# Service Manual

## HUMAREADER

Rev. A1.00-94
Release approved

Best.-Nr. / Cat.-No.: 18598

# Human Humareader

# Service Manual

## Table of Contents



# I. Introduction

This manual is designed to help you troubleshoot and service the Humareader plate reader. It is divided into 7 main sections:

I. Introduction
II. Hardware Description
III. Auxiliary and Optional Equipment
IV. Principles of Operation
V. Troubleshooting
VI. Alignment
VII. Schematics, layouts, and other information including service tests and descriptions

## 1. Features

The Humareader microwell plate reader is an economical, versatile, and rugged instrument for performing endpoint procedures. The main features are:

A. Extended photometric range (0.0-3.0 absorbance.)
B. Fully automatic read of single strips to full plates.
C. Four filters standard with both monochromatic and bichromatic capabilities (6 filters available on request).
D. A full on board software menu. Calculations supported are:
    1. Single Calibrator (in singlicate and duplicate)
    2. Multi-Calibrator (in singlicate and duplicate)
        a. Point to Point
        b. Regression (linear/linear, log/linear, linear/log, and log/log)
        c. Polynomial Curve Fit
    3. Cutoff (with or without cutoff controls)
E. User memory for test creation and storage, real time and date.
F. Curve plotting functions.
G. Serial and/or parallel interfaces.

# 2. Specifications

***Photometric***

| | |
|---|---|
| Linear Measurement Range: | 0.00 to 3.0 Absorbance Units (A) |
| Photometric Accuracy: | +/- (1% of the reading + 0.01 A from 0 to 1.5A)<br>+/- (2% of the reading + 0.01 A from 1.5 to 3.0A) |
| Stability: | Drift of no more than 0.005A in 8 hours |
| Warm up time: | 45 seconds, built-in |
| Light Source: | Tungsten Lamp |
| Standard Wavelengths: | Humareader: 405, 450, 492, and 600nm<br>Six Filter UV Option: 405, 450, 492, 630, 545, and 340 nm<br>Six Filter VIS Option: 405, 450, 492, 630, 545, and 690 nm<br>(Substitute filters from 400nm-700nm, available on special order) |
| Type of filter: | 3 cavity sealed interference, 10nm half bandpass typical |
| Vessel: | Standard 96 well plates (round or flat bottom wells) also accepts strip trays of standard size (8x12 configuration) |

***Electronic and Software***

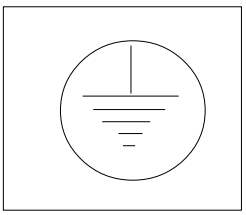
| | |
|---|---|
| Microprocessor | Z80A |
| Speed: | Reads, calculates and prints results for 1 plate in about 2 minutes |
| Display: | 2 line LCD, alpha numeric |
| Keyboard: | 29 key, enunciating, membrane switch |
| Calculation Modes: | Absorbance only, single point calibration from a standard, cutoff, uptake, point to point curve fit, best fit linear, ln, and quadratic |
| Other features: | Mixer, real-time clock, self check system, controls locator, partial plate reading, complete user prompting, flags and error messages, cutoff comparisons, curve editing and graphing, monochromatic option, read format 8 vs 12 direction |
| Fuse Requirements: | Two 1/2 A SLOW BLOW 3AG |
| Power Requirements: | 110-120/220-240 VAC, 50-60 Hz, 50 W (switch selectable) |
| Serial Port: | Output only, 2400 Baud, 1 start bit, 8 data, 1 stop, no parity, no handshake serial cable provided |

***Other***

| | |
|---|---|
| Safety Certification: | Listed to UL 1262, Laboratory Equipment |
| Enclosure: | Fire-retardant ABS Plastic cover with metal base |
| Dimensions: | Approx. 17"x 14.5" X 7" 25 lbs, 43 x 37 x 18 cm, 11.4 kg |
| Optional Accessories: (available from your dealer) | serial printer, DRI-DYE Check Strips (for instrument QC), PC-Plate Reader or MacPlate Reader (interface packages) |

### 3. Power Requirements

For units for use at 110-120 V inside the US: Use a UL listed cord set consisting of a minimum 18 AWG, Type SVT or SJT three conductor cord, maximum 15 feet in length, rated 10 A, 125 V, with a parallel blade, grounding type attachment plug. The cord set provided by the manufacturer meets these requirements.



For units for use at 220-240 V inside the US: Use a UL listed cord as above, except rated 250 V, with a tandem blade, grounding type attachment plug.

The safety classification of this instrument is Class 1. To avoid the risk of electric shock, the third prong of the AC power plug must be connected to conductive parts internal to the equipment by means of internal toothed solder lugs and stainless steel screws and nuts marked internally by the IEC 417 symbol 5019 (see margin). DO NOT loosen or remove these screws.

### 4. Voltage Selection

Locate the voltage select switch on the rear panel. This is a 2 position slide switch that will configure the instrument to accept either 230V or 115V input. Do not connect equipment to the power supply before changing the line voltage selection switch.

**Warning: To prevent permanent damage to the instrument, the voltage select switch must be set for the appropriate input voltage prior to powering up.**

When you can see the 230V label, the instrument is set for 230V input. If you plug the instrument into a 115V power supply while 230V is selected, the instrument will have insufficient operating power.

To select 115V input, insert a straight screw driver blade (or similar instrument) into the slot on the switch, and slide it into its alternate position. Upon sliding the switch, you will see the 115V label appear.

**Warning: If the instrument is configured to accept 115V and you plug it in to a 230V power supply, the fuses will blow and permanent damage to the electronics may result.**

The circuit used should be substantially free of large voltage transients (Kilovolt amp loads) such as large pumps, large centrifuges, refrigerators and freezers, air conditioners, large autoclaves, ovens, and dryers. The instrument may fail to operate normally if the power supply is interrupted. If this occurs, turn the instrument off for a moment. When you turn the instrument back on, it will resume normal operation, but a standard curve which was not stored in non-volatile memory will be lost.

The fuses are located internally in the instrument; there are two fuses, fusing both sides of the main power supply. Fuse failure is a very rare occurrence and should indicate malfunction of the equipment requiring service by qualified personnel.

The fuses used with this instrument are 1/2 Amp Slow blow 250 V 3AG, dimensions 1/4 x 1-1/4" (6.3 x 32 mm). For continued protection against risk of fire, use the same fuse for either 115 or 230 V line voltage selection.

The power requirements label, located on the bottom of the instrument, is summarized below.

**Power Requirements:**

Input voltage range, 110-120 or 220-240 volts alternating current, switch selectable (indicated as 115 or 230).

Current consumption is 0.4 Amperes when in the 115 range and 0.2 Amperes when in the 230 range.

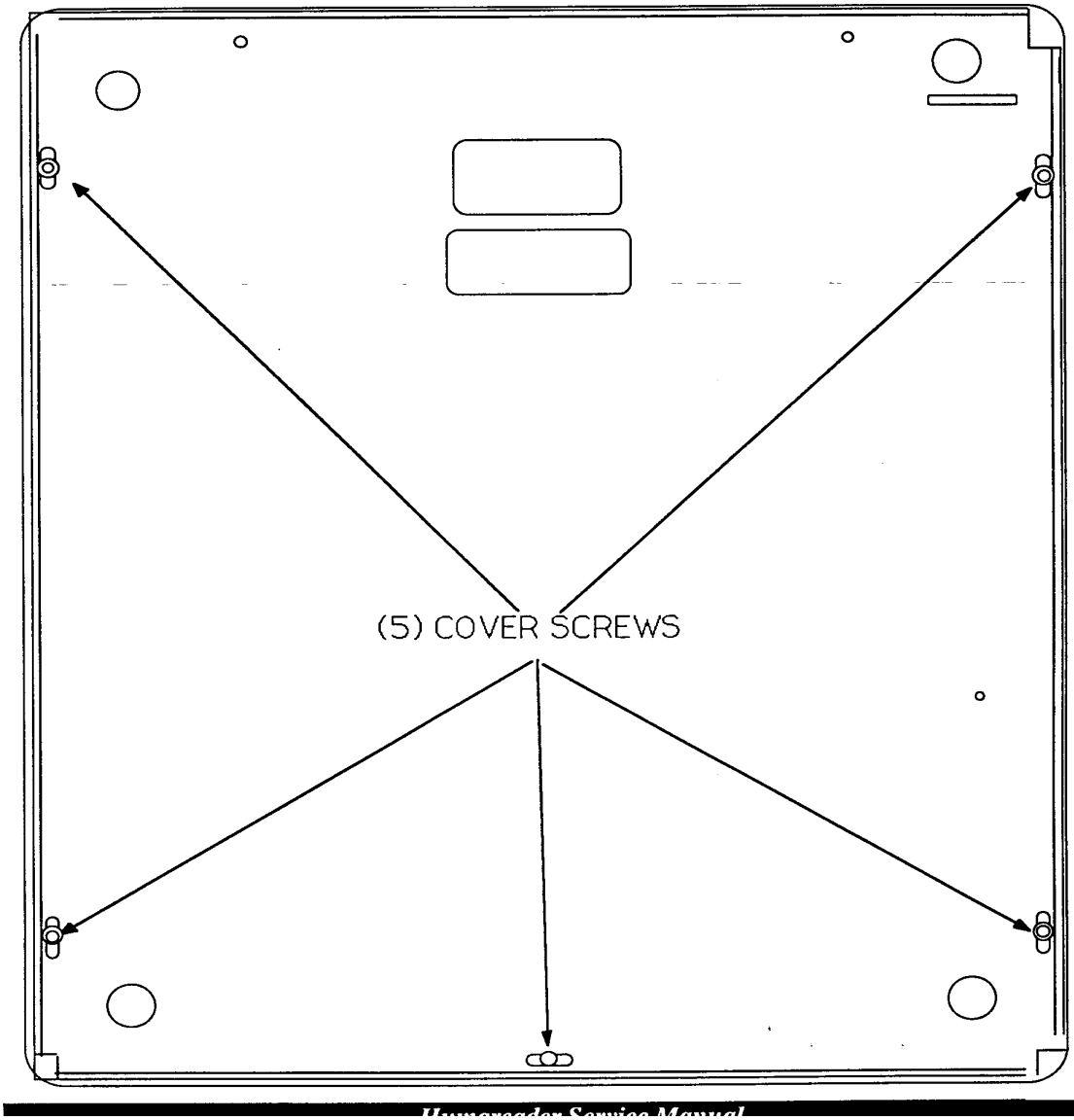
Operating power consumption is 50 Watts.

Frequency of the alternating current is 50-60 Hertz.

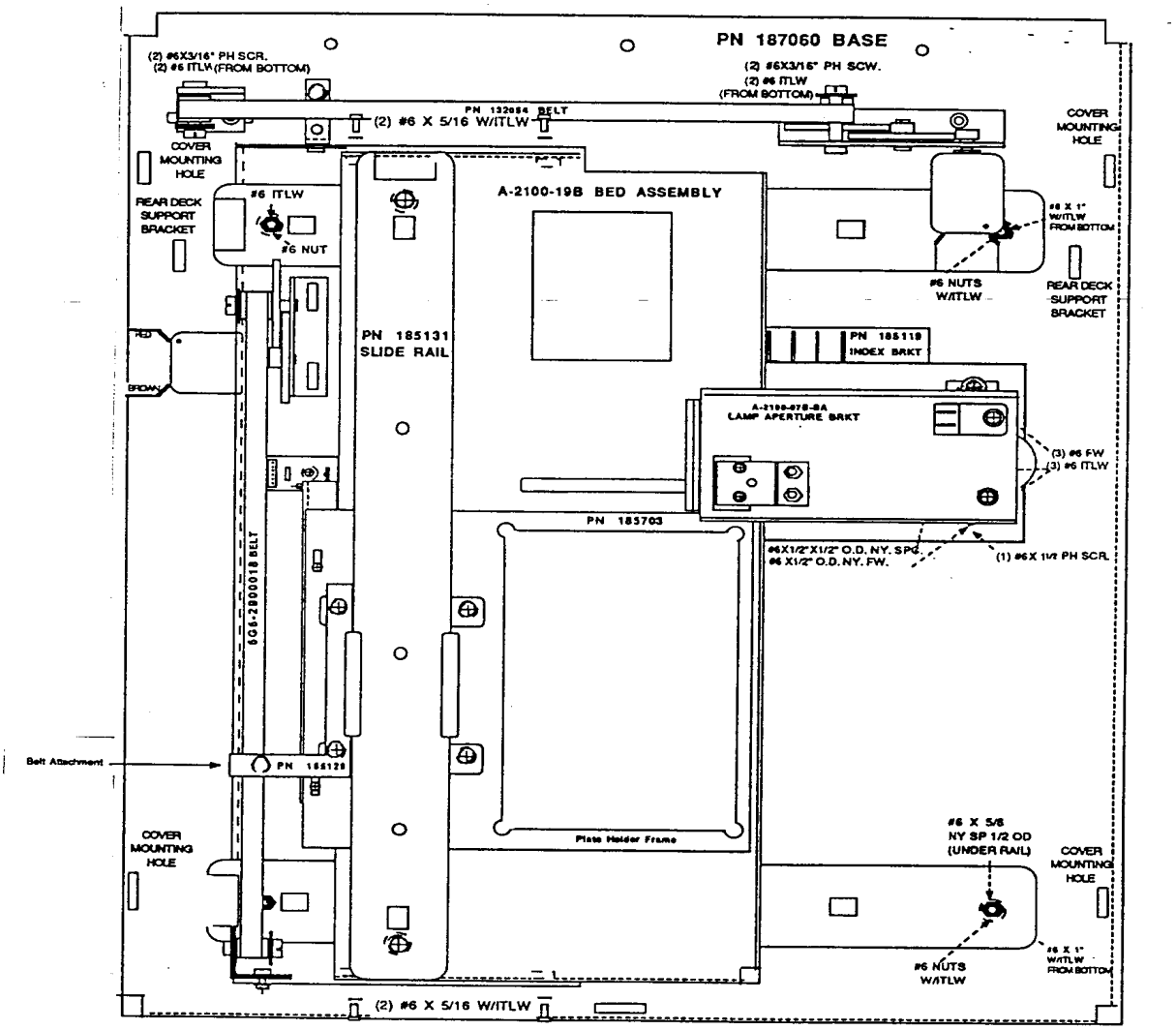
Fuse requirements are two 1/2 Amp Slow blow 250V 3AG type fuse.

## 5. Cover Removal

Unplug the instrument, then turn it over, and place it on a padded or protective surface. Remove the 5 #4 self-tap screws as shown. Do not remove any other screws. Place the unit back on its feet. Lift off the cover and place it directly behind the instrument. This will allow access to all internal assemblies.



## 6. General Layout



# II. Hardware Description

## 1. The Chassis

The chassis consists of three main elements:

*1.1* Cover: The cover is a pressure formed fire-retardant ABS enclosure meeting UL specification 94V-0. It is attached to the main chassis with five #4 self-tap screws. The cover front panel assembly which it attached to main cover contains the LCD display, the interface circuit board, keyboard assembly (keypads and overlay), and the hatch panel (containing the optional parallel interface.)

*1.2* Base: The base supports the rear electronic deck, and is the foundation for the plate transport and photometer mechanisms.

*1.3* Rear Deck or Electronic Support Deck: The deck is the platform mounted on the rear of the base. It contains the main circuit board and the electronic support system. It is hinged so that it may be swung back revealing the AC line connections, fuses, and the plate transport mechanism.

## 2. Plate Transport Mechanism

The Plate Transport system consists of three main elements:

*2.1* Drive Mechanisms (2): One of the two drive mechanisms move the plate in the X or A-H direction, and the other moves it in the Y or 1-12 direction.

*2.2* Position Detection Systems (2): The detection system for each axis consists of one index bracket and two optical gates or opto-switches.

*2.3* Carriage Mechanism: The carriage mechanism consists of three linear, ball-bearing slides, the upper carriage, the lower carriage, and the microwell retainer frame for holding the 96 well microwell plate in place while it is transported to the read site.

## 3. The Photometer Mechanism

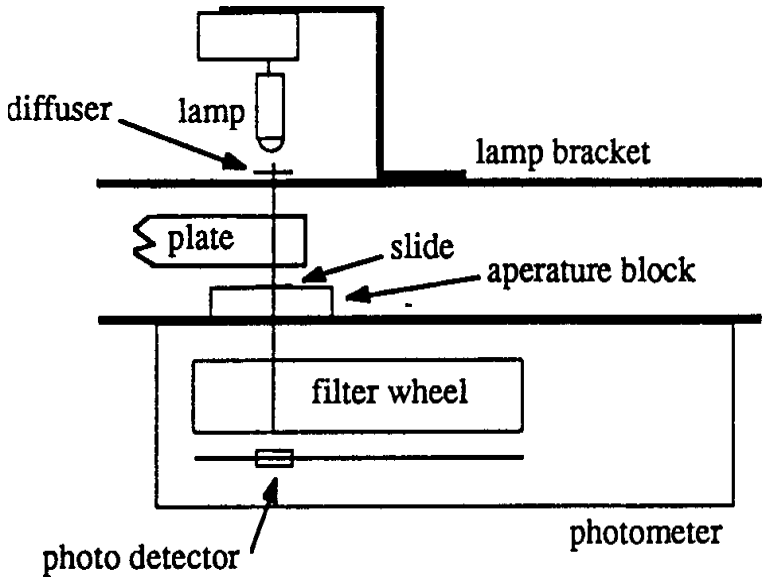
The photometer mechanism consists of 4 elements:

*3.1* The Filter Wheel and Rotation Mechanism: The filter wheel is rotated by a small DC motor connected to the wheel by a rubber belt. The wheel speed is software controlled to 4 revolutions a second. As the wheel turns, the filters mounted in it pass between the light source and the photodetector. When the filter passes through the light beam, the reading is taken.

*3.2* Filter Wheel Position Detection System: Optical gates like those used in the Plate Position Detection System are used to control the filter wheel. Normally the infrared light from the LED side of the gate is blocked, but when the small holes in the filter wheel pass by, the light passes through, and the microprocessor receives a signal. There are two sets of holes. One set consists of four holes, one at each filter. When one of these holes is detected, the filter is lined up, and a sample is taken. The other set is only one hole and it is used primarily for synchronizing the filter count.

*3.3* Light Source: The light source consists of the lamp itself, the diffuser, the lamp aperture block, and the protective glass slide. The light, originating at the lamp, passes through the diffuser, then through the plate, the glass slide, the aperture block, and then into the photometer. This area is also known as the read site. The lamp and filter wheel motor are connected to the junction PCB with an IDC (Insulation Displacement Connector.)

*3.4* Optical Detection System: This system consists of the interference filters, the light sensitive photodiode, the operation amplifier, and the position detectors described in section 3.3. Note: The photodiode, and the operational amplifier are mounted on the



# III. Auxiliary and Optional Equipment

## 1. Auxiliary Equipment

Serial Printer. The Humareader can print its results out to an Epson compatible serial printer using the included serial interface port. The data is sent at 2400 baud, No Parity, 8 data bits, and 1 stop bit. The connection requires the custom cable included with the Reader.

## 2. Optional Equipment

*2.1* Parallel Port: Most of the Humareaders have a 25 pin female connector on the back of the hatch cover. This connector is a standard parallel port. A cable to a parallel printer can be purchased from any computer store. See the schematic for the pinouts.

*2.2* PC-Plate Reader: This package allows the Plate Reader to be controlled from an IBM-PC/ Compatible. Using the computer keyboard, the user sets up and runs tests. The data can then be saved to disk and later imported into a spreadsheet. Test parameters can also be saved to disk. A 360K 5 1/4" or (800K 3 1/2") disk, cable, instructions, and an EPROM upgrade (if necessary) are included.

*2.3* MacPlate Reader: This package performs the same functions as PC-Plate Reader for the Macintosh. Program comes on an 800K 3 1/2" disk. Cable, instructions, and EPROM upgrade (if necessary) are included.

# IV. Principles of Operation

This section of the manual describes the operation and the interaction of the Plate Reader's main systems. Almost all systems are controlled by the Z80 microprocessor on the main circuit board.

## 1. Front Panel Electronics

*1.1* The Interface Board: All of the systems on the front panel (keyboard, display, and parallel port) are centered around the 2100-100 interface board. The interface board is connected to the main board via a 26 pin double row header cable. Note: Earlier units used a 26 pin DIP cable.

*1.2* The Display: The LCD is driven directly off of the Z80 bus. Address decoding is done on the interface board. See the 2100-100 schematic for more information.

*1.3* The Keyboard: The keyboard consists of two identical 4 X 4 membrane keypads. The large keys are actually made up of the two smaller ones. The software recognizes them as the same key. Ports PB0 through PB7 provide the key scan input, and ports PC0 through PC3 provide the scan output. The keys are connected as shown in the drawing in section V.1. Scanning is performed from PB0 to PB7 and reading from PC0 to PC3. The input ports (PC0-3) are pulled up by a 10K SIP.

*1.4* The Parallel Port: The parallel port uses the 8255 located on the interface board. Both the input and output signals are buffered through the two 74HC14s located on the interface board. A cable runs from the board to the hatch panel where the connector is located.

## 2. Normal Carriage Movement

Home position is when the carriage is as far left and front as it can go. In order to sense the home position, the X axis-opto switch must be clear of the X indexing bracket at the left end of the bracket. The Y axis indexing bracket must move clear of the Y axis opto switch at both ends of its travel. The mechanism must be able to be positioned so that the last well (12th well of the plate) can be put at the read site. This is the slot in the index bracket nearest the front of the Reader.

## 3. Position Detection System

*3.1* The Optical Switches: The position of both axes is detected by two nearly identical electro-optical detectors, also referred to as opto-switches. The indexing brackets act to interrupt the light path between the two halves of the switch. The TTL level signal is sent back to the main circuit board to the 8255 PPI and on to the Z80 CPU. The state of the switches is indicated by the 7 segment LED mounted on the main board. Each one of the segments corresponds to one of the gates. Not all segments are used. See section V.3.8. Note: On earlier units, four discrete LEDs are used. The indexing bracket has two sets of slots. The thin slots are used to position the wells in the read site and are read by the upper opto switch. The wider

slots (located every other well) are read by the shorter opto switch, and are used to verify that the plate transport mechanism is functioning correctly.

*3.2* The X Axis Switch: The optical switch for the X axis (left/right) is located on the lower carriage, near the rear center, and can be seen though the large rectangular cutout in the upper carriage. The small circuit board on which the LED and transistors are mounted is attached to the lower carriage by a small angle bracket and spacer. It moves with the carriage. Infrared light from the LED half of the switch, marked "L" on the PCB, shines through index bracket which is mounted on the chassis. The transistor side, which has the black stripe and is marked "T" on the PCB picks up the light from the LED. The connector is on the top edge of the circuit board, and the wires point upwards. Note: Later units have two switches and the earlier ones have only one.

*3.3* The Y Axis Switch: The optical switch for the Y axis is mounted on the lower carriage in about the middle of the left side. The Y indexing bracket is attached to the frame. Infrared light from the LED half of the switch, marked "L" on the PCB, passes through the movable indexing bracket. The transistor side of the switch which is marked with a black stripe, and labeled "T" on the PCB picks up the light. The connector is on the left edge of the circuit board, wires pointing left.

*3.4* Electrical Connection: A cable made up of 6 separate wires attached to an IDC connector starts from the main board and runs to the X opto switch. From there it goes to the Y opto switch.

## 4. Plate Transport Mechanisms

*4.1* Drive Mechanisms: The two axis movement of the plate (X and Y or left/right and in/out) is powered by identical low voltage DC motors. Each motor is geared down 32:1 and attached to a pulley which drives a belt. The belts are attached directly to the carriage by a #4-40 screw through a small hole in the belt. The X axis belt is attached to the lower carriage, and the Y axis belt is attached to the frame. Both motors are connected to the main circuit board on the rear deck. From the main circuit board, a ten conductor cable travels to the junction board. Four wires from the cable go from the junction board to the motors. The rest go to the photometer assembly. In parallel to both motors is a 100ý 1/2 watt resistor. Both resistors are located on the junction board. Note: The earlier units did not have the junction board. The wiring went directly to the motor, and the resistors were located directly on the motor. Both motors are driven by the L293B driver chip located on the main board. The driver chip is run by the 8255 programmable interface chip.

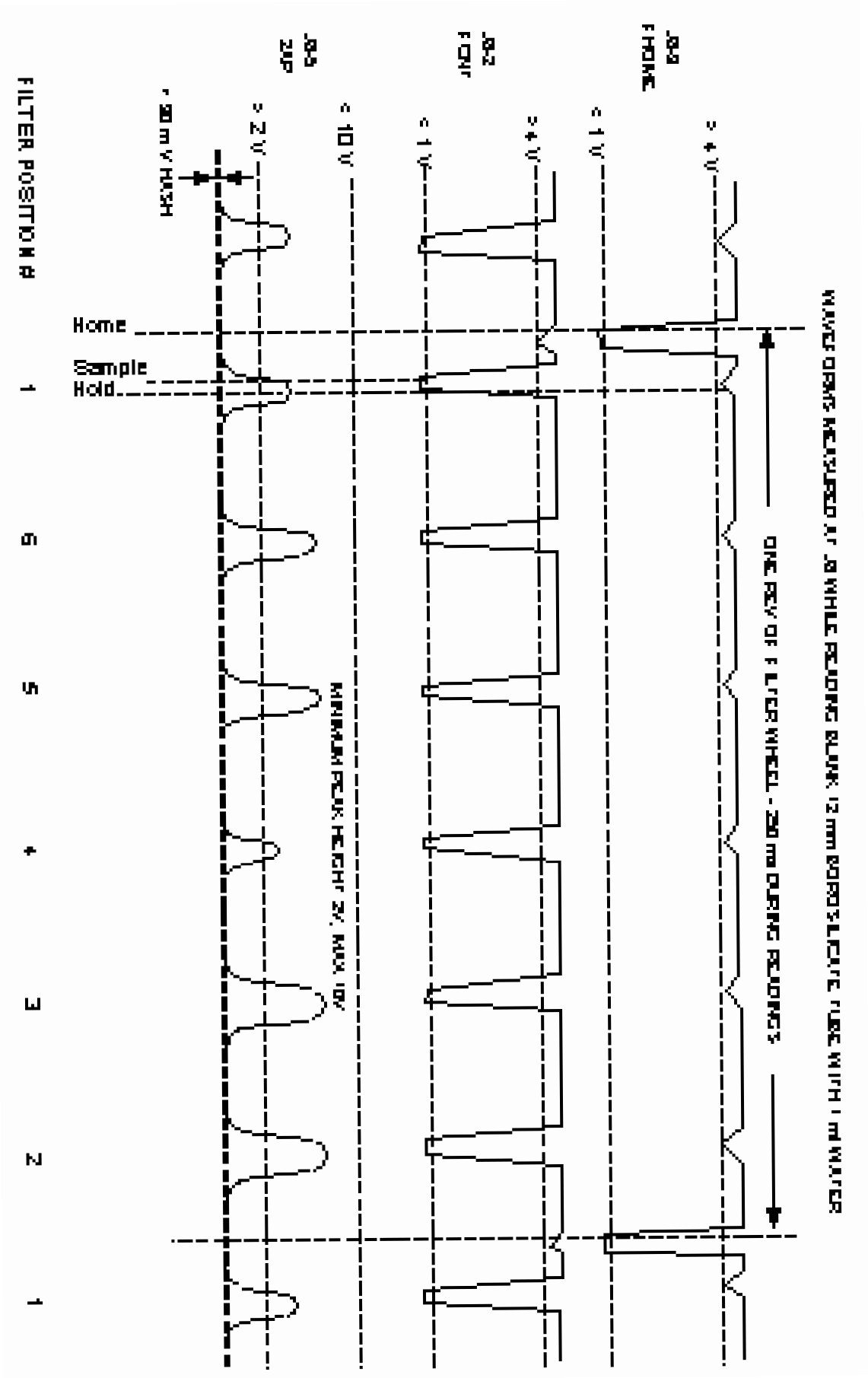
*4.2* Carriage Mechanism: The carriage mechanism consists of the linear ball-bearing slides, the upper carriage, the lower carriage, and the retainer frame that holds the microwell plate. The upper position of the carriage extends over the read site and is supported in the center by a mechanical damper. The damper, affixed to the top of the photometer steadies the mechanism when in motion, and reduces mechanical vibration. The retainer frame which holds the microwell plate and moves it to the read site also has damping material in its corners. This holds the plate securely in place while in motion. There should be sufficient clearance between

the top of the plate and the underside of the photometer lamp bracket so that the two do not come in contact.

### 5. Photometer Mechanism

The Humareader uses a single channel silicon diode detector to read the light, and a gas-filled lens-end tungsten lamp operated at 6 volts as the light source. The continuously rotating filter wheel (see section II.3) contains four 3 cavity interference filters, and is located inside the photometer housing underneath the microwell plate. This arrangement greatly reduces problems due to ambient light and allows the open frame structure of the plate transport system. The photometer is operated under microprocessor control. The filter wheel is software controlled to 4 revolutions per second. Infrared opto switches provide commutation (filter identification) using the holes in the edge of the filter wheel. One pair provides a count pulse, and the other provides a home indication. See the timing diagram below:

Each filter peak is sampled and held and simultaneously converted from an analog signal to a digital absorbance by an exponential capacitor decay circuit and one of the 16 bit counters in the 8253. (See the photometer schematic.) The photometer output is proportional to the power of the light signal whereas the width of the positive phase of the pulse at the 8253 counter chip is proportional to the absorbance. The resistance across the log cap (simple RC decay) determines the base of the log (10 for absorbance.) and is used to adjust the low end absorbance calibration (gain.) Another potentiometer is used to null the offset voltages in the circuits and serves to adjust the hi-end absorbance indications.



# V. Troubleshooting

Presented below are some possible problems and their solutions

## 1. Keyboard Problems

*1.1* No keys function.

If on power up the LCD functions, the interconnection between the main circuit board and the interface board is OK. If the unit beeps continuously at power-up and no keys function, either the calbe is not plugged in correctly, the keytail is shorted, or there is a stuck key. Unplug each of the keypads to determine which of the keypads is malfunctioning. Check that the tracks are covered down to the insertion point. If the covering has been damaged, insulate it with clear tape. If the problem still persists, massage over the keypad until the beeping starts. If necessary, stick the key with a pin to equalize the air pressure inside. If necessary, replace the keypad.

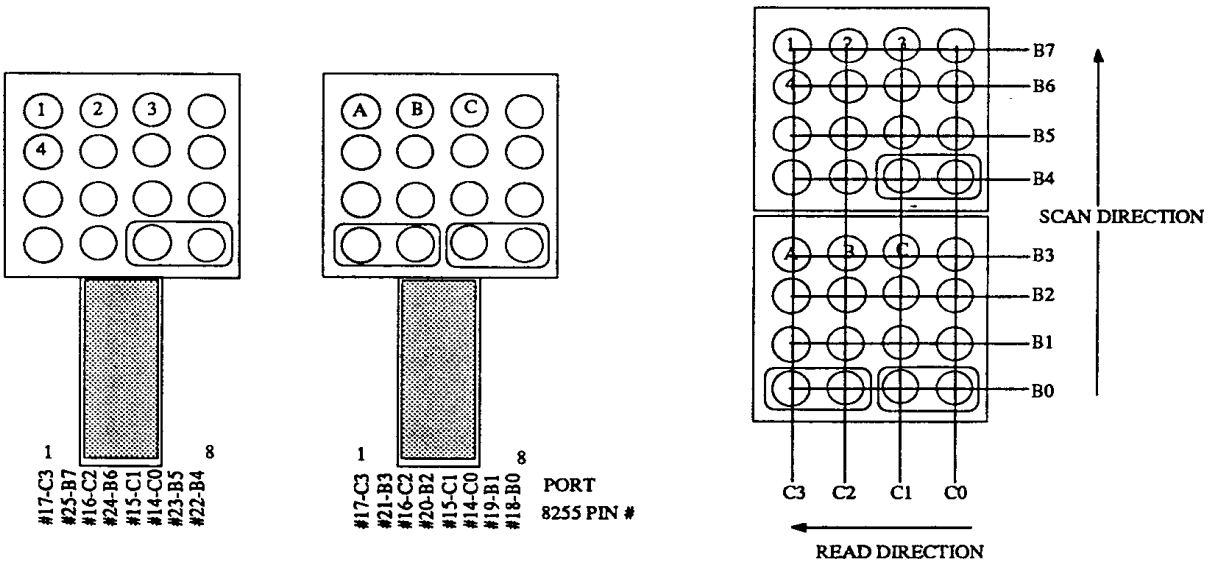
*1.2* A row or column of the keypad does not function.

Check that the keytails are properly inserted and covered to 1/4" from the end as discussed in section 5.1.1. If a row (horizontal) does not function, check that the low level on the appropriate line of Port B can be transmitted to the desired line of Port C. See the drawing below. It is highly unlikely that a component has failed. It is more likely that a plated through hole on the interface board has failed. Trace the circuit on the board, and replace if necessary.

*1.3* The keyboard does not function, and neither does the display.

The problem is probably the connection between the interface board and the main board. Make sure that the 26 pin cable is plugged in correctly on both ends.

## 2. Photometer Problems



*2.1* Lamp Low message is displayed

Check that the lamp is illuminated and is properly aligned. Select test #186, and the filter voltages will be displayed in the following order: 0=405nm, 1=450nm, 2=600nm, and 3=492nm. Make sure that all are greater than 2 volts. If a particular channel is low, the filter may be degrading. Replace if less than 1 volt. **Make sure the lamp is OK first.**

*2.2* Wheel does not rotate.

Check that the 10 conductor wire that goes from the main circuit board to the junction board is installed properly. If the filter wheel is running, but the filter wheel does not seem to be rotating, check the two rubber belts. If the motor is not turning then check that the motor has between +5 and +6 volts across the motor terminals. (Make sure that the reader is attempting to read a plate or running test 186) If there is no voltage on the motor, check for a high level on ULN2003, pins 1 and 2. Also check that the 7806 has +6 volts on its output terminal.

*2.3* Wheel runs at an uncontrolled rate.

Check that the wheel count pulse is being transmitted to the NMI pin of the Z80. It should be a narrow, negative spike. Also check that the wheel home pulse is arriving at the 8255 port, PC6 pin 11. If neither are present and the cables are installed correctly, check the IR LED pair on top of the photometer housing for 1.2 to 1.5 volts between the black and the white wire. +5 volts here indicates and open LED or unterminated return.

## 3. Mechanism Errors

The most commonly encountered problem with the Humareader series of plate readers is a mechanism error. This means that the microprocessor was unable to effect the desired movement or that after being moved the plate was determined to be in an incorrect position. Several aides are available to assist technical personnel in diagnosing and correcting this problem:

1) The location of the last mechanism error is recorded and can be recalled by running test #188.

2) On the main circuit board is a 7 segment LED display. Each segment shows the state of one of the opto switches. (Note: Only the outer four segments are used.) These LEDs can be used to determine the proper position of the plate.

3) Selecting test #187 allows the operator to single step through the plate by pressing the "enter" key.

*3.1* A Note on Mechanism Errors

When the display shows -"Mechanism error at PS-W" where PS-W indicates the first invalid plate, strip, and well respectively, the instrument is alerting the operator to difficulty getting to the proper location in the allotted time. This message is generally indicative of restriction in free movement or of failure of component(s) in the drive train. See also: the operators manual, section on mechanical control.

Although component failure is rare, mechanism failure or degradation is usually caused when parts come loose, or the shipping screw is not used when shipping the machine. Most failures can be readily fixed by doing in-the-field adjustments. Typical problem areas are pinion gears, spur gears, gear shafts, belt clamps or any part under stress when shipped.

To install the shipping screw, first move the carriage to the home position. When installing the screw make sure that it does not bend or put pressure on the lowere carriage bracket.

*3.2* The Pinion Gear

Problems occur when the pinion gear to motor shaft contact slips. Either the gear slips off the motor shaft or the motor shaft spins without turning the gear. This is usually noticed when the instrument is first turned on as a fast whirring noise is heard and mechanism movement on one axis is absent. If the fit of the pinion gear on either the X or Y motor shaft feels loose or can be readily pulled or slid with finger nail pressure from the motor shaft, thread the hole inside the pinion gear with a 2-56 tap and replace the gear by pushing on the shaft with finger pressure. As with all gears, whenever testing fit, removing, or replacing gears, do not touch gear teeth with any kind of tool, or damage to the teeth will occur resulting in gear meshing noise. If, especially after fitting new gears, a loud sawing sound appears to be coming from the pinion gear meshing with the combination gear, adjust the mesh by loosening the motor attachment screws and move the motor so the backlash gives the least amount of noise. A small gap between gears is desirable. Do not leave so small a gap that gear is slowed due to extra friction.

*3.3* The Drive Train

Problems occur when drive train backlash is excessive. Usually this occurs when either the pulley to gear contact or the belt to carriage contact is loose. Excessive backlash is usually noticed when grabbing the carriage with one hand while either applying medium pressure to move the carriage and holding the pinion gear stationary with the other hand or when applying light pressure, with spur gears which come loose on timing pulleys (#2-56 screws),

*3.4* The Belt Clamp

Problems with a belt clamp which comes loose (#4-40 1/4" screw and FW). Other problems occur when for example the shipping screw is left in or out at an inappropriate time, or the customer disassembles more than is necessary, or one part or another comes loose in shipment.

*3.5* Belt Tension

If there is a problem with belt tension, a loud popping noise may be heard when the mechanism reaches the normal end of its travel in either the X or the Y direction.

A-H belt: This belt is located at the rear and may be adjusted by loosening the (2) screws below the left idler pulley bracket. Adjust the tension by moving the bracket accordingly.

1-12 belt: Loosen the (2) screws holding the motor drive assembly and slide it according to the desired tension adjustment.

*3.6* Mechanism error "out of the box."

The Humareader's are shipped from the factory with a shipping screw to hold the plate transport mechanism during shipment. This screw, located on the bottom of the machine must be removed before using the reader. If the screw is still in place a mechanism error will be indicated by the message "MECHANISM ERROR AT ." Normally the message would indicate the well at which the error occurred. However, since the screw is blocking all motion, the message will be displayed without a location.

*3.7* Mechanism errors at the ends of plate.

If a mechanism error occurs repeatedly at well 12 or H, there is a good chance that the bearing race within a transport guide has moved such that it is obstructing the plate movement at its extremes. This problem is simply corrected. Note the "plate can't get home -- move plate left" is an indication of this condition.

The bearing race may be re-positioned without removing the cover by moving the plate frame manually through its range. For example, if well 12 cannot be read, move the plate frame toward the back of the machine until a resistance is felt, then push harder until the motion resumes. Continue pushing until a hard stop is felt. The race is now re-positioned. If well H cannot be read, perform this procedure by pushing the transport bed right until the resistance is felt. Alternately, the race may be moved by holding the plate frame and pushing the race back with a thin screwdriver.

*3.8* Randomly located mechanism errors

If mechanism errors occur at random locations on the plate, a more detailed analysis is required.

Remove the cover of the machine per the cover removal procedure in section I.5. Set the cover to one side or to the back leaving the cable to the interface board attached to the main PC board. Move the plate holder by hand through its range of motion. Feel for any mechanical resistance over the range. It is possible that a fastener has worked loose or that a wire is snagging at some place. Next, note the proper indication on the 7 segment LED. The function of each segment is shown in the margin.

Note: Earlier units have four discrete LEDs. They are read left to right as follows:

1) Y axis (1-12) well indicator Off=on well
2) Y axis (1-12) odd/even Well 1=on, 2 off etc
3) X axis (A-H) odd even well A=off,B=on etc
4) X axis (A-H) well indicator Off=on well

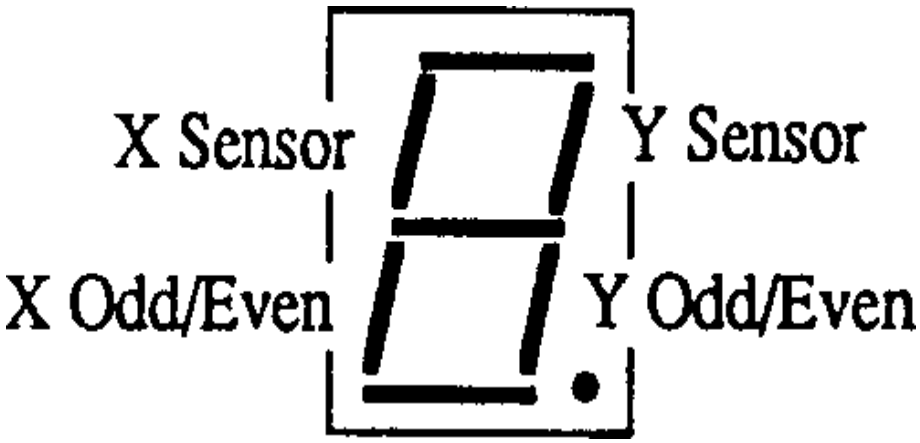
As the plate is moved, each LED should function accordingly. Failure of any LED to light/extinguish at the proper position will result in a mechanism error. Note: the well indicator is position sensitive and a slight overshoot will cause this indicator to light. This is normal. If any LED fails, check the connectors located at each sensor board. Pay careful attention to the insertion of the wires into the connectors. A wire that is not fully inserted (displaced) will cause a problem. Component failure is highly unlikely. Most of the time, the problem is a probably a faulty mechanical connection or mounting. Check that no sensor pair has been mechanically disturbed. Check the voltages at the connector on the main PC board. As the IR LEDs are connected in series (2 each), an open in the interconnect will result in lighted LEDs for either both odd/ detectors or both position detectors. The straight through (unobstructed) phot. transistor voltage should be less than 0.5 volts.

**4. Drive mechanism problems**

Check that the motor pinion gear has not worked off the shaft or along the shaft and disengaged from the 2nd stage gear. Press the pinion back on the shaft and if necessary spot with a small amount of thread locker or similar rapid bond adhesive. Take care to use a sparing amount such that it does not wick into the motor.

There is a possibility that overly tight belt tension will stall the drive. The belts should be modestly deflectable--if they pop on the return to home position they are too loose.

There have been a few cases where shipping the instrument without the shipping screw installed has resulted in the A-H drive pulley shaft mount (press fastener) pulling from the bracket. The shaft should extend straight from the bracket and not lean. If pulled loose, remove the assembly by loosening the 2 mounting screws through the base then remove the shaft. Using a vise, press the fastener back into place.



# VI. Alignment

## 1. A Note on Alignment

Critical to high end performance (>2.0 absorbance units) is the proper alignment of the plate transport system and photometer assembly. Any time the photometer assembly is moved, this alignment procedure must be performed. However, the mechanical alignment should not change once set.

## 2. Lamp and Lamp Assembly Alignment

The lamp should always be positioned to illuminate the lamp aperture and screen evenly. Further the body of the lamp must point straight down. Caution: The lamp may be hot. Do not allow it to contact the diffusion screen. (See the lamp replacement procedure.) If the lamp does not point vertically down, it may be aimed by grasping the lamp lightly with a pair of needle nose pliers and then bending the leads to achieve the desired orientation. It is also necessary that the lamp aperture be positioned directly over the photometer entrance aperture. If it is not evenly illuminating the lamp plate aperture, align it by loosening the lamp bracket screws moving the lamp bracket until even filling is achieved. Tighten the screws. A significant misalignment of any of these will deteriorate the > 2.0 abs performance. The lamp aperture plates have alignment holes, such that a rod (either .09 or .12 od) may be passed through the lamp aperture plate and into the photometer housing in order to check this alignment.

## 3. Plate Transport Alignment

Alignment of the plate transport system is accomplished by moving the photometer assembly so that the lamp beam/photometer entrance lies on a vertical line passing through the center of the well.

For the following steps it will be necessary to use the test plate available from Human GmbH or a modified standard plate. The plate must be altered to reduce the light passing through the wells to a small dot in the center of several wells. This may be achieved by inserting washers or using a marking pen to color the bottoms of the wells leaving only the centers open. Use the wells in the center of the plate for this alteration.

Insert the test plate or the modified regular plate into the plate holder frame. Place the unit in the single step mode by selecting test #187. If necessary then select the absorbance mode using any filters. Press the READ button. The instrument will than move the plate to read well A-1.

Advance the plate to the center of the plate by using the Enter key as required. When one of the occluded wells is parked at the photometer observe the illumination of the photometer entrance. The circle of light on the entrance should be centered. If not ,loosen the (3) photometer hold down screws (See fig. PLATE ALIGNMENT). Move the photometer such that the entrance is centered in the illumination. Tighten the screws. Move to the next well. Check and repeat.

## 4. Checking the Readings

As a final check on the alignment, prepare a Dri-Dye Check Strip or prepare a dilution of a material that reduces to approximately 2.0 abs.

Read the Dri-Dye as specified in the package insert. Compare the results to the expected values. Next turn the plate around, repeat the readings. They should agree to within +/- 1% +.005 abs. This must be especially true at the 2.0 abs end. Any significant deviations at the high ends indicates unacceptable alignment.

# Filter Replacement

Materials and equipment:

- Replacement filter set
- Phillips screw driver
- Flat blade screw driver
- Silicone adhesive

Procedure:

Materials / tools required:
Replacement filter with neutrals and wheel location drawing 1-Phillips screw driver
1 -small flat blade screw driver

Silicone glue

Step 1:
Disconnect the unit from the AC mains and detach the power cord. Remove the cover and unplug the cover cable per the instructions in the service manual. Set the cover out of the way.

Step 2:
Locate the photometer. Unplug the 4 pin lamp and motor cable from the interconnect printed circuit board (PCB). Using the fiat blade screw driver, unplug the grey cable from the interconnect PCB.

Step 3:
This is an important step. Locate the (3) red stand-offs retaining the photometer to the chassis base. From the bottom of the unit, remove the (3) 6-32 screws securing the photometer to the chassis. Remove tile photometer assembly with the red spacers attached. Note: Do not remove the spacers from the photometer. Removing or altering their position on the photometer will require the unit be re-aligned per the procedure in the service manual. Do not move the lamp or the lamp bracket.

Step 4:
Remove the (4) 6-32 screws retaining the photometer cover. Set the cover aside. Remove the (2)4-40 screws securing the photometer PCB. Remove the drive belt from the filter wheel. Using the blade screwdriver, remove loosen the filter wheel shaft. Remove the wheel. Remove the shaft taking care not to misplace the nylon spacer/washers.

Step 5:
Referring to the filter position drawing, locate the filter to be removed. The filter may be pushed from the wheel using the eraser end of a pencil or other blunt object. Remove any neutral or screen disks that may remain in the filter cavity within the wheel. Locate the neutral filters and/ or screens that were included with the replacement filter and drop them first into the cavity. Now insert the filter with the mirror side down. Using the smallest amount of silicone glue, place (2) dabs on either side of the filter to prevent it from working loose. Do not block the centre of the filter.

Step 6:
Re-install the filter wheel on the bracket taking care not to pinch any washer under the shaft. Tighten tile shaft. Replace the belt. Replace the photometer PCB taking care to centre the board around the shaft. Tighten the (2) 4-40 screws. Replace the optical cover taking care to position the grey cable in the slot of the cover. Do not pinch the cable under the cover. Insert the (4) 6-32 screws and snug up. Do not over tighten.

Step 7.
Install the photometer assembly to the chassis by replacing the (3) 6-32 screws through the base. Insert the (2) cables removed in step ~ 2.

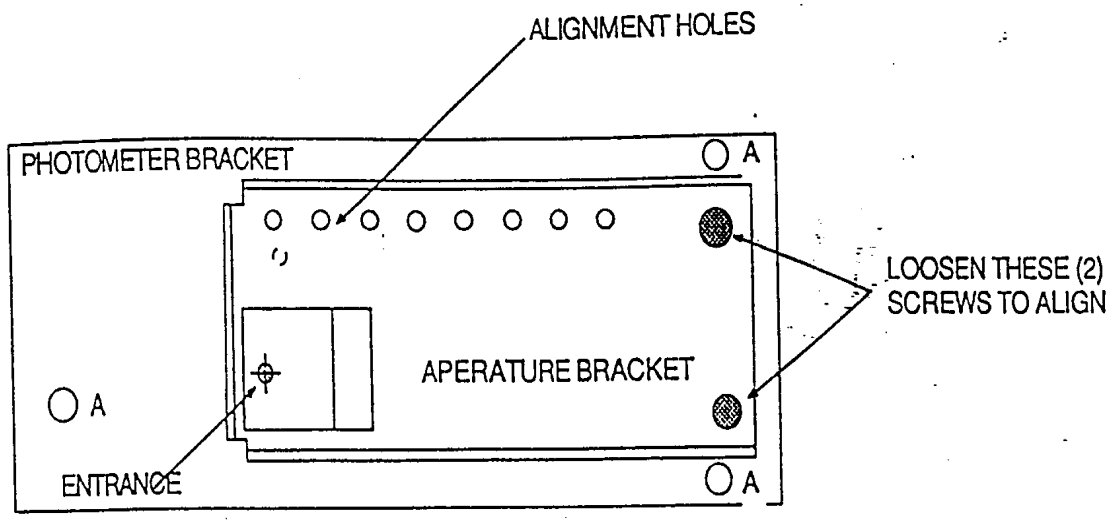
Step 8:
Check that the lamp hangs vertically down and is aimed at the screen and aperture. This step is only required if the lamp was disturbed during the above Operations. If necessary refer to the lamp alignment procedure in the Service manual.

Step 9:
plug the cover cable back into the main PCB. Replace the cover but do not install the cover screws. If an updated EPROM was included with the filter replacement kit, install it now referring to the EPROM replacement sheet.

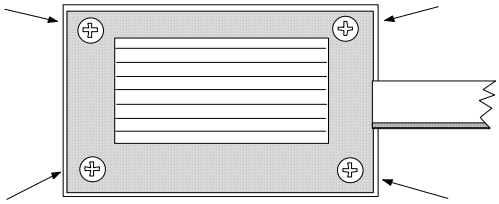
Step 10:
Attach the power cord and connect the unit to the mains supply. Turn the unit on. Select Test ~ 186. The displayed numbers represent the voltages of the installed filters. All voltages should be between 2 and 11 volts. To terminate this mode, press Clear as required.

Step 11:
Detach the unit from the mains supply. Replace the (5) cover screws.

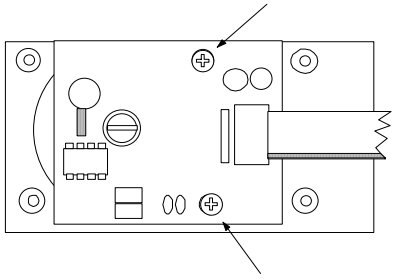
LAMP APERATURE PLATE ALIGNMENT.



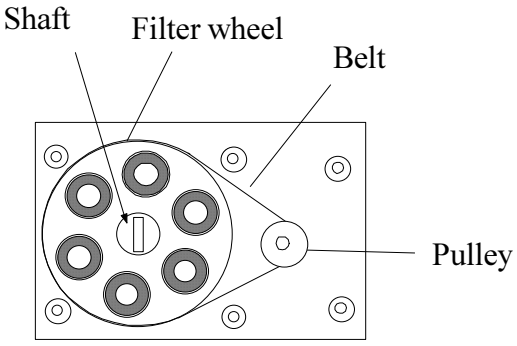

THE LAMP APERATURE HOLE DIRECTLY BELOW THE LAMP MUST LIE DIREOTLY ABOVE THE PHOTOMETER ENTRANCE APERATURE. THIS ENTRANCE SHOULD BE UNI FORMLY AND SYMETRICALLY ILLUMINATED.
ALIGNMENT HOLES IN THE APERATURE BRACKET WITH CORRESPONDING HOLES IN THE PHOTOMETER BRACKET MAY BE USED TO EFFECT THIS ALIGNMENT.
INSERT A .093" RGD THRU THE ALIGNMENT HOLES INTO THE PHOTOMETER BRACKET HOLES AND ASSURE THAT THE ROD STANDS VERTICALLY UP.



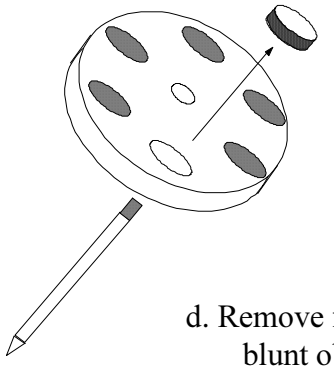
a. Remove screws holding photometer cover.



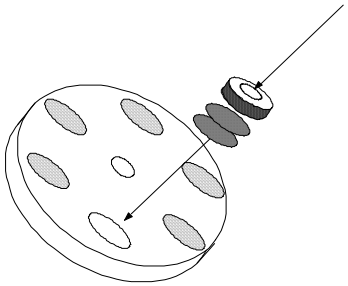
b. Remove screws holding photometer PCB.




c. Remove filter wheel belt and filter wheel.

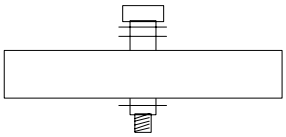


d. Remove filter with blunt object.



e. Install neutral density filters, dot screens, and interference filters.

One or two nylon washers as disassembled.



One nylon washer

f. Assemble washers and filter wheel to filter wheel shaft.

*Figure 12. Filter Replacement*

# Lamp Replacement

The lamp should be replaced only if it fails to light, or several filter voltages are reported as low.

Materials and equipment:

- Replacement lamp
- Phillips screw driver
- Flat blade screw driver

Procedure:

1. Set the power switch to OFF (O). Open the instrument. Refer to Figure 3, Chassis Layout. Locate the strip mechanism and the lamp bracket.

   **CAUTION**

   **Lamp is HOT. Allow the lamp to cool before handling.**

3. Refer to Figure 10, Lamp Replacement. Loosen but do not remove the lamp terminal screws. Do not loosen or remove any other screws. Remove the lamp by lowering it out of the connector.

4. Use a pair of pliers or tweezers to handle the new lamp. Avoid handling with bare skin, since the oil from your skin can reduce lamp life. Insert the lamp leads into the connector until they bottom out. The lamp lens end must be centered on the aperture and the lamp body must be perpendicular to the horizontal. While holding the lamp in alignment, tighten the lamp terminal screws.

5. Set the power switch to ON. Shield your eyes from the lamp beam and observe the projection of the beam onto the aperture. Refer to Figure 11, Spot Alignment. The spot should be small and centered on the aperture. The spot should be sufficiently large to just encircle the aperture. If the spot is not centered, repeat step 4.

6. Select test #186. The instrument prints the detected voltage for each filter position. All voltages should be between 2.00 volts and 10.00 volts. If all the voltages report low, repeat step 4 until optimum lamp position is obtained.

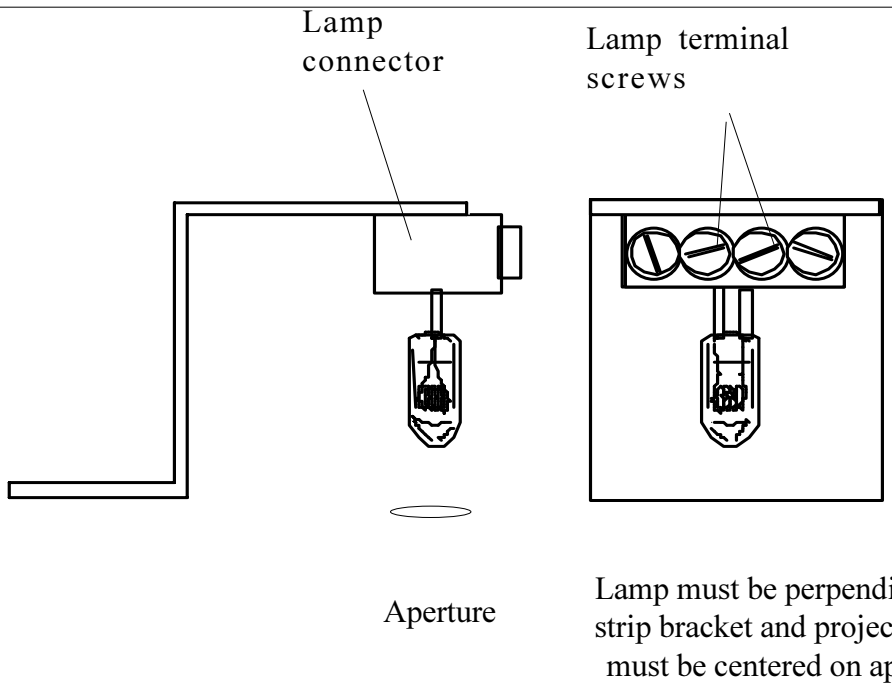



*Figure 10. Lamp Replacement*

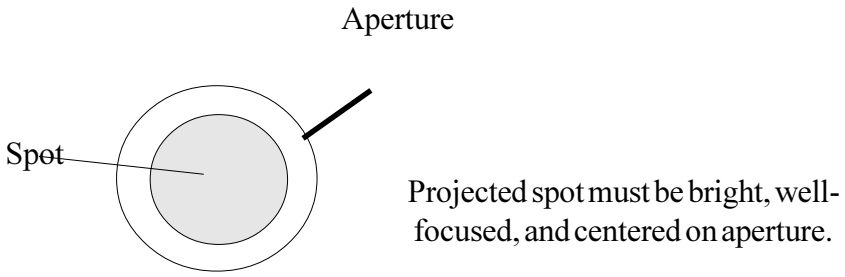



*Figure 11. Spot Alignment*

# Filter Label

The filter label located on the photometer cover describes the specific filter wheel configuration for your particular instrument. Refer to Figure 14.

Filter wheel position (POS) is the physical placement of the filter on the wheel. The filter wheel position numbers are shown in Figure 13. Note the position of the Index hole and the Home hole.

Each filter position can have several filter elements installed. Configuration (WAVELENGTH column) describes the various screens and filters in that position . Each element is separated by a slash (/). The first 3 digit value in this column is always the wavelength of the interference filter, in nanometers. The other values indicate either dot screens, neutral density filters, or transmittance filters. A "D" suffix indicates a dot screen and the first two digits are the percent blockage. A 2 digit value followed by a percent sign signifies a dot screen. A 3 digit value (other than the first value in the line) indicates one or more transmittance filters. The first digit is the quantity; the last two digits are the percent transmittance. A 2 digit value separated by a decimal point indicates a neutral density filter. The value is the absolute absorbance of the filter. "BLOCKED" indicates an opaque disk is installed in that position.

LOT# is the interference filter manufacturers' production code lot number or date. The percent transmittance for the lot is included in this column.

The production date (DATE) is the date the filter wheel was assembled.

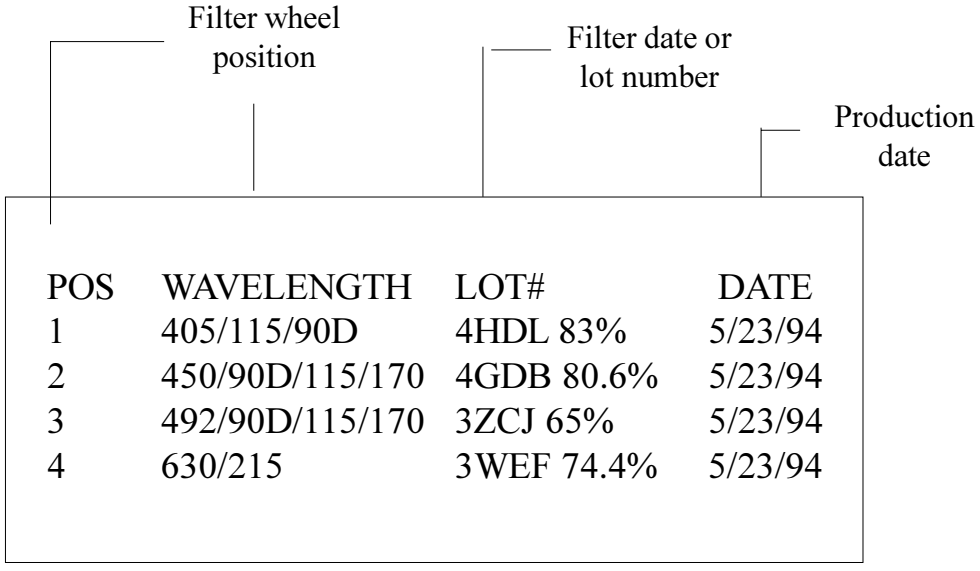
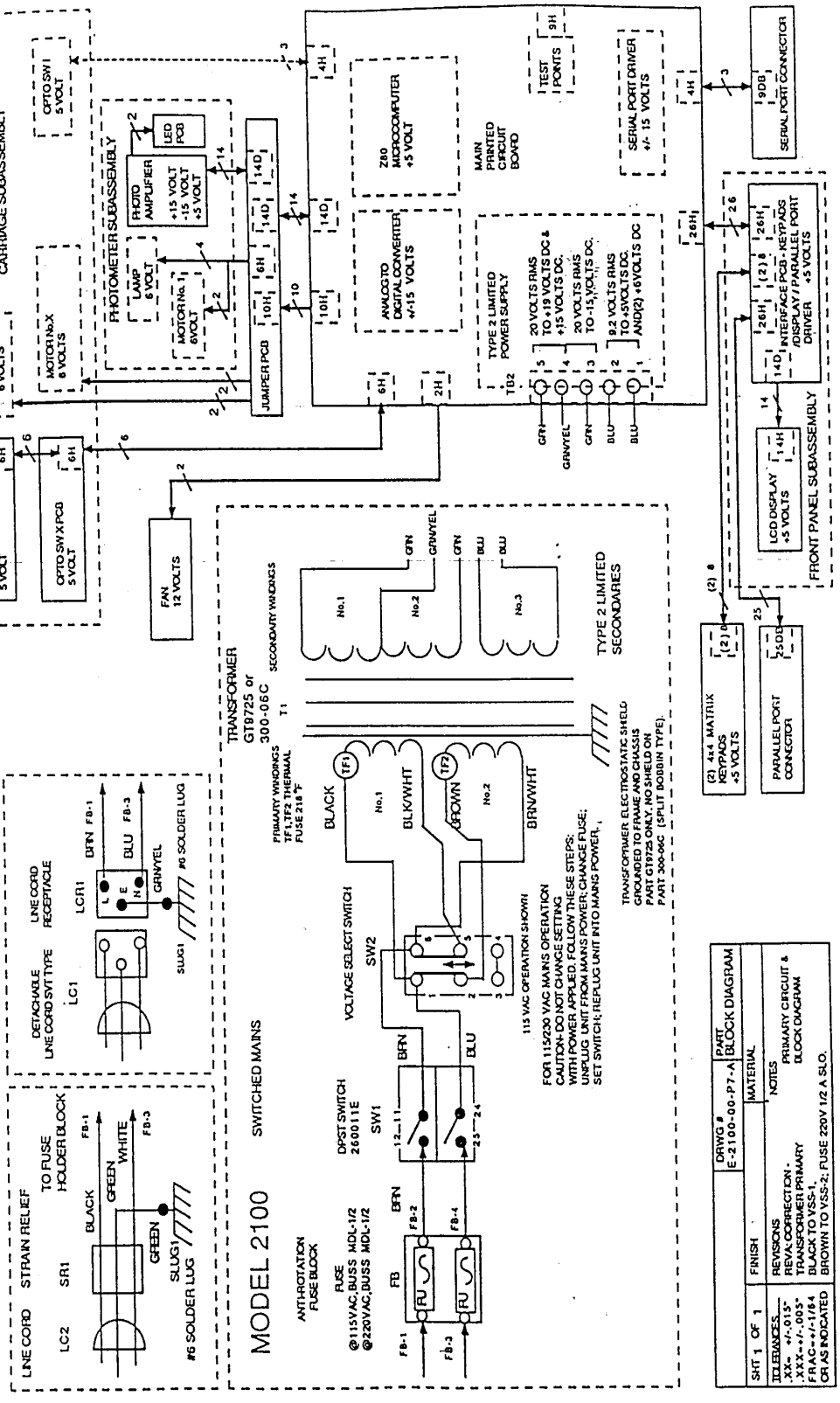
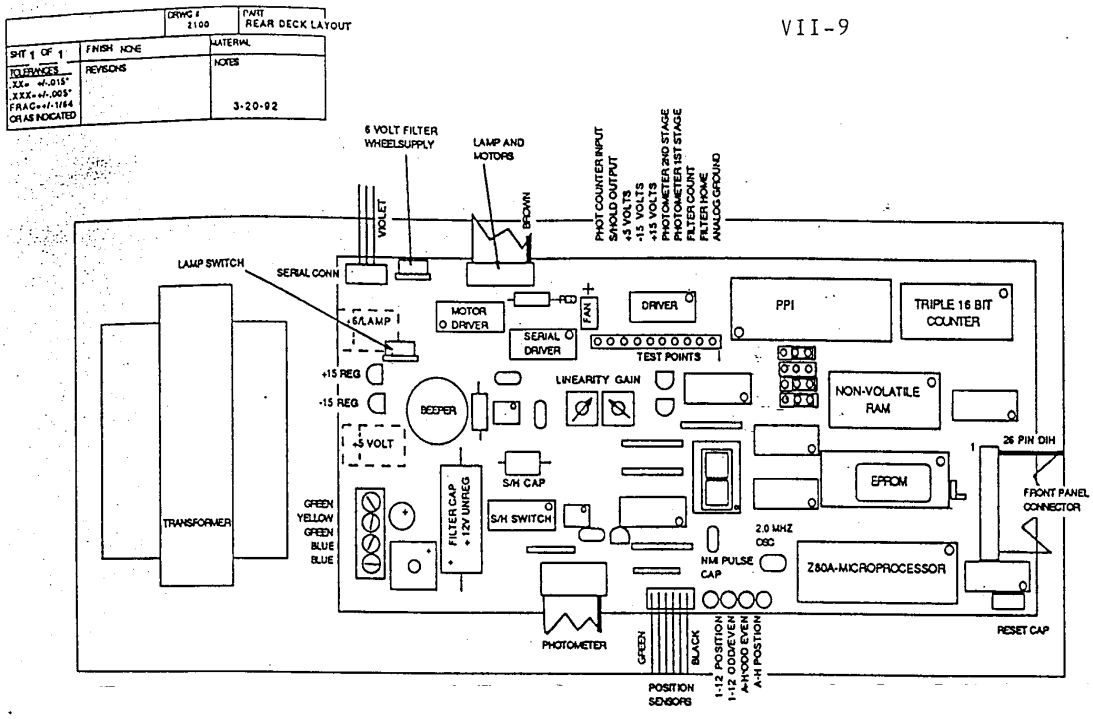
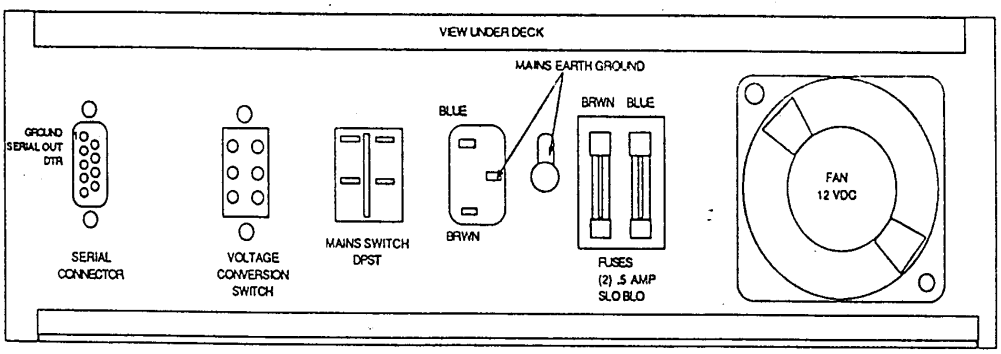
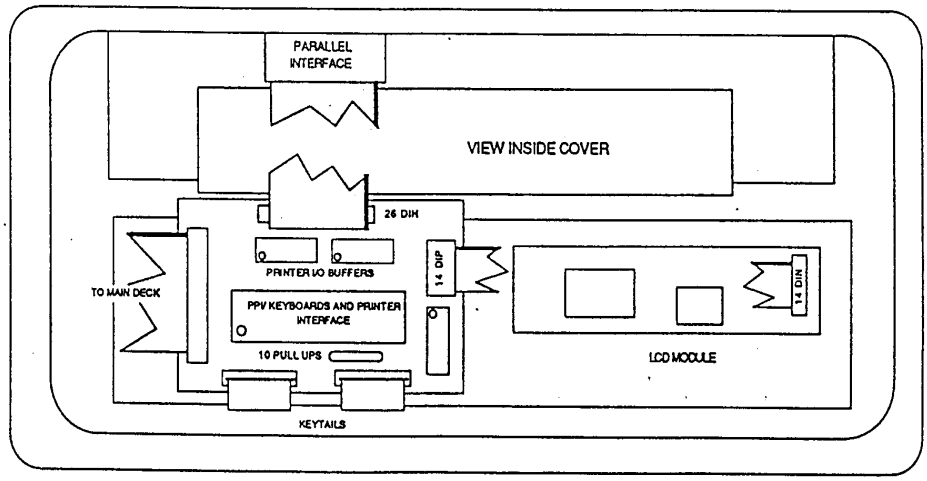


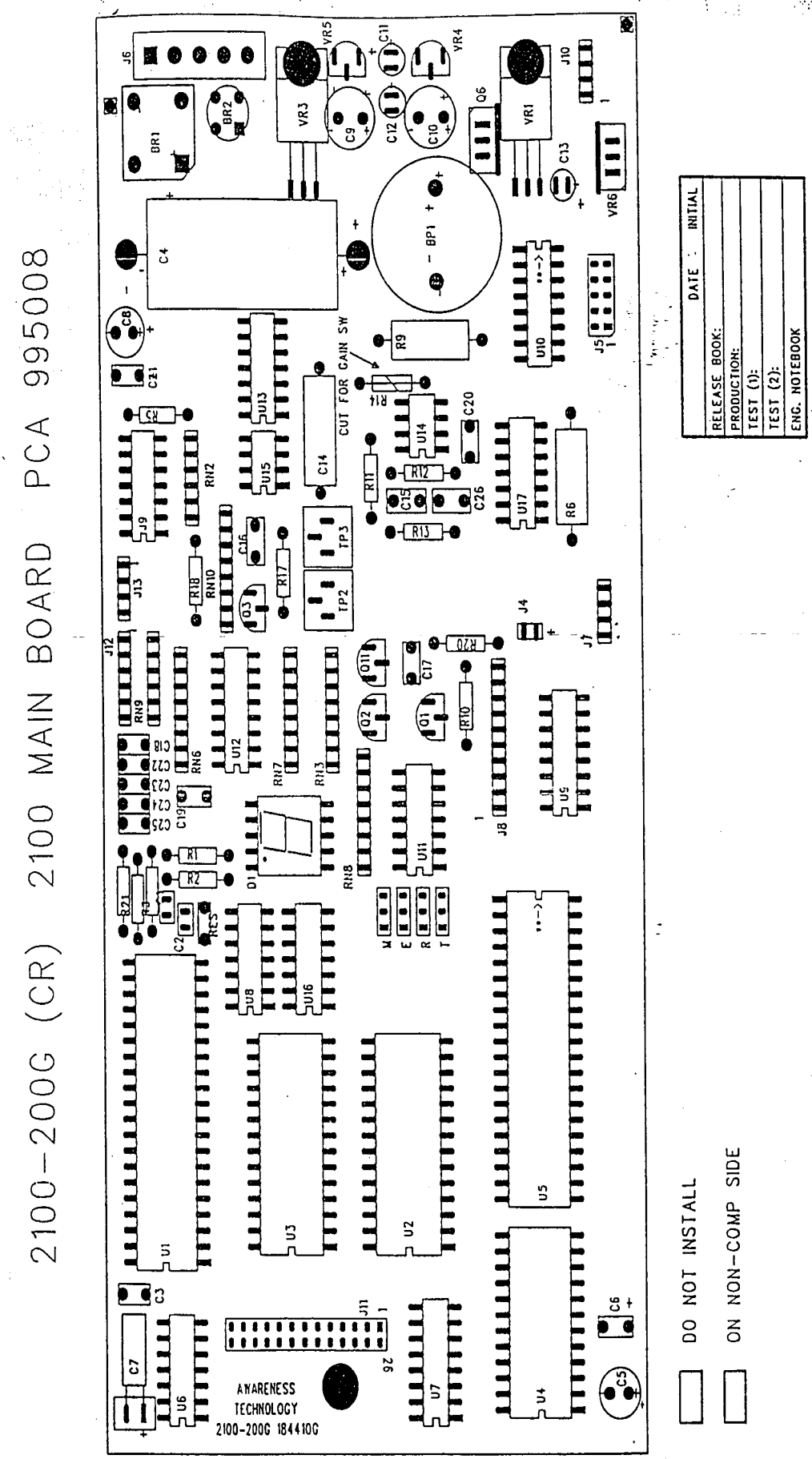

*Figure 14. Filter Label*

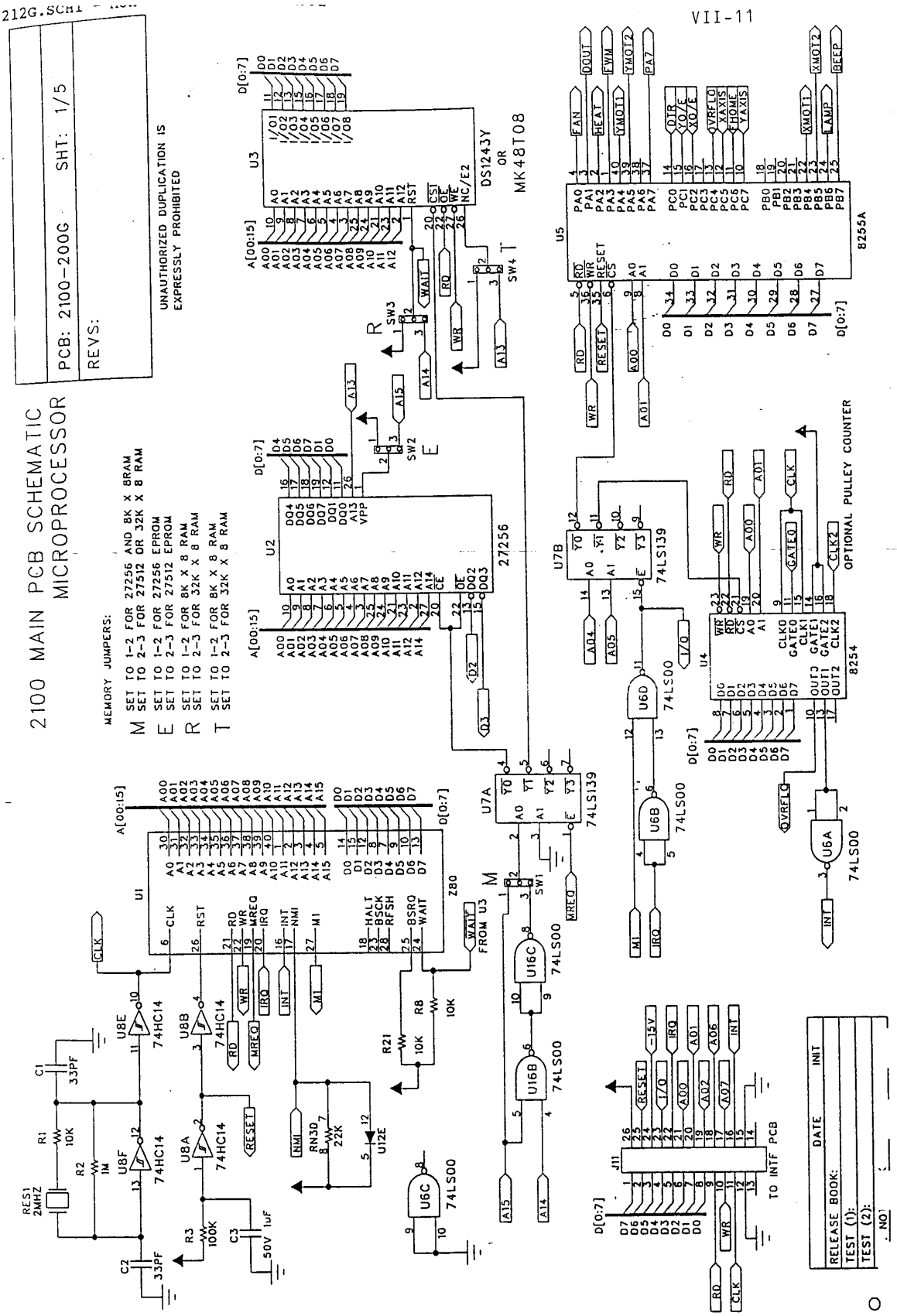

MODEL 2100
SWITCHED MAINS
CARRIAGE SUBASSEMBLY
MOTOR NoY 6 VOLTS
MOTOR NoX 6 VOLTS
OPTO SW I 5 VOLT
PHOTOMETER SUBASSEMBLY
LAMP 6 VOLT
MOTOR No. 1 6 VOLT
PHOTO AMPLIFIER
+15 VOLT -15 VOLT +5 VOLT
LED PCB
OPTO SW Y PCB 5 VOLT
OPTO SW X PCB 5 VOLT
JUMPER PCB
FAN 12 VOLTS
ANALOG TO DIGITAL CONVERTER +/-15 VOLTS
Z80 MICROCOMPUTER +5 VOLT
MAIN PRINTED CIRCUIT BOARD
TYPE 2 LIMITED POWER SUPPLY
TB2
20 VOLTS RMS TO +19 VOLTS DC & +15 VOLTS DC
20 VOLTS RMS TO -15 VOLTS DC
9.2 VOLTS RMS TO +5VOLTS DC AND(2) +6VOLTS DC
TEST POINTS
SERIAL PORT DRIVER +/- 15 VOLTS
9DB
SERIAL PORT CONNECTOR
FRONT PANEL SUBASSEMBLY
INTERFACE PCB - KEYPADS /DISPLAY / PARALLEL PORT DRIVER +5 VOLTS
LCD DISPLAY +5 VOLTS
(2) 4x4 MATRIX KEYPADS +5 VOLTS
PARALLEL PORT CONNECTOR
25DB
TRANSFORMER GT9725 or 300-06C
PRIMARY WINDINGS TF1,TF2 THERMAL FUSE 216°F
SECONDARY WINDINGS T1
No.1
No.2
No.3
TYPE 2 LIMITED SECONDARIES
TRANSFORMER ELECTROSTATIC SHIELD GROUNDED TO FRAME AND CHASSIS PART GT9725 ONLY, NO SHIELD ON PART 300-06C (SPLIT BOBBIN TYPE).
VOLTAGE SELECT SWITCH
SW2
115 VAC OPERATION SHOWN
FOR 115/230 VAC MAINS OPERATION
CAUTION- DO NOT CHANGE SETTING WITH POWER APPLIED. FOLLOW THESE STEPS:
UNPLUG UNIT FROM MAINS POWER; CHANGE FUSE;
SET SWITCH; REPLUG UNIT INTO MAINS POWER.
DPST SWITCH 260011E
SW1
ANTI-ROTATION FUSE BLOCK
FUSE
@115VAC,BUSS MDL-1/2
@220VAC,BUSS MDL-1/2
FB
LINE CORD
STRAIN RELIEF
TO FUSE HOLDER BLOCK
SR1
LC2
SLUG1
#6 SOLDER LUG
DETACHABLE LINE CORD SVT TYPE
LINE CORD RECEPTACLE
LC1
SLUG2
#6 SOLDER LUG
BLACK
GREEN
WHITE
BRN
BLU
GRN/YEL
BLK/WHT
BRN/WHT
GRN
BLU
DRWG # E-2100-00-P7-A
PART BLOCK DIAGRAM
MATERIAL
FINISH
SHT 1 OF 1
NOTES
PRIMARY CIRCUIT & BLOCK DIAGRAM
REVISIONS
REV A: CORRECTION - TRANSFORMER PRIMARY BLACK TO VSS-1, BROWN TO VSS-2; FUSE 220V 1/2 A SLO.
TOLERANCES
.XX= +/-.015"
.XXX=+/-.005"
FRAC=+/-1/64
OR AS INDICATED

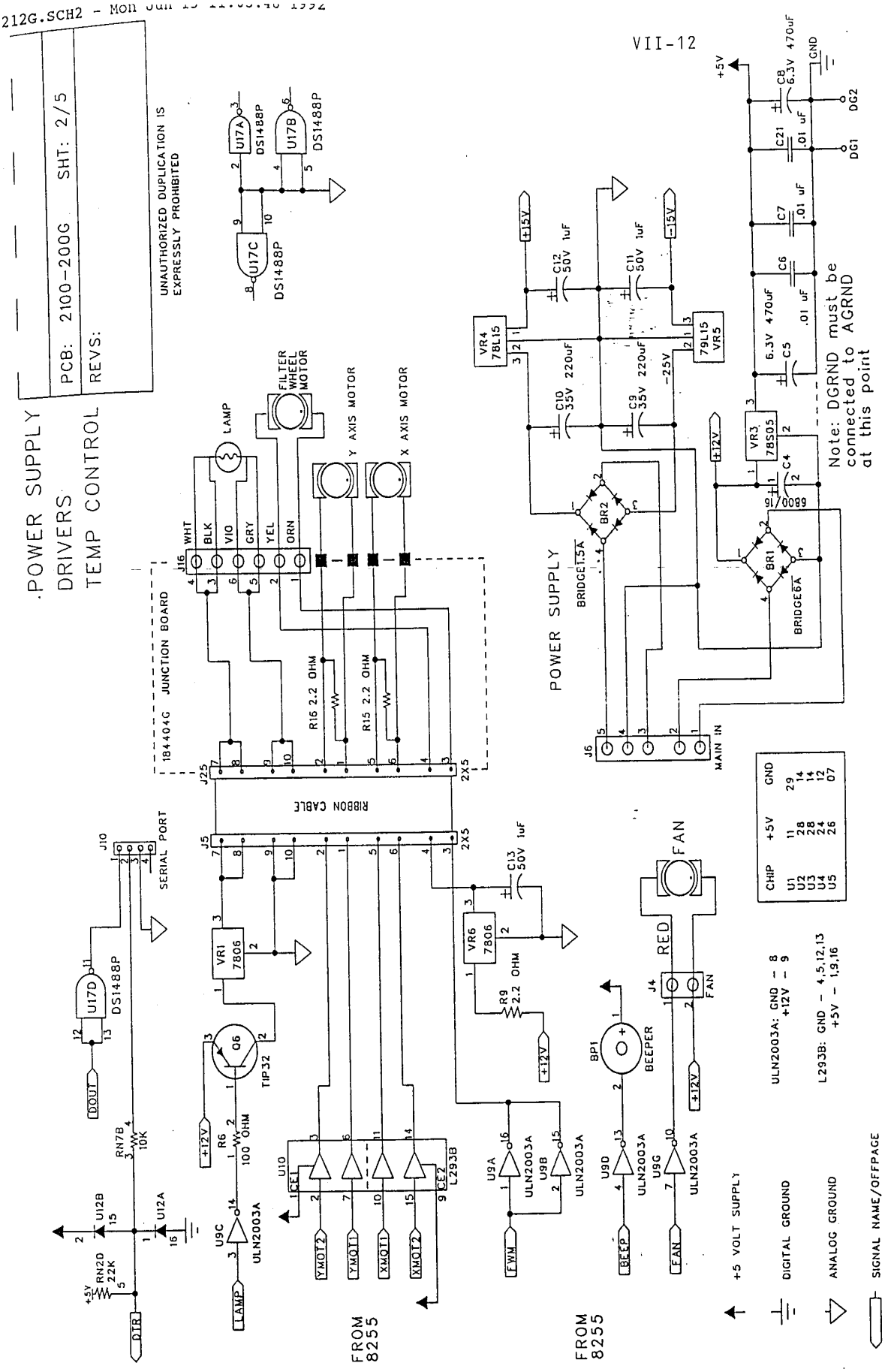

DRWG # 2100
PART REAR DECK LAYOUT
SHT 1 OF 1
FINISH NONE
MATERIAL
TOLERANCES .XX= +/-.015" .XXX=+/-.005" FRAC=+/-1/64 OR AS INDICATED
REVISIONS
NOTES
3-20-92
6 VOLT FILTER WHEELSUPPLY
LAMP AND MOTORS
VIOLET
BROWN
PHOT COUNTER INPUT
S/HOLD OUTPUT
+5 VOLTS
-15 VOLTS
+15 VOLTS
PHOTOMETER 2ND STAGE
PHOTOMETER 1ST STAGE
FILTER COUNT
FILTER HOME
ANALOG GROUND
LAMP SWITCH
SERIAL CONN
+6/LAMP
MOTOR DRIVER
SERIAL DRIVER
FAN
DRIVER
PPI
TRIPLE 16 BIT COUNTER
TEST POINTS
+15 REG
-15 REG
+5 VOLT
BEEPER
LINEARITY GAIN
NON-VOLATILE RAM
26 PIN DIH
EPROM
FRONT PANEL CONNECTOR
TRANSFORMER
GREEN
YELLOW
GREEN
BLUE
BLUE
FILTER CAP +12V UNREG
S/H CAP
S/H SWITCH
2.0 MHZ OSC
NMI PULSE CAP
Z80A-MICROPROCESSOR
PHOTOMETER
GREEN
BLACK
1-12 POSITION
1-12 ODD/EVEN
A-H ODD EVEN
A-H POSITION
POSITION SENSORS
RESET CAP

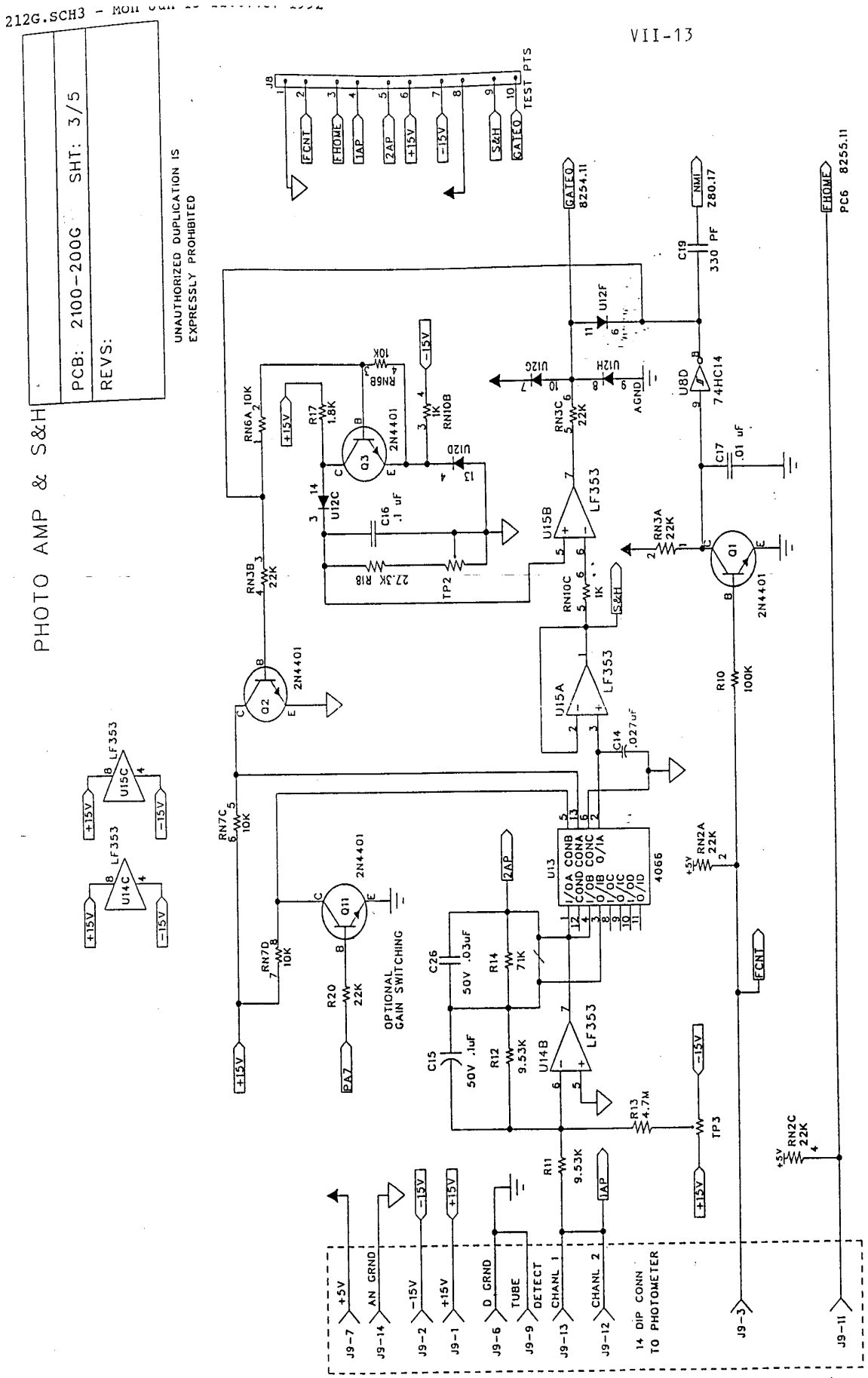

VIEW UNDER DECK
MAINS EARTH GROUND
GROUND
SERIAL OUT
DTR
BLUE
BRWN BLUE
FAN
12 VDC
SERIAL CONNECTOR
VOLTAGE CONVERSION SWITCH
MAINS SWITCH DPST
BRWN
FUSES
(2) .5 AMP
SLO BLO

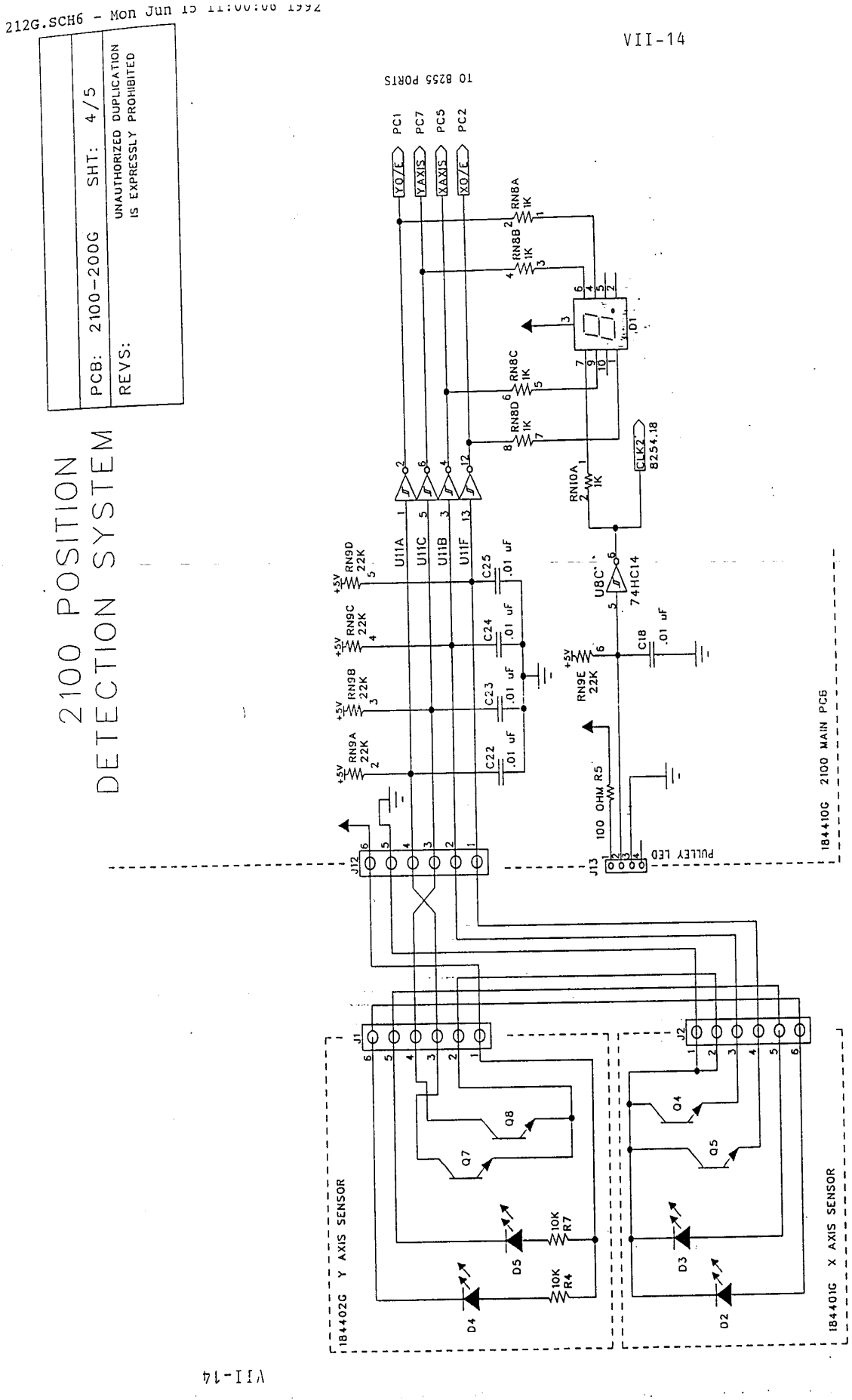

PARALLEL INTERFACE
VIEW INSIDE COVER
26 DIH
PRINTER I/O BUFFERS
14 DIP
14 DIN
TO MAIN DECK
PPI KEYBOARDS AND PRINTER INTERFACE
10 PULL UPS
LCD MODULE
KEYTAILS

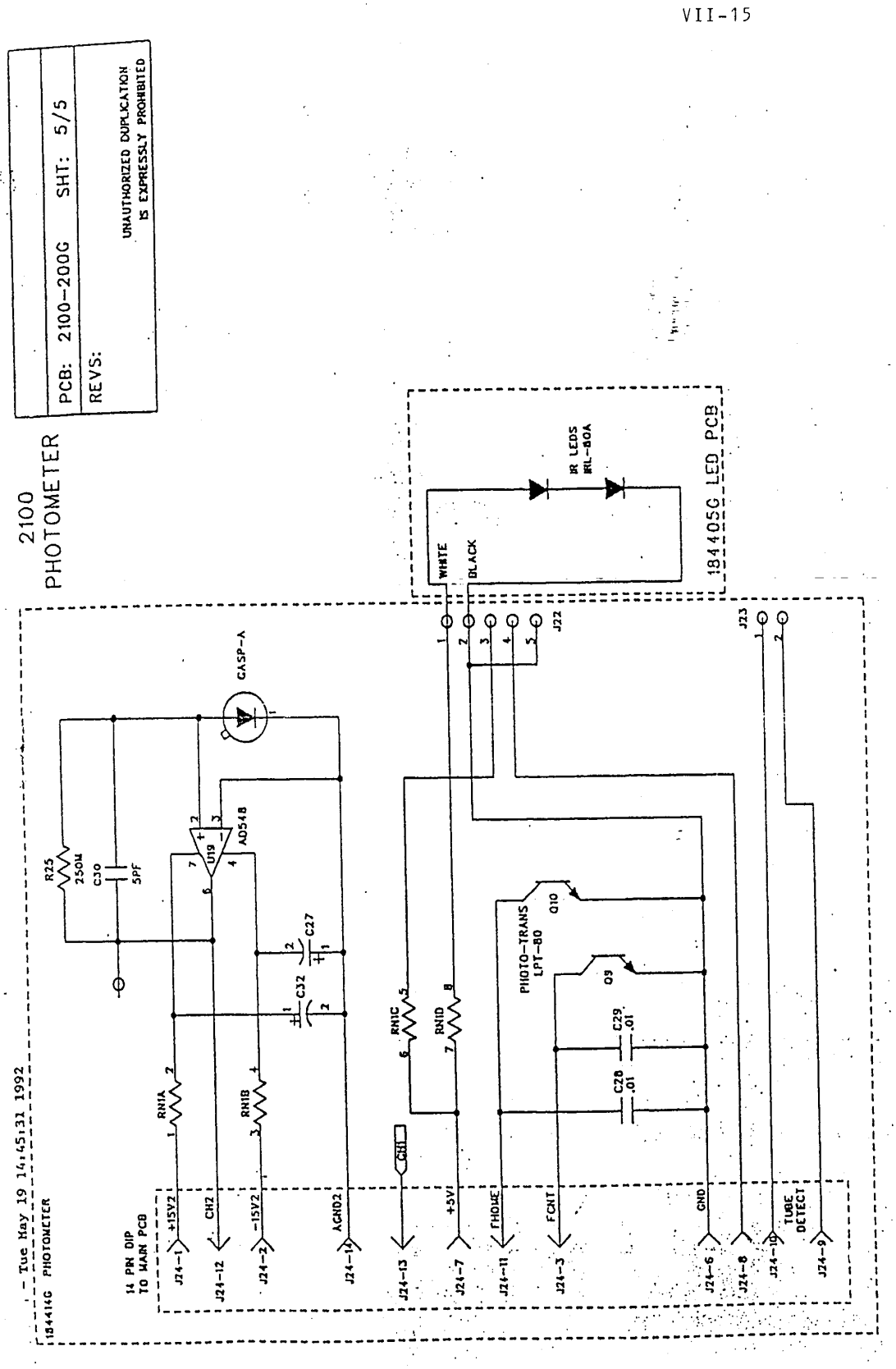

2100-200G (CR) 2100 MAIN BOARD PCA 995008
DATE : INITIAL
RELEASE BOOK:
PRODUCTION:
TEST (1):
TEST (2):
ENG. NOTEBOOK
DO NOT INSTALL
ON NON-COMP SIDE
CUT FOR GAIN SW
AWARENESS TECHNOLOGY
2100-200G 184410G

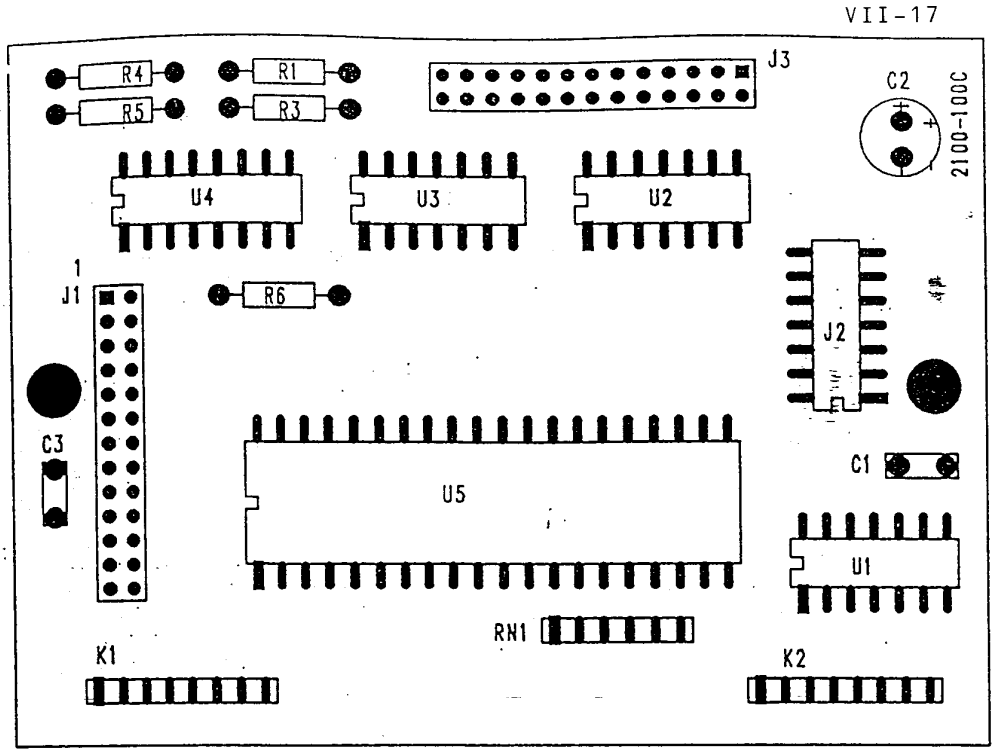

212G.SCH1
PCB: 2100-200G SHT: 1/5
REVS:
UNAUTHORIZED DUPLICATION IS EXPRESSLY PROHIBITED
2100 MAIN PCB SCHEMATIC
MICROPROCESSOR
VII-11
MEMORY JUMPERS:
M SET TO 1-2 FOR 27256 AND 8K X 8RAM
SET TO 2-3 FOR 27512 OR 32K X 8 RAM
E SET TO 1-2 FOR 27256 EPROM
SET TO 2-3 FOR 27512 EPROM
R SET TO 1-2 FOR 8K X 8 RAM
SET TO 2-3 FOR 32K X 8 RAM
T SET TO 1-2 FOR 8K X 8 RAM
SET TO 2-3 FOR 32K X 8 RAM
DS1243Y
OR
MK48T08
27256
74HC14
74LS00
74LS139
8254
8255A
OPTIONAL PULLEY COUNTER
TO INTF PCB
RELEASE BOOK:
TEST (1):
TEST (2):
NO:
DATE
INT


212G.SCH2
VII-12
POWER SUPPLY
DRIVERS
TEMP CONTROL
PCB: 2100-200G SHT: 2/5
REVS:
UNAUTHORIZED DUPLICATION IS EXPRESSLY PROHIBITED
184404G JUNCTION BOARD
RIBBON CABLE
SERIAL PORT
FILTER WHEEL MOTOR
LAMP
Y AXIS MOTOR
X AXIS MOTOR
FAN
BEEPER
POWER SUPPLY
BRIDGE1.5A
BRIDGE6A
MAIN IN
Note: DGRND must be connected to AGRND at this point
FROM 8255
FROM 8255
ULN2003A: GND - 8 +12V - 9
L293B: GND - 4,5,12,13 +5V - 1,9,16
+5 VOLT SUPPLY
DIGITAL GROUND
ANALOG GROUND
SIGNAL NAME/OFFPAGE


212G.SCH3
PCB: 2100-200G SHT: 3/5
REVS:
UNAUTHORIZED DUPLICATION IS EXPRESSLY PROHIBITED
PHOTO AMP & S&H
VII-13
TEST PTS
FCNT
FHOME
1AP
2AP
+15V
-15V
S&H
GATE0
GATE0 8254.11
NMI
NMI Z80.17
FHOME
PC6 8255.11
C19 330 PF
U12F
U12G
U12H
U8D 74HC14
AGND
C17 .01 uF
RN6A 10K
RN6B 10K
R17 1.8K
Q3 2N4401
RN10B 1K
U12D
U12C
C16 .1 uF
27.3K R18
TP2
RN3C 22K
U15B LF353
RN3A 22K
Q1 2N4401
RN3B 22K
Q2 2N4401
RN10C 1K
U15A LF353
R10 100K
C14 .027uF
U15C LF353
U14C LF353
RN7C 10K
RN7D 10K
Q11 2N4401
R20 22K
OPTIONAL GAIN SWITCHING
PA7
U13 4066
I/OA COND CONA I/OB CONC O/1A O/IB O/IC O/ID I/OD
C26 50V .03uF
R14 71K
C15 50V .1uF
R12 9.53K
U14B LF353
R13 4.7M
TP3
R11 9.53K
RN2A 22K
RN2C 22K
+5V
J8
J9-7 +5V
J9-14 AN GRND
J9-2 -15V
J9-1 +15V
J9-6 D GRND
J9-9 TUBE DETECT
J9-13 CHANL 1
J9-12 CHANL 2
14 DIP CONN TO PHOTOMETER
J9-3
J9-11


212G.SCH6 - Mon Jun 15 11:00:06 1992
VII-14
TO 8255 PORTS
PC1
PC7
PC5
PC2
XO/E
XAXIS
XAXIS
XO/E
RN8A 1K
RN8B 1K
RN8C 1K
RN8D 1K
RN10A 1K
CLK2 8254.18
U11A
U11C
U11B
U11F
U8C
74HC14
RN9D 22K
RN9C 22K
RN9B 22K
RN9A 22K
RN9E 22K
C25 .01 uF
C24 .01 uF
C23 .01 uF
C22 .01 uF
C18 .01 uF
+5V
100 OHM R5
PULLEY LED
J12
J13
J1
J2
Q8
Q7
Q4
Q5
10K R7
10K R4
D5
D4
D3
D2
PCB: 2100-200G SHT: 4/5
REVS:
UNAUTHORIZED DUPLICATION IS EXPRESSLY PROHIBITED
2100 POSITION DETECTION SYSTEM
184410G 2100 MAIN PCB
184402G Y AXIS SENSOR
184401G X AXIS SENSOR
VII-14

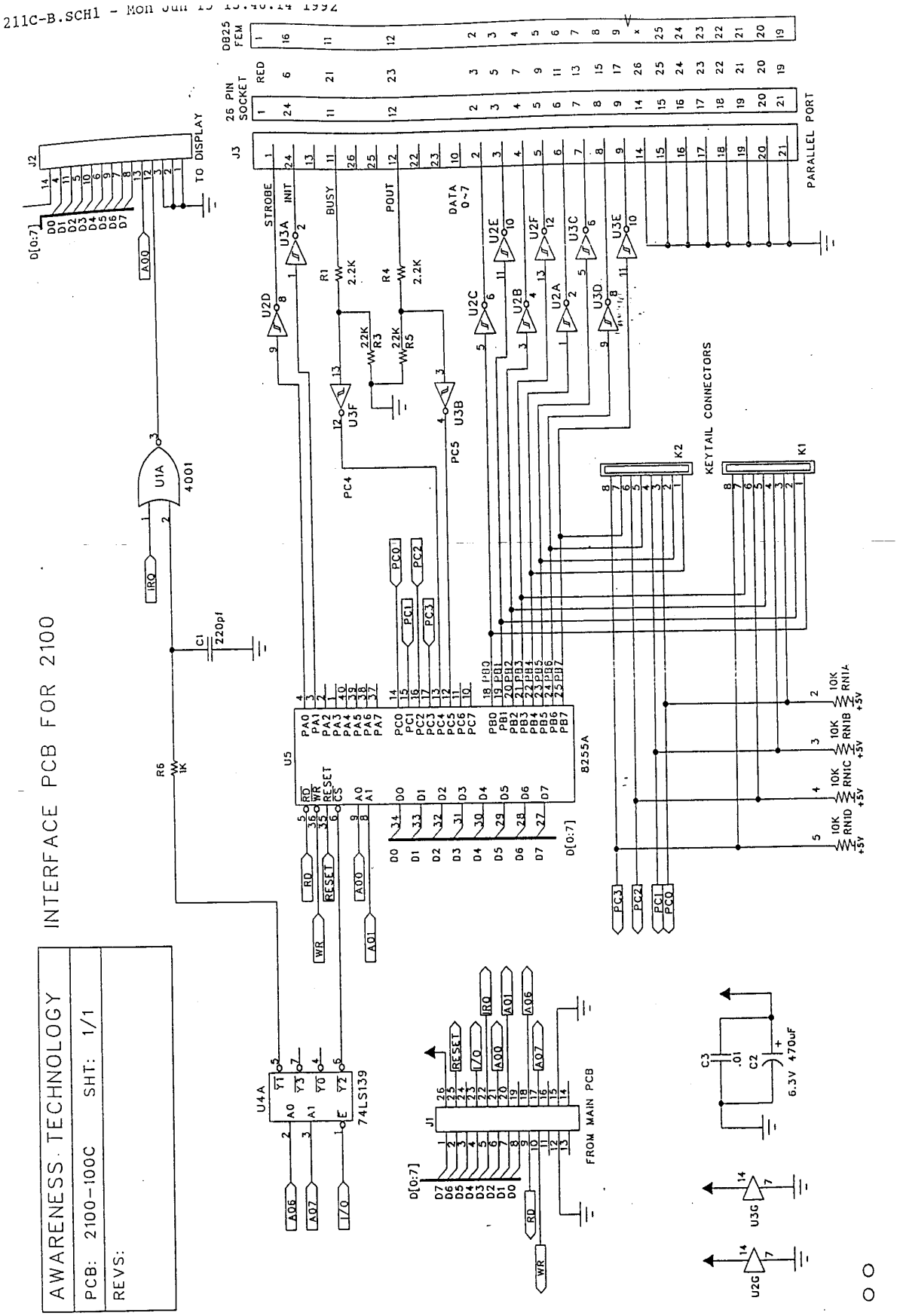

2100
PHOTOMETER
PCB: 2100-200G SHT: 5/5
REVS:
UNAUTHORIZED DUPLICATION
IS EXPRESSLY PROHIBITED
1844056 LED PCB
IR LEDS
IRL-80A
WHITE
BLACK
J22
J23
GASP-A
R25
250M
C30
5PF
U19
AD548
C27
C32
RN1A
RN1B
RN1C
RN1D
PHOTO-TRANS
LPT-80
Q10
Q9
C29
.01
C28
.01
CH1
14 PIN DIP
TO MAIN PCB
J24-1 +15V2
J24-12 CH2
J24-2 -15V2
J24-14 AGND2
J24-13
J24-7 +5V1
J24-11 THOUT
J24-3 FCNT
J24-6 GND
J24-8
J24-10
J24-9 TUBE DETECT
1844146 PHOTOMETER
Tue May 19 14:45:31 1992




# 2100-100C, INTERFACE PCB

PARTS LIST REPORT -- 211C-CR.job -- Sat Feb 09 10:12:33 1991

| Ref Des. | Desc. |
|---|---|
| C1 | 220pf CAP |
| C2 | 470pf, 6.3V CAP |
| C3 | .01pf CAP |
| J1 | 2-ROW, 26 PIN HEADER |
| J2 | 14 PIN DIP SOCKET |
| J3 | 2-ROW, 26 PIN HEADER |
| K1 | KEYTAIL CONNECTOR |
| K2 | KEYTAIL CONNECTOR |
| R1 | 2.2K 1/4W |
| R3 | 22K 1/4W |
| R4 | 2.2K 1/4W |
| R5 | 22K 1/4W |
| R6 | 1K 1/4W |
| RN1 | 10K SIP |
| U1 | 4001 |
| U2 | 74HC14 |
| U3 | 74HC14 |
| U4 | 74LS139 |
| U5 | 8255 |


211C-B.SCH1
INTERFACE PCB FOR 2100
AWARENESS TECHNOLOGY
PCB: 2100-100C SHT: 1/1
REVS:
TO DISPLAY
PARALLEL PORT
KEYTAIL CONNECTORS
FROM MAIN PCB
8255A
74LS139
4001
6.3V 470uF

Service Test Codes

| Test number | Function |
|---|---|
| 99 | Print stored tests |
| 100 | Date format change |
| 183 | Erase user defined tests and set memory to 8 open channels |
| 185 | Simulates a 50 plate run and checks for errors |
| 186 | Shows filter voltages |
| 187 | Advanve mechanism 1 step when ENTER is pressed |
| 188 | Displays location of last mechanism error |
| 189 | Displays total number of plates read |
| 190 | Runs 3 plates at 405 and 630 nm |
| 213 | Opens additional memory space |