 Configuration Parameters

The RS232 hardware and software configuration is defined by codes entered in the CD2A configuration registered as described in section 4.1.

3.4.13.2 Input/Output Sequences

A. One-way RS232 — Configuration Element 21, bit #1 = 0

In the simplest communication scheme, the CD2A outputs position information to external devices while actual control of operations and parameters remains with the CD2A keyboard. Output is initiated by pressing the REMOTE key prior to calling for a SCAN or SET operation. The red LED on the key should light. Data transmission begins as soon as the SCAN or SET operation is ordered from the keyboard.

There are three versions of one-way RS232 communication.

1. No external response required.
2. External acknowledgement of data reception required (<ACK>/<NAK>).
3. In addition to 2 above, CD2A issues a service request prior to transmission (<ENQ>CD).

1. One-way transmission with no handshake

With configuration element 21 bit #1 = 0, #4 = 0 and element 22 bit #1 = 0. The following protocol is observed:

Data transmission without the ACK/NAK bit-set looks like this

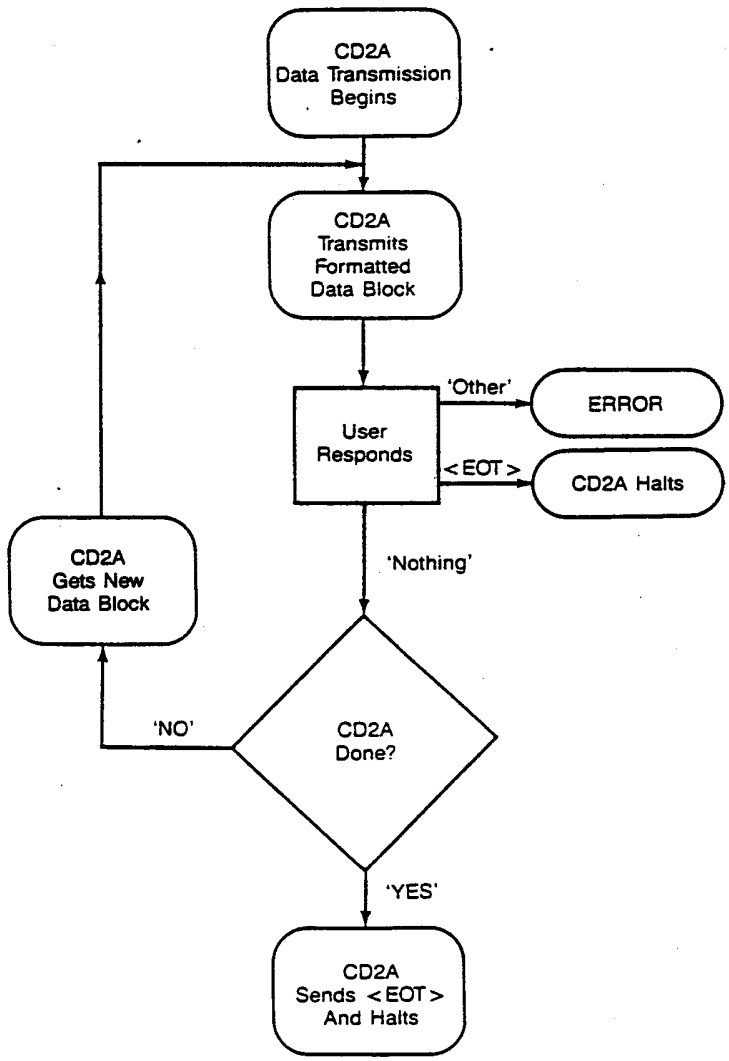


Fig 1

As soon as a SCAN or SET is ordered, CD2A begins transmitting position data in the format selected by configuration element 21 bit #3. A new data block is sent each time the POSITION display is updated. The transmission continues until one of the following three occur:

a. The SCAN or SET is completed. CD2A then sends an <EOT> to the external device and HALTS.

b. CD2A receives an <EOT> from the external device. CD2A HALTS operation.

c. CD2A receives any other transmission from the external device. CD2A HALTS operation and generates an appropriate error code (Section 3.4.13.8).

2. One-way Transmission with ACK/NAK Handshake

When configuration element 21 has bit #1 = 0, the protocol enforced follows this sequence:

Data transmission with ACK/NAK is different

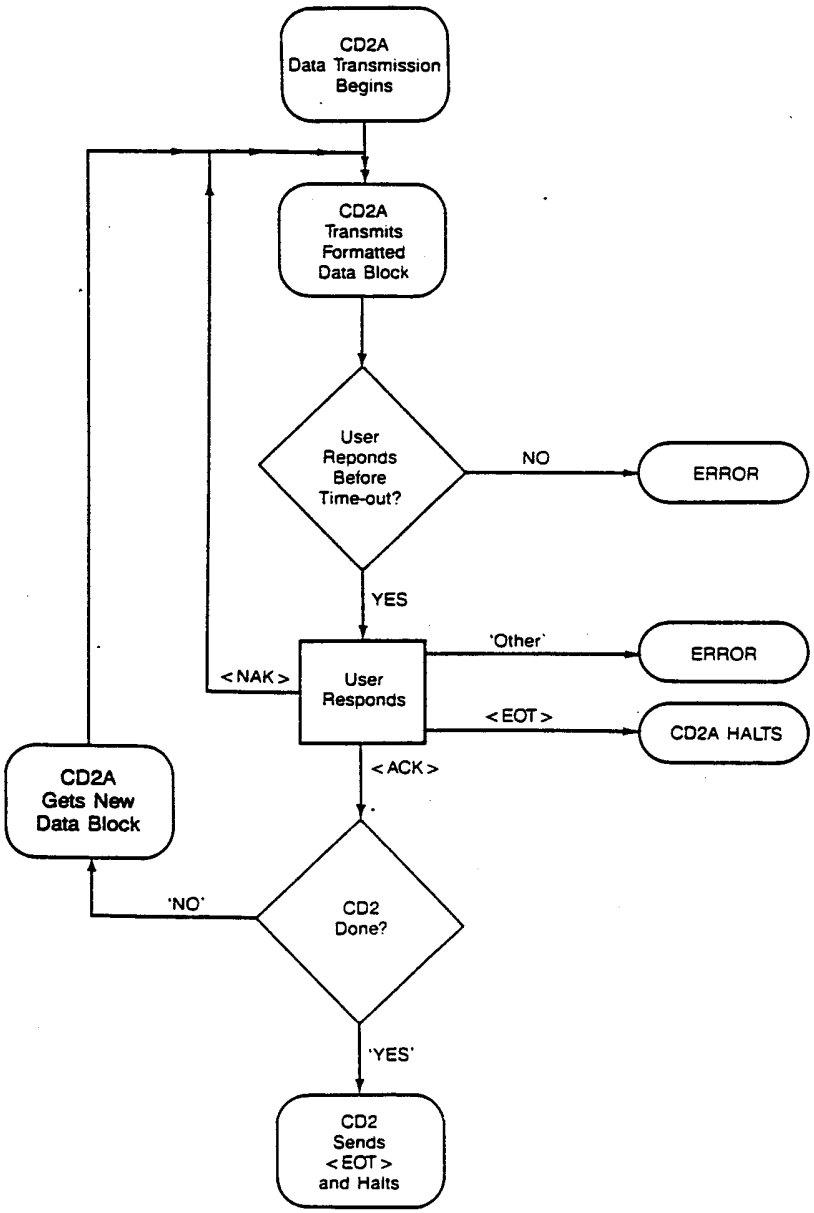


Fig 2

After a SCAN or SET is ordered, CD2A begins transmitting exactly as in (1) above. But after the first Data Block has been transferred, CD2A waits for a time set by Configuration element 19 for the external device to respond.

a. If no response is received in that time, an appropriate error code is issued (Section 3.4.13.8) and CD2A halts.

b. If <NAK> is received, the same Data Block is transmitted again. SCAN or SET continues as normal, without the retransmission delaying progress.

c. If <ACK> is received, a new Data Block is transmitted, unless the end of SCAN or SET is reached, in which case CD2A transmits <ACK> and halts.

d. If <EOT> is received, CD2A halts.

e. If any other character is received, an appropriate error code is issued and CD2A halts.

3. One-way Transmission with ACK/NAK handshake and <ENQ>CD.

With Configuration element 21 bit #1 = 0, #4 = 1 and element 22 bit #1=1, the following protocol is enforced:

In one-way communication the CD2A will issue a service request if the enquire configuration bit is set and the ACK/NAK configuration bit is set.

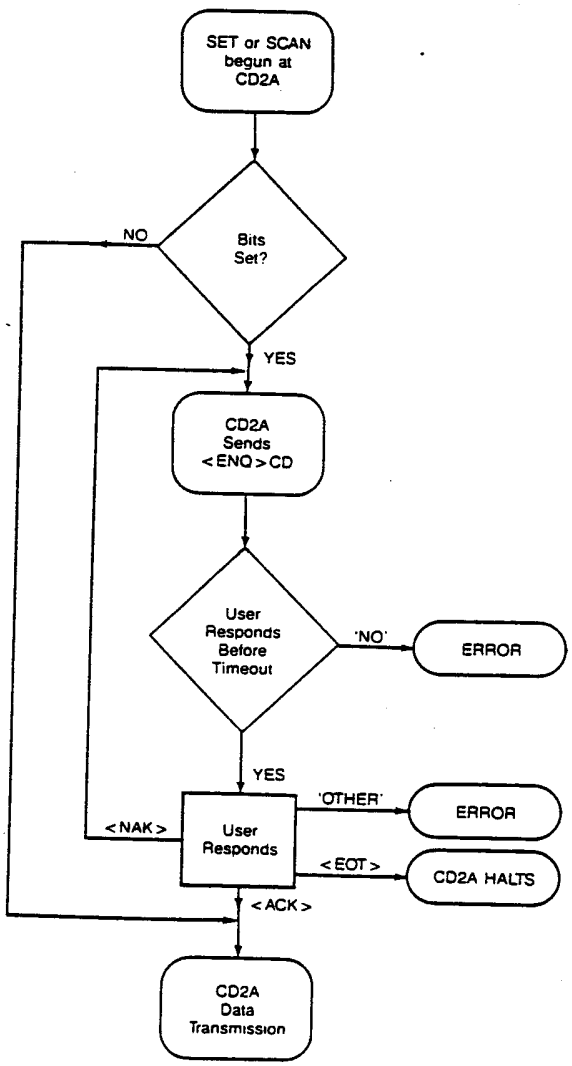


Fig 3

After SCAN or SET is ordered, CD2A transmits an <ENQ>CD to the external device and waits for a response for a time set by configuration element 19.

a. If no response is received, an appropriate error code is issued (Section 3.4.13.8) and CD2A halts.

b. If <NAK> is received, the <ENQ>CD sequence is reinitiated.

c. If <ACK> is received, transmission follows in a manner similar to (2) above.

d. If <EOT> is received, CD2A halts.

e. If any other character is received, an appropriate error code is issued and CD2A halts.

B. Two-way RS232

When element 21, bit #1 = 1, CD2A is configured for two-way RS232. In this configuration, the <ENQ>CD function, element 22 bit #1, is ignored.

To initiate two-way RS232, the REMOTE key is pressed. Note, however, that as long as the red LED on this key is lit, CD2A keys, except for HALT, are disabled. Parameters and instructions must be sent in by an external device.

The actual operation of two-way RS232 involves the interaction of two components:

1. Data blocks can be transmitted to external devices just as in one-way RS232.

2. Parameters and commands can be input into CD2A from external devices.

Note that CD2A two-way RS232 is full duplex, so messages can be sent in and out simultaneously.

Also, an <EOT> received by CD2A at any time will HALT operation.

1. Transmission of Data Blocks

The protocol and format of this operation is essentially the same as in Section A1, or A2 above, depending on configuration of the ACK/NAK bit. However, note that as soon as REMOTE is pressed, CD2A sends an <ACK><CAN> to signal that it is ready. Actual transmission of Data Blocks commences upon receipt of an order to SCAN or SET from the external device.

2. Input of Commands and Parameters

The special feature of two-way RS232 is that CD2A accepts and responds to outside orders, just as the user might set a parameter or order up an operation from the keyboard.

In this mode, CD2A sends an <ACK><CAN> as soon as Remote is pressed to signal that it is ready to receive commands or parameters.

Parameter input format is presented in Section 3.4.13.6 Command input format is presented in Section 3.4.13.7.

On receipt of a parameter command, CD2A will respond as follows:

a. A <NAK> is sent if the command or parameter message was received incorrectly (parity or related failure).

b. An <ACK><BEL> (error code) <EOT> indicates the message was received but not executed due to syntax or illegal characters (see Section 3.4.13.8).

c. An <ACK><CAN> means the message was received and the command executed or parameter assigned.

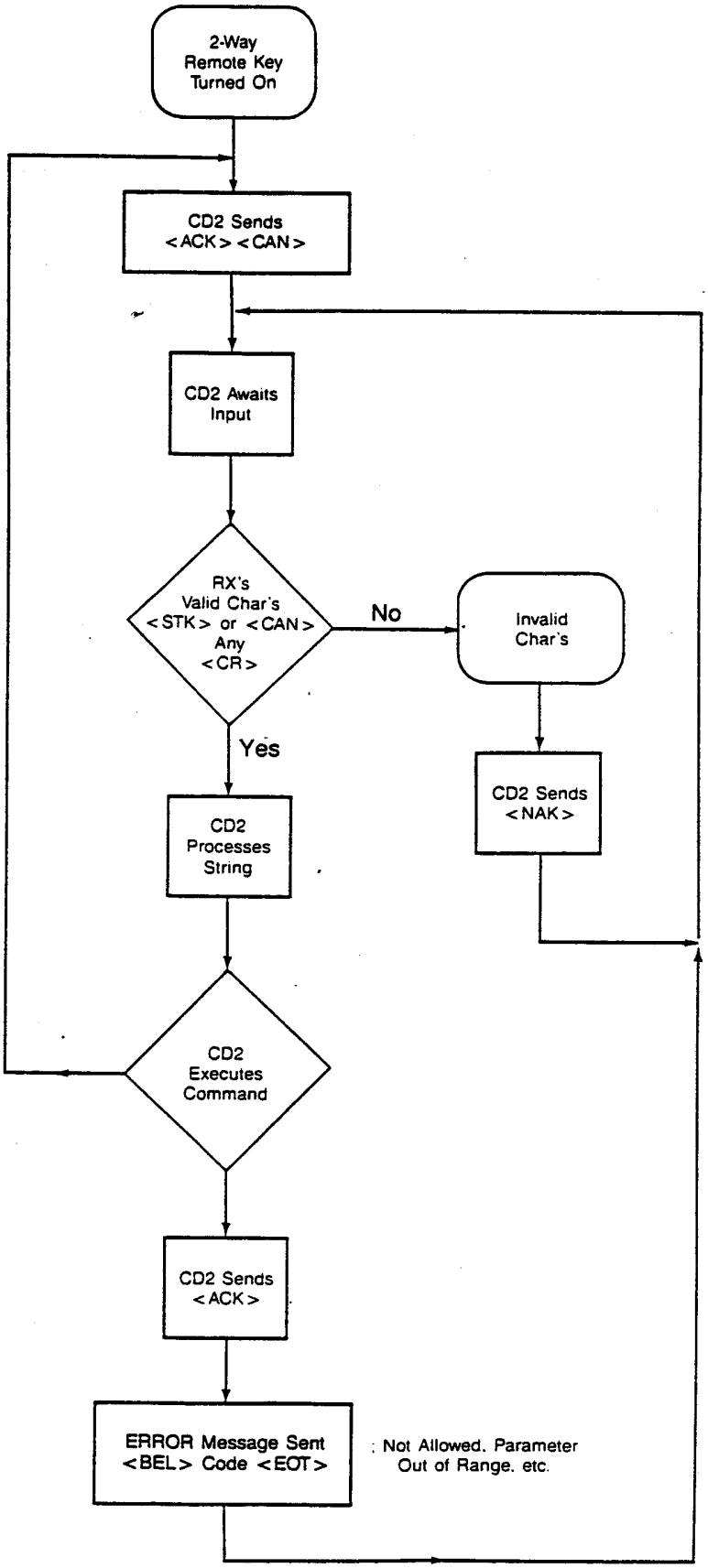

2-Way
Remote Key
Turned On
CD2 Sends
<ACK><CAN>
CD2 Awaits
Input
RX's
Valid Char's
<STK> or <CAN>
Any
<CR>
No
Invalid
Char's
Yes
CD2 Sends
<NAK>
CD2
Processes
String
CD2
Executes
Command
CD2 Sends
<ACK>
ERROR Message Sent
<BEL> Code <EOT>
: Not Allowed. Parameter
Out of Range. etc.

Fig 4

3.4.13.3 Datalogger Format of Data-Block Output

When Conf. Element 21 has bit #3 = 1, Data Blocks are sent in the following format:

Transmission sequence:
(Status), (Units), MSD,_,_,_,_,_,_,LSD,[(CS)], <CR>, [<LF>]

Description:

(Status): P —Positioning
* —Set Position (end of set positioning)
S —Start of Scan (end of scan positioning)
E —End of Scan
B —End of Burst (burst movement complete, waiting for trigger or end of dwell time)

(Units): N —Nanometers
W —Wavenumbers
D —Delta wavenumbers
A —Angstroms

MSD through LSD — Scan position, MSD is Most Significant Digit, LSD is Least Significant Digit.

Example:
End of burst position is 460.52 nanometers.
Transmission:
B N 0 0 4 6 0 . 5 2 (CR)

3.4.13.4 Standard Format of Data-Block Output

When Config. Element 21 has bit #3 = 0, Data Blocks are sent in the following format:

Transmission sequence:
<STX>, (Status), (Units), MSD,_,_,_,_,_,_, LSD, <ETX>, [(CS)], <CR>, [<LF>]

Description:

<STX>: Start of Message

(Status): P —Positioning
* —Set Position (end of set positioning)
S —Start of Scan (end of scan positioning)
E —End of Scan
B —End of Burst (burst movement complete, waiting for trigger or end of dwell time)

(Units): MSD through LSD, same as Section 3.4.13.3

<ETX>: End of message body

(CS)— two ASCII-hexadecimal characters representing binary sum of preceding characters, overflow ignored, STX or ETX inclusive.

3.4.13.5 Input Formats

If the REMOTE key is activated on the CD2, it will accept the following parameters and commands from the user's computer, when configuration element 21 is set to select 2-way RS232.

PARAMETERS

Start Position
End Position
Burst Increment
Continuous Scan Rate
Burst Dwell Time
Scan Type
Shutter High Position
Shutter Low Position
Enter Set Position
Number of Scans
Delay Between Scans
Laser Line

COMMANDS

START SCAN
START TRIGGER SCAN
HALT
ENABLE TRIGGER SCAN
GO TO SET POSITION
PAUSE
CONTINUE

When the CD2A receives data and commands in the correct syntax, it will respond first with an ACK character (ASCII 06) or a NAK (ASCII 21).

3.4.13.6 Parameter Input Format

All numerical values transmitted or received are ordered with the most significant digit first. Leading zeroes or spaces are accepted, but the field width is only 8 characters maximum. The <ETX> must follow the last numerical character.

Examples: <STX>ST19000.34<ETX>
<STX>EN 11000<ETX>

NOTE: <LF>and Nulls are ignored and can generally be sent anytime for the user's convenience (such as in half duplex mode). The above characters (<LF>,Null) are not added to an input checksum when they are sent to the CD2 before the <ETX> character when checksums are configured.

The CD2A accepts parameters in the following format:

<STX>, (Parameter ID), [(Parameter)], <ETX>, [(CS)], <CR>, [<LF>]

Description	Max. No. of Characters
<STX>: Start of message	1 =02 ASCII
(Parameter ID) Identifies:	(parameter)
ST Start Position	8
EN End Position	8
BI Burst Increment	6
SR Continuous Scan Rate	6

DT	Burst Dwell Time	5	
TY	Scan Type	1	(C or B)
SH	Shutter High Position	8	
SL	Shutter Low Position	8	
SE	Set Position	8	
NS	Number of Scans	3	
SD	Delay Between Scans	5	
LL	Laser Line	8	
<ETX>	End of Message	1	=03 ASCII
<CS>	Two ASCII-hexadecimal characters representing binary sum of preceding characters, overflow ignored, STX to ETX inclusive. This may be omitted with configuration register change.	2	

3.4.13.7 Command Formats

The CD2A accepts commands in the following format:

<CAN>, (Command Character),
<ETX>,[(CS)],<CR>,[<LF>]

Description:

<CAN> Command identifier character =24 ASCII

Command Character:	Command:
S	START SCAN
T	ENABLE TRIGGER SCAN
H	HALT
E	TRIGGER SCAN
P	SET
<SO>	PAUSE =14 ASCII
<SO>	CONTINUE

3.4.13.8 Error Reporting

If any command or parameter specification causes an error condition in the CD2A, an error code is transmitted back to the user's computer in the following format:

<BEL>,(Error Code),<EOT>

where <BEL> =ASCII 07

(Error Code) is the two character error code described in the CD2A error summary

<EOT> end of error reporting =ASCII 04

The user must take appropriate action to recover from the error condition.

3.4.13.9 Hardware Notes

CD2A has a female DB25 connecter for RS232.

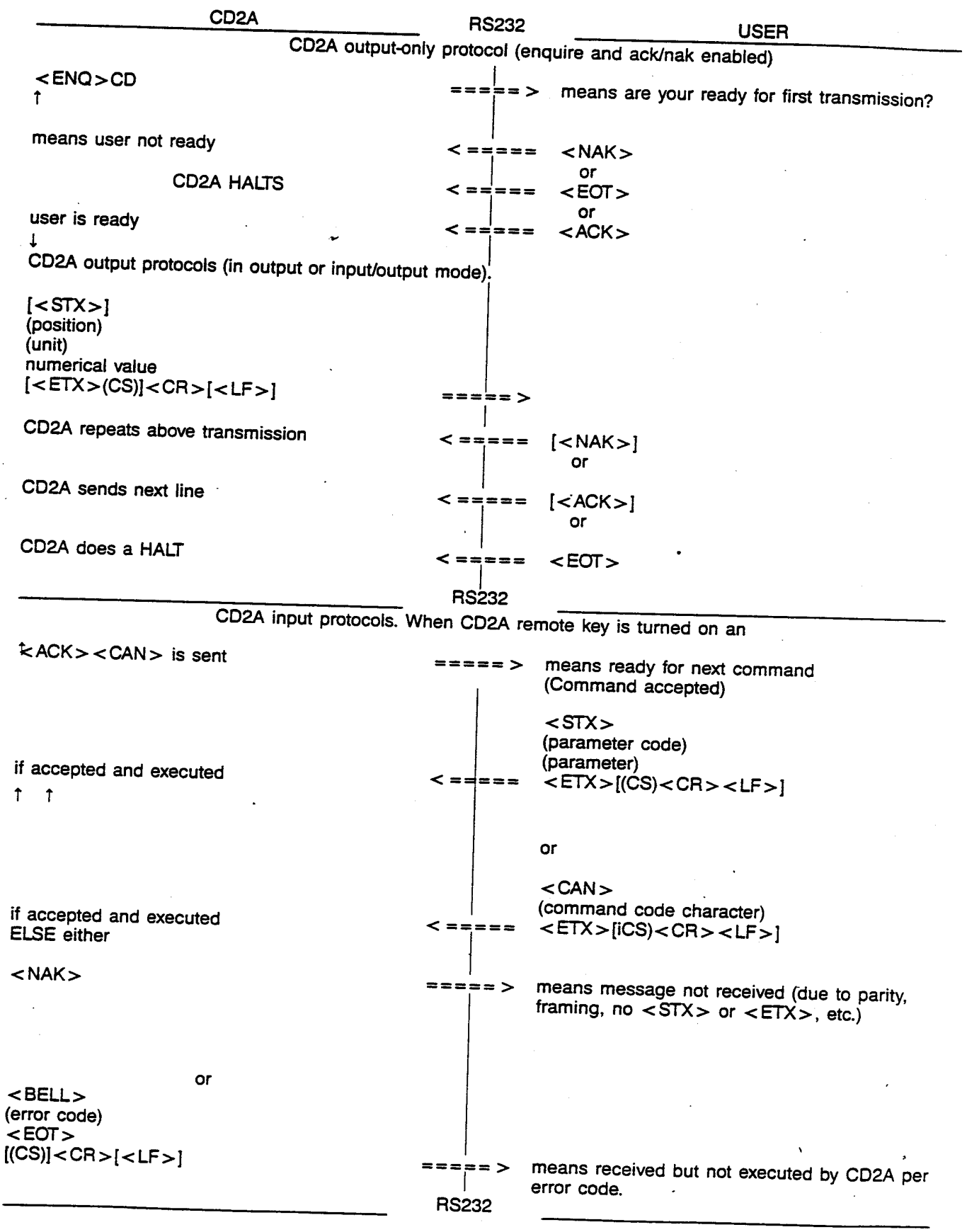
CD2A is DTE (terminal NOT modem).

RS232 pin assignments:

—pin—	—symbol—	—generic term—	—function—
2	BA	Transmit data	data output
3	BB	Receive data	data input
4	CA	RTS	control output (true when CD2A remote is on)
5	CB	CTS	control input (disables CD2A transmit when false)
6	CC	DSR	control input (HALTS CD2A when false)
7			Signal ground
8	CF	DCD	control input (HALTS CD2A when false)
19	SCA	Carrier	control output (true when CD2A power is on)
20	CD	DTR	control output (true when CD2 completes power-on tests successfully)

CD2A treats loss of DCD or DSR as a disconnect and executes a HALT and further turns off CD2A remote (drops its RTS line).

Loss of CTS longer than the configured timeout (0 to 9.9 sec) also results in HALT and remote off as above.


CD2A
RS232
USER
CD2A output-only protocol (enquire and ack/nak enabled)
<ENQ>CD
means are your ready for first transmission?
means user not ready
<NAK>
or
CD2A HALTS
<EOT>
or
user is ready
<ACK>
CD2A output protocols (in output or input/output mode).
[<STX>]
(position)
(unit)
numerical value
[<ETX>(CS)]<CR>[<LF>]
CD2A repeats above transmission
[<NAK>]
or
CD2A sends next line
[<ACK>]
or
CD2A does a HALT
<EOT>
RS232
CD2A input protocols. When CD2A remote key is turned on an
<ACK><CAN> is sent
means ready for next command
(Command accepted)
<STX>
(parameter code)
(parameter)
if accepted and executed
<ETX>[(CS)<CR><LF>]
or
<CAN>
(command code character)
if accepted and executed
ELSE either
<ETX>[iCS)<CR><LF>]
<NAK>
means message not received (due to parity, framing, no <STX> or <ETX>, etc.)
or
<BELL>
(error code)
<EOT>
[(CS)]<CR>[<LF>]
means received but not executed by CD2A per error code.
RS232

Suggested interface for DCE (modems) and DTE (terminals):

CD2A (always DTE)	USER (as DCE)
2	2 (RX)
3	3 (TX)
4	4 (CTS)
5	5 (RTS)
6	6 (DTR)
7	7 (GND)
8	8 (SCA)
19	19 (DCD)
20	20 (DSR)

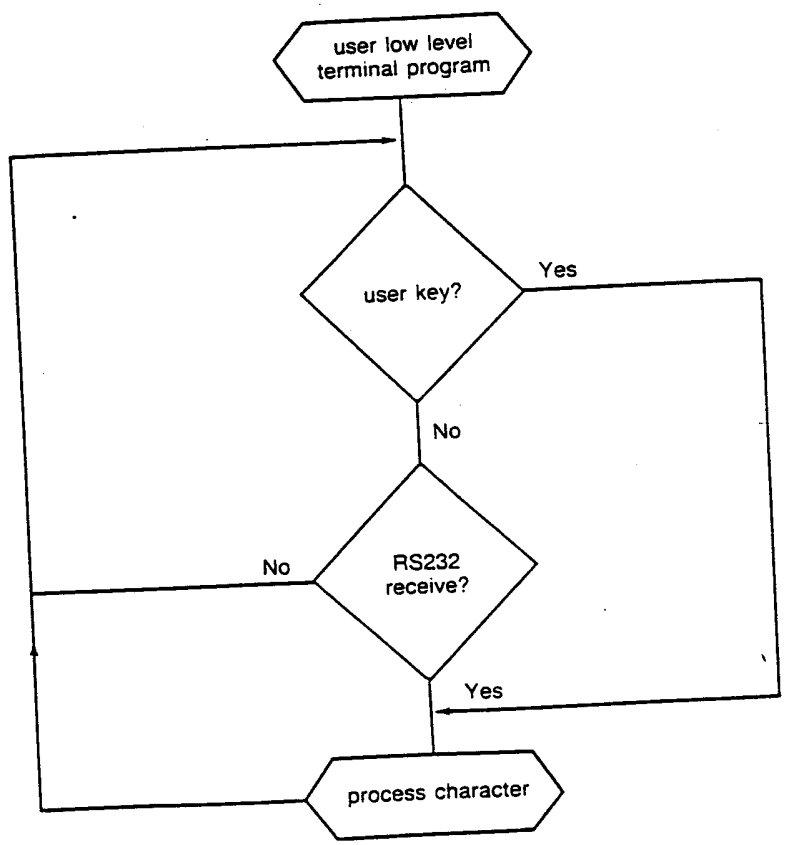
CD2A (always DTE)	USER (as DTE; null modem)
2	3
3	2
4	5
5	4
6	20
7	7
8	19
19	8
20	6

For no hardware handshake, i.e. ONLY pins 2, 3, and 7 (transmit data, receive data, and ground with no ACK NAK configured), the CD2A will transmit position etc. with no pauses and data may be lost at the user's end especially at high baud rates unless a true communication program is in effect. The CD2A will receive all characters sent, but always sends handshake characters ACK, NAK, etc., to signal the user of the results of the command sent.

3.4.13.10 User Programs

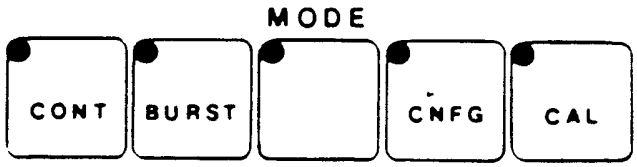
The following flow chart, when used in conjunction with the protocols in the following page, will help you formulate your own programs to fully utilize CD2A's RS232 capabilities.

Suggested standard program for user:



3.5 MODE Keys

This bank of keys gives the operator access to the COMPUDRIVE CD2's internal configuration registers, allows recalibration of spectrometer spectral position, and tells the CD2 whether scans, when they are eventually ordered, will be in a continuous or burst mode.



3.5.1 CONT or BURST

Either of these keys must be selected before a SCAN or TRIG SCAN (Section 3.6.1) is ordered so CD2 knows whether to proceed smoothly (CONT, continuous scanning) from the START POS to the END POS at a constant RATE (see Section 3.4.3 for a full explanation of rates and special fast-scanning override), or to slew by increments and remain stationary between them until the DWELL TIME (Section 3.4.4.) expires (BURST scanning), or an external trigger signal is received (TRIG SCAN). The LED on each key will light so you know at a glance which type of scan will be executed.

3.5.2 CNFG

Selecting this key puts you in the configuration mode in which you can check or modify CD2's compatibility with peripherral devices, as you would when changing gratings, spectrometers, spectral orders, recorders, and the like. Full details of CD2's configuration elements are listed in Section 4.

The only way to leave the Configuration mode after a change has been entered is by pressing HALT (Section 3.6.5). If no change has been made, any mode or command key returns the system to its previous state.

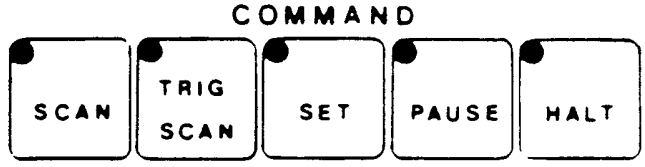
3.5.3 CAL

To alter the counter reading CD2 recognizes as your spectrometer's spectral position, press this key. Cr—— will apear in the PARAMETER display. Key in the proper sequence of numerical keys, then press ENTER to lock it into memory. The reading now appears in the POSITION display and will be updated as required. During power up, always calibrate with the spectral position corresponding to the standard grating, Configuration element 9, Section 4. In most cases, this will be the value shown in the mechanical counter built into the side of the spectrometer.

For wavenumber instruments always calibrate in wavenumber units, even if a laser line has been entered (Section 3.4.7). CD2 will make the necessary adjustment before transferring the deltawavenumber equivalent to the POSITION display.

3.6 COMMAND Keys

This set of keys controls all spectrometer movements except for manual adjustments with the toggle switch, Section 3.7.



3.6.1 SCAN

When you wish to drive the monochromator through a spectral region defined by START and END POS (Section 3.4.1-2) in a manner that is independent of what any outside devices, such as detectors or counters, might be doing, select this command. As soon as the key is pressed, CD2 drives the spectrometer to the START POS, always approaching from below to remove any backlash in the drive mechanism.

The movement from this point on is governed by your selection of CONT or BURST (Section 3.5.1). If the CONT key is lit, the spectrometer will move smoothly to the END POS at a speed set by RATE (see Section 3.4.3 if scan RATE exceeds spectrometer start speed. There it will stop if REP SCAN (Section 3.4.5) is 1. If not, CD2 will wait for any SCAN DELAY (section 3.4.6) to run out before returning to the START POS. The sequence continues for as many cycles as set in the value of REP SCAN.

If, on the other hand, BURST had been selected before SCAN, the sequence is identical except for the movement between START and END POS. After reaching START, CD2 waits for the DWELL TIME (Section 3.4.4) to expire, then it slews for a distance set by INC (Section 3.4.3). There it again waits for the dwell time, slews, and follows that sequence until END is reached.

For CONT/SCAN, the following parameters *must* be set:

START POS, END POS, INC/RATE, CONT

For BURST/SCAN, the following parameters *must* be set:

START POS, END POS, INC/RATE, DWELL TIME, BURST

For recorder tracking and control, see Sections 3.4.9-12.

The POSITION display will be updated as the scan progresses.

3.6.2 TRIG SCAN

To link spectrometer movement to some outside timing sources such as a sample changer or photon-counting circuitry, choose TRIG SCAN (Section 3.9 and 6 describe the necessary trigger inputs).

When TRIG SCAN is pressed after CON (Section 3.5.1), CD2 proceeds as with a regular SCAN, except it pauses at the START POS until the trigger is received. Scanning then goes on as normal unless more than one REP SCAN (Section 3.4.5) is requested. In that case, CD2 pauses with the spectrometer at the END POS until another trigger signal is received, before the sequence repeats. Note that any SCAN DELAY (Section 3.4.6) is inoperable in a TRIG SCAN.

When TRIG SCAN is selected with BURST, the scan not only requires a trigger at every START and END POS, but also at every INC. In this case both DWELL TIME (Section 3.4.4) and SCAN DELAY are inoperable, having no influence on the evolution of a scan. In conjunction with the STATUS LINES, Section 3.8, BURST/TRIG SCAN can dialog with your detection system in such a way that no data is recorded except when the spectrometer is stationary at a dwell point.

For CONT/TRIG SCAN, the following parameters *must* be set:

START POS, END POS, INC/RATE, CONT

For BURST/TRIG SCAN, the following parameters *must* be set:

START POS, END POS, INC/RATE, BURST

3.6.3 SET Spectrometer Position

When this key is pressed, the CD2 responds with POS——in the PARAMETER display and it expects you to key in a spectral position that will be the destination for the SET command slew. Once the number is loaded into the display, CD2 ramps and slews the spectrometer to that position as soon as ENTER is pressed, removing backlash as required.

SET only operates when the CD2 is in the idle mode, that is, no other operation is taking place when SET is pressed.

The POSITION display is updated as the slew progresses.

3.6.4 PAUSE Before Next Scan

This key tells CD2 to stop when the current task is completed and wait for further instructions. There are two specific cases when it applies.

During repeat scans, press PAUSE and CD2 stops aft the present scan is complete, overriding any SCA DELAY (Section 3.4.6) that might be inserted. It w remain there until you press PAUSE again, befo resuming repeat scanning where it left off. For instanc if PAUSE was pressed in the middle of the third sca of eight, CD2 now goes on to the fourth scan.

The HALT key (Section 3.6.5) *must* be pressed befo any non-scanning operation can be ordered.

Pressing PAUSE during a slew to the START POS w halt the scan at its beginning until PAUSE or HALT pressed.

3.6.5 HALT All Operations

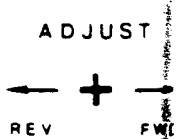
Pressing this key during a scan aborts all operations stopping the spectrometer in the position it happens t be at the time of the command.

HALT is also handy to clear illogical operations an errors.

CAUTION: Pressing HALT during backlash remova may knock CD2 out of step with your spectrometer drive For this reason, NEVER press HALT while backlash i being removed, or recalibration may be required.

Finally, HALT is the only way to exit the configuration mode (section 4).

3.7 MANUAL ADJUST and Limit Switch Protection



The toggle in the center of CD2's keyboard allows yo to slowly move the spectrometer manually to a spectral position within its range while you watch th POSITION display or monitor your detector output preparation for peaking the optics on a selected ban Ramping is also supplied so speed control is a questio of how many times, and, how long, you toggle th switch. Don't forget to remove the backlash wh moving in a non-scan direction by overshooting th mark and making the final approach in a scan directio

Should the spectrometer, for any reason, ever be driv into one of the safety limit switches that define t mechanical range of the lead scew, all automa scanning controls are disabled. Manual ADJUST th becomes the only way to alter the spectral position a Errors 2A and 2B are displayed depending on wh limit has been reached. In such cases, ADJUST o drives the spectrometer *away* from the limit swit Once the drive is freed, CD2 asks you to recalibr (Cr——) before it returns to normal operation.

Enable 4 is active low (ground sink) when CD2 running a BURST scan and happens to be dwell between increments, waiting for a trigger or expiration of the dwell time before moving on. Ena 4 does not apply to the START and END POS.

3.8 STATUS LINE Output to Peripherals

To let peripheral devices such as scalers or computers know what the CD2 is doing at a given instance, four status output lines are located in the TRIGGER CONNECTOR on the rear panel. (See Section 6 for pin locations.) Each is an open collector device, capable of sinking 48mA. Maximum pull-up voltage is 5.5 VDC.

Enable 1 is active low (ground sink) when the spectrometer is being positioned during a SET, a move to the START POS, or during incremental movements in BURST scanning. In essence, it tells the peripheral device that any data collected at this time should be ignored since the spectrometer is slewing.

Enable 2 is active low (ground sink) when the spectrometer is poised at the START of a scan after a PAUSE operation, or waiting for a trigger, or the expiration of the first DWELL TIME.

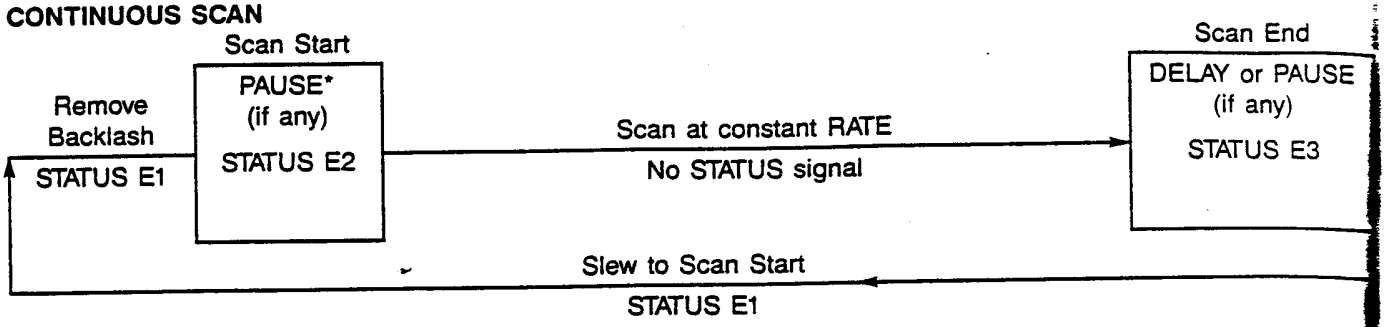
Enable 3 is active low (ground sink) when the spectrometer is sitting at the end of a scan.

3 Trigger Inputs

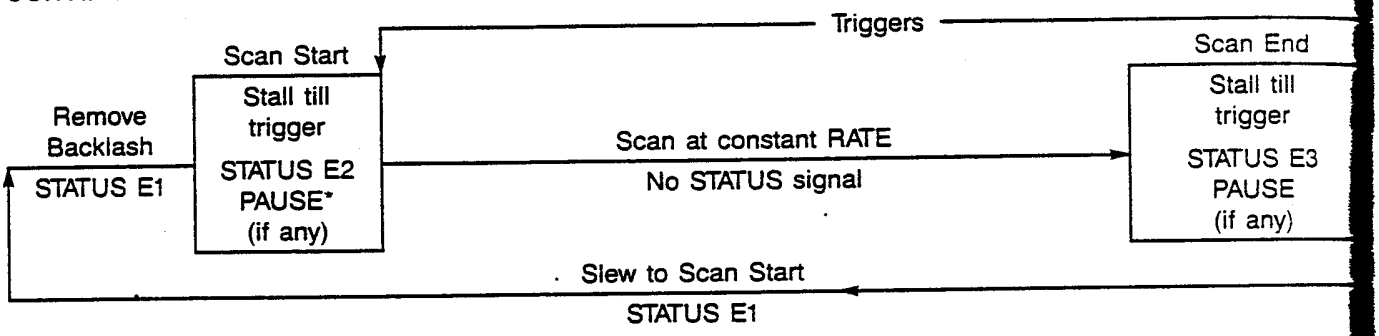
Fed into the corresponding connector in the rear panel, a trigger pulse should be a FORM A SWITCH to ground lasting at least 2 μsec. By correlating Status Lines and trigger inputs with the TRIG SCAN mode, a dialog can be established with your data counters, such as our DPC2, so data is taken only while the spectrometer is stationary.

(See schematic on following page)

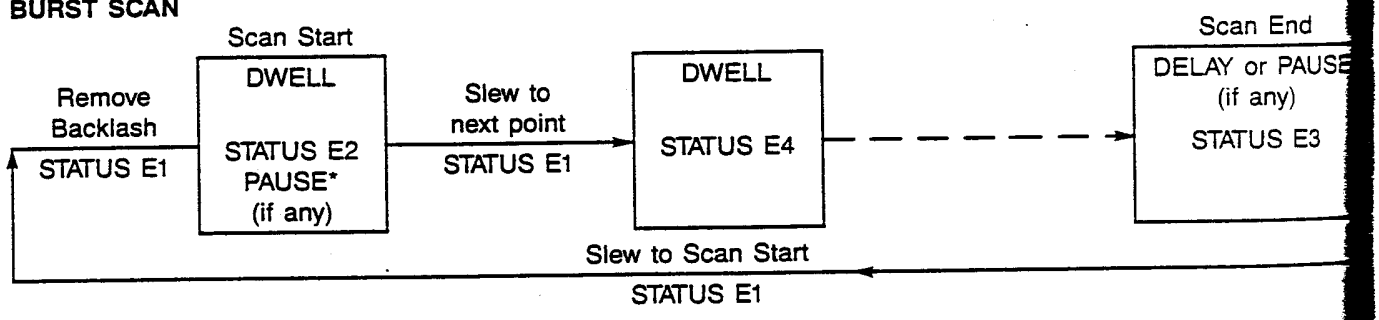
CONTINUOUS SCAN



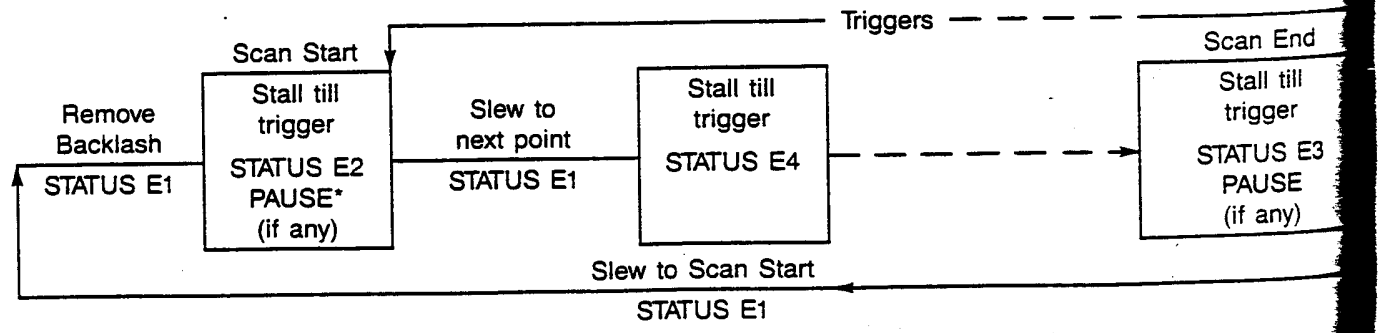
CONTINUOUS TRIGGER SCAN



BURST SCAN



BURST TRIGGER SCAN



*PAUSE requested during slew to start.

4 CONFIGURATION

Each CD2 comes to you with a configuration best suited to your particular instrument and experimental designs. However, should you at any time want to modify your system by substituting a grating with a different groove density, another recorder, or even change to a completely different SPEX spectrometer, you'll find CD2 ready and willing to adapt to the situation with only a few keystroke modifications of the configuration table. These changes are volatile, so the next time you power up, the factory configuration reappears.

Access to the configuration table is through the CNFG key. When you press it while the CD2 is halted, the first element in the table appears. You can step through the rest of the elements by pressing ENTER till you reach the last, or 23rd element. The next ENTER returns the configuration table to the first element, and so on.

THE ONLY WAY TO EXIT CONFIGURATION MODE AFTER AN ALTERATION IS BY PRESSING HALT.

Configuration elements come in two forms, 4-bit binary or decimal. Note that element one, for example, is a binary presentation of four bits, each having the value zero or one. Referring to the table at the end of this section, and reading left to right, you can see that 0100 translates into a wavelength (0) drive system that reads in angstroms (1). The next number is always zero (0), but the last tells us no PMT protection is installed (0).

Other elements may be of the decimal type, such as element five. It might read 1200 to signify a grating with 1200 gr/mr has been installed in the instrument.

To alter a configuration element, press the CNFG key, then ENTER until the chosen element appears. Key in the new value, lock in with ENTER, and move on to the next element on your list. When done, press HALT. A row of dashes (——) in the PARAMATER displays signals that CD2 is confirming that the modification is consistent with the remaining configuration elements. (Be patient, reconfiguration takes about 10 seconds.) If the new configuration is cleared, CD2 returns to normal operation with a beep. If not, an error code is displayed (Section 5). Press EXAM to view the offending element. (You can change as many elements as you like, as long as they're mutually compatable.) Severely illogical modifications of the configuration elements may necessitate turning off the CD2 and beginning from scratch. All modifications of the configuration from the keyboard are lost when the power is cut.

4.1 CD2 Configuration Table

Element #			Significance
1	Four-bit binary code, left to right		1 2 3 4
	First bit	—	If one, the spectrometer has a wave-number drive. If zero, the spectrometer is wave-length drive.
	Second bit	—	(Only applies if bit 1 = 0) If one, the spectrometer untis are angstroms. If zero, the spectrometer units are nanometers.
	Third bit	—	Must remain zero.
	Fourth bit	—	If one, a shutter is installed for PMT protection. If zero, no shutter has been installed.
2	Four-bit binary code, left to right		1 2 3 4
	First bit	—	Must remain zero.
	Second bit	—	If one, the spectrometer is fitted with limit switches. If zero, no limit switches.
	Third bit	—	Undefined.
2	Fourth bit	—	Type of drive unit: 1 = Mini-Step Driver (MSD) 0 = Large-Step Driver (LSD)
3	Six decimal digits specify the lower (in wavelength, upper in wavenumber) mechanical scan limit of the spectrometer.		

Element #	Significance
4	Six decimal digits set the upper (in wavelength, lower in wavenumber) mechanical limit of the spectrometer. CD2 will not knowingly drive the spectrometer outside the limits set by elements 3 and 4 but will instead respond with an error code.
5	Four decimal digits specify the grooves/mm of the grating actually installed in the spectrometer (e.g. 1200)
6	A four-digit number specifies the grooves/mm of the standard grating, that is, the one for which the mechanical counter on the side of the spectrometer is accurate.
7	Four decimal digits for the number of motor steps that will drive the spectrometer one spectral unit with standard grating, e.g. 400 for 1400 and 1700 series spectrometers, and 500 for a 1269 (all MS Drivers). 50 for LSD's.
8	Units of backlash removed from spectrometer drive in reverse to approach START or SET position
9	Start speed of spectrometer slew (two decimal digits) in units of 100 steps/sec MSD, (typically 40 is 4000 steps/sec) or 10 steps/s LSD (50 for LSD).
10	Maximum speed of spectrometer (two decimal digits) in units of 1000 steps/sec MSD (typically 28 is 28000 steps/sec) or 100 step/s LSD (0 for LSD)
11	Recorder options is a four-bit binary code (usually reading 0101), formed from the following three binary set, left to right (1 2 3 4): Bit 1 — Unused Bit 2 — If one, a marker exists. If zero, no marker. Bit 3 — Must be zero. Bit 4 — Set to zero for a time-base strip chart. Set to one for stepper-drive strip chart.
12	Motor steps that will drive the recorder one of its chart units: four-digit decimal (typically 200 steps for SPEX recorders).
13	Max speed of recorder (two decimal digits) in units of 10 steps/sec (typically 20 is 200 steps/s
14	Duration of the marker pulse (two-digit decimal) in units of 10 msec (10 is 100 msec).
15	RS232: Baud rate (two decimal digits).

Code	00	01	02	03	04	05	06	07	08	09
Baud	110	150	300	600	1200	1800	2400	4800	9600	19200

16	Four binary bits specify RS232 option output character with the following meaning, left to (1 2 3 4): Bit 1 — If zero the character contains one stop bit. If one, two stop bits.

Bit 2 and 3 — If 0 and 0, there are eight data bits in each character.
If 0 and 1, seven bits per character.
If 1 and 0, six bits per character.
If 1 and 1, five bits per character.

Bit 4 — Unused.

Each RS232 character consists of a start bit, eight to five data bits (16:2,3,above), a parity bit (17:2,3,4, below), then the stop bits (16:1, above). Each bit passes out of XMIT DATA in the REMOTE connector (Section 6.2.1).

Element #	Significance
17	Four binary bits specify RS232 option output character with the following meaning, left to right (1 2 3 4): Bit 1 — Unused Bit 2,3, and 4 — Parity option 000,100,010,110 — no parity 001 — odd parity 011 — even parity 101 — always 1 (MARK) 111 — always 0 (SPACE)
18	CTS delay 00 to 99 (in units of 100 ms)
19	<ACK><NAK> delay, 00 to 99 (in units of 100 ms)
20	LF delay 00 to 99 (in units of 100 ms)
21	Four binary bits (1 2 3 4): Bit 1 — If one, 2-way RS232 If zero, 1-way RS232 Bit 2 — Unused Bit 3 — If 1, datalogger output format If 0, standard Bit 4 — If 1, wait for <ACK><NAK> If 0, don't wait
22	Four binary bits (1 2 3 4): Bit 1 — If one, <ENQ> CD before first CD2 transmission If zero, no <ENQ> Bit 2 — Unused Bit 3 — If 1, no checksum on input or output If 0, checksum enabled Bit 4 — If 1, <LF> sent If 0, no <LF>
23	Revision level of proms.

4.2 Changing Gratings or Spectral Order

The mechanical counter on the side of your spectrometer is designed to read accurately only when the standard grating is fitted and run in first order diffraction. Should, for any reason, you wish to change the original grating or operate the spectrometer in a higher order for enhanced resolution, the installed grating configuration, element 3, will have to be modified.

After power up and calibration (Section 3), press CNFG. Element 1 will appear in the PARAMETER display. Press ENTER 4 times to get to element 5. If this is a grating change, key in the new density in grooves/mm, and press ENTER.

To move to a higher order, simply multiply the actual grating density by the order number. For example, a 1200 gr/mm grating should have 2400 in element 5 if you want to work in second order, and so on. Key in the modifications and secure with ENTER.

When you press HALT and the consistency check completes its run successfully, you'll note that the spectrometer POSITION reading has changed and no longer agrees with the mechanical counter. However, this position is the true one for the particular grating or spectral order in which you've selected to work. The mechanical counter on the side of the spectrometer does *not* read correctly. In addition, the parameters, such as START, END, etc., that define your spectral scanning region, will all now reflect the modification and you can go on to scan as though the system were actually designed around this new grating or order.

5. ERROR HANDLING

There are two families of errors detected by CD2. The simplest type includes operations that are forbidden, such as trying to enter a number into the display without pressing a parameter key first. These blunders are answered with a beep.

The second variety of error detection extends to both operator and hardware malfunctions, and will usually be identified by the error codes at the end of this section. You may have neglected to turn on the stepper drive before you turned on the CD2 (ERROR 26:CD2 detects an open limit switch since there is no power to the circuit). Or you may merely have pressed the wrong keys (ERROR 81: invalid number entry).

In any case, error codes are usually accompanied by a beep and, where applicable, the offending parameter key is lit to help you localize the spot where you went astray. If the error is not too serious, you can usually CLEAR it, rectify the offending parameter, and go on as though nothing has happened. However, for particularly gross or multiple errors, you may have to resort to turning off CD2's power and starting all over again.

When an error occurs on power up, pressing any key will send CD2 back into the diagnostic routine to check if the source of the error has been eliminated. When an error has been detected during reconfiguration, press the EXAM key to display the offending entry.

Errors during reconfiguration may be especially taxing, for any modification of CD2's configuration must be compatible with all other elements. In most cases, errors in reconfiguring result in CD2 displaying the offending element. As an example of the difficulties the operator can get into, consider changing from a wavelength instrument that operates between 0 and 15000A, to a wavenumber instrument that operates from 30,000 to 11,000 cm^{-1}. If, on power up, you entered 9000 to calibrate position, on reconfiguring you will receive an error 53. Press EXAM and it will isolate element 4 to show you there is an inconsistency in limit values. Once you're aware of such a problem, however, you can anticipate and avoid it by calibrating to a number compatible with both configurations (e.g. 12000) on power up, irregardless of the actual counter reading. Turn CD2 off and try again. Once you're successful, recalibrate to the actual counter value.

ERROR CODES

CODE #	MEANING
01	ACIA (RS232) Status Reg Error
02	ACIA (RS232) Control Reg Error
03	ACIA (RS232) Command Reg Error
11	Read/Write Memory Failure (I.C. 44)
12	Read/Write Memory Failure (I.C. 39)
13	Read/Write Memory Failure (I.C. 15)
14	Program Memory Failure (I.C. 3)
15	Program Memory Failure (I.C. 4)
16	Program Memory Failure (I.C. 9)
17	Program Memory Failure (I.C. 10)
18	Program Memory Failure (I.C. 15)
19	Program Memory Failure (I.C. 16)
1A	Program Memory Failure (I.C. 17)
1B	Program Memory Failure (I.C. 22)
1C	Program Memory Failure (I.C. 27)
1D	Program Memory Failure (I.C. 28)
21	Command Out of Range
22	PIA Side A Failure (I.C. 48)
23	PIA Side B Failure (I.C. 48)
24	Timer Count Failure (I.C. 32)
25	Timer Slew Failure (I.C. 32)
26	Limit Switch Open Cable
27	Invalid Command
29	Open Limit Switch Cable During Operation
2A	High Limit
2B	Low Limit
30	Hardware Failure
35	Invalid Number Entry
36	Math. Error (Divide by 0)
40-5E	Configuration Error press "exam" to review the bad entry if yo have tried to reconfigure. If a power-on test failure, press any key to retry the test that failed, else power off/on. See below for possible sources of Configuration Errors.
5F	Invalid Configuration of Baud Rate
60	Invalid Configuration of Cts Delay
61	Invalid Configuration of Ack Nak Delay
62	Invalid Configuration of If Delay
64	ACIA Control Register
67	Parity/Framing/Overrun
69	Invalid Command
6B	<EOT> rx'd. Results in a halt
6C	Loss of Carrier Detect <DCD>. Results in a halt and shut off of remote
6D	Loss of Data Set Ready <DSR>. Results in a halt and shut off of remote.
6F	Loss of Clear to Send <CTS> for more than configured time. Results in a halt and shut off of remote.
70	Neither <ACK>nor <NAK> received within configured time delay after CD2A transmits a position line.
73	Unknown Command Received by CD2A
74	Bad Operand for Command Received by CD2A
75	Received Command Not Allowed at This Time
76	Missing Operand in Received Command
77	Received Line Has Too Many Characters.
78	Checksum Error on Received Line.
79	Limit Switch Hit

Scan Time Errors

81	Start Position Outside of Machine Limits
82	Start & End Positions in Incorrect Order
83	End Position Outside of Machine Limits
84	Increment/Rate Entry Invalid
85	Increment/Rate Entry Too Small (< =0)
86	Rate Too Fast
87	Dwell Time too Short (<.01sec)
88	No Scan Mode Selected
8A	High Shutter Outside of Machine Limits
8B (8b)	Low Shutter Outside of Machine Limits
8C	Shutters in Wrong Order
8D	Invalid Marker Period Value
8E	Increment or Rate Out of Range
8F	In Burst Mode, Increment = Integer Multiple Scan Increment for Continuous Mode Marker Period < Scan Rate
90	Invalid Recorder Scale
91	In Continuous Scan, Invalid Scan Rate
92	Continuous Scan Rate too fast for Selected Recorder Scales

POSSIBLE CAUSES OF CONFIGURATION ERRORS

Element 1 (may also be Element 2)	a) wavenumber and Angstrom both selected b) limit switch selected and no limit cable detected c) MSD selected and ramp table is for LSD (special order situation only)
Element 3 (really element 3 or 4)	limits in incorrect order
Element 5	must be non-zero
Element 6	must be non-zero
Element 7	must be non-zero
Element 9	a) if MSD (Element 2) must be >00 b) if MSD (Element 2) must be ≤40 c) if LSD (Element 2) must be ≥02 d) if LSD (Element 2) must be ≤50 (unless special ramp ordered)
Element 10	a) must be ≥ $\frac{\text{Element 9}}{10}$ b) if MSD must be ≤50 (unless special ramp ordered) c) if LSD must be 0 (unless special ramp ordered)
Element 11	bit 3 and bit 4 both selected
Element 12	must be non-zero
Element 13	must be non-zero
Element 14	must be non-zero
Element 15	must be between 00 and 09 inclusive
Element 23	Hardware error. Correct problem and start over.

ON RECONFIGURATION

1) Normally laser line, shutters, and parameters are unchanged.

2) If the system type is changed (e.g. WN←→WL)
   a) the counter reading must be reentered
   b) shutters are reset to the limits (if they exist)
   c) scan start, end, and set position are cleared
   d) the laser line is cleared

3) If shutter is configured on after having been off, shutters are reset to the limits

4) If limits are changed or if steps per unit are changed
   a) counter reading must be reentered
   b) shutters are reset to the limits (if they exist)

6 SPECIFICATIONS AND PIN LOCATIONS

6.1 SPECIFICATIONS

Parameter Display: 8 characters, ½" high LEDs; for parameters, promoting messages, error codes, and self-diagnostics.

Position Display: seven digits plus decimal point, ½" high LEDs, continuously update spectrometer position (in nm, A, etc) during movement.

Shutter Control: for PMT protection or auxiliary device such as a filter for any designated spectral range; pin 9 in MOTOR CONTROL set to ground in shutter region.

Drive Limits: pulses to stepper disabled when spectrometer reaches upper or lower boundary of the scanning range. Manual override only in direction away from limit.

Recorder Drive: TTL pulses, slaved at a selectable scale (e.g., untis/cm). Marker pulses, also selectable, calibrate chart scale.

Scan Parameters: Scanning in Continuous, Burst, or Triggered modes, between selected limits. Burst dwell from 0.01 to 600 seconds, or through external trigger. Burst dwell from 0.00001 to 10^5 scan units (nm, etc). Continuous scan rates settable to 0.001 units/sec, in accordance with scan rate table. Repeat up to 999 times, delays 0 to 655 seconds between repetitions.

SCAN RATES
(Actual rates are a function of individual spectrometer and gratings)

Continuous Scan Rates (See 3.4.3)

Instrument		Step Resolution	NORMAL (No ramp)	HI SPEED (Ramped)*
1269	(1)	0.0002 nm	0.0001-0.8 nm/sec	0.8-5.6 n/sec
1403	(2)	0.0025 cm^{-1}	0.001-10 cm^{-1}/sec	10-70 cm^{-1} /sec
1404	(1)	0.00025 nm	0.0001-1 n/sec	1-7 nm/sec
1680B	(1)	0.02	0.001-10	—
1681B	(1)	0.02	0.001-10	—
1701, 1703	(1)	0.0025 cm^{-1}	0.0025-10 cm^{-1} /sec	10-90 cm^{-1} /sec
1702, 1704	(1)	0.00025 nm	0.0001-1 nm/sec.	1-7 nm/sec
1870B	(1)	0.002	0.0001-1 nm/sec	1-7 nm/sec
1870C	(1)	0.00025 nm	0.0001-1.0 nm/sec	1-7 nm/sec

(1) Equipped with 1200 gr/mm grating, first order.
(2) Equipped with 1800 gr/mm grating, first order.

Ramping: software controls starting and maximum speed as well as acceleration.

SET POSITION: slews to a spectral position and halts automatically.

Status Outputs in TRIGGER Connector:

Line 1 — Indicates that the spectrometer is slewing to a START or SET position.

Line 2 — Indicates that the spectrometer has reached its START wavelength (or wavenumber), and is waiting for further instruction, such as a trigger pulse.

Line 3 — Indicates that the spectrometer is stationary at its selected upper wavelength (wavenumber) scan limit, and is awaiting the next command.

Line 4 — Indicates that the spectrometer is awaiting the next trigger pulse or burst dwell to expire.

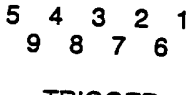
Driver Unit Inputs:

Scan Direction: TTL high, forward; TTL low, reverse
Scan Steps: TTL negative going pulse, 1 μsec wide or greater.
Motor advances on 0-1 transition of pulse.

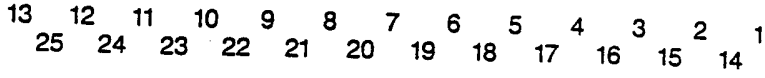
	Control Unit	Driver Unit
Power:	115/230V, 50/60 Hz 50W	90W
Dimensions:(HWL, cm)	14x46x30	32x15x35
Weight (kg):	7	6

6.2 PIN LOCATIONS

6.2.1 CD Rear Panel



TRIGGER



MOTOR, REMOTE, RECORDER

PIN NUMBER	TRIGGER	MOTOR	REMOTE (RS232)	RECORDER
1	TRIG. *	DS*	CHASSIS	PEN COMMON
2	ENABLE 1*	DI	XMIT DATA	PEN N. C.
3	ENABLE 2*	DO	RECV DATA	EVENT N. O.
4	ENABLE 3*	DP	RTS	EVENT N. C.
5	ENABLE 4*	D3	CTS	
6	GROUND	D2	DSR	PULSE +
7	GROUND	SS1*	GROUND	PULSE −
8	GROUND	+5VDC	DCD	FRWD +
9	GROUND	SH. OP. −		FRWD −
10		FRWD −		
11		STEP −		
12		LO. LIM +		
13		HI. LIM. +		
14		GROUND		GROUND
15		GROUND		PEN N. O.
16		GROUND		GROUND
17		GROUND		EVENT COM.
18		GROUND		GROUND
19		GROUND	(SCA)	GROUND
20		GROUND	DTR	GROUND
21		GROUND		GROUND
22		GROUND		GROUND
23		GROUND		GROUND
24		GROUND		GROUND
25		GROUND		GROUND
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				

N.O. — Normally Open; N.C. — Normally Closed

6.2.2 Mini-step Driver (MSD) with typical options (See Section 6.3)

Pin #	CONTROL INPUT (25-pin female)	MONO OUTPUT (37-pin female)
1		Motor Phase 01
2		Motor Phase 02
3		Motor Phase 03
4		Motor Phase 04
5		Motor Phase 05
6		Motor Phase 06
7		Motor Phase 07
8		Motor Phase 08
9	SHUTTER OPEN (neg. true)	+24V/RET
10	FORWARD	
11	STEP	
12	LIMIT SWITCH LOW (pos. true when open)	
13	LIMIT SWITCH HIGH (pos. true when open)	
14		
15		
16		
17		+5 dc (to counter lights etc.)
18		LOW LIM
19		
20		
21	RET	01/RET
22	SHUTTER OPEN RET	02/RET
23	FORWARD/RET	03/RET
24	STEP/RET	04/RET
25	LIMIT SWITCH LOW/RET	05/RET
26		06/RET
27		07/RET
28		08/RET
29		
30		AC GND
31		
32		+24V SHUTTER SUPPLY
33		XH1 CLUTCH XACTIVE (+24V)
34		
35		
36		
37		GROUND (VAC/RET)
		HIGH LIM

6.2.3 Large-step Driver (LSD)

Pin #	MONO OUTPUT (9-pin female)	Pin #	CONTROL INPUT (25-pin female)
1	01	9	N/C
2	03	10	DIR
3	024 COMMON	11	STEP
4	SW HIGH LIMIT	12	LSWL
5	SW LOW LIMIT	13	LSWH
6	013 COMMON	21	5V/RET
7	02	22	5V/RET
8	04	23	DIR/RET
9	SW LIMIT/RET	24	STEP/RET
		25	LSW/RET

6.3 MSD Options

Each MSD driver has a set of 12 pairs of pins that define the way the driver interprets signals it receives from the controller unit (CD2, DATAMATE, etc.) or from the spectrometer itself. Each pair of pins is labelled appropriately on the circuit board and to enable a function listed below, *a jumper must be placed across the specified pair only.*

6.3.1 LIMIT OPTION

The six pairs of pins that define the way a signal from a spectrometer limit switch is interpreted are AH, BH, CH (High limit input pin 37 on MSD driver connector) and AL, BL, CL (Low limit input pin 18). *One* pair in each of the two groups should be jumpered to give the following performance.

High Limit Input (jumper within one pair only)

AH — High limit condition achieved on receipt of an Active High (+5V)
BH — High limit condition achieved on receipt of an Active Low (OV)
CH — High limit condition disabled

Low Limit Input (jumper one pair only)

AL = Low limit condition achieved on receipt of an Active High (+5V)
BL = Low limit condition achieved on receipt of an Active Low (OV)
CL = Low limit condition disabled

6.3.2 STEP, STEP

When a jumper is connected across *one* of these pairs, MSD expects a STEP signal from the controller unit (pin 11 on rear panel of CD2, DATAMATE, etc.) to take the following form:

$\overline{\text{STEP}}$ — A positive pulse for STEP
STEP — A negative pulse for STEP

6.3.3 DIRECT. OPTION

When a jumper is connected across *one* of these pairs of pins, the MSD expects the FORWARD signal from the control unit (pin 10 on rear panel of CD2, DATAMATE, etc.) to take the following form:

A — FORWARD is High True (+5V)
B — FORWARD is Low True (OV)

6.3.4 SHUTTER OPTION

When a jumper is connected across *one* of these pairs, the MSD supplies current to the shutter when the control unit (pin 9 on rear panel of CD2, DATAMATE, etc.) gives the following signal:

A — current supplied to shutter when input is Low True (OV)
B —current supplied to shutter when input is High True (+5V)

30 March 1983 | **External Control over COMPUDRIVE through RS232** | Technical Note No. **D-3**

The CD2A COMPUDRIVE's keyboard puts control over any SPEX spectrometer at your fingertips. Scan a spectrum in continuous, trigger, or burst modes, set to a chosen wavelength position; trip a shutter or slave a recorder — all at the push of a button. Yet, the occasion may arise when there's need to go a step further in automation via an external computer without suffering the headaches of hardware interfacing and software generation. After all, keeping track of motor steps, limit switches, ramping and backlash removal can be an intimidating chore. That's when you'll begin to appreciate the two-way RS232 interface that is a standard feature of all CD2As.

In its simplest role, the RS232 interface is just a communications port that outputs spectrometer position and status to an external device, such as a printer. The full potential of the interface, however, is only approached when a computer is linked with CD2A to take the place of the operator's fingers. Now programs generated in your favorite language send standard ASCII characters through the interface to specify scan regions, set destinations and other relevant parameters. On signal, CD2A performs, keeping track of the details, slewing when necessary, removing the backlash, activating shutters, and performing any other operation normally ordered from the keyboard. And, when the job is done, CD2A signals the external computer that it's ready for the next assignment.

In this Tech Note, we'll present an example of a program that externally commands a CD2A through an Apple III computer. The flow chart and logic can readily be adapted to any computer that happens to be available to you (as long as it has an asynchronous, full duplex RS232 input/output channel). A complete description of configuration choices that will make your COMPUDRIVE compatible with other devices is presented in Section 3.4.13 of your instruction manual.

Because it is didactic, the program to follow has been kept rudimentary. Designed to deliver access to CD2A's functions without any reference to the details of data acquisition, storage or processing, it demonstrates how to control your spectrometer and may become the kernel of a more sophisticated master program.

Configuration

The first step is to set up a rapport between the two communicating devices by matching configurations of the two RS232 ports. We chose 9600 BAUD, no parity, and 8 data bits. This particular set of parameters is not mandatory; others will work, as long as both CD2A and your computer are in accordance.

To link CD2A and APPLE III, a null-modem cable was connected to their RS232 ports. This arrangement crosses the transmit/receive, ready-to-send/clear-to-send, and various control lines between the instruments (Fig 1), a necessary step since both devices are DTE RS232 (i.e. terminals).

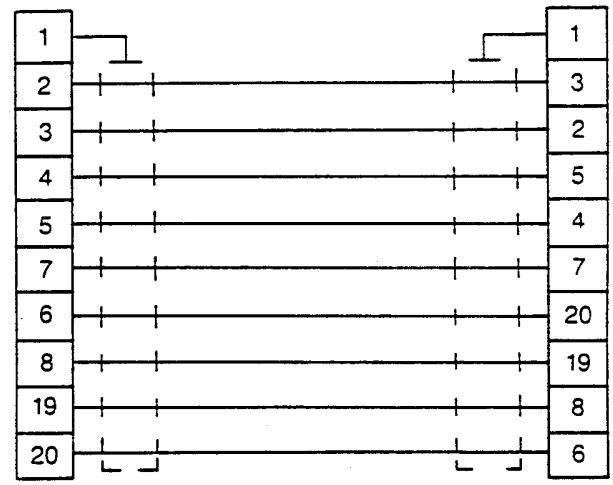


Figure 1
A null modem cable consists of an RS232 cable wired as shown above.

At both ends, pin 1 is grounded to the metal mainframe.

Pin 2 (data transmission path) at one end is connected to pin 3 (data reception path) at the other end.

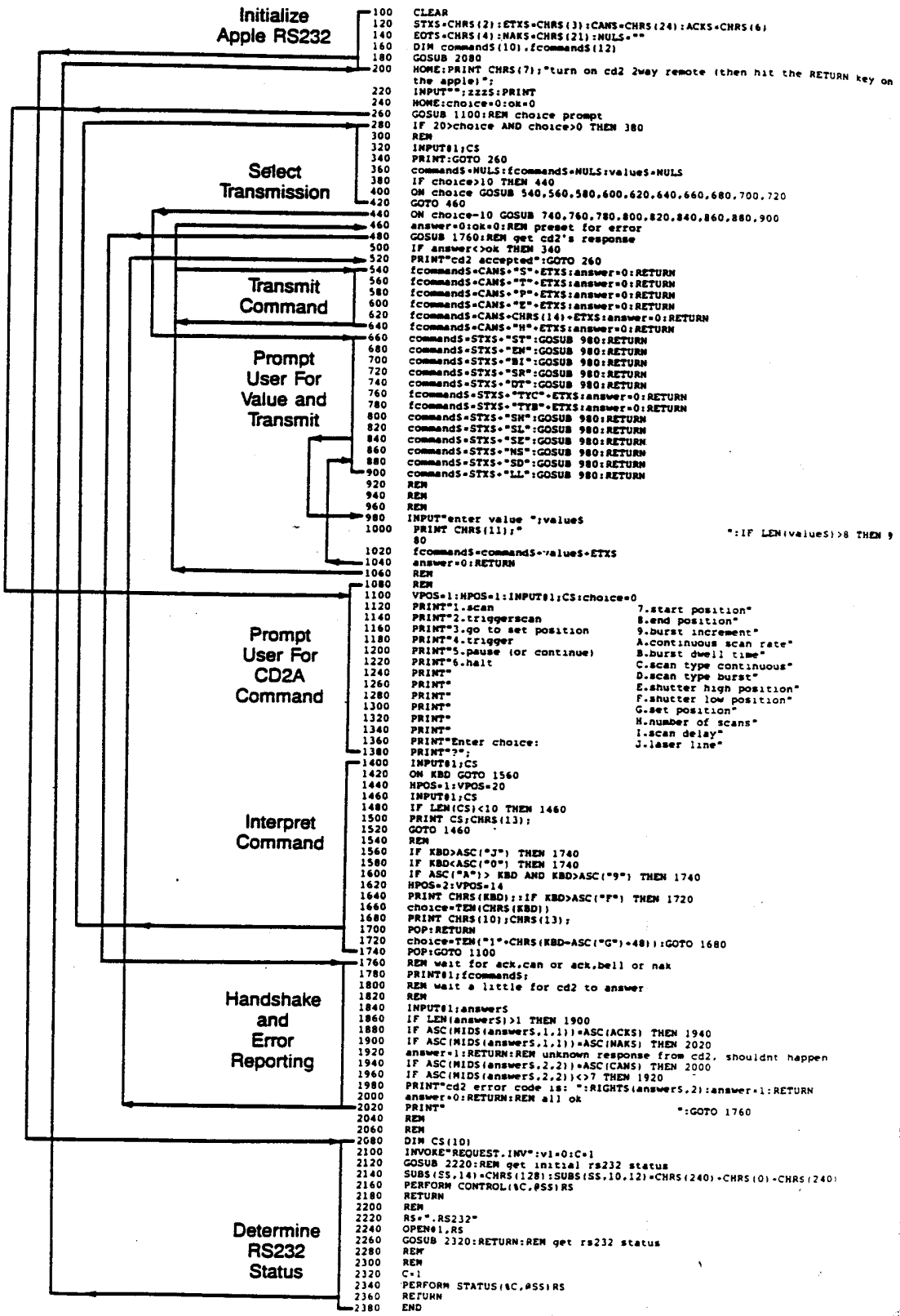
Pin 4 (request-to-send line) at one end is connected to pin 5 (clear-to-send line) at the other end.

Pin 7 (signal ground) is connected to pin 7.

Pins 6 and 20 as well as pins 8 and 19 are crossed, here somewhat specific for the case of the Apple III computer.

The Program

The scenario of this program proceeds along a fairly conventional format. Apple III prompts the user to




```
100  CLEAR
120  STX$=CHR$(2):ETX$=CHR$(3):CAN$=CHR$(24):ACK$=CHR$(6)
140  EOT$=CHR$(4):NAK$=CHR$(21):NUL$=""
160  DIM command$(10),fcommand$(12)
180  GOSUB 2080
200  HOME:PRINT CHR$(7);"turn on cd2 2way remote (then hit the RETURN key on
     the apple)";
220  INPUT"":zzz$:PRINT
240  HOME:choice=0:ok=0
260  GOSUB 1100:REM choice prompt
280  IF 20>choice AND choice>0 THEN 380
300  REM
320  INPUT#1;C$
340  PRINT:GOTO 260
360  command$=NUL$:fcommand$=NUL$:value$=NUL$
380  IF choice>10 THEN 440
400  ON choice GOSUB 540,560,580,600,620,640,660,680,700,720
420  GOTO 460
440  ON choice-10 GOSUB 740,760,780,800,820,840,860,880,900
460  answer=0:ok=0:REM preset for error
480  GOSUB 1760:REM get cd2's response
500  IF answer<>ok THEN 340
520  PRINT"cd2 accepted":GOTO 260
540  fcommand$=CAN$+"S"+ETX$:answer=0:RETURN
560  fcommand$=CAN$+"T"+ETX$:answer=0:RETURN
580  fcommand$=CAN$+"P"+ETX$:answer=0:RETURN
600  fcommand$=CAN$+"E"+ETX$:answer=0:RETURN
620  fcommand$=CAN$+CHR$(14)+ETX$:answer=0:RETURN
640  fcommand$=CAN$+"H"+ETX$:answer=0:RETURN
660  command$=STX$+"ST":GOSUB 980:RETURN
680  command$=STX$+"EN":GOSUB 980:RETURN
700  command$=STX$+"BI":GOSUB 980:RETURN
720  command$=STX$+"SR":GOSUB 980:RETURN
740  command$=STX$+"DT":GOSUB 980:RETURN
760  fcommand$=STX$+"TYC"+ETX$:answer=0:RETURN
780  fcommand$=STX$+"TYB"+ETX$:answer=0:RETURN
800  command$=STX$+"SH":GOSUB 980:RETURN
820  command$=STX$+"SL":GOSUB 980:RETURN
840  command$=STX$+"SE":GOSUB 980:RETURN
860  command$=STX$+"NS":GOSUB 980:RETURN
880  command$=STX$+"SD":GOSUB 980:RETURN
900  command$=STX$+"LL":GOSUB 980:RETURN
920  REM
940  REM
960  REM
980  INPUT"enter value ";value$
1000  PRINT CHR$(11);"                                    ":IF LEN(value$)>8 THEN 9
      80
1020  fcommand$=command$+value$+ETX$
1040  answer=0:RETURN
1060  REM
1080  REM
1100  VPOS=1:HPOS=1:INPUT#1;CS:choice=0
1120  PRINT"1.scan                    7.start position"
1140  PRINT"2.triggerscan             8.end position"
1160  PRINT"3.go to set position      9.burst increment"
1180  PRINT"4.trigger                 A.continuous scan rate"
1200  PRINT"5.pause (or continue)     B.burst dwell time"
1220  PRINT"6.halt                    C.scan type continuous"
1240  PRINT"                          D.scan type burst"
1260  PRINT"                          E.shutter high position"
1280  PRINT"                          F.shutter low position"
1300  PRINT"                          G.set position"
1320  PRINT"                          H.number of scans"
1340  PRINT"                          I.scan delay"
1360  PRINT"Enter choice:             J.laser line"
1380  PRINT"?";
1400  INPUT#1;CS
1420  ON KBD GOTO 1560
1440  HPOS=1:VPOS=20
1460  INPUT#1;CS
1480  IF LEN(CS)<10 THEN 1460
1500  PRINT CS;CHR$(13);
1520  GOTO 1460
1540  REM
1560  IF KBD>ASC("J") THEN 1740
1580  IF KBD<ASC("0") THEN 1740
1600  IF ASC("A")> KBD AND KBD>ASC("9") THEN 1740
1620  HPOS=2:VPOS=14
1640  PRINT CHR$(KBD);:IF KBD>ASC("F") THEN 1720
1660  choice=TEN(CHR$(KBD))
1680  PRINT CHR$(10);CHR$(13);
1700  POP:RETURN
1720  choice=TEN("1"+CHR$(KBD-ASC("G")+48)):GOTO 1680
1740  POP:GOTO 1100
1760  REM wait for ack,can or ack,bell or nak
1780  PRINT#1;fcommand$;
1800  REM wait a little for cd2 to answer
1820  REM
1840  INPUT#1;answer$
1860  IF LEN(answer$)>1 THEN 1900
1880  IF ASC(MID$(answer$,1,1))=ASC(ACK$) THEN 1940
1900  IF ASC(MID$(answer$,1,1))=ASC(NAK$) THEN 2020
1920  answer=1:RETURN:REM unknown response from cd2, shouldnt happen
1940  IF ASC(MID$(answer$,2,2))=ASC(CAN$) THEN 2000
1960  IF ASC(MID$(answer$,2,2))<>7 THEN 1920
1980  PRINT"cd2 error code is: ":RIGHT$(answer$,2):answer=1:RETURN
2000  answer=0:RETURN:REM all ok
2020  PRINT"                                    ":GOTO 1760
2040  REM
2060  REM
2080  DIM CS(10)
2100  INVOKE"REQUEST.INV":v1=0:C=1
2120  GOSUB 2220:REM get initial rs232 status
2140  SUBS(S$,14)=CHR$(128):SUBS(S$,10,12)=CHR$(240)+CHR$(0)+CHR$(240)
2160  PERFORM CONTROL(%C,@S$)RS
2180  RETURN
2200  REM
2220  RS=".RS232"
2240  OPEN#1,RS
2260  GOSUB 2320:RETURN:REM get rs232 status
2280  REM
2300  REM
2320  C=1
2340  PERFORM STATUS(%C,@S$)RS
2360  RETURN
2380  END
```

Figure 2
Apple III BASIC program for external control of CD2A COMPUDRIVE via RS232.

supply a command (START SCAN, GO TO SET POSITION, ENABLE TRIGGER SCAN, etc. Section 3.4.13.5) or to alter a parameter value (Start Position, Number of Scans, Laser Line, etc.). Once this information is typed in, Apple III relays it to CD2A which then executes the command or alters the parameter value. When the action is accomplished, CD2A signals Apple III which again prompts the user.

To run the program, load it into your Apple III and execute. Refer to Figure 2 and note the following sequence of events:

1. Steps 0 through 180 (including the subroutine 2080-2380) are spent configuring Apple III's RS232 for CD2A compatibility.
2. At Step 200, Apple asks the operator to switch CD2A to the REMOTE mode.
3. Step 260 calls up the subroutine 1100-1740 which prompts the user to supply a command or parameter name to be passed along to CD2A. If a parameter is selected, steps 660-1040 ask for a numerical value.
4. Steps 280 to 420 interpret the operator's response to select the correct transmission to CD2A (See Section 3.4.13.6 of your manual). The actual transmission takes place in Step 1780.
5. Steps 1800-2000 wait for handshake acknowledge from CD2A that the message was, in fact, received. If an error is detected, control characters are stripped off the transmission, and CD2A's error code is displayed for the operator on the Apple CRT.
6. The operator is once again asked to supply a command or parameter name (Step 260).

NOTE: Triggers for trigger-scan modes may also be supplied via the RS232 port. In this program, a trigger is sent to CD2A each time the menu choice of trigger is entered on Apple III's keyboard (in this case "4" Step 1180). This transmits a "T" (step 560) which corresponds to a hexidecimal 54 (See Fig 3).

HEXADECIMAL

LEAST SIGNIFICANT CHARACTER	MOST SIGNIFICANT CHARACTER 0	1	2	3	4	5	6	7
0	NUL	DLE	SP	0	@	P	`	p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	ETX	DC3	#	3	C	S	c	s
4	EOT	DC4	$	4	D	T	d	t
5	ENQ	NAK	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	'	7	G	W	g	w
8	BS	CAN	(	8	H	X	h	x
9	HT	EM	)	9	I	Y	i	y
A	LF	SUB	*	:	J	Z	j	z
B	VT	ESC	+	;	K	[	k	{
C	FF	FS	,	<	L	\	l	:
D	CR	GS	-	=	M	]	m	}
E	SO	RS	.	>	N	^	n	≈
F	SI	US	/	?	O	—	o	DEL

EXAMPLES

W = 57
H = 48
a = 61
t = 74
@ = 40
NUL = 00
DEL = 7F

Figure 3
ASCII Code Conversion Table

7 INDEX

10-25-87

CD2B

IEEE Example program

```
111     until (spr<>chr($80)) or (i=100);
112       wait_for_char:=(i<>100);
113   end;
114
115     (*************************************************************)
116     (* This function reads num_of_chars into the buffer rd.      *)
117     (* In addition the characters are returned as a string.      *)
118     (*************************************************************)
119
120   function read_chars(num_of_chars: integer): string;
121       var
122          rd     : cbuf;        (* read data buffer          *)
123          spr    : char;        (* serial poll response byte *)
124          i: integer;
125          temp: string;
126
127   begin
128       temp:='';
129       i:=1;
130       repeat
131          if wait_for_char then
132          begin
133               ibrd(compudrive,rd,1);
134               if ((ibsta AND ERR) <> 0) then error;
135               temp:=concat(temp,rd[1]);
136               i:=i+1;
137          end;
138       until (i>num_of_chars) or keypressed;
139       read_chars:=temp;
140   end;
141
142     (*************************************************************)
143     (* Send the message using first_char to initiate and etx     *)
144     (* to terminate, then wait for a response and read until     *)
145     (* no more characters.                                       *)
146     (*************************************************************)
147
148   Procedure Send_Message(first_char: char; message: string);
149       var i: integer;
150          wrt    : cbuf;              (* write data buffer       *)
151          length_message: integer;
152
153   begin
154     (* Determine length of message                              *)
155
156       length_message:=length(message);
157
158     (* Put the first character into the write buffer            *)
159
160       wrt[1]:=first_char;
161
162     (* Put message into write buffer starting at position 2     *)
163
164       for i:=1 to length_message do
165          wrt[i+1]:=message[i];
```

```
56  procedure error;
57  begin
58     writeln (' Error');
59     prvars
60  end;
61
62     (*************************************************************)
63     (* This routine displays the result of a read on the screen*)
64     (*************************************************************)
65
66  procedure display(result_str: string);
67     var i: integer;
68        ch: char;
69
70  begin
71     for i:=1 to length(result_str) do
72        begin
73           ch:=result_str[i];
74           if ch=bel then
75              begin
76                 gotoxy(10,21);
77                 clreol;
78                 write('Error code =');
79                 error_in_process:=true;
80              end;
81           if(ch in [bel,lf,cr,' '..'~']) then
82              begin
83                 write(ch);
84              end
85           else
86              if error_in_process then
87                 if ch<>eot then
88                    write(ord(ch):4)
89                 else
90                    error_in_process:=false;
91        end;
92  end;
93
94     (*************************************************************)
95     (* This function waits for characters to be available, or  *)
96     (* until a particular *) (* delay has been reached.  The   *)
97     (* function returns true if characters are available       *)
98     (* otherwise false.                                        *)
99     (*************************************************************)
100
101 function wait_for_char:boolean;
102    var i: integer;
103       spr    : char;       (* serial poll response byte      *)
104
105 begin
106    i:=0;
107    repeat
108       i:=i+1;
109       ibrsp (compudrive,spr);
110       if ((ibsta AND ERR) <> 0) then error;
```

```
(****** Turbo Pascal Example Program - Device Level *******)

program main;

uses crt,tpdecl;

Type
   cbuf  = array[1..13] of char;

Var
   bd      : integer;          (* board or device number *)
   compudrive    : integer;    (* device number          *)
   result_str: string;     (* Result string for each read *)
   error_in_process: boolean;
   ack,
   bel,
   ch,
   can,
   cr,
   eot,
   etx,
   lf,
   nak,
   so,
   stx: char;

(*************************************************************)
(* This routine would notify you of the values of status,    *)
(* error, and byte in the event of errors.                   *)
(*************************************************************)

procedure  prvars;
begin
   writeln ('ibsta=',ibsta,' iberr=',iberr,' ibcnt=',ibcnt);
end;

(*************************************************************)
(* This routine would notify you that the IBFIND call        *)
(* failed, and refer you *) (* to the driver software       *)
(* configuration procedures.                                 *)
(*************************************************************)

procedure finderr;
begin
   writeln (' Find error');
end;

(*************************************************************)
(* This routine  would,  among  other things, check  IBERR *)
(* to  determine the exact cause of the error condition &  *)
(* then take action appropriate  to the application.  For  *)
(* errors during  data transfers, IBCNT may be examined to *)
(* determine the actual number of bytes transferred.       *)
(*************************************************************)

```

Instructions for the CD2B Compudrive

The operation of the CD2B Compudrive is similar to the operation of the CD2A, except that the CD2B receives and transmits data through the IEEE-488 bus rather than the RS-232 interface. The commands used to communicate with another device through IEEE-488 interface are the same as those used to communicate through the RS-232 interface.

To install the CD2B, follow the instructions in the CD2A manual. The configuration table has been set at the factory for communication through IEEE-488 bus. Element 21 has been set for two-way RS-232 interface and element 15 has been set for a baud rate of 4800. Increasing the baud rate may decrease data integrity. If it is necessary to change these settings, refer to the CD2A manual, section 4.

The IEEE-488 address of the CD2B has been set at the factory as device #10. To verify the address, check the settings of IEEE-488/CD2 switches 1-5 on the rear panel of the CD2B. The address can be determined by adding together the hexadecimal numbers of switches 1-5 that are set to 'HI'. For example, the switch settings below assign the address 10 (8 + 2).

switch setting	LO	HI	LO	HI	LO	LO	LO	HI
switch number	1	2	3	4	5	6	7	8
Hex number	16	8	4	2	1			

To change the address, change the settings of switches 1-5.

After the CD2B has been turned on and has completed its self-test, press the Remote key. The CD2B is now ready to be controlled by another device through the IEEE-488 interface.

CONFIGURATION

CD2 comes to you with a configuration best suited your particular instrument and experimental designs. However, should you at any time want to modify your system by substituting a grating with a different groove ...n ty, another recorder, or even change to a ...mpletely different SPEX spectrometer, you'll find CD2 ady and willing to adapt to the situation with only a w ...eystroke modifications of the configuration table. ...e changes are volatile, so the next time you power ..., the factory configuration reappears.

...ss to the configuration table is through the CNFG ...y. When you press it while the CD2 is halted, the first ...ement in the table appears. You can step through the ...st of the elements by pressing ENTER till you reach ...e ast, or 23rd element. The next ENTER returns the ...onfiguration table to the first element, and so on.

...F ONLY WAY TO EXIT CONFIGURATION MODE ...ER AN ALTERATION IS BY PRESSING HALT.

...onfiguration elements come in two forms, 4-bit binary ...r ecimal. Note that element one, for example, is a ...ry presentation of four bits, each having the value ...ero or one. Referring to the table at the end of this section, and reading left to right, you can see that 0100 translates into a wavelength (0) drive system that reads in angstroms (1). The next number is always zero (0), but the last tells us no PMT protection is installed (0).

Other elements may be of the decimal type, such as element five. It might read 1200 to signify a grating with 1200 gr/mr has been installed in the instrument.

To alter a configuration element, press the CNFG key, then ENTER until the chosen element appears. Key in the new value, lock in with ENTER, and move on to the next element on your list. When done, press HALT. A row of dashes (——) in the PARAMATER displays signals that CD2 is confirming that the modification is consistent with the remaining configuration elements. (Be patient, reconfiguration takes about 10 seconds.) If the new configuration is cleared, CD2 returns to normal operation with a beep. If not, an error code is displayed (Section 5). Press EXAM to view the offending element. (You can change as many elements as you like, as long as they're mutually compatable.) Severely illogical modifications of the configuration elements may necessitate turning off the CD2 and beginning from scratch. All modifications of the configuration from the keyboard are lost when the power is cut.

4.1 CD2 Configuration Table

...ement #			Significance
1	Four-bit binary code, left to right		1 2 3 4
	First bit	—	If one, the spectrometer has a wave-number drive. If zero, the spectrometer is wave-length drive.
	Second bit	—	(Only applies if bit 1 = 0) If one, the spectrometer untis are angstroms. If zero, the spectrometer units are nanometers.
	Third bit	—	Must remain zero.
	Fourth bit	—	If one, a shutter is installed for PMT protection. If zero, no shutter has been installed.
2	Four-bit binary code, left to right		1 2 3 4
	First bit	—	Must remain zero.
	Second bit	—	If one, the spectrometer is fitted with limit switches. If zero, no limit switches.
	Third bit	—	Undefined.
2	Fourth bit	—	Type of drive unit: 1 = Mini-Step Driver (MSD) 0 = Large-Step Driver (LSD)
3	Six decimal digits specify the lower (in wavelength, upper in wavenumber) mechanical scan limit of the spectrometer.		

Element #	Significance
4	Six decimal digits set the upper (in wavelength, lower in wavenumber) mechanical limit of the spectrometer. CD2 will not knowingly drive the spectrometer outside the limits set by elements 3 and 4 but will instead respond with an error code.
5	Four decimal digits specify the grooves/mm of the grating actually installed in the spectrometer (e.g. 1200).
6	A four-digit number specifies the grooves/mm of the standard grating, that is, the one for which the mechanical counter on the side of the spectrometer is accurate.
7	Four decimal digits for the number of motor steps that will drive the spectrometer one spectral unit with standard grating, e.g. 400 for 1400 and 1700 series spectrometers, and 500 for a 1269 (all MSD Drivers). 50 for LSD's.
8	Units of backlash removed from spectrometer drive in reverse to approach START or SET position
9	Start speed of spectrometer slew (two decimal digits) in units of 100 steps/sec MSD, (typically 40 is 4000 steps/sec) or 10 steps/s LSD (50 for LSD).
10	Maximum speed of spectrometer (two decimal digits) in units of 1000 steps/sec MSD (typically 28 is 28000 steps/sec) or 100 step/s LSD (0 for LSD)
11	Recorder options is a four-bit binary code (usually reading 0101), formed from the following three-bit binary set, left to right (1 2 3 4): Bit 1 — Unused Bit 2 — If one, a marker exists. If zero, no marker. Bit 3 — Must be zero. Bit 4 — Set to zero for a time-base strip chart. Set to one for stepper-drive strip chart.
12	Motor steps that will drive the recorder one of its chart units: four-digit decimal (typically 200 steps/in for SPEX recorders).
13	Max speed of recorder (two decimal digits) in units of 10 steps/sec (typically 20 is 200 steps/sec).
14	Duration of the marker pulse (two-digit decimal) in units of 10 msec (10 is 100 msec).
15	RS232: Baud rate (two decimal digits).

Code	00	01	02	03	04	05	06	07	08	09
Baud	110	150	300	600	1200	1800	2400	4800	9600	19200

16	Four binary bits specify RS232 option output character with the following meaning, left to right (1 2 3 4): Bit 1 — If zero the character contains one stop bit. If one, two stop bits.

```
166
167    (* Put etx as the last character in the write buffer       *)
168
169       wrt[length_message+2]:=etx;
170
171    (* Now write the buffer                                    *)
172
173       ibwrt (compudrive,wrt,length_message+2);
174       if ((ibsta AND ERR) <> 0) then error;
175
176    (* If first_char <> can then wait until characters are     *)
177    (* available then read one at a time until none are       *)
178    (* available                                               *)
179
180       if first_char <> can then
181       ┌──begin
182       │      while not wait_for_char do;
183       │
184       │      gotoxy(10,21);
185       │      clreol;
186       │   ┌──repeat
187       │   │      result_str:=read_chars(1);
188       │   │      display(result_str);
189       │   └──until not wait_for_char;
190       └──end;
191    └──end;
192
193
194    ┌──function find_the_device(name: string): integer;
195       var i,
196          len_name: integer;
197          devname: nbuf;                    (* device name buffer *)
198
199    ├──begin
200       │  len_name:=length(name);
201       │  if len_name>nbufsize then
202       │     len_name:=nbufsize;
203       │  devname:='       ';
204       │  for i:=1 to len_name do
205       │     devname[i]:=name[i];
206       │  find_the_device:=ibfind (devname);
207    └──end;
208
209    ┌──procedure initialize;
210    ├──begin
211      (* Initialize a few variables                             *)
212
213       ack:=chr(6);
214       bel:=chr(7);
215       can:=chr(24);
216       cr:=chr(13);
217       eot:=chr(4);
218       etx:=chr(3);
219       lf:=chr(10);
220       nak:=chr(21);
```

```
221     so:=chr(14);
222     stx:=chr(2);
223     error_in_process:=false;
224
225     bd := find_the_device('gpib0  ');
226     ibsic (bd);
227
228  (* Assign a unique identifier to the device "compudrive":  *)
229
230     compudrive := find_the_device('DEV10');
231
232  (* Check for ibfind error:                                 *)
233
234     if (compudrive < 0) then finderr;
235
236  (* Clear the device:                                       *)
237
238     ibclr (compudrive);
239
240  (* Check for an error on each GPIB call to be safe...      *)
241
242     if ((ibsta AND ERR) <> 0) then error;
243
244     clrscr;
245     gotoxy(10,10);
246     write(bel,
247     'Turn on CD2B remote, then hit any key on your PC');
248     while not keypressed do;
249     ch:=readkey;
250
251     repeat
252        result_str:=read_chars(1);
253        display(result_str);
254     until not wait_for_char;
255  end;
256
257  (* Display a message on the screen at column x, row y      *)
258
259  procedure show_message(x,y: integer; message: string);
260  begin
261     gotoxy(x,y);
262     write(message);
263  end;
264
265  (* Put the menu on the display                             *)
266
267  procedure show_menu;
268  begin
269     clrscr;
270     show_message(10,3,'1.scan');
271     show_message(10,4,'2.trigger scan');
272     show_message(10,5,'3.goto set position');
273     show_message(10,6,'4.trigger');
274     show_message(10,7,'5.pause/continue');
275     show_message(10,8,'6.halt');
```

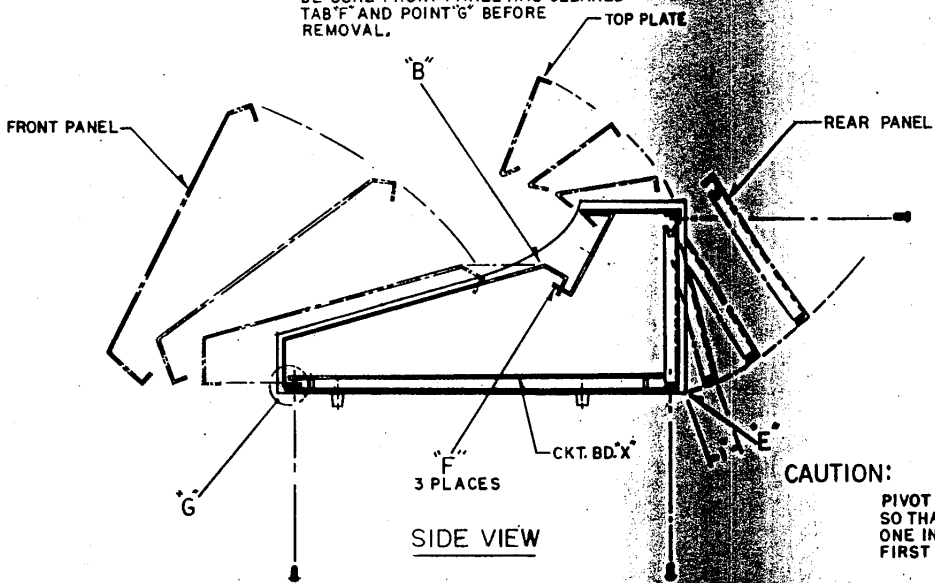
```
276         show_message(10,10,'Q.quit');
277         show_message(50,3,'7.start position');
278         show_message(50,4,'8.end position');
279         show_message(50,5,'9.burst increment');
280         show_message(50,6,'A.continuous scan rate');
281         show_message(50,7,'B.burst dwell time');
282         show_message(50,8,'C.scan type continuos');
283         show_message(50,9,'D.scan type burst');
284         show_message(50,10,'E.shutter high position');
285         show_message(50,11,'F.shutter low position');
286         show_message(50,12,'G.set position');
287         show_message(50,13,'H.number of scans');
288         show_message(50,14,'I.scan delay');
289         show_message(50,15,'J.laser line');
290     end;
291
292     (* Display a message on the screen, get the user's input    *)
293     (* then send it on the the CD2B                             *)
294
295     procedure get_and_send(command,message: string);
296         var temp: string;
297
298     begin
299         gotoxy(10,20);
300         clreol;
301         write(message,':');
302         readln(temp);
303         send_message(stx,concat(command,temp));
304     end;
305
306     (* Get the users choice of operation, then do it            *)
307
308     procedure get_user_input;
309     begin
310         gotoxy(10,20);
311         clreol;
312         show_message(10,20,'Enter choice:');
313         ch:=upcase(readkey);
314       case ch of
315         '1': send_message(can,'S');
316         '2': send_message(can,'T');
317         '3': send_message(can,'P');
318         '4': send_message(can,'E');
319         '5': send_message(can,so);
320         '6': send_message(can,'H');
321         '7': get_and_send('ST','Start position');
322         '8': get_and_send('EN','End position');
323         '9': get_and_send('BI','Burst increment');
324         'A': get_and_send('SR','Continuous scan rate');
325         'B': get_and_send('DT','Burst dwell time');
326         'C': send_message(stx,'TYC');
327         'D': send_message(stx,'TYB');
328         'E': get_and_send('SH','Shutter high position');
329         'F': get_and_send('SL','Shutter low position');
330         'G': get_and_send('SE','Set position');
```

```
331     'H': get_and_send('NS','Number of scans');
332     'I': get_and_send('SD','Scan delay');
333     'J': get_and_send('LL','Laser line');
334     'Q': exit;
335     else
336         begin
337             show_message(10,20,
338             'Invalid choice!! (press any key to continue)');
339             ch:=readkey;
340         end
341   end;
342
343   (* We're moving so let's read whatever comes at us          *)
344   case ch of
345       '1',
346       '2',
347       '3',
348     '4': begin
349            gotoxy(10,21);
350            clreol;
351            while not wait_for_char do;
352
353   (* Now read until not ack, bell, or can                     *)
354            result_str:=read_chars(1);
355            while result_str[1] in [ack,bel,can] do
356              begin
357                display(result_str);
358                result_str:=read_chars(1);
359                if keypressed then
360                  begin
361                    ch:=upcase(readkey);
362                    exit;
363                  end;
364              end;
365            gotoxy(10,22);
366            clreol;
367
368   (* Read the rest of this data block                         *)
369            result_str:=concat(result_str,read_chars(11));
370            display(result_str);
371            if keypressed then
372              begin
373                ch:=upcase(readkey);
374                exit;
375              end;
376
377   (* Now keep reading 12 characters at a time until there is *)
378   (* an *, then you are done                                 *)
379
380            while not (result_str[1] in ['*','E']) do
381              begin
382                gotoxy(10,22);
383                if wait_for_char then
384                  begin
385                    result_str:=read_chars(12);
```

```
386                                display(result_str);
387                                if keypressed then
388                                begin
389                                    ch:=upcase(readkey);
390                                    if ch in  ['5','6'] then
391                                    case ch of
392                                      '5': send_message(can,so);
393                                      '6': send_message(can,'H');
394                                    end
395                                    else
396                                       exit;
397                                end;
398                            end;
399                        end;
400                    end;
401                end;
402            end;
403
404            procedure shut_down;
405            begin
406              (* To close out a programming sequence, send IFC to        *)
407              (* initialize the bus and call the IBONL function to       *)
408              (* disable the hardware and software:                      *)
409
410                 bd := find_the_device('gpib0  ');
411                 ibsic (bd);
412                 writeln;
413            end;
414
415              begin
416              initialize;
417              show_menu;
418            repeat
419                 get_user_input;
420            until ch in ['Q','q'];
421              shut_down;
422              end.
```

CAUTION:

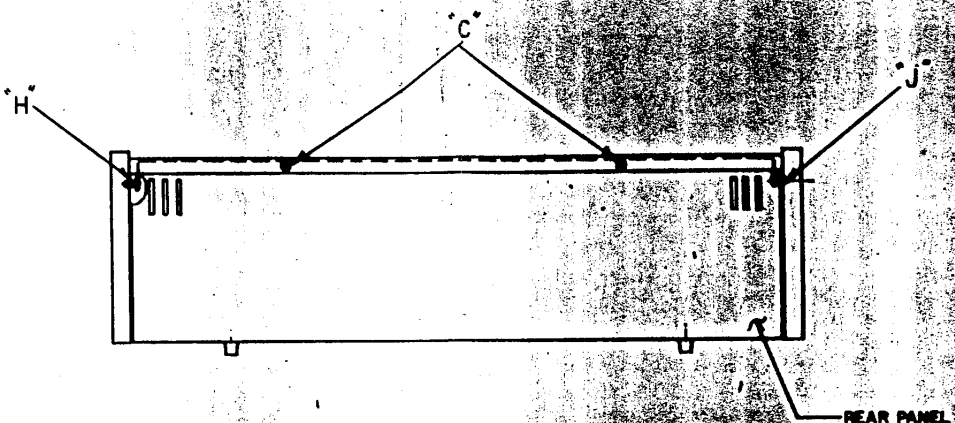
TO AVOID DAMAGE TO CIRCUIT BD "X" BE SURE FRONT PANEL HAS CLEARED TAB "F" AND POINT "G" BEFORE REMOVAL.



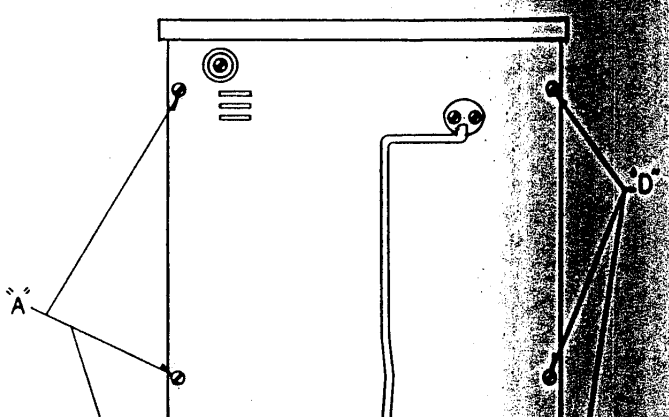
SIDE VIEW

CAUTION:

PIVOT REAR PANEL AT POINTS H&J SO THAT POINT "E" HAS APPROXIMATELY ONE INCH CLEARANCE, THEN DISENGAGE FIRST POINT "H", THEN POINT "J".



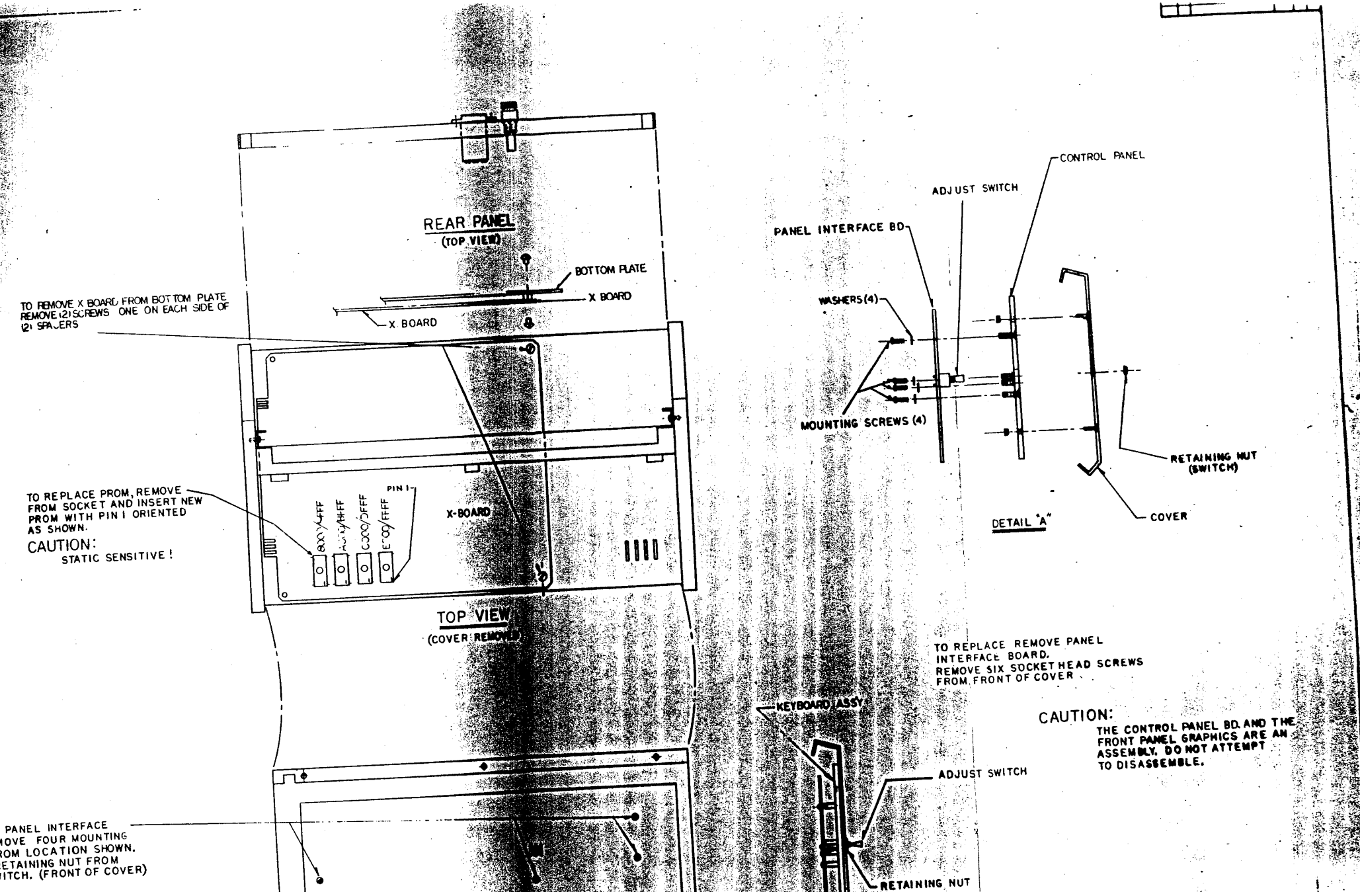
REAR VIEW

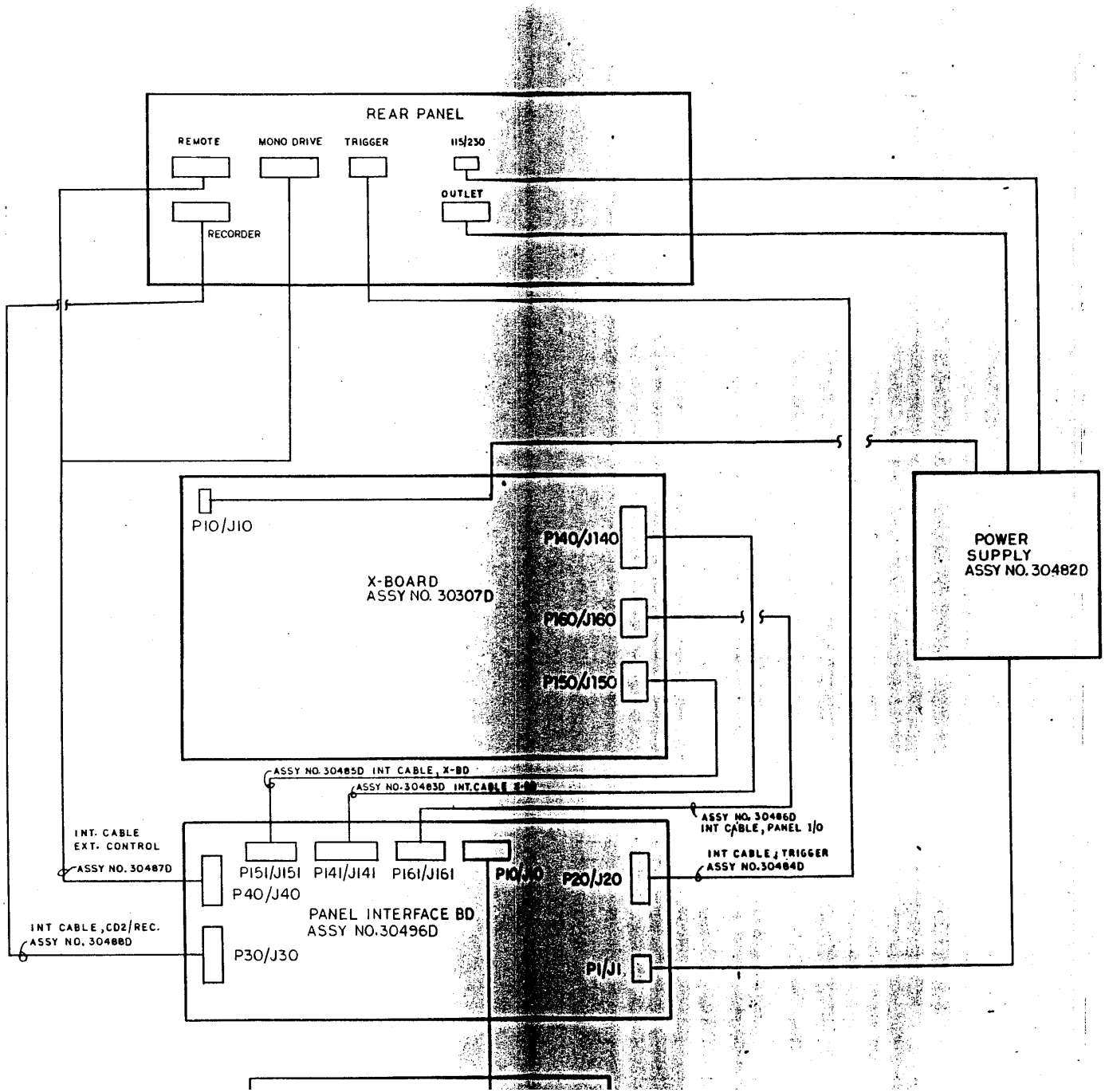


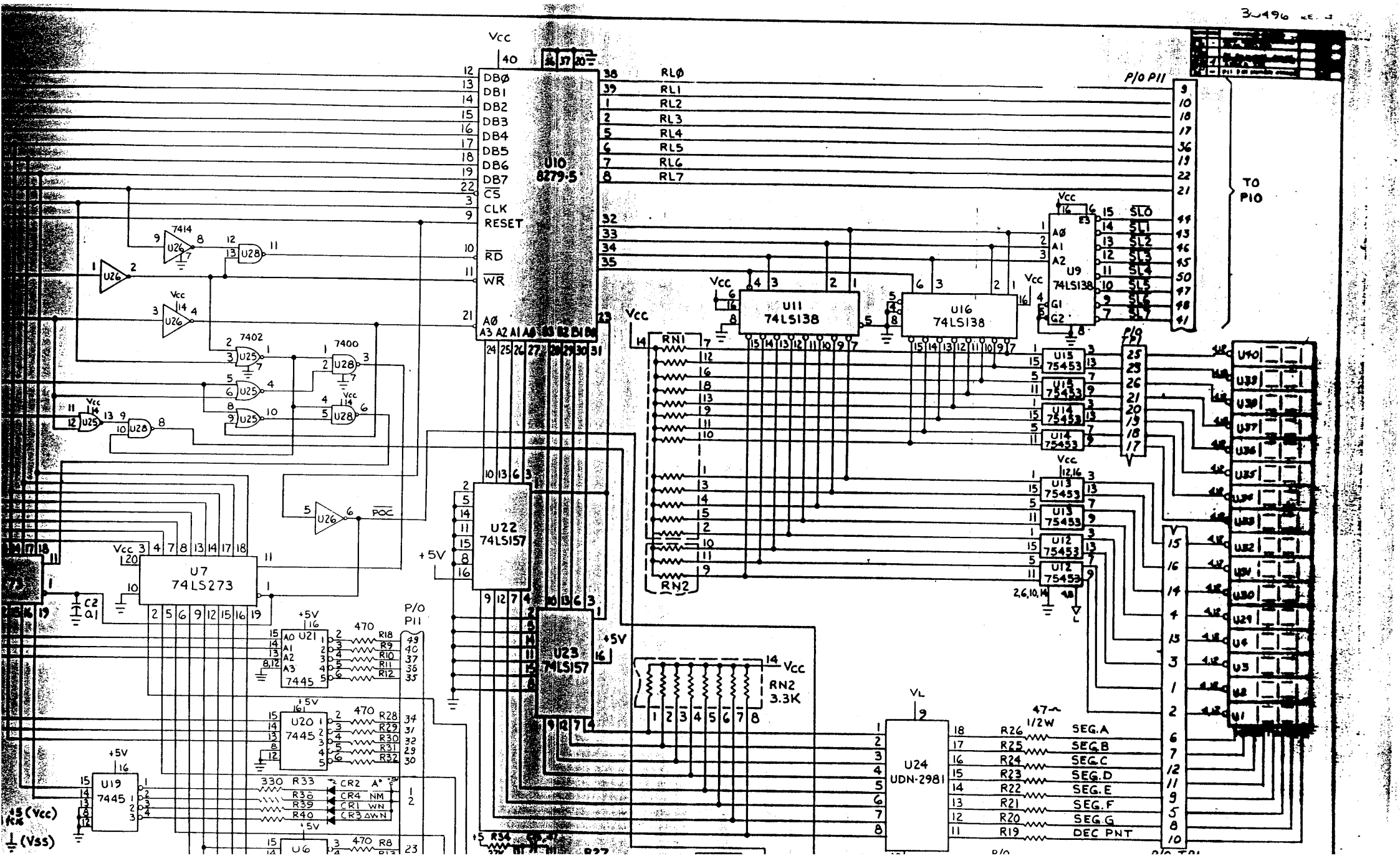
BOTTOM VIEW

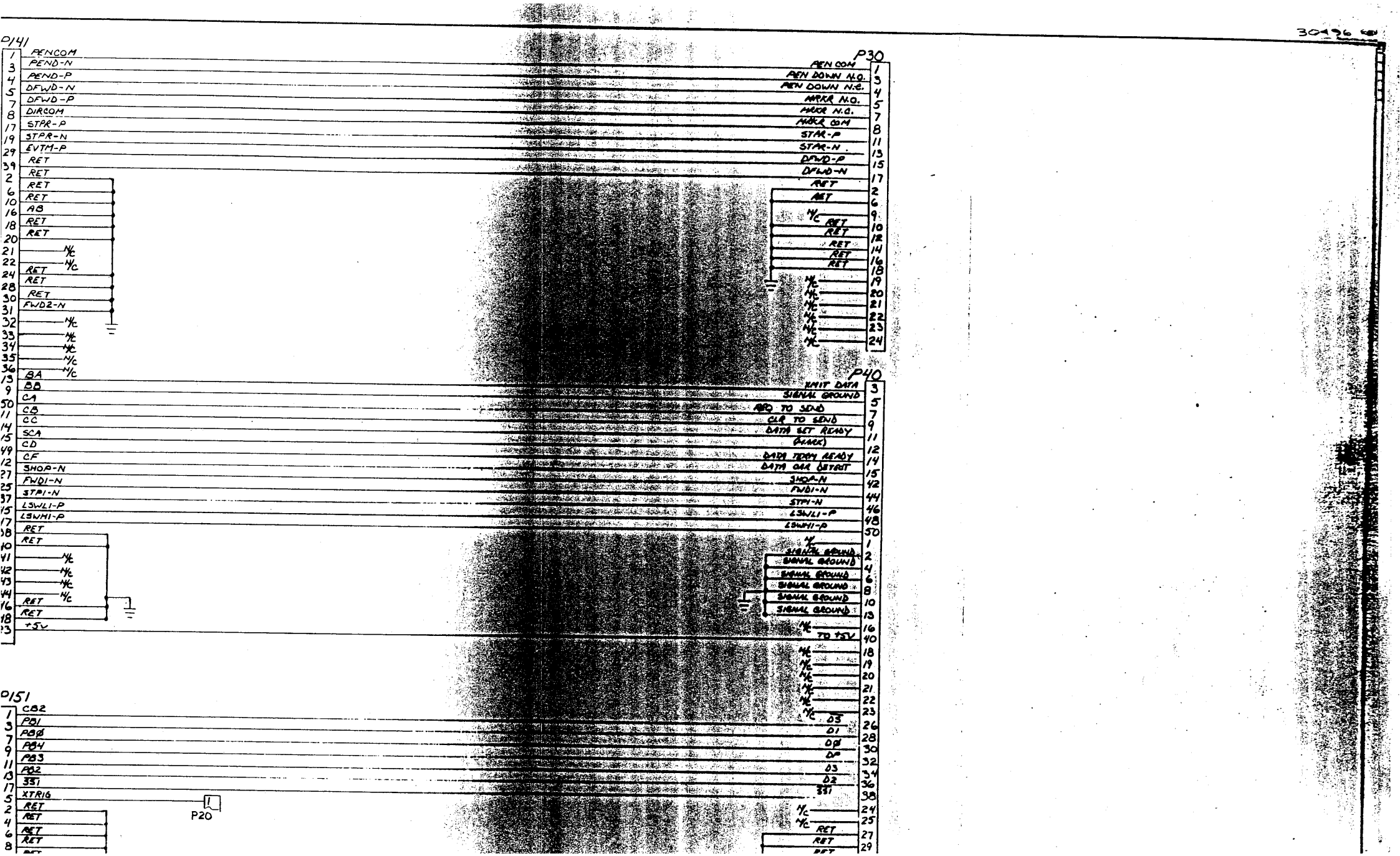
NOTES

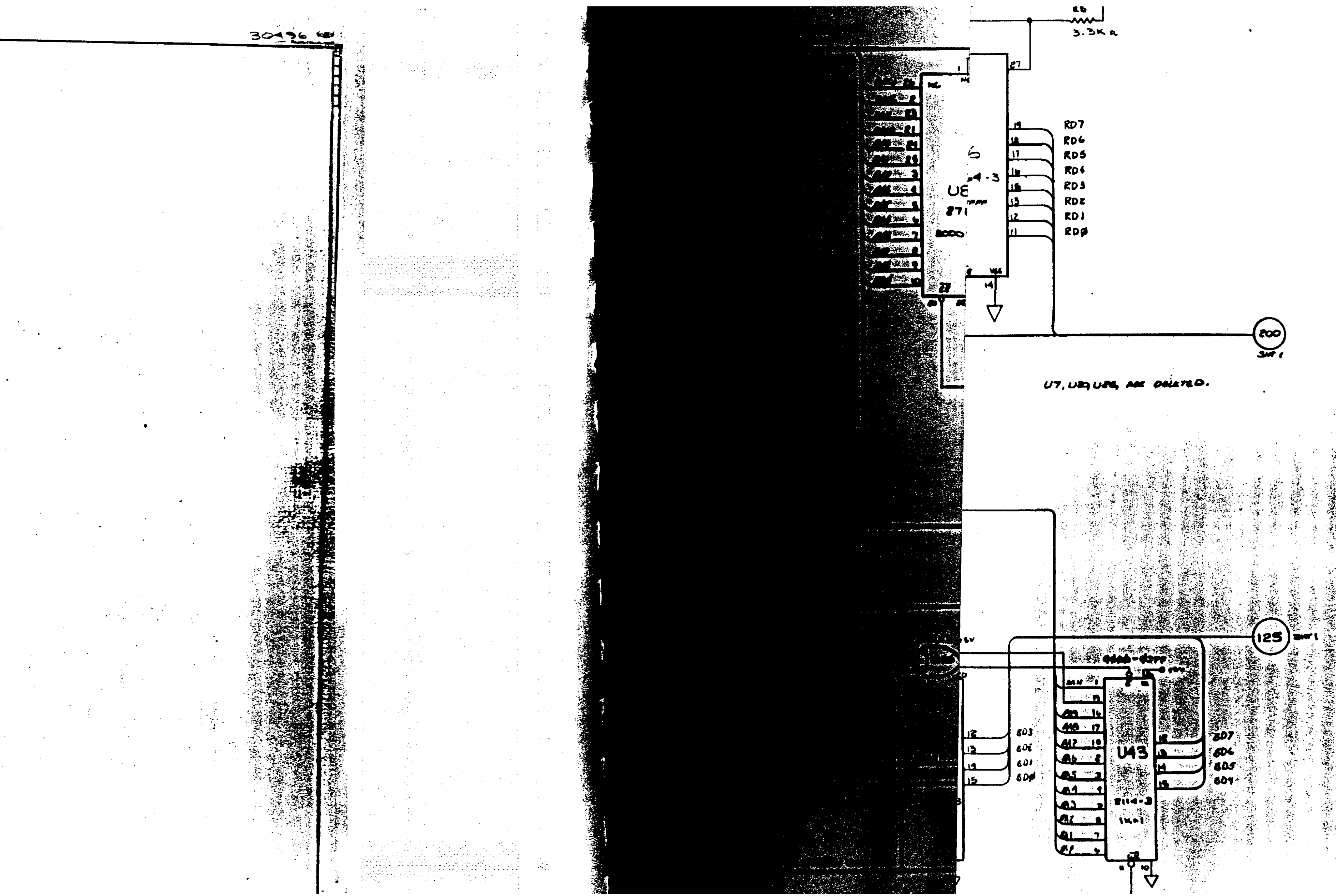
1. TO REMOVE FRONT PANEL, REMOVE 3 MOUNTING SCREWS MARKED "A" FROM BOTTOM OF UNIT AND LIFT COVER AT POINT MARKED "B".
2. TO REMOVE REAR PANEL, REMOVE 2 MOUNTING SCREWS MARKED "C" WHICH SECURE TOP PLATE, THEN REMOVE "3" MOUNTING SCREWS MARKED "D" FROM BOTTOM OF UNIT. LIFT FROM POINT MARKED "E".

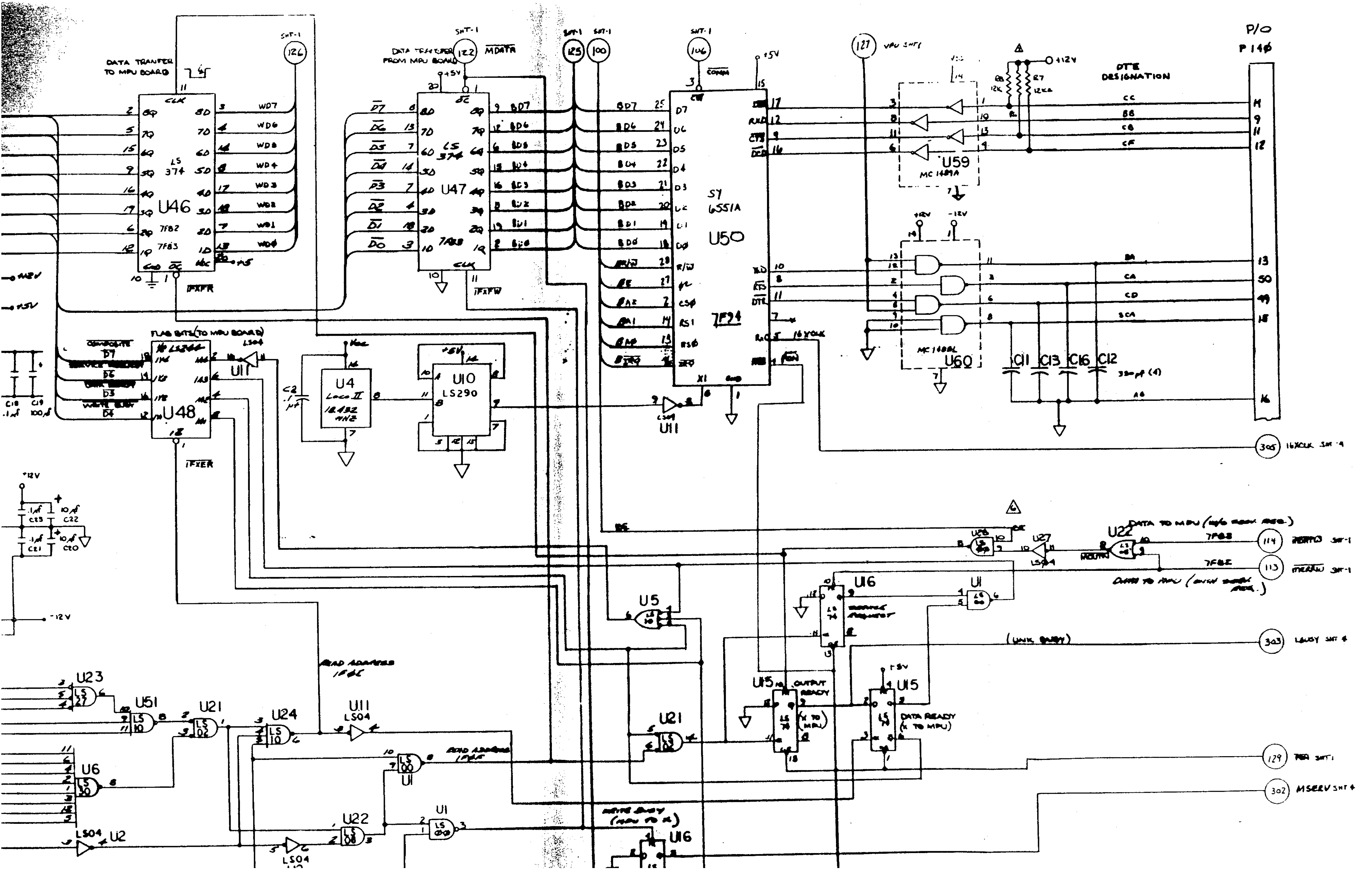

REAR PANEL
(TOP VIEW)
BOTTOM PLATE
X BOARD
X BOARD
TO REMOVE X BOARD FROM BOTTOM PLATE REMOVE (2) SCREWS ONE ON EACH SIDE OF (2) SPACERS
TO REPLACE PROM, REMOVE FROM SOCKET AND INSERT NEW PROM WITH PIN 1 ORIENTED AS SHOWN.
CAUTION:
STATIC SENSITIVE!
PIN 1
X-BOARD
TOP VIEW
(COVER REMOVED)
CONTROL PANEL
ADJUST SWITCH
PANEL INTERFACE BD.
WASHERS (4)
MOUNTING SCREWS (4)
RETAINING NUT (SWITCH)
COVER
DETAIL "A"
TO REPLACE REMOVE PANEL INTERFACE BOARD.
REMOVE SIX SOCKET HEAD SCREWS FROM FRONT OF COVER.
CAUTION:
THE CONTROL PANEL BD. AND THE FRONT PANEL GRAPHICS ARE AN ASSEMBLY. DO NOT ATTEMPT TO DISASSEMBLE.
KEYBOARD ASSY
ADJUST SWITCH
RETAINING NUT
PANEL INTERFACE
OVE FOUR MOUNTING
OM LOCATION SHOWN.
ETAINING NUT FROM
ITCH. (FRONT OF COVER)

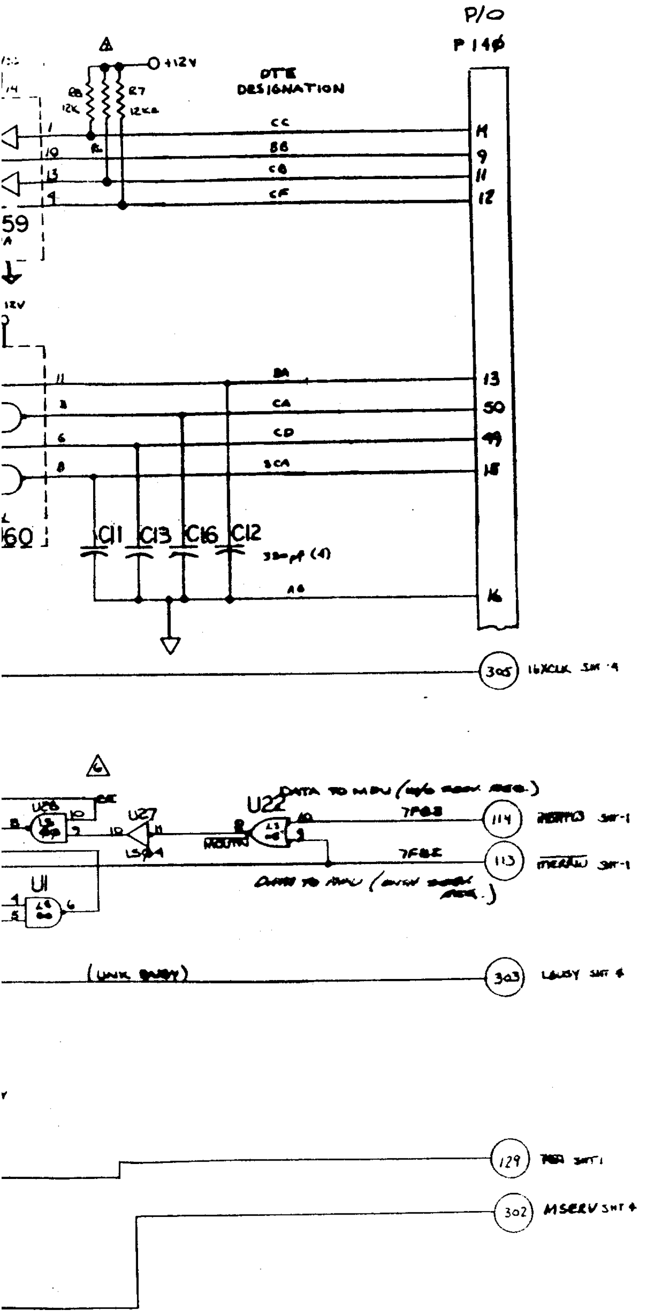
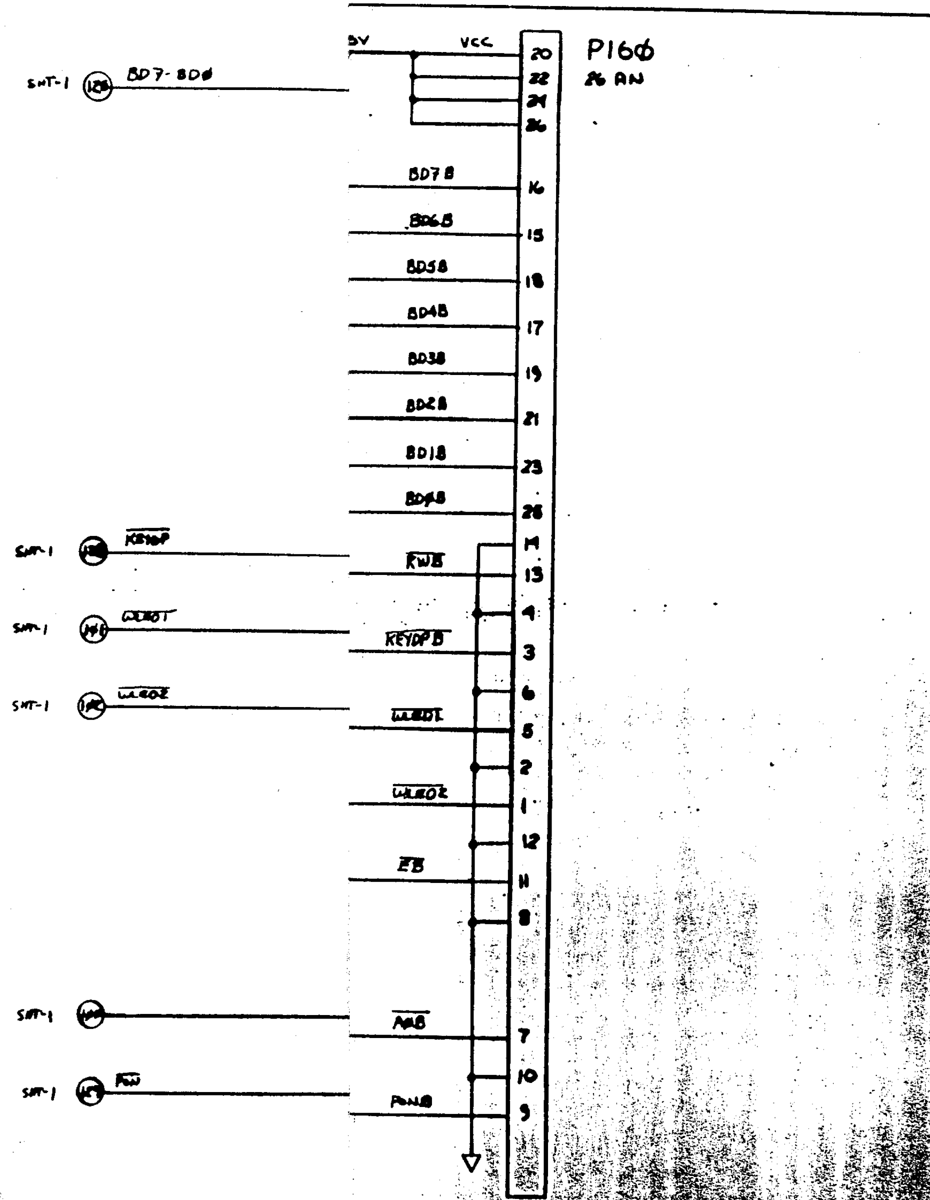

REAR PANEL
REMOTE
MONO DRIVE
TRIGGER
115/230
OUTLET
RECORDER
P10/J10
X-BOARD
ASSY NO. 30307D
P140/J140
P160/J160
P150/J150
POWER
SUPPLY
ASSY NO. 30482D
ASSY NO. 30485D INT CABLE, X-BD
ASSY NO. 30486D
INT CABLE, PANEL I/O
INT. CABLE
EXT. CONTROL
ASSY NO. 30487D
P151/J151
P141/J141
P161/J161
P40/J40
PANEL INTERFACE BD
ASSY NO. 30496D
P20/J20
INT CABLE, TRIGGER
ASSY NO. 30484D
INT CABLE, CD2/REC.
ASSY NO. 30488D
P30/J30
P1/J1


U10
8279-5
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
CS
CLK
RESET
RD
WR
A0
RL0
RL1
RL2
RL3
RL4
RL5
RL6
RL7
U11
74LS138
U16
74LS138
U9
74LS138
U7
74LS273
U22
74LS157
U23
74LS157
U24
UDN-2981
RN1
RN2
RN2
3.3K
U15
75453
U14
75453
U13
75453
U12
75453
U19
7445
U21
7445
U20
7445
U6
7414
7402
7400
U26
U25
U28
R18
R9
R10
R11
R12
R28
R29
R30
R31
R32
R33
R36
R39
R40
R8
R26
R25
R24
R23
R22
R21
R20
R19
R34
CR2
CR4
CR1
CR3
SEG.A
SEG.B
SEG.C
SEG.D
SEG.E
SEG.F
SEG.G
DEC PNT
Vcc
+5V
VL
P/O P11
TO P10
POC
C2
0.1
330
470
47Ω 1/2W


P141
PENCOM
PEND-N
PEND-P
DFWD-N
DFWD-P
DIRCOM
STPR-P
STPR-N
EVTM-P
RET
RET
RET
RET
AB
RET
RET
N/C
N/C
RET
RET
RET
FWD2-N
N/C
N/C
N/C
N/C
BA
BB
CA
CB
CC
SCA
CD
CF
SHOR-N
FWDI-N
STPI-N
LSWLI-P
LSWMI-P
RET
RET
N/C
N/C
N/C
N/C
RET
RET
+5V
P30
PEN COM
PEN DOWN N.O.
PEN DOWN N.C.
MRKR N.O.
MRKR N.C.
MRKR COM
STAR-P
STAR-N
DFWD-P
DFWD-N
RET
RET
N/C
RET
RET
RET
RET
RET
N/C
N/C
N/C
N/C
N/C
N/C
N/C
P40
XMIT DATA
SIGNAL GROUND
RTS TO SEND
CLR TO SEND
DATA SET READY
(BLANK)
DATA TERM READY
DATA CAR DETECT
SHOR-N
FWDI-N
STPI-N
LSWLI-P
LSWMI-P
N/C
SIGNAL GROUND
SIGNAL GROUND
SIGNAL GROUND
SIGNAL GROUND
SIGNAL GROUND
N/C
TO +5V
N/C
N/C
N/C
N/C
N/C
N/C
D5
D1
D4
D0
D3
D2
351
N/C
N/C
RET
RET
RET
P151
CB2
PD1
PB0
PB4
PB3
PB2
351
XTRIG
RET
RET
RET
RET
P20


30496
3.3K Ω
RD7
RD6
RD5
RD4
RD3
RD2
RD1
RDØ
8000
200
U7, U8, U49 ARE DELETED.
125
U43
2114-3
1Kx1
BD7
BD6
BD5
BD4
BD3
BD2
BD1
BDØ


P/O P14Ø
DTE DESIGNATION
DATA TRANSFER TO MPU BOARD
DATA TRANSFER FROM MPU BOARD
MDATR
FLAG BITS (TO MPU BOARD)
U46
LS 374
U47
LS 374
U50
SY 6551A
U59
MC 1489A
U60
MC 1488L
U4
U10
LS290
U48
U11
U5
U6
U16
U15
U21
U22
U23
U24
U27
U51
U1
U2
C11
C13
C16
C12
DATA TO MPU
DATA READY
OUTPUT READY
READ ADDRESS
WRITE BUSY
16XCLK
LBUSY
MSERV
+12V
-12V
+5V


P/O
P 14Φ
+12V
DTE
DESIGNATION
CC
BB
CB
CF
BA
CA
CD
SCA
AB
R7
12K
R8
12K
C11
C13
C16
C12
305
16XCLK SHT 4
U28
U27
U22
U1
DATA TO MPU
7F83
7F82
114
113
303
LBUSY SHT 4
(LINK BUSY)
129
302
MSERV SHT 4

P16Φ
26 AN
5V
VCC
SHT-1
BD7-BDΦ
BD7B
BD6B
BD5B
BD4B
BD3B
BD2B
BD1B
BDΦB
KEYOP
RWB
KEYOPB
WLEOZ
WLEOZ
ZB
ANB
PONB
RW
20
22
24
26
16
15
18
17
19
21
23
25
14
13
4
3
6
5
2
1
12
11
8
7
10
9