785A Variable Wavelength UV Detector

Service Documentation

Applied Biosystems

PROGRAMMABLE ABSORBANCE DETECTOR

MODEL 785A

Service Documentation

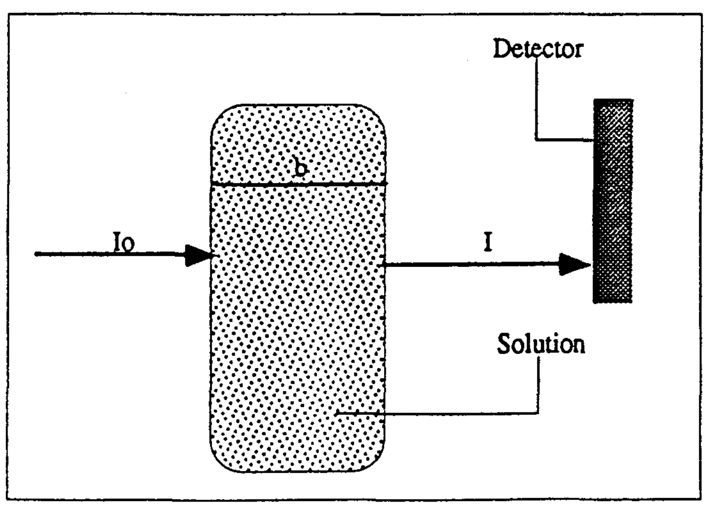
Applied Biosystems

THEORY OF OPERATION

The Applied Biosystems 785A Absorbance Detector belongs to a class of analytical instruments known as spectrophotometers. This class of optical instruments measures the transmittance of light through a cell containing a solution of chemical compounds. The light which has passed through the cell is collected and converted to an electrical current by a silicon photodiode. The amount of current produced by the photodiode is directly proportional (within a well-defined and specified range) to the amount of light striking the photodiode. The spectrophotometer then internally converts the current to a voltage corresponding to absorbance, which may then output to a recording device, computer, meter or display on the front panel so that the user may monitor the instrument activity.

The Model 785A, like other spectrophotometers, operates on the principle that certain solutions absorb light in an amount directly proportional to the concentration of solute presented to the light. Bouger and Lambert discovered that when light is passed through a thin layer of material, a portion of that light energy is absorbed and the remainder is transmitted. The amount of light absorbed is proportional to the thickness (pathlength) of the material and is dependent on the material composition and wavelength of the light. An exponential relationship was developed between transmitted light and thickness. Later, Beer extended this principle to solutions and demonstrated that the absorption of light in a solution is proportional to the concentration of solute and the distance the light travels within the solution (pathlength). This led to the now well-known Beer-Lambert Law. Briefly, Beer's Law states that the absorbance of light by a chemical compound in solution is directly proportional to:

- Concentration of the solute
- Light pathlength of the cell containing the solution
- Molar absorptivity of the solute (i.e., the amount of light that may be absorbed by one mole of the solute; this property is specific to the material itself).



Beer's Law can be expressed in mathematical form as follows:

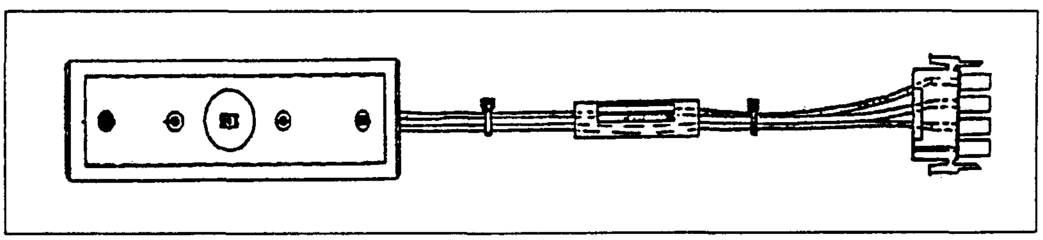
$$\text{Absorbance} = \log (Io/I) = abc$$

- Io = intensity of light beam at flowcell entrance
- I = intensity of light at flowcell exit
- a = molar absorptivity
- b = cell pathlength
- c = solute concentration

When a and b are held constant (which is the case in most HPLC applications), the absorbance measured should be directly proportional to the solute concentration in the cell. The linear relationships predicted by Beer's Law remain strictly true only for a monochromatic (single wavelength) light beam. Also, the linear relationship between absorbance and concentration holds only at low absorbances; at high absorbance levels, this relationship usually becomes non-linear. Furthermore, in the chromatographic process there are other factors that contribute to nonlinearity. These include sample preparation, injection, loading factors, reversible and nonreversible absorption on the column, wide spectral bandwidth and high background absorbance of the mobile phase. The chromatographer should therefore control these parameters as carefully as possible.

DEUTERIUM LAMP

Deuterium lamps have high output in the UV region and stable, continuous spectrum. They are widely used in spectrophotometers, fluorescent spectrometers, and other optical devices requiring such ultraviolet light sources.



ABI-Designed Deuterium Lamp

The lamp inner structure consists of a cathode, anode, and cover for the electrodes. The outer envelope is a proprietary UV glass compound with a thin window at the output port. The glass envelope is filled with deuterium gas to a slight pressure (above atmospheric pressure) at room temperature. Pressure increases when the lamp reaches operating temperature; it is this change in deuterium pressure during the lamp warm-up phase that causes spectral output drift as the lamp temperature stabilizes. The effect of temperature can also be of concern when the lamp housing area is exposed to drafts or open windows. The anode is close to the center of the envelope and is completely insulated from the other parts of the lamp. A 1-mm-diameter aperture is positioned near the front surface of the anode in a concave inner surface of the housing. This aperture provides a point source exit for the arc discharge, enhanced by the reflective surface surrounding the aperture. Slight oxidation of this surface during the first 100 h of use causes a slight decrease of the lamp output energy. This is the main reason why all lamps sold by ABI go through a "burn-in" phase.

The deuterium lamp employs an arc discharge. When a voltage is applied to two separated flat-plate electrodes in a gas environment, the negative electrode becomes the cathode, the positive electrode becomes the anode, and there is a current flow. As applied voltage is increased, current increases proportionally to voltage. While slope of the current depends on the ion and electron density, further voltage increase beyond saturation causes all supplied electrons to be transported. If the applied voltage is increased still further, there is a sharp increase in current; this occurs when enough energy is imparted to the gas molecules to cause electrons to break away. This is the discharge (breakdown) mechanism, which is marked by a complete drop in resistance to electron flow from the anode to the cathode.

If the correct voltage is applied to the lamp with a series resistor, stable gas discharge will be achieved. When the discharge current is small, positive ions colliding with the cathode produce secondary emission called "subnormal-discharge." As current is increased, a linear region of output is seen, followed by a steep increase as thermionic emission of electrons occurs, with subsequent breakdown of the surrounding gas. With deuterium lamps, the colliding positive ions are not used to bring about thermionic emission, although this occurs in the warm-up phase. Instead, a separate power supply is used to heat the cathode and stimulate thermionic emission and subsequent breakdown. When the anode voltage is raised to 350 V, the electrons are accelerated to an energy level that is capable of breaking down the gas molecules to form positive ions. While these ions migrate towards the cathode, their mass, being larger than that of electrons, causes their motion to become slowed, leaving them between the electrodes for long periods. This results in neutralization of the negative space charge, making possible a large current flow. When enough positive ions are generated in this way, increasing numbers of electrons are released from the cathode to neutralize the space charge. These electrons break the gas molecules down further and create additional positive ions. When the process is allowed to continue, arc discharge occurs, and the lamp passes a current that is limited by the external load resistance.

The lifetime of a deuterium lamp is defined as either (1) the time period required for the radiant intensity to fall to 50% of its initial value or (2) the time when step or oscillation noise exceeds 0.1%. Theoretical lifespan is determined by not only the number of hours used but also the deuterium gas pressure. If deuterium gas pressure is held within a certain range, there can be an increased output with use. The transmittance of the window material falls as a result of solarization within the glass; this decrease is greater at shorter wavelengths and becomes smaller as the wavelength increases. In time, lamp aging can cause excessive baseline noise, or drift, especially in the low ultraviolet region. Eventually, the lamp may fail to ignite or require repeated power-up to start arc discharge. For most instruments this is cause for lamp replacement. But for some applications, the operator may decide to leave the lamp on, as long as the difficulty relates to ignition and baseline noise and drift are within acceptable limits. ABI-manufactured lamps are warranted for 1000 h, as indicated on the hour-usage indicator attached to the lamp cable. This device monitors presence of current across the cathode and does not distinguish between "full-power" and "half-power" settings.

MONOCHROMATOR

The monochromator is composed of the light source, optical unit, and cells.

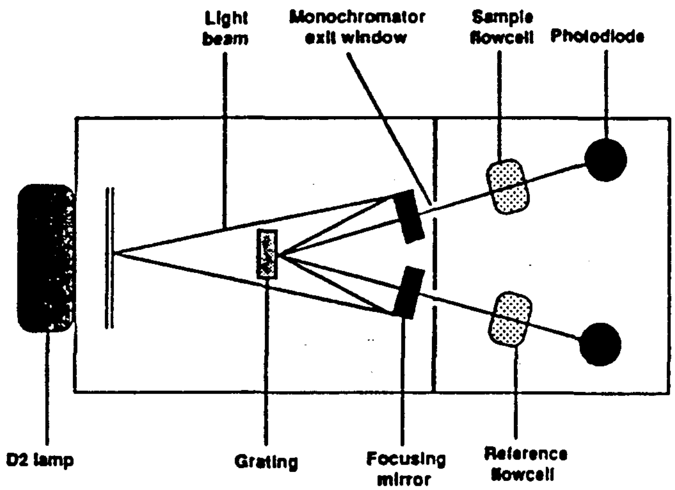
The light source (deuterium or tungsten lamp) passes through a set of slits that define the beam and the bandwidth. After passing through the slits, the beam strikes a pair of curved mirrors. Because the mirrors are independent of each other, the reflection angle can be adjusted to divide the incoming light beam into two equal, independent beams. Through this feature, a single monochromator effectively becomes a dual monochromator whose two beams share the same grating and are thermally and mechanically compensated.

The beams coming from the mirrors become the incident beam to the diffraction grating, which disperses the incident light into different wavelengths. A particular wavelength is dependent upon the angle of incidence*

*Angle of incidence is the angle between the incident beam and the grating "normal"; the normal is the line that is at 90 deg to the grating surface.

as the incident beam and the aperture of the monochromator are fixed. This requires rotating the grating. Because the grating movement is rotational, the grating rotation is converted into linear movement that is controlled by the wavelength drive screw.

After the beams pass through the exit windows (whose main function is to protect the monochromator from the environment) they pass through the entrance aperture of the cell. The diameter of the entrance aperture determines the instrument bandwidth, as it blocks the diffracted beam and allows only beams of a selected wavelength range to pass. Because a grating disperses light linearly, the bandwidth is constant throughout the wavelength range.



Light entering the cell passes along the cell pathlength to the exit aperture, where its intensity is measured by the photodiodes. The basis for absorption measurement is Beer's Law (discussed previously) and involves the following parameters:

- Incoming light intensity (Io)
- Light intensity measured by the photodiode (I)
- Cell pathlength (b)
- Physical properties of the solvent flow

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SPECIFICATIONS

Wavelength Range	190-700nm
Bandwidth	5nm
Wavelength Accuracy	±1nm
Wavelength Reproducibility	±0.5nm
Optics	Dual beam
Sensitivity Range	0.0005-3.000 AUFS, in 0.0001 increments from 0.0005-0.1, and 0.001 increments above 0.1 AUFS
Recorder Output	10mV full scale for any selected range
Computer Output	1 V/AU, 0.5 V/AU, 0.2 V/AU (software selectable)
Noise	<±1 x 10-5 AU, 210-280nm, 1 sec rise time, standard 12uL flowcell; flowing conditions are 50/50 ACN-H2O at 1 mL/min
Drift	<1 x 10-4 AU/hour, after warmup
Operation Below 200nm or in Cold Room	Nitrogen purge provision in the monochromator
Light Sources	Deuterium (190-360nm) or optional tungsten (360-700nm)
Displays	Four line x forty column; alphanumberic Supertwist, liquid crystal display

Noise Filter	Digitally controlled active filter with eight selectable rise time values from 0.02 to 5.0 sec
Number of Programs	8 in battery-backed-up memory
Number of Steps/Program	32 maximum; multiple simultaneous events may occur in any given step
Program Time	360 minutes total/program
Programmable Functions	Time, wavelength, range, rise time, auto zero, relay closures, program number, number of injections, shutdown procedure (program execution by means of a run table)
Scan	Stopped flow scan, scan speed selectable from 0.2 to 1.0nm/sec
External Communications	Through RS232 port for all detector functions. Through remote connector by manual switch closure for auto zero, event mark, program load, lamp high/low, and abort
Keypad	Provided
Self Diagnostics	Self-check routine upon demand. A complete self-check routine is done upon power-up. Continuous monitoring of power supply condition, lamp status, fan operation, and leak sensor
Microprocessor	Intel 8085
Control Outputs	4 SPDT relays, 1 A/48 V (max); relays retain state even with power off
Dimensions	12.5 W x 15.0 D x 8.0 H (inches) 31.8 x 38.1 x 20.3 (cm)

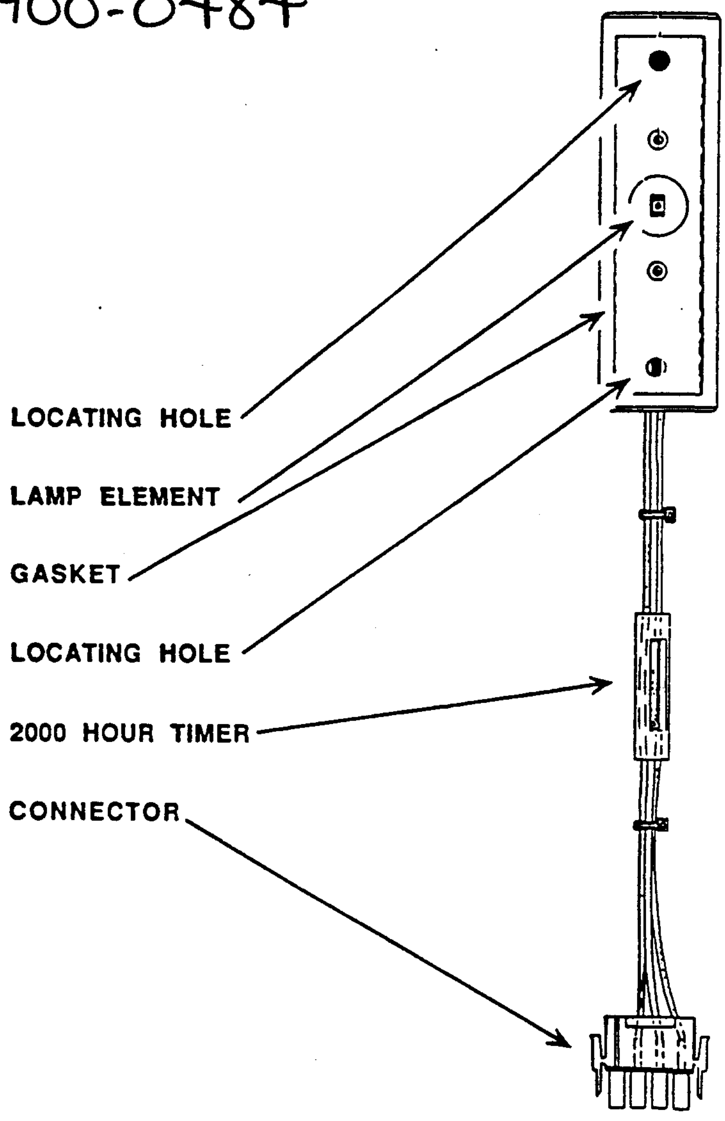
Weight	30 lbs (13.6 kg)
Power Requirements	100/120/220/240 Vac, 50/60 Hz, 65 W

MAJOR ASSEMBLIES

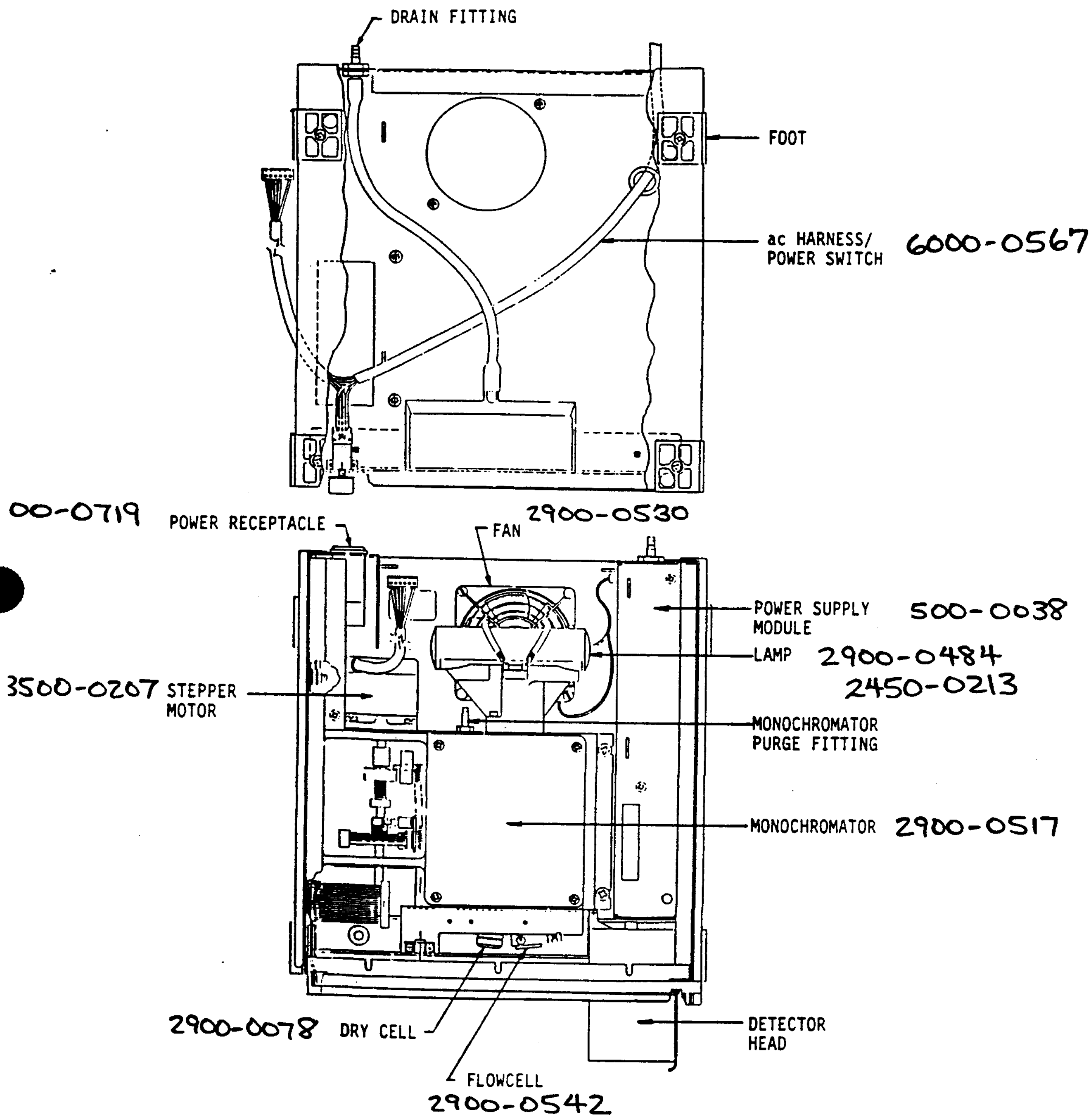
This section contains illustrations of Model 785A major assemblies.

DEUTERIUM LAMP

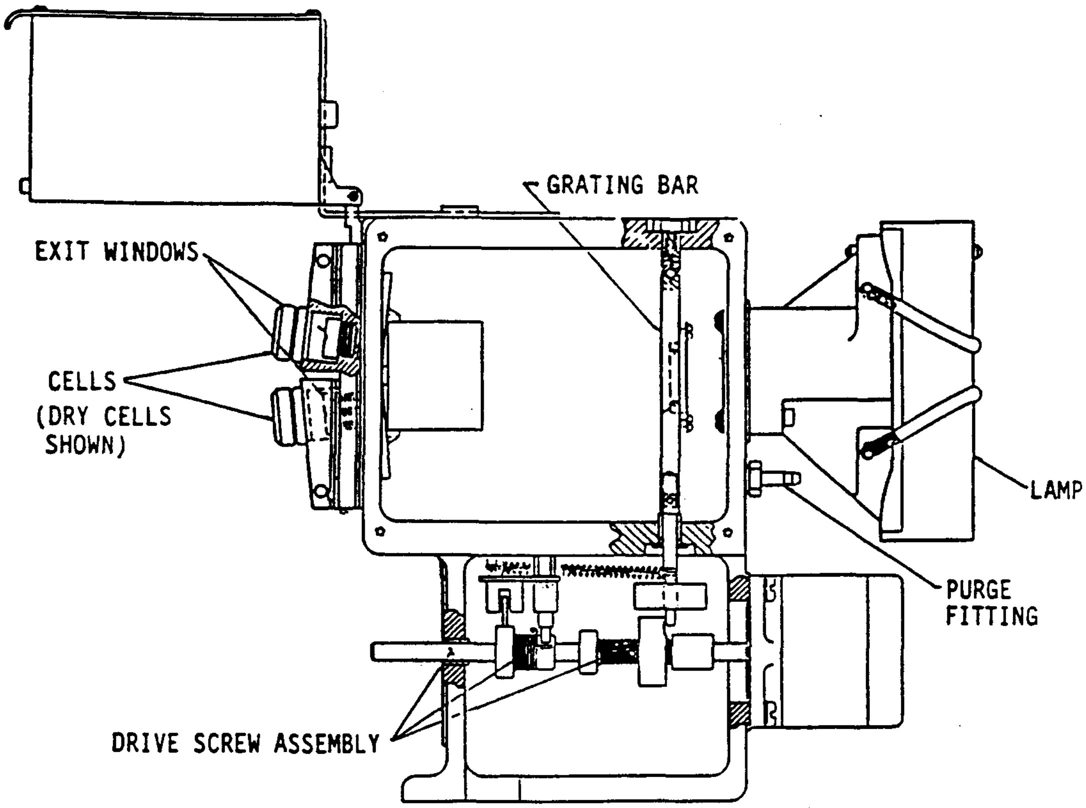
2900-0484



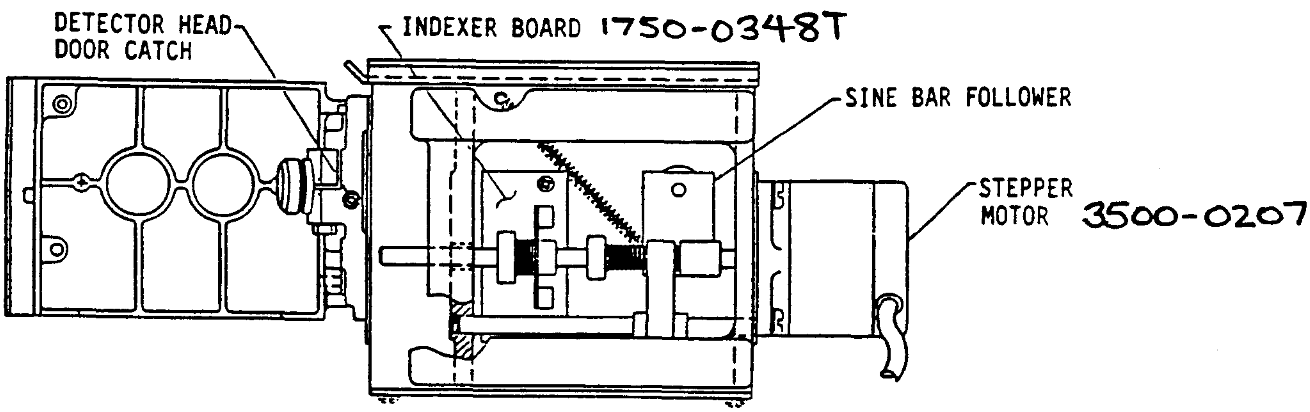
CHASSIS


DRAIN FITTING
FOOT
ac HARNESS/ POWER SWITCH
6000-0567
00-0719
POWER RECEPTACLE
FAN
2900-0530
POWER SUPPLY MODULE
500-0038
LAMP
2900-0484
2450-0213
3500-0207
STEPPER MOTOR
MONOCHROMATOR PURGE FITTING
MONOCHROMATOR
2900-0517
2900-0078
DRY CELL
DETECTOR HEAD
FLOWCELL
2900-0542

MONOCHROMATOR
2900-0517

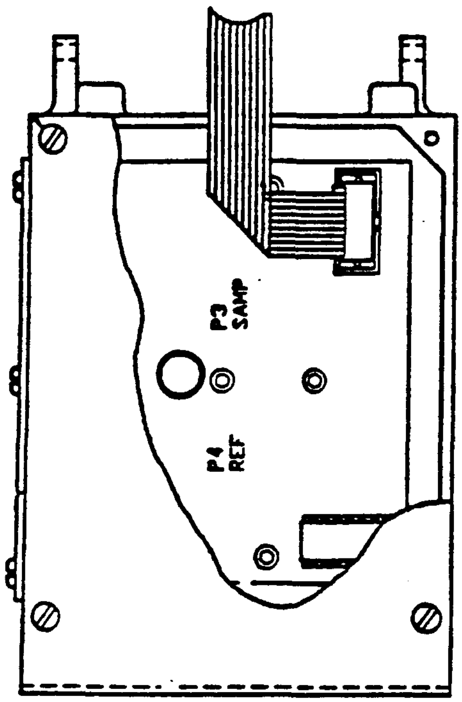


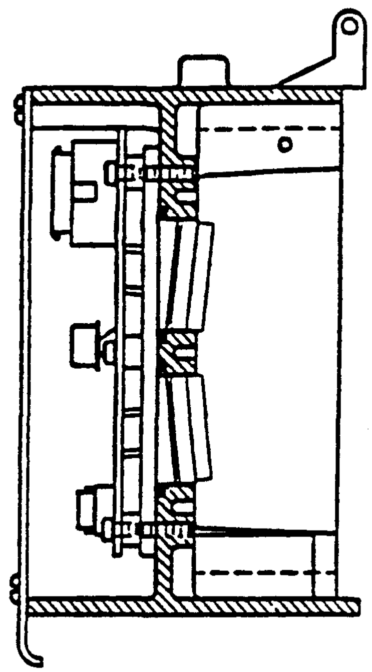
TOP VIEW

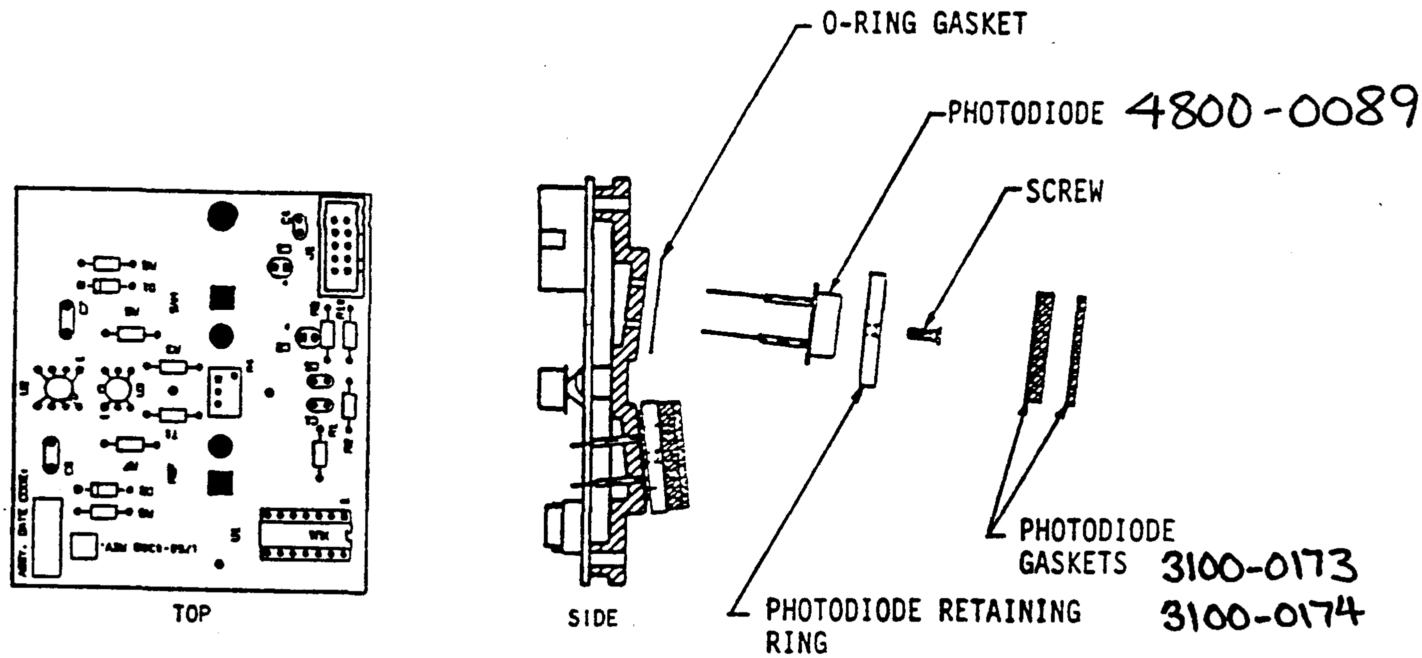


SIDE VIEW

DETECTOR HEAD



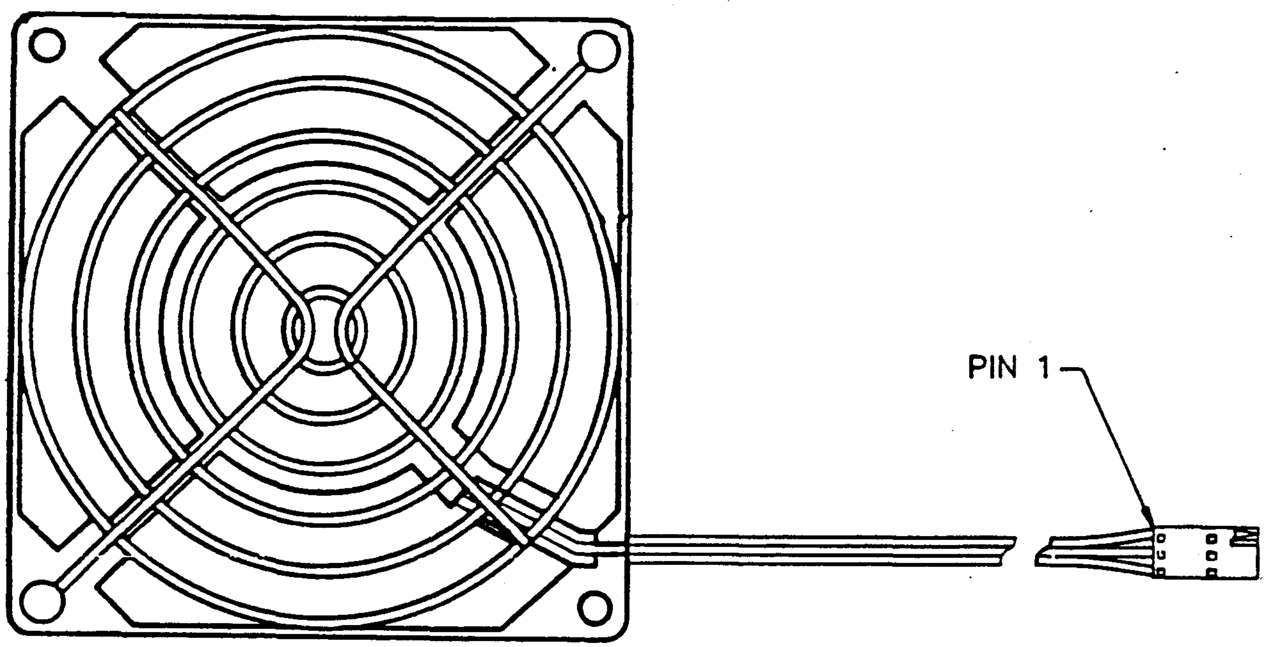




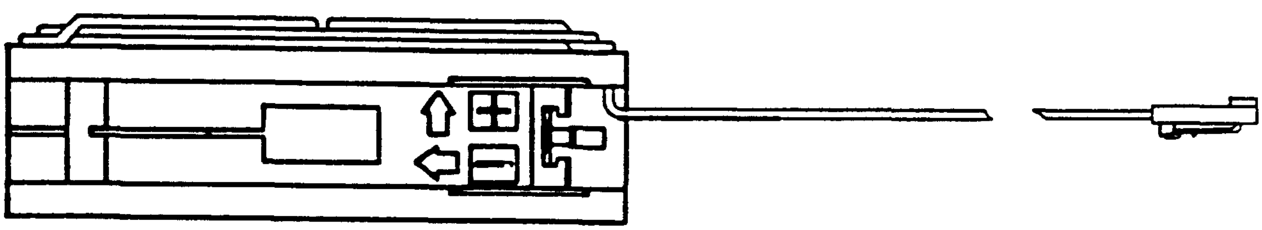
DETECTOR HEAD PCB w/ PHOTODIODES
2900-0478

FAN

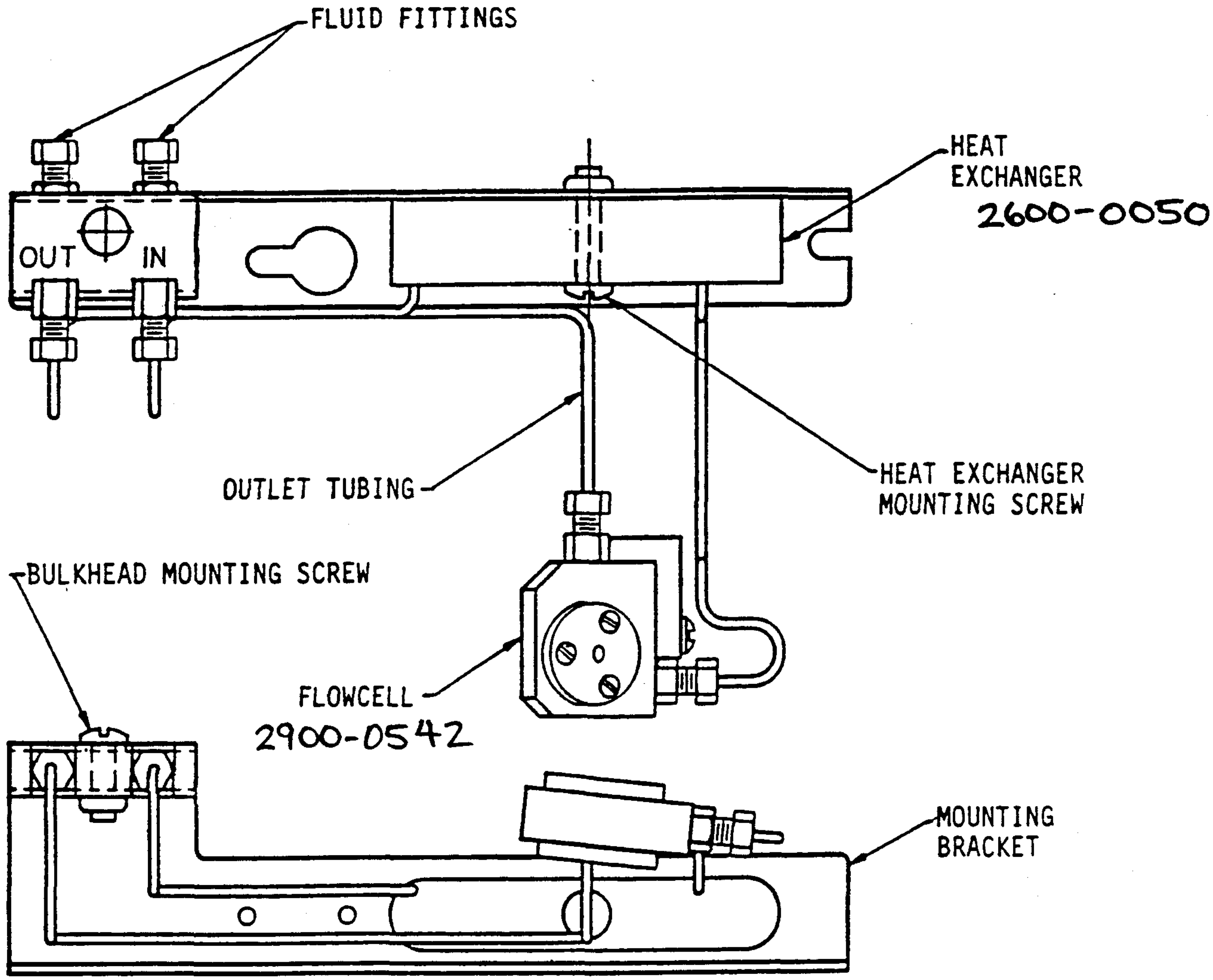
2900-0530



Pin 1	Red	Fan + (12Vdc)
Pin 2	Black	Fan - (Gnd)
Pin 3	Orange	Tachometer



FLOWCELL ASSEMBLY (COMPLETE)

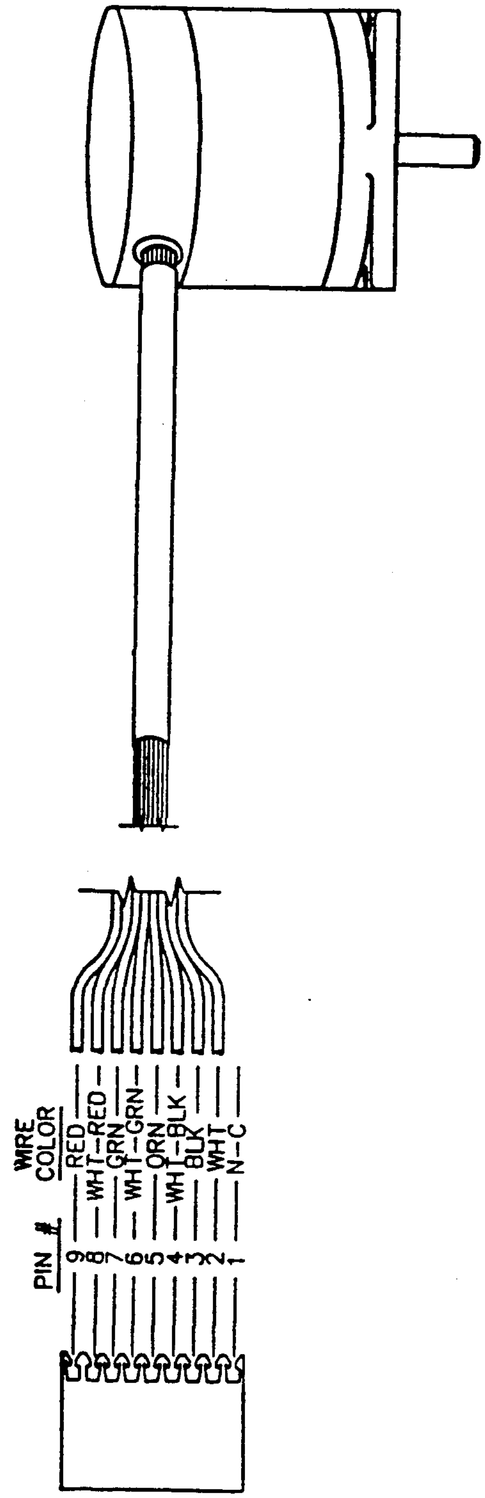


LEAK SENSOR 4700-0602

The leak sensor is located below the flowcell in the drip pan. Its purpose is to detect leakage that may occur in the fluid system.

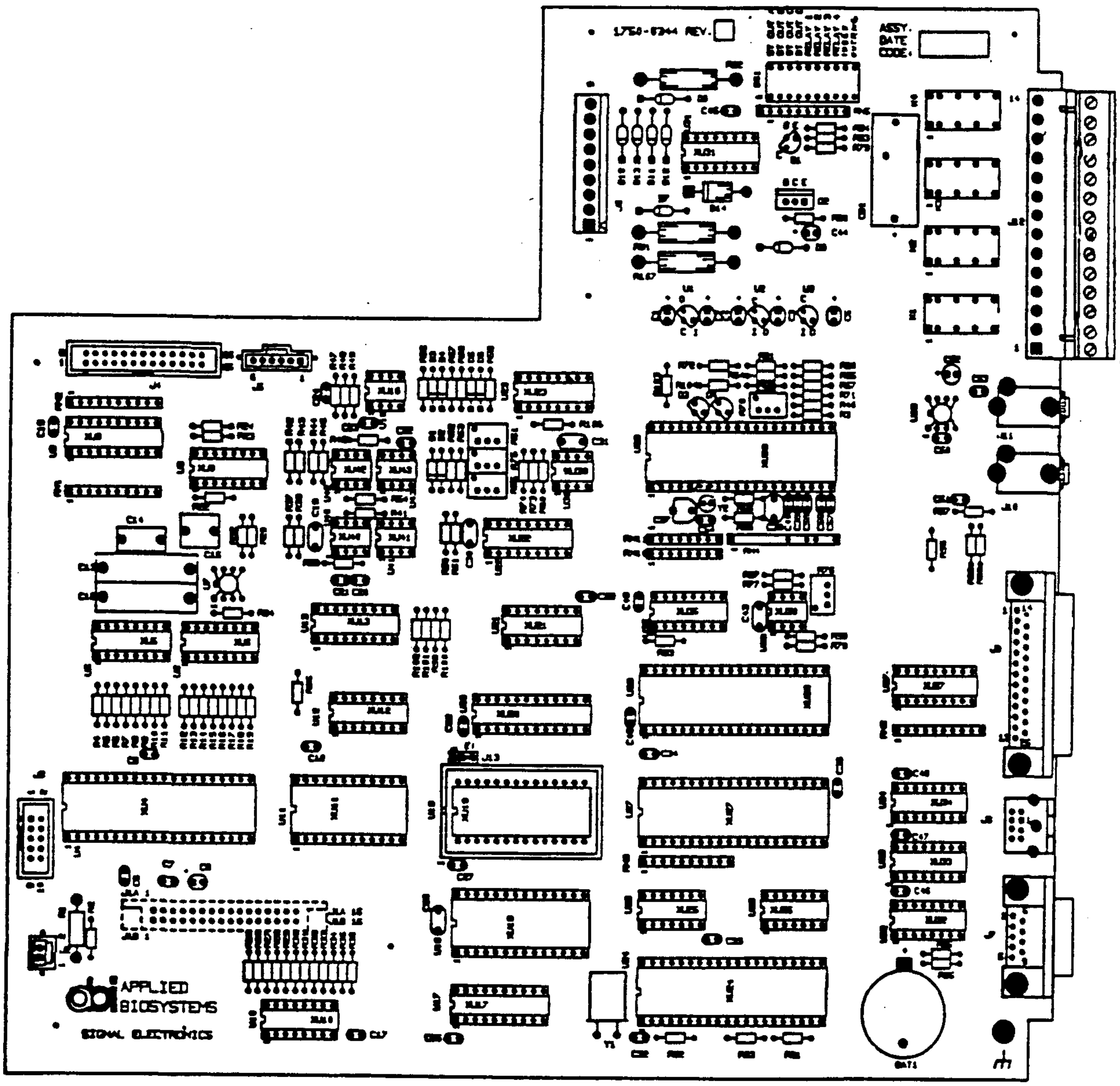
STEPPER MOTOR ASSEMBLY

3500-0207

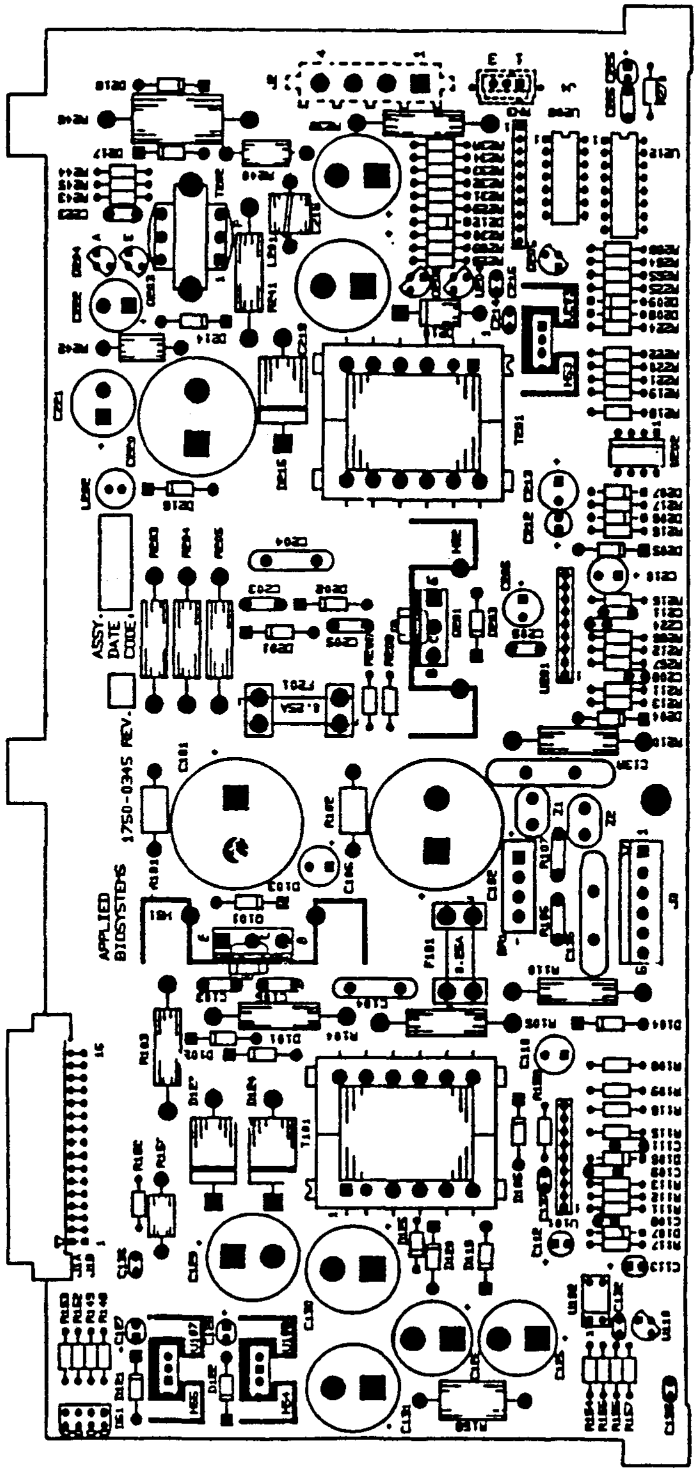


MAIN PCB (MICROPROCESSOR/SIGNAL ELECTRONICS)

1750-0344T



POWER SUPPLY MODULE
500-0038



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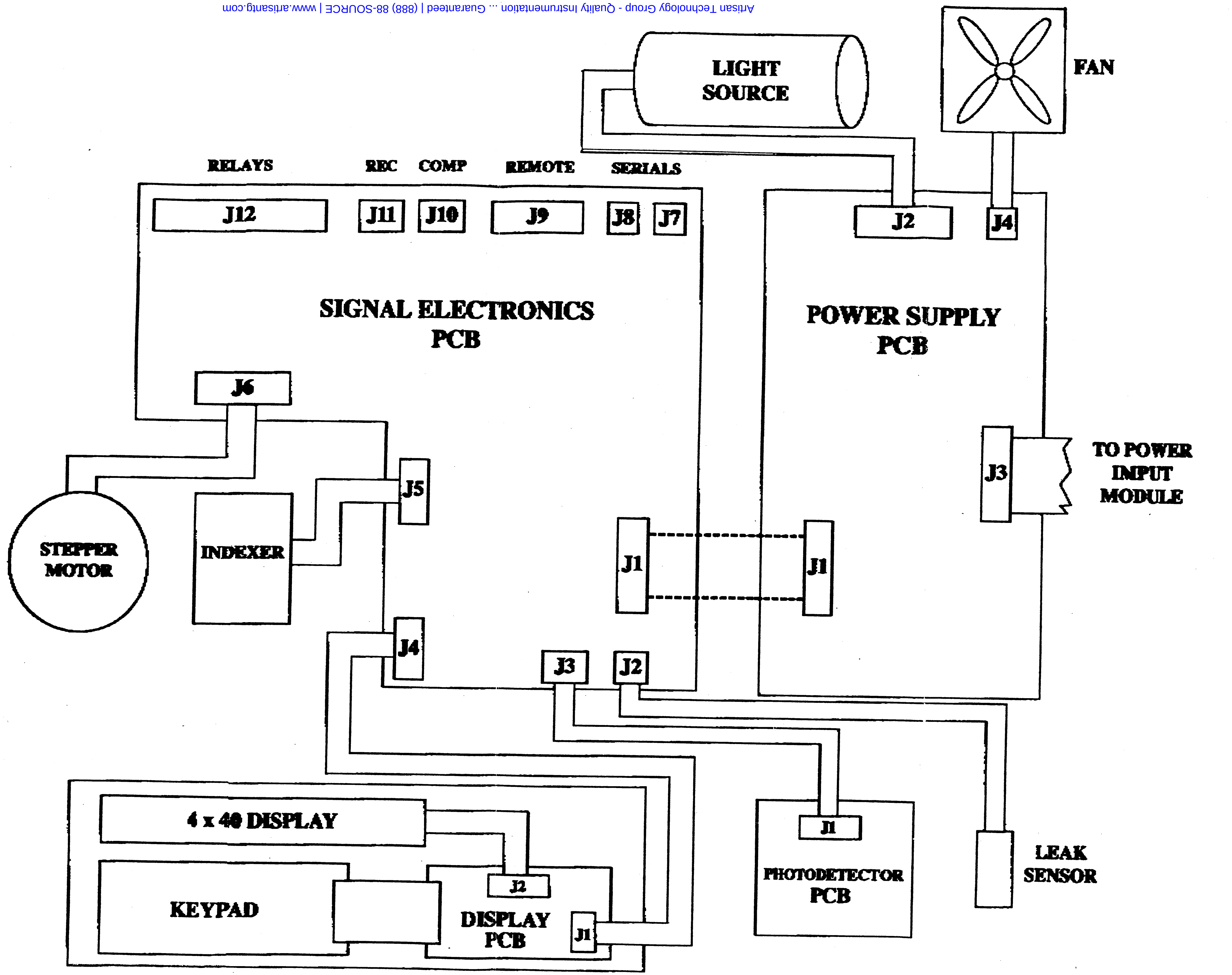
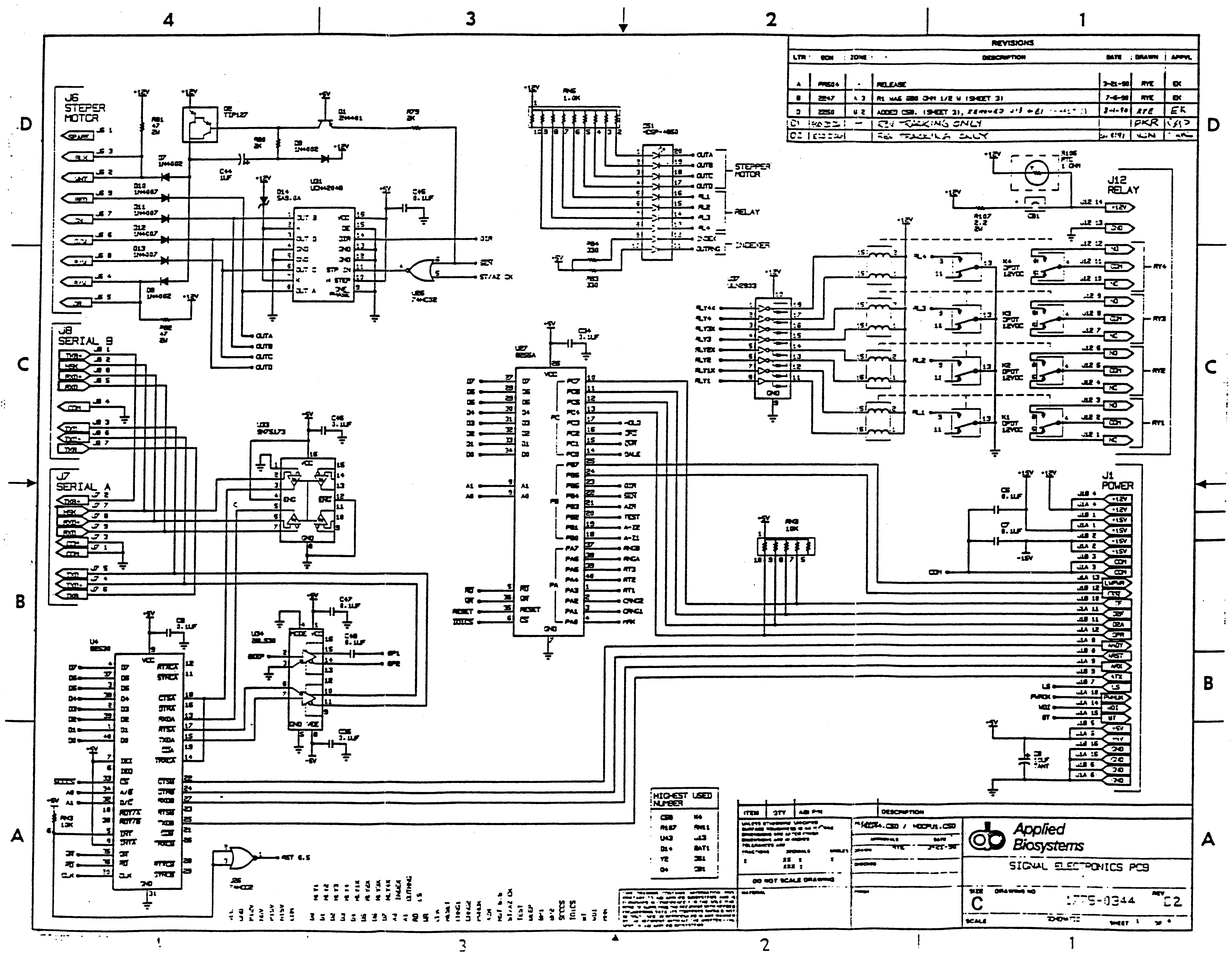
SCHEMATICS & DIAGRAMS

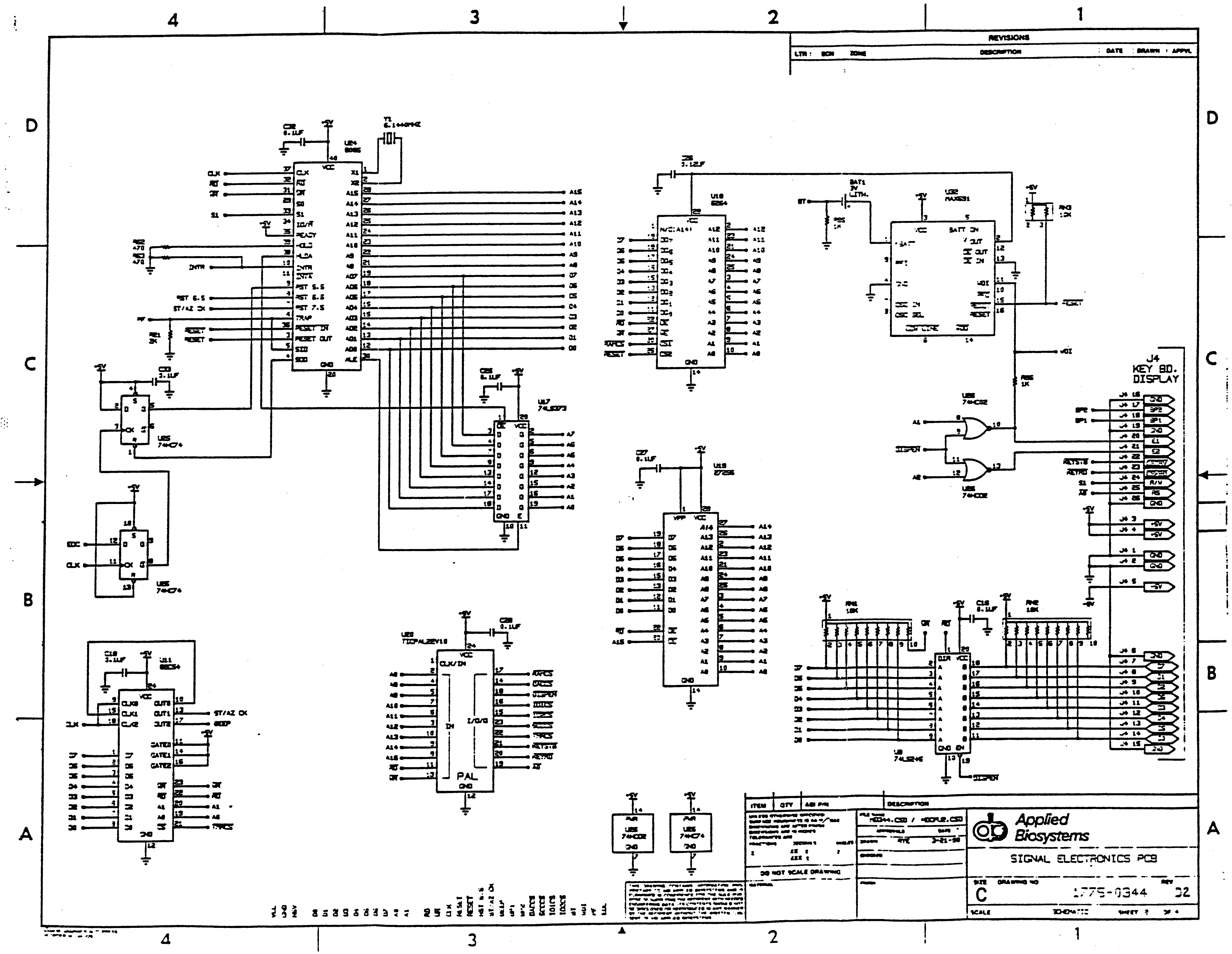


785A INTERCONNECT DIAGRAM

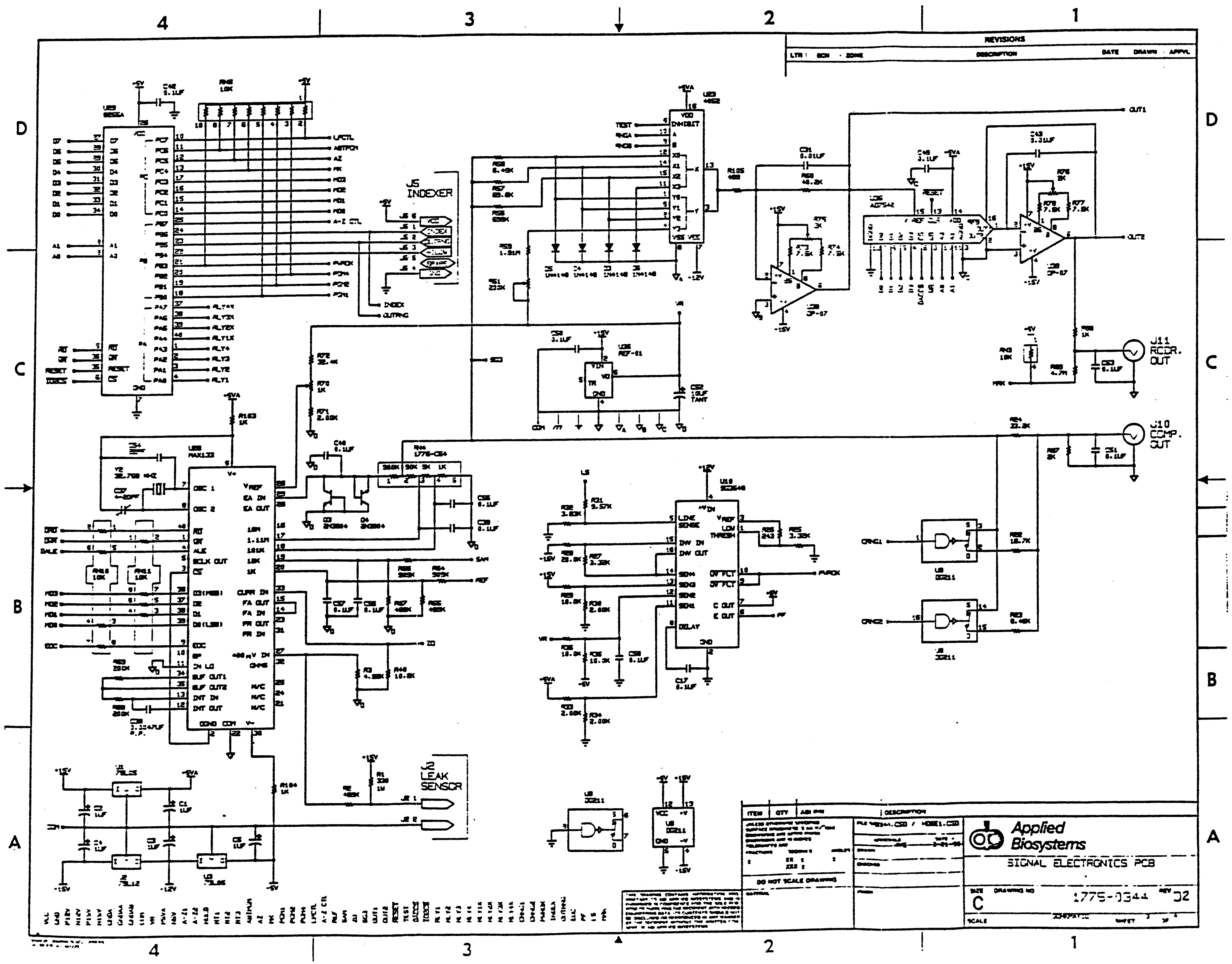
1775-0344 1 of 4



1775-0344 2 of 4

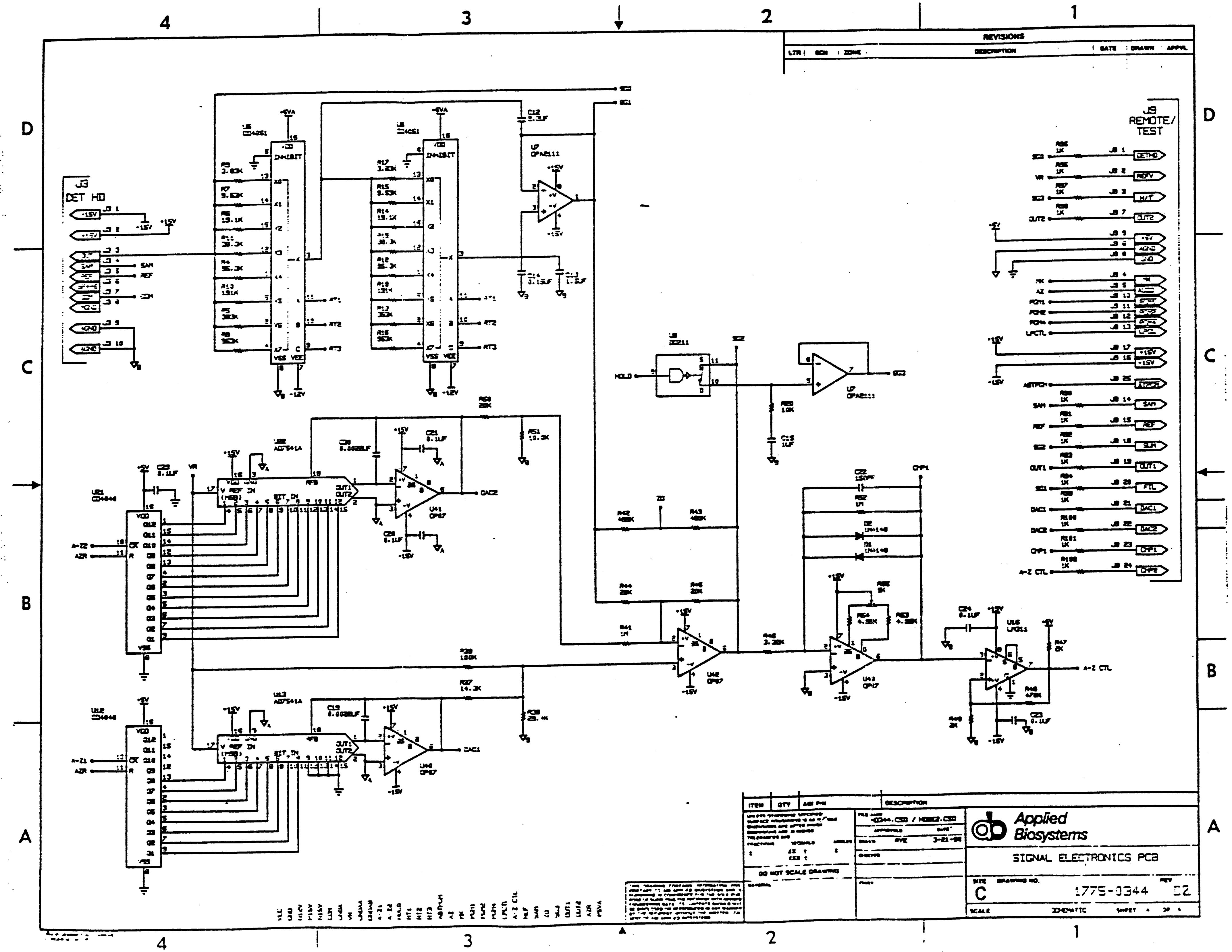


1775-0344 3 of 4



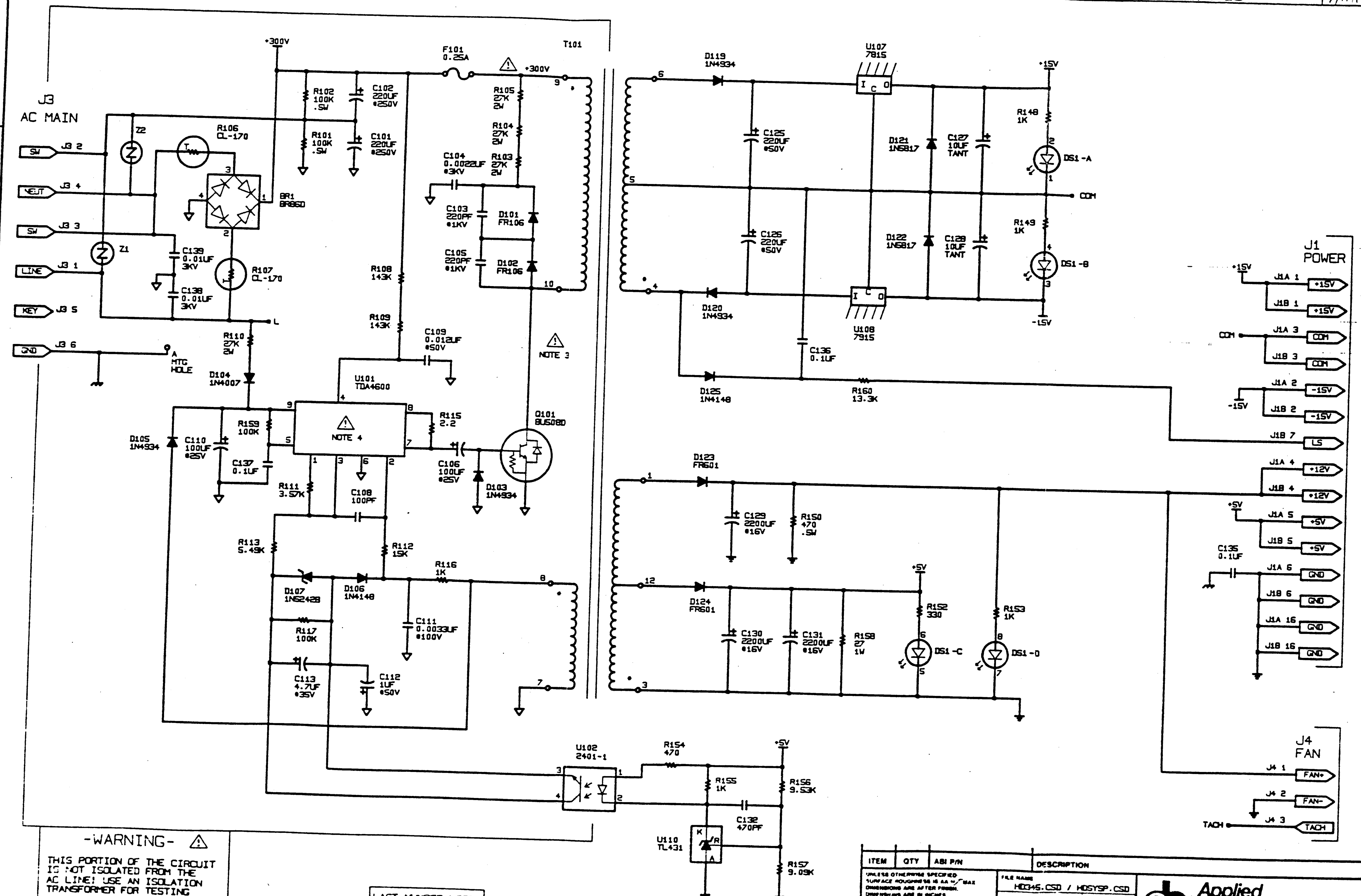
1775-0344

4 of 4



REVISIONS

LTR	ECN	ZONE	DESCRIPTION	DATE	DRAWN	APPVL
A	PR493	B3	RELEASE, C108 WAS 22 PF	2-14-90	RYE	EK
B	PR507	—	BOM CHANGE, ITEM # 76	3-21-90	RYE	EK
C	2241	02	SHT. 2, R243 WAS 47, C223 WAS 0.01 & C3 WAS .1	5-17-90	RYE	EK
C1	[illegible]	—	REV. TRACKING ONLY	5/5/91	PKE	[illegible]
D	2125	—	REV. TRACK - FAB REV ROLL	7/1/91	PKZ	[illegible]



-WARNING-

THIS PORTION OF THE CIRCUIT IS NOT ISOLATED FROM THE AC LINE! USE AN ISOLATION TRANSFORMER FOR TESTING

LAST NUMBER USED 100 SERIES

J4	R160	Q101
Z2	C139	D125
BR1	U110	T101
DS1	F101	

ITEM	QTY	ABI P/N	DESCRIPTION

UNLESS OTHERWISE SPECIFIED SURFACE ROUGHNESS IS AA √ MAX. DIMENSIONS ARE AFTER FINISH. DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS ±1/64; DECIMALS XX ±.02, XXX ±.005; ANGLES ±2°

DO NOT SCALE DRAWING

MATERIAL —
FINISH —

FILE NAME: HD345.CSD / HDSYSP.CSD
APPROVALS — DRAWN: RYE, DATE: 2-14-90
CHECKED

THIS DRAWING CONTAINS INFORMATION PROPRIETARY TO APPLIED BIOSYSTEMS AND IS FURNISHED IN CONFIDENCE FOR THE SOLE PURPOSE OF SUPPLYING THE RECIPIENT WITH NEEDED INFORMATION. THIS DRAWING SHOULD NOT BE DISCLOSED OR REPRODUCED IN ANY MANNER BY THE RECIPIENT WITHOUT THE WRITTEN CONSENT OF APPLIED BIOSYSTEMS.

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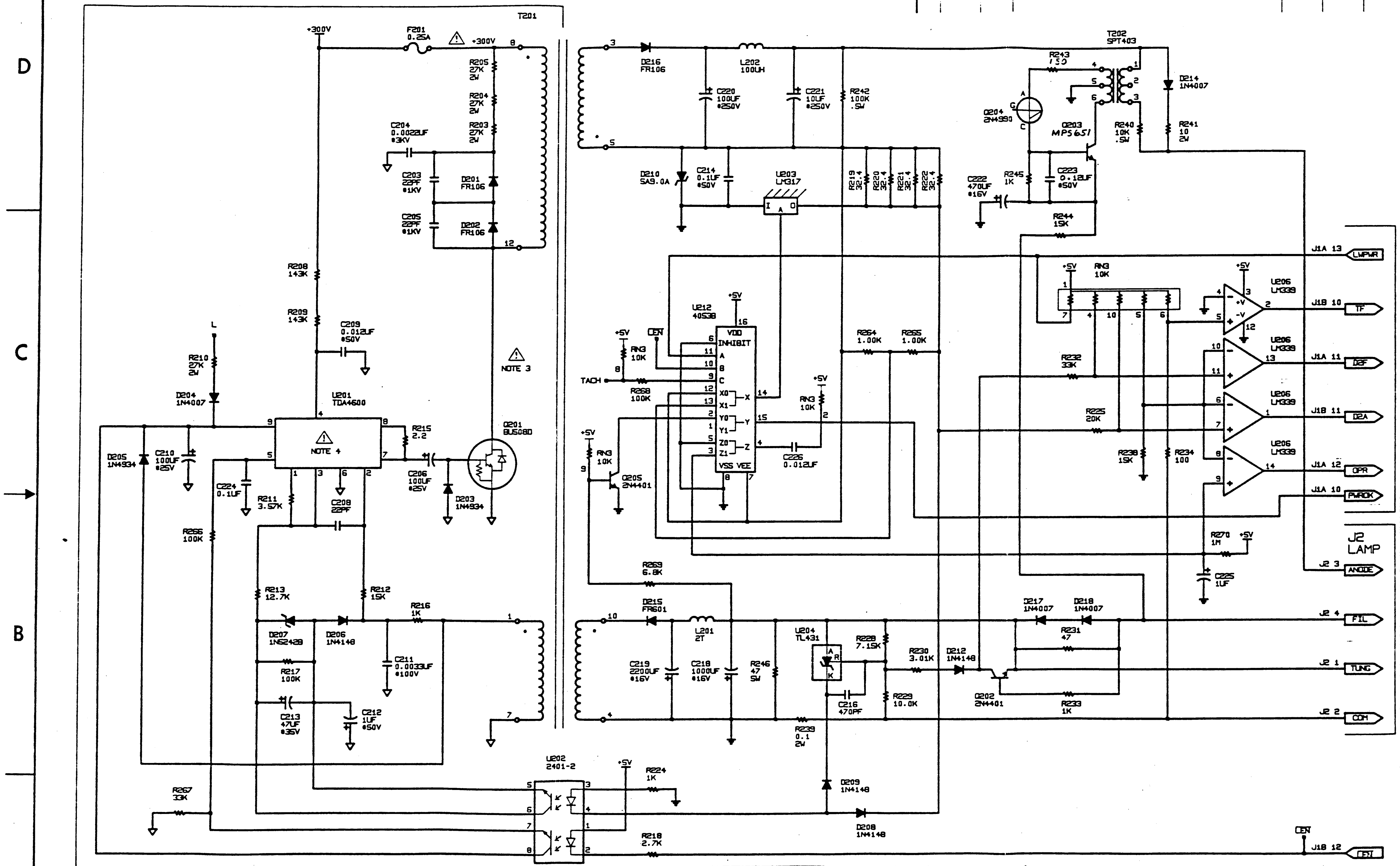
POWER SUPPLY
SYSTEM P/S SECTION 785A

SIZE: C
DRAWING NO.: 1775-0345
REV.: D
SCALE: —
SCHEMATIC
SHEET 1 OF 2

LTR	ECN	ZONE	DESCRIPTION	DATE	DRAWN	APPVL

REVISIONS



-WARNING- ⚠

THIS PORTION OF THE CIRCUIT IS NOT ISOLATED FROM THE AC LINE! USE AN ISOLATION TRANSFORMER FOR TESTING

NOTES:

1. ⏚ SYMBOL INDICATES NON-ISOLATED (HOT) COMMON
2. ⚠ SYMBOL INDICATES SPECIAL CAUTION!
3. PEAK COLLECTOR VOLTAGE IS 1100V. BE CERTAIN TEST EQUIPMENT IS RATED TO WITHSTAND THIS!
4. DO NOT APPLY POWER WITH I.C. REMOVED, OR OVERVOLTAGE DAMAGE TO ASSOCIATED COMPONENTS WILL RESULT !

LAST NUMBER USED 200 SERIES

	C226	Q205
	R270	T202
	U212	F201
RN3	D216	L202

VCC GND L P300V GNDA TACH

ITEM	QTY	ABI P/N	DESCRIPTION

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DO NOT SCALE DRAWING

FILE NAME HC345.CSD / HDLAMP.CSD

DRAWN RYE DATE 2-14-90

CHECKED

MATERIAL —

FINISH —

Applied Biosystems

POWER SUPPLY
LAMP P/S SECTION 785A

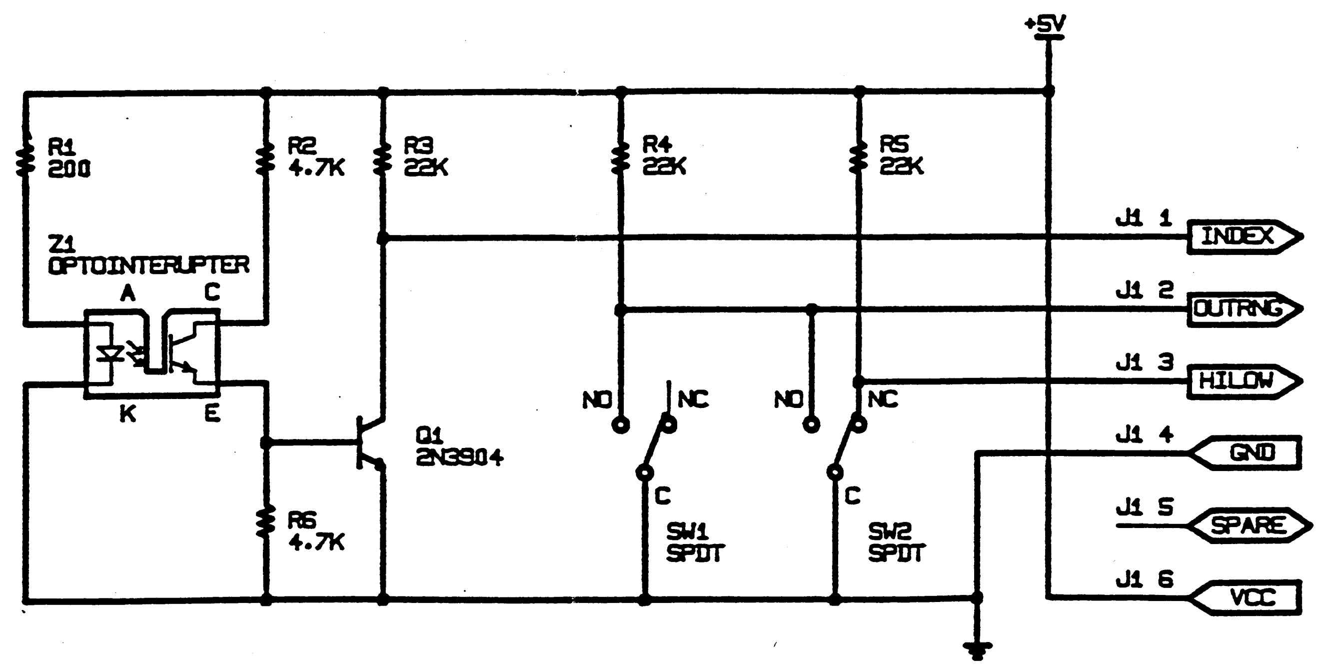
SIZE C DRAWING NO. 1775-0345 REV D

SCALE — SCHEMATIC SHEET 2 OF 2

1775-0345

REVISIONS

LTR	ECN	ZONE	DESCRIPTION	DATE	DRAWN	APPVL
B	PECO 454	/	RELEASE	1-19-90		[illegible]
B1	ECO 2026	—	REV TRACKING ONLY		PKR	[illegible]



ITEM	QTY	ABI P/N	DESCRIPTION

UNLESS OTHERWISE SPECIFIED:
SURFACE ROUGHNESS IS AA ✓ MAX.
DIMENSIONS ARE AFTER FINISH.
DIMENSIONS ARE IN INCHES.
TOLERANCES ARE:
FRACTIONS ± 1/64 DECIMALS .XX ± .02 .XXX ± .005 ANGLES ± 2°

DO NOT SCALE DRAWING

FILE NAME INDEXER.CSD

APPROVALS		DATE
DRAWN	RYE	1-4-90
CHECKED	[illegible]	1-5-90

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MATERIAL —
FINISH —

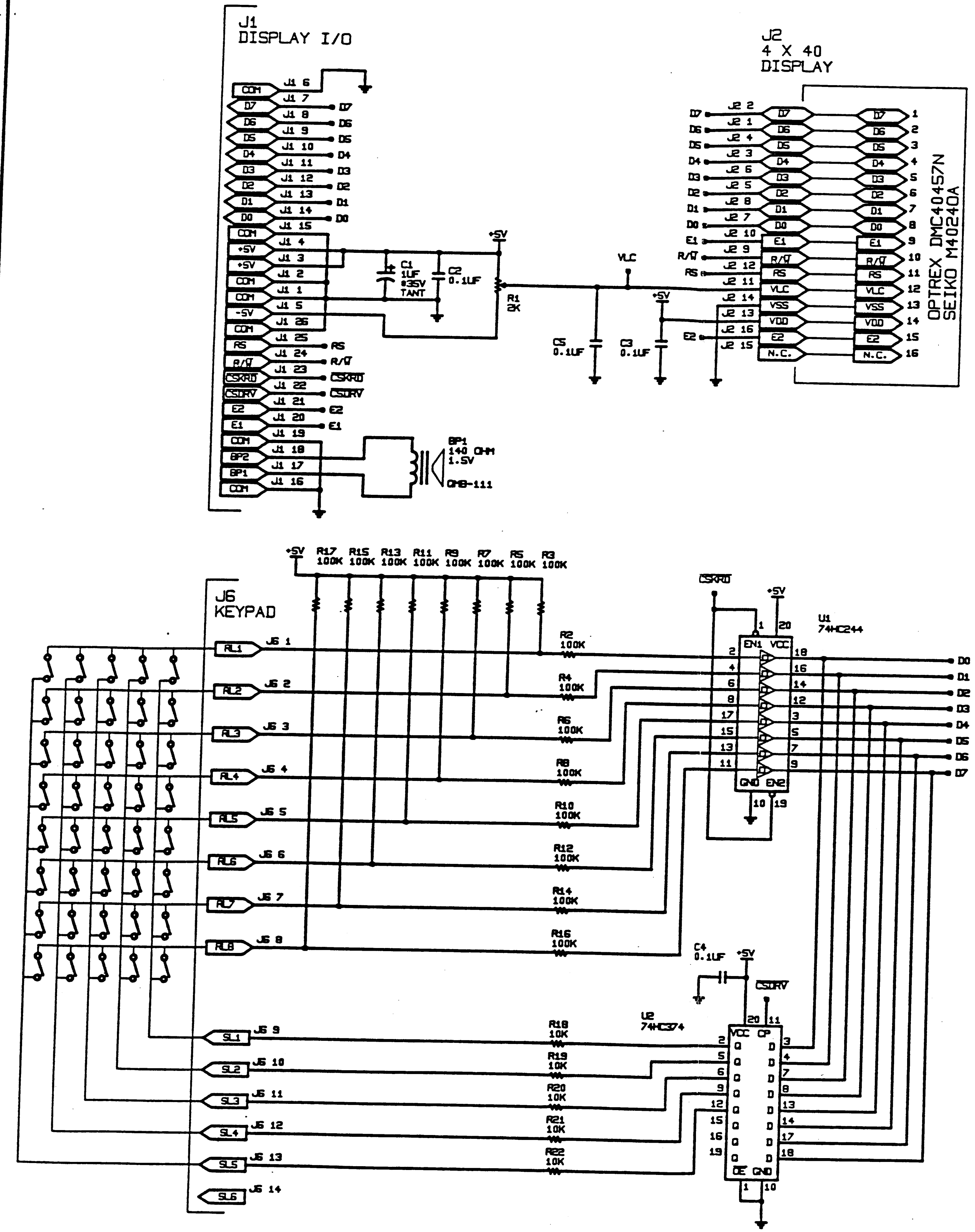
abi Applied Biosystems

INDEXER SCHEMATIC

SIZE B | DRAWING NO. 1775-0348 | REV. B1

SCALE — | SHEET 1 OF 1

BISHOP GRAPHICS/ACCUPRESS



LTR	ECN	ZONE	DESCRIPTION	DATE	DRAWN	APPVL
B	2234	—	80M CHANGES, RE-DRAWN	4-25-90	RYE	EK
B1	EO2026	—	REV TRACKING ONLY		PKR	9/93

UNLESS OTHERWISE SPECIFIED: SURFACE ROUGHNESS IS AA ✓ MAX. DIMENSIONS ARE AFTER FINISH. DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

DO NOT SCALE DRAWING

FILE NAME: DIS343.CSD

DRAWN: RYE DATE: 4-18-90

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DISPLAY I/O, STAND ALONE

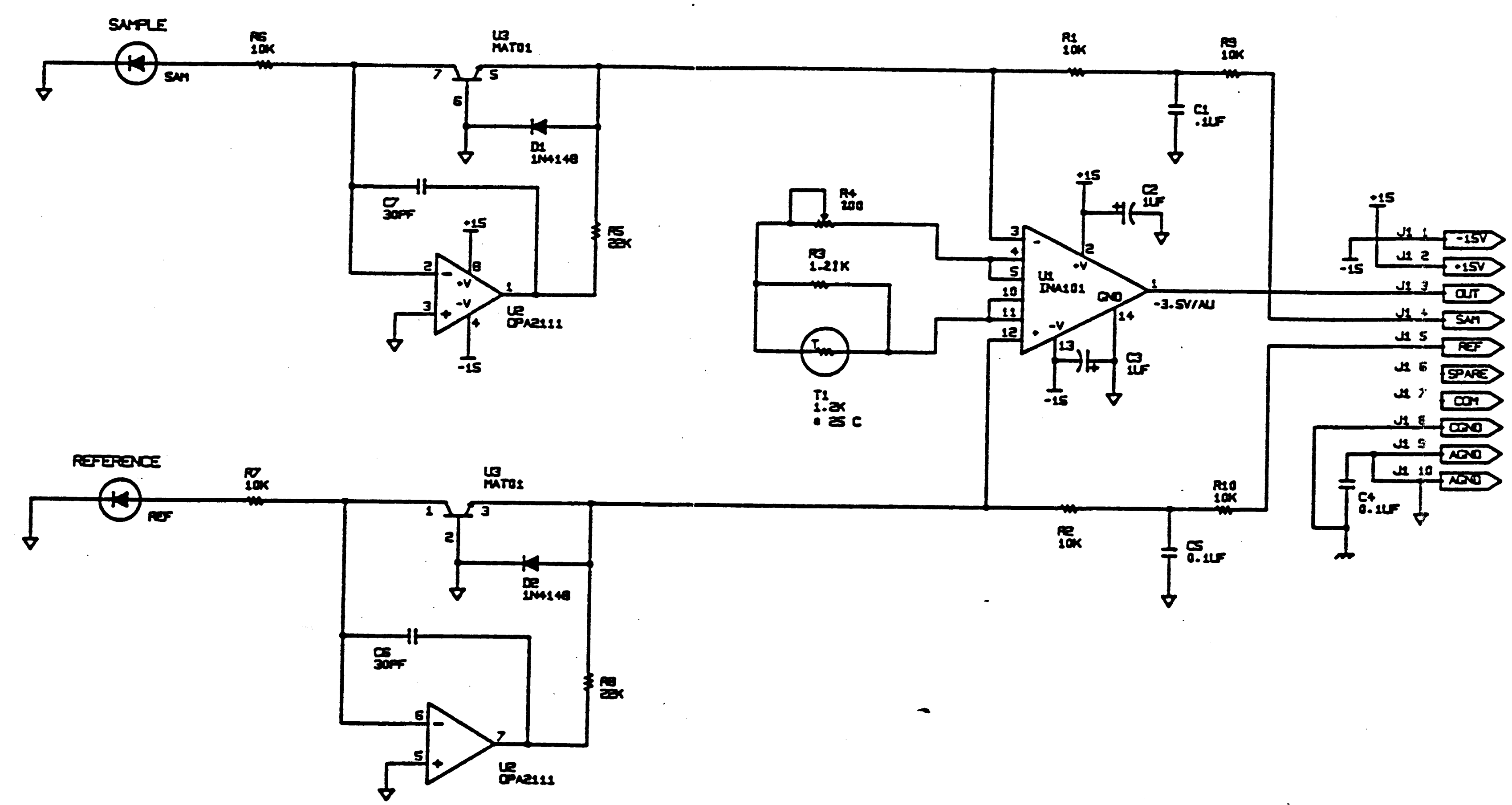
SIZE: C DRAWING NO.: 1775-0343 REV.: B1

SCALE: — SCHEMATIC SHEET 1 OF 1

1750-0343 B1

REVISIONS

LTR	ECN	ZONE	DESCRIPTION	DATE	DRAWN	APPVL
A	PR171	-	RELEASE	9-19-88	TBS	STOEPEL
B	PR212	2B,C	ADDED R9,R10 & C4	12-14-88	RYE	[illegible]
C	PR506	C-3	R3 was 1.33K, R4 was 100 Ω	3-23-90	RYE	[illegible]
C1	EC2026	—	REV TRACKING ONLY		[illegible]	[illegible]



ITEM	QTY	ABI P/N	DESCRIPTION

UNLESS OTHERWISE SPECIFIED: SURFACE ROUGHNESS IS AA √ MAX. DIMENSIONS ARE AFTER FINISH. DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS, DECIMALS, ANGLES

DO NOT SCALE DRAWING

FILE NAME: PHD309.CSD

APPROVALS		DATE
DRAWN	TBS	5-2-88
CHECKED	JAZ	8-15-88

Applied Biosystems
Ramsey Analytical Division

SCHEMATIC, PHOTO DIODE BD.

SIZE	DRAWING NO.	REV.
C	1775-0309	C1

SCALE — SCHEMATIC SHEET 1 OF 1

Spare Parts List

Part Number	Description
402-0041	Trip strip, 759/785
500-0038	Power Supply PCA
602263	Backpressure assembly (connects to flowcell outlet on Procise-HT)
1400-2453	Keypad
1600-0088	Lubricant, Tufoil
1750-0343T	Display Adaptor PCA
1750-0344T	Signal Electronics PCA
1750-0348T	Indexer PCA, (Phase 2 mono)
2050-0038	PAL Assy.
2050-0039	EPROM Assy.
2100-0719	Module, AC Input
2100-0720	Fuse Drawer, AC Input
2100-0721	Voltage Selector Insert
2600-0050	Heat Exchanger
2900-0078	Reference Aperture (Dry cell)
2900-0197	Flowcell Assy., 2.5 μl, 6 mm path length (for Procise-cLC)
2900-0478	Photodetector PCA with diodes
2900-0484	Deuterium lamp
2900-0517	Monochromator Assy. (Phase 2)
2900-0530	Fan Assy.
2900-0542	Flowcell Assy., 12 μl, 8 mm path length (for Procise-HT)
3100-0173	Photodiode Gasket, 1/8 in.
3100-0174	Photodiode Gasket, 1/16 in.
3500-0207	Stepper Motor Assy.
3900-0006	Battery, Lithium, 3.0 V
4700-0602	Leak Sensor Assy.
4800-0089	Photocell, UV enhanced
4800-0202	Display, 4 x 40
5100-0089	Fuse, 5 x 20, 0.25 Amp
5100-0160	Fuse, 1 Amp, time lag
6000-0564	Cable Assy., Detector to SE
6000-0565	Cable Assy., Display to I/O
6000-0566	Cable Assy., I/O to SE
6000-0567	Harness, AC Input
6000-0569	Cable Assy., Indexer

Applied Biosystems

TROUBLESHOOTING & PROCEDURES

TROUBLESHOOTING THE MODEL 785A

1 TESTING NOISE AND DRIFT SPECIFICATION ON THE MODEL 785A

1. Allow the Model 785A to warm up for at least 2 h.
2. Install a dry cell into the Model 785A.
3. Plug a chart recorder into the Model 785A, and set the chart recorder to 10 mV full-scale at 10 cm/h.
4. Set the rise time to 1 s.
5. Set the range to 0.001 AU.

NOISE:

6. Test for 2% peak-to-peak noise at 238 nm.

DRIFT:

7. Test for 10% drift/h/°C at 238 nm.

2 FAULTS AND SYMPTOMS

SYMPTOM	CAUSE	SOLUTION
1. Nothing works	• No power at outlet • Faulty power cord • Blown fuse • Faulty switch/ac harness • Faulty power supply	• Check for correct voltage at ac outlet • Replace power cord • Replace main fuse • Check for ac at J3 pins 1 and 4 on power supply • Replace power supply
2. Nothing works except fan	• Faulty power supply • Faulty main PCB	• Check status LEDs • Replace main PCB
3. No display	• Faulty display or contrast • Control out of adjustment	• Check contrast control • Replace display
4. No keyboard function	• Faulty display I/O PCB • Faulty keyboard • Faulty main PCB	• Replace display I/O • Replace keyboard • Replace main PCB
5. Fan fail message	Faulty fan	Replace fan

SYMPTOM	CAUSE	SOLUTION
6. Leak message	• Leak • Faulty leak sensor • Faulty main PCB	• Repair leak • Replace leak sensor • Replace main PCB
7. Lamp failure	• Faulty lamp • Faulty fuse F201 • Faulty power supply	• Replace lamp • Replace fuse F201 in power supply • Replace power supply
8. Wavelength drive fault	• Software fault ("glitch") • Dirty drive screw • Faulty main PCB • Faulty indexer PCB • Faulty stepper motor • Faulty monochromator	• Reset system by holding "+/-" key while turning the instrument on • Clean drive screw in monochromator with contact cleaner spray and re-lubricate with Tufoil® lubricant • Replace main PCB • Replace indexer PCB • Replace stepper motor • Replace monochromator
9. "Garbage" on display	• Software fault ("glitch") • Faulty display • Faulty main PCB	• Reset system by holding "+/-" key while turning the inst.ument on • Replace display • Replace Main PCB
10. No auto-zero	• Bubble in flowcell • Unequal light entering detector head • Faulty main PCB • Faulty detector head PCB	• Check for bubble by running wavelength to 656 nm and comparing the red light from the flowcell to the light from the dry cell. The light beams should appear identical. • Check sample and reference values by using two dry cells. If the values are unequal, replace monochromator. • Replace main PCB • Replace detector head PCB
11. Baseline drift	• Flowcell or mobile phase • Defective lamp • Unstable ambient (surrounding) conditions. Excessive air circulation. Changing temperatures. • Outgassing in monochromator • Faulty detector head PCB • Faulty main PCB	• Install dry cells to isolate problem • Replace lamp • Relocate instrument or protect it from draft • Purge monochromator with nitrogen • Replace detector head PCB • Replace main PCB

SYMPTOM	CAUSE	SOLUTION
12. Noisy baseline	• Flowcell or mobile phase • Defective lamp • Outgassing in monochromator • Faulty detector head PCB • Faulty main PCB	• Install dry cells to isolate problem • Replace lamp • Purge monochromator with nitrogen • Replace detector head PCB • Replace main PCB
13. Negative peaks	• Polarity of output cable reversed • Contaminated mobile phase	• Correct polarity of output cable • Install dry cells to isolate problem
14. Keyboard locked message	• Keyboard locked • Software fault ("glitch") • Faulty main PCB	• Unlock keyboard by going to second utility screen and holding the keyboard key while pushing the "+/-" key • Reset system by holding "+/-" key while turning the instrument on • Replace main PCB
15. No RS-232 communication	Faulty RS-232 cable	Verify RS-232 Port is functional by running Model 785A diagnostics. If it is functional, check the system that provides control of the Model 785A. If it is not functional, replace main PCB
16 No output	Faulty main PCB	Replace main PCB
17. Relays not working	Faulty main PCB	Replace main PCB
18. Remote functions not working	• Faulty remote cable • Host device defective • Faulty main PCB	• Replace remote cable • Test remote function by shorting appropriate pins of the remote connector of the Model 785A • Replace main PCB

ELECTRONICS

1 SIGNAL ELECTRONICS PCB

1.1 Microprocessor and Memory

The microprocessor is an 8085 operating at 3 MHz. The processor address and data lines connect to (1) a 27256 (32 kB) EPROM that stores the system software and (2) a 4464 (32 kB) RAM with battery backup that stores the user programs.

1.2 Reset, "Watchdog Circuit," and Battery Backup

The U32 IC provides (1) a reset output during power-up, power-down, or low voltage conditions; (2) battery backup switching in case of power failure; and (3) a reset signal if the "watchdog" timer does not detect software activity within a selected interval.

The battery voltage (Vbatt) is connected to U32. If the "+5 V" voltage drops below 4.65 Vdc, the "V out" output is switched from "+5V" to the battery voltage, thereby protecting the data in RAM (U18). At the same time, a reset signal is sent to the microprocessor.

The "watchdog" circuit monitors pulses on "WDI." "WDI" is connected to the enable line of the top half of the front panel display. If no pulses are sensed within a 1.6-s period, a reset signal is sent to the microprocessor.

1.3 Keyboard/Display Connector

The keyboard display connector (J4) provides the data lines, +5 V, -5 V, Gnd, "beep" signal, keyboard strobe line, and other control signals to the display I/O PCB through a ribbon cable.

1.4 Programmable Interval Timer

The programmable interval timer IC (U11) provides clock pulses for the stepper motor driver, auto-zero clock, and tone frequency required for the "beep" function.

1.5 Remote/Test Connector

The remote/test connector allows external commands to be sent to the instrument through remote cable. This connector also provides various test signals for diagnostic purposes. The signals are as follows:

1	DETHD	RAW DETECTOR HEAD OUTPUT
2	REFV	+10 Vdc REFERENCE VOLTAGE
3	H/T	AZ SAMPLE AND HOLD VOLTAGE
4	OUT2	OUTPUT SIGNAL 2 (FINE RANGE)
5	+5 V	+5 Vdc
6	AGND	ANALOG GROUND
7	MK	REMOTE MARK INPUT
8	AOZO	REMOTE AUTO ZERO INPUT
9	-PGM1	REMOTE PROGRAM SELECT 1 INPUT
10	-PGM2	REMOTE PROGRAM SELECT 2 INPUT
11	-PGM4	REMOTE PROGRAM SELECT 4 INPUT
12	LPCL	LAMP CONTROL INPUT
13	+15 V	+15 Vdc
14	-15 V	-15 Vdc
15	-ATPGM	REMOTE PROGRAM ABORT INPUT
16	SAM	SAMPLE VOLTAGE
17	REF	REFERENCE VOLTAGE
18	SUM	AZ CORRECTED SIGNAL
19	OUT1	OUTPUT SIGNAL 1 (COARSE RANGE)
20	FIL	FILTER OUTPUT
21	DAC1	COARSE RAMP OUTPUT
22	DAC2	FINE RAMP OUTPUT
23	CMP1	END AUTO ZERO FUNCTION (LO)
24	CMP2	END AUTO ZERO FUNCTION (HI)

1.6 Detector Signal Electronics Circuitry

The signal electronics receive a signal from the detector head and condition the signal for correct output. The following three major functions are performed:

- Filter the signal to reduce noise (rise-time value).
- Add a dc level to the signal to establish a baseline (auto-zero).
- Attenuate the signal to set the full-scale value (range selection)

1.6.1 Rise-Time Filter Section

The filter section of the signal electronics consists of integrated circuits U5 and U6 and their associated resistors and capacitors C12, C13, and C14. The circuit is a Bessel, two-pole, low-pass, active filter. Component values are chosen to give a Bessel response. Rise-time values are related directly to both resistance and capacitance values in the circuit. Only the resistance values are switched to change the rise-time values.

U5 and U6 are CMOS analog switches. Each switch selects one of a pair of resistors that are connected into the circuit, controlling the rise-time. A digitally encoded signal from the microprocessor informs the CMOS switches which resistor pair to connect. Because of possible noise contributions, U5 and U6 use a separate, regulated +5-Vdc supply ("+5VA") from that used for the digital circuitry.

The signal from the detector head is at -3.5 V/AU when it enters the filter section. The U7 amplifier has a gain of 1. Filter-stage output is therefore -3.5 V/AU.

1.6.2 Auto-Zero Circuitry

The purpose of the auto-zero circuitry is to add a voltage to the signal from the filter section so that the sum of the two signals equals zero. This establishes a baseline within the range of the output device or recorder.

The signal for the auto-zero dc level is generated by two 12-bit digital-to-analog converters (DACs), U22 and U13. Two 4040 counter ICs (U21, U13) provide digital "ramping" that is input to the DACs. A comparator (U43 and associated components) detects the zero voltage condition and the microprocessor shuts down the ramping. Current from the DACs, which hold their values, and the signal input are summed in the auto-zero op amp (operational amplifier) (U42).

1.6.3 Range and Output Circuitry

The signal level from the filter section is -3.5 V/AU. This signal is inverted to +3.5 V/AU by the auto-zero summing amplifier.

The range-and-output circuitry attenuates the signal for output to a chart recorder or other devices.

In the Model 785A, the computer output is software-selectable to three ranges: 0.2, 0.5, and 1 V/AU. Control signals from U27 (CRNG1 and CRNG2) are connected to analog switch U8. Resistors are switched in to change the value of the resistance in series with the computer output.

The recorder output attenuation is obtained in two stages, a coarse (approximate) gain stage and a fine gain stage. The coarse gain stage is a voltage divider with an integrated CMOS switch (U23) and a series of resistors. This divides the signal by 0.349, 3.49, or 34.9. The attenuated signal proceeds through the coarse gain amplifier (U38) to the fine gain stage. The fine gain stage is an amplifier (U39) whose gain is determined by the output of a 12-bit DAC (U35). The microprocessor writes three times to get 12 bits on four lines. In this way, output ranges can be selected from 0.0005-3 in 0.0005 increments. These ranges are expressed in absorbance units full scale (AUFS). Full scale is defined as 10 mV.

1.6.4 Event Mark

When U27 provides the "MRK" control signal, an approximately 1-mV event-mark voltage is added to the chart recorder output. The TTL level of the "MRK" signal is pulled up to +5 Vdc through RN3 and divided by 5000 by resistor R89.

1.7 DVM

The DVM IC (U28) performs the tasks necessary for reading the signal voltage level from the detector as well as the sample, reference, and zero-offset voltages. This IC also monitors the leak sensor and provides the real-time clock frequency to the microprocessor. The DVM IC has two adjustment devices associated with its function, one for the reference voltage adjustment and the other for trimming the oscillator frequency.

1.8 Leak Sensor

The leak sensor is a heated thermistor within a glass envelope. It is located below the flowcell in the drip pan. The sensor resistance is inversely proportional to the temperature at the end of the sensor. A leak can be sensed because of the difference in heat conductivity between air and liquids. If the sensor is dry, the temperature of the heated sensor tip is high. If the sensor is wet, heat is absorbed by the liquid, the temperature drops, and resistance increases rapidly. Software senses the voltage change through the sensor as measured by the DVM IC.

1.9 Signal Electronics Power Supplies

A separate +5 Vdc, called "+5VA," is provided by voltage regulator U1. +5VA is used where noise-free +5 Vdc is required. -5 Vdc, provided by U2, is used by U34. -12 Vdc, provided by U3, is used by U5 and U6.

1.10 Power Fault Monitor

U10 is a quad power fault monitor IC that monitors four dc voltages and the ac line voltage. "+5 VA," "VR," "+15V," and "-15V" are monitored. If a power fault is present at any input of U10, the pin 6 output, called "PF," goes high. "PF" is connected to the microprocessor (U24) "TRAP" input and gives the microprocessor a non-maskable interrupt.

1.11 Indexer Input Connector

The indexer input connector provides operating voltage to the indexer PCB and receives signals (OUTRNG, HI/LOW, and INDEX) from the indexer PCB.

1.12 Stepper Motor Control

Two control lines from the U27 controller IC (DIR and -SEN) and the ST/AZ CK clock signal from U11 are used to control the stepper motor driver (U31). DIR controls direction of the stepper motor. ST/AZ CK controls step rate and gives one clock pulse for each half-step when stepper motor movement is required. When -SEN (step enable) is high, the output of U26 stays low. This prevents the clock pulse from reaching the driver.

-SEN also controls (through Q2) the amount of power applied to the stepper motor. When the motor is not moving, -SEN is high and power is reduced to the stepper motor by the current limiting resistors R81 and R82. This amount of power is enough to hold the motor in place. When -SEN is low, Q2 allows full current to the motor windings to move the stepper motor.

1.13 LED Status Indicators

The LED status indicators give a visual feedback of key signals for diagnostic purposes. The signals are as follows:

ST OUT A	STEPPER DRIVER OUTPUT A BEING DRIVEN
ST OUT B	STEPPER DRIVER OUTPUT B BEING DRIVEN
ST OUT C	STEPPER DRIVER OUTPUT BEING DRIVEN
ST OUT D	STEPPER DRIVER OUTPUT D BEING DRIVEN
RELAY 1	RELAY 1 IN NORMALLY OPEN POSITION
RELAY 2	RELAY 2 IN NORMALLY OPEN POSITION
RELAY 3	RELAY 3 IN NORMALLY OPEN POSITION
RELAY 4	RELAY 4 IN NORMALLY OPEN POSITION
INDEX	OPTICAL INTERRUPTER ON INDEX BOARD IN BLOCKED POSITION
OUTRNG	OUT OF RANGE SWITCH ON INDEX BOARD IN CLOSED POSITION

1.14 Relay Control Circuitry

The Model 785A makes use of four independent latching relays (K1 - K4). These relays hold their last position when power is removed. Each relay has three rear panel connections, located on J12: NO (normally open), NC (normally closed), and COM (common). Each relay has two windings, one for NO and one for NC. U37 (an octal driver) receives control signals (RLY1 - RLY4X) from the U29 controller and drives the corresponding relay windings. A RLY1 signal, for example, connects the K1 NC terminal to the COM terminal; an RLY1X signal connects the NO terminal to the COM terminal.

1.15 Auxiliary +12 Vdc Output

The J12 connector provides an external low current +12-Vdc power source (terminal 14). A ground connection is provided on J12 terminal 13. A self-resetting circuit breaker (CB1) provides overcurrent protection for the 12-V supply.

1.16 Serial Communications

Serial communications in the Model 785A is through connectors J7 and J8. Connector J7 is a female DB-9, and J8 is an eight-pin mini-DIN. The different styles of the serial connectors permit correct polarization of the ABI serial communication standard. In this standard, because units are "daisy-chained" together, receive and transmit lines must be correctly oriented.

The Model 785A uses the RS232 or RS422 protocol. Baud rates from 300-9600 are supported. The communication ports can be configured by selection at the front panel keypad.

U4 is a serial communications controller with two independent duplex channels. Channel A is used for the external serial communications. Channel B is connected to J1 (the power supply connector) for possible future use.

U34 is a dual differential line driver IC used for the transmit lines. Data from the U4 TXDA output is converted by U34 to two differential transmit lines, TXD+ and TXD. TXD+ can be used alone for RS232 or with TXD for RS422 protocol. The second driver of U34 is used to convert the "beep" signal to BP1 and BP2. BP1 and BP2 are used to drive the sound-producing device in the front panel.

U33 is a line receiver IC that conditions the receive lines and optional "handshake" line to TTL levels. The receive lines (RXD+ and RXD) can be used together for the RS422 protocol. The RXD+ can be used alone for RS232. The handshake line (HSK) is connected to the CTSA (clear-to-send) and TRXCA (transmit/receive clock) lines of U4.

2 MAIN POWER SUPPLY

2.1 Main ac Input

The main ac input of the power supply provides surge protection (Z1 and Z2) and full-wave rectification (BR1) for the two switching transformers in both halves of the main power supply. The main ac input also provides voltage selection for the different ac levels that can power the instrument. Pins 2 and 3 of J3 are shorted for 100/110-Vac operation but are open for 220/240-Vac operation.

2.2 Low Voltage Section

The low voltage section is the first half of the two-part power supply. It has its own transformer and support circuitry. It contains its own fuse (F101), a high-frequency switching driver IC, and a feedback circuit that is completely independent of the second half. This power supply section provides instrument with the main power, consisting of +15, -15, +12, and +5 Vdc.

This section of the power supply contains the diagnostic LEDs, which provide status indication for the following:

DS 1D	+12 VDC
DS 1C	+5 VDC
DS 1B	-15 VDC
DS 1A	+15 VDC

LED Status Indicators
(as viewed from top to bottom)

2.3 High Voltage Section

The high voltage section is the second half of the two-part power supply. It has its own transformer and support circuitry. It contains its own fuse (F201), a high-frequency switching driver IC, and a feedback circuit that is completely independent of the first half. This power supply section powers the lamp (either 6 Vdc to a tungsten lamp or 10 Vdc for filament voltage of a deuterium lamp). The voltage is selected by the lamp connector itself (pins 1 and 2 of J2 for tungsten, or pins 2 and 4 for deuterium). Pin 3 of J2 provides the anode voltage for a deuterium lamp.

.3 DISPLAY I/O PCB

The display I/O PCB consists of two active logic circuits (U1 and U2) that provide the keyboard matrices, a 140 Ωhm impedance mini-speaker, and a contrast control potentiometer (R1) for the Supertwist (high contrast display) display. R2-18 provides electrostatic protection for the keyboard.

4 LCD DISPLAY

The LCD display is a blue Supertwist module with its own on-board RAM that maintains the screen characters. The module has a four-line x forty-column screen and implements a bi-directional data bus with an enable line to select between read and write cycles.

5 WAVELENGTH INDEXER PCB

The wavelength indexer PCB consists of two mechanical switches and an infrared optical sensor. The mechanical switches detect the monochromator limits of 30 below 0 and 800 nm. The optical sensor is interrupted by an indexer pin once every 360 deg of rotation of the wavelength drive shaft. The wavelength changes 100 nm for each revolution of the shaft. On startup, a software routine drives the monochromator wavelength downward toward 0 nm. When the lower limit switch is activated (30 below 0), the stepper motor reverses rotation and counts up to the previous wavelength setting.

6 PHOTODETECTOR PCB

The photodetector PCB is located within the detector head attached to the front of the monochromator.

Mounted on the PCB are two photodiodes, two log (logarithmic) amplifiers, and a differential amplifier. Each photodiode has an associated log circuit. The log circuit provides an output voltage that is a logarithmic function of the current from the photodiode. The log circuit uses an operational amplifier (U2) connected as a current-to-voltage converter with a transistor (U3) as the feedback element instead of the usual resistor. The op amp (U2) automatically adjusts the transistor's emitter potential so that its collector current the photodiode current.

The differential amplifier (U1) subtracts the sample log signal from the reference log signal and amplifies it to a level required by the signal processor. Potentiometer (R4) adjusts the gain of the differential amplifier. The thermistor T1 changes value by 0.33% for each degree Celsius to provide temperature compensation for the differential amplifier. Output level is -3.5 Vdc for each AU through J1 pin 3. Nontemperature-compensated values of the sample and reference log signals are output through pins 4 and 5 for diagnostic purposes.

Applied Biosystems

Using the Absorbance Filter Kit for Monochromator Wavelength Linearity Verification

Absorbance Filter Kit, Part No. 0602-0037
(For use on the following Kratos/ABI UV detectors: 120A, 130A, 757, 759A, 773, 783, 783A, 783G, 785A and 1000S)

The Absorbance Filter Kit is a set of six (6) interference filters mounted in housings which have the same diameter as the detector flow cells. The filters wavelengths are nominally: 200nm, 280nm, 360nm, 380nm, 460nm and 542nm. The actual peak wavelength of each filter is marked on the filter housing. These filters can be used to verify the wavelength linearity of the monochromator at the marked wavelengths ± 2nm.

1. Turn on the detector. Allow the detector to warm up for twenty (20) minutes.

2. Remove the flow cell from the detector (Suggestion: remove the cell with the inlet and outlet tubings intact). Replace with the 200nm absorbance filter. Close the detector head.

3. For detectors with manual wavelength selection (eg. 120A, 130A, 757, 759A, 773) monitor the sample side energy while dialing the wavelength from 195 to 205nm. Make a note of the wavelength at maximum energy. Always dial the wavelength up from lower wavelengths to higher wavelengths. Repeat the process for the 280nm and 360nm filters on the sample side. Then, move the dry cell to the sample side and repeat the process with the same three filters on the reference side, monitoring the reference energies.

NOTE: To monitor sample and reference energy on the 757 detector, connect a Digital Volt Meter between pin 15 (reference) or pin 16 (sample) and pin 22 (ground) on the Remote Test connector on the rear panel.

4. For detectors with motorized wavelength selection, make a table like the one below. With the 200nm filter in the sample side, select a wavelength of 197nm. Make a note of the energy reading (in the table) and then select the next higher wavelength. Always remember to move up in wavelength. Repeat the process with the 280nm and 360nm filters on the sample side. Again, move the dry cell to the sample side and repeat the process with the same three filters on the reference side, monitoring the reference energies.

Wavelength	Sample Energy	Reference Energy
197		
198		
200		
201		
202		
203		

Applied Biosystems

Using the Neutral Density Filter Kit for Detector Absorbance Linearity Verification

Neutral Density Filter Kit, Part No. 0602-0041
(For use on the following Kratos/ABI UV detectors: 757, 759A, 773, 783, 783A, 783G, 785A and 1000S)

The Neutral Density Filter Kit is a set of three (3) neutral density filters mounted in housings similar to the detector flow cell housing. Also included is an empty housing for setting the initial zero point on the detector. The nominal absorbances of the three filters are 0.2 AU, 0.5 AU and 1.0 AU at 238nm. The absorbances are marked on each filter.

1. Turn on the detector. Allow the detector to warm up for twenty (20) minutes. Set the wavelength to 238nm.

2. Remove the flow cell from the detector (Suggestion: remove the cell with the inlet and outlet tubings intact). Replace with the empty filter housing from kit. Close the detector head.

NOTE: It is important to close the detector head in a consistent manner.

3. Autozero the detector. Monitor the absorbance signal on the detector display or on a Digital Volt Meter attached to the fixed absorbance output (comp out). If the autozero point is not .000, make a note of the value in order to subtract it from the absorbance filter values.

NOTE: Monitor the absorbance for ten (10) minutes. If the drift exceeds 1x10-4 in ten minutes, do not perform the linearity test.

4. Again autozero the detector, making a note of the absorbance value. Remove the empty filter housing. Put the 0.2 AU filter in its place. Close the detector head. Do NOT autozero the detector. Write down the absorbance value.

5. Replace the 0.2 AU filter with the 0.5 AU filter. Again close the detector head. Write down that absorbance value.

6. Repeat with the 1.0 AU filter.

The absorbance values from the detector should agree with the marked values on the filters within the following limits (after subtracting or adding any zero point differences):

0.2 AU (nominal) ±.03 AU
0.5 AU (nominal) ±.035 AU
1.0 AU (nominal) ±.06 AU

NOTE: These reproducibilities are due primarily to the variability from filter to filter. Applied Biosystems detectors are typically linear to ±1%.

Typical causes of non-linearity are:

1) Light scatter within the monochromator caused by a spill.
2) Misaligned monochromator.
3) A bad photodiode PCB.