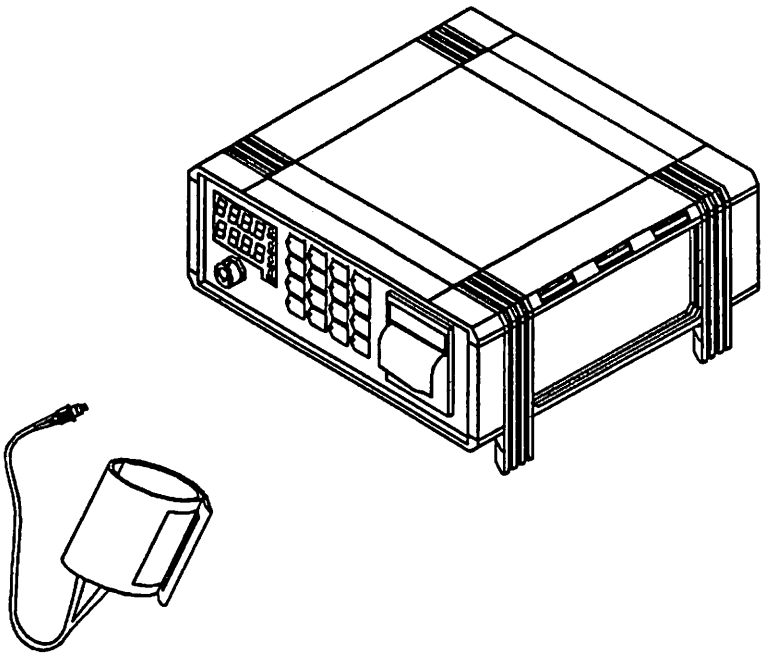
VASCUMAP®

NONINVASIVE VASCULAR DIAGNOSTIC SYSTEM

CALIBRATION & MAINTENANCE MANUAL



Carolina Medical

VascuMAP® Calibration & Maintenance Manual
revision of May 1996
for software release 2.00

Edited by James. S. Campbell, EE, MD.

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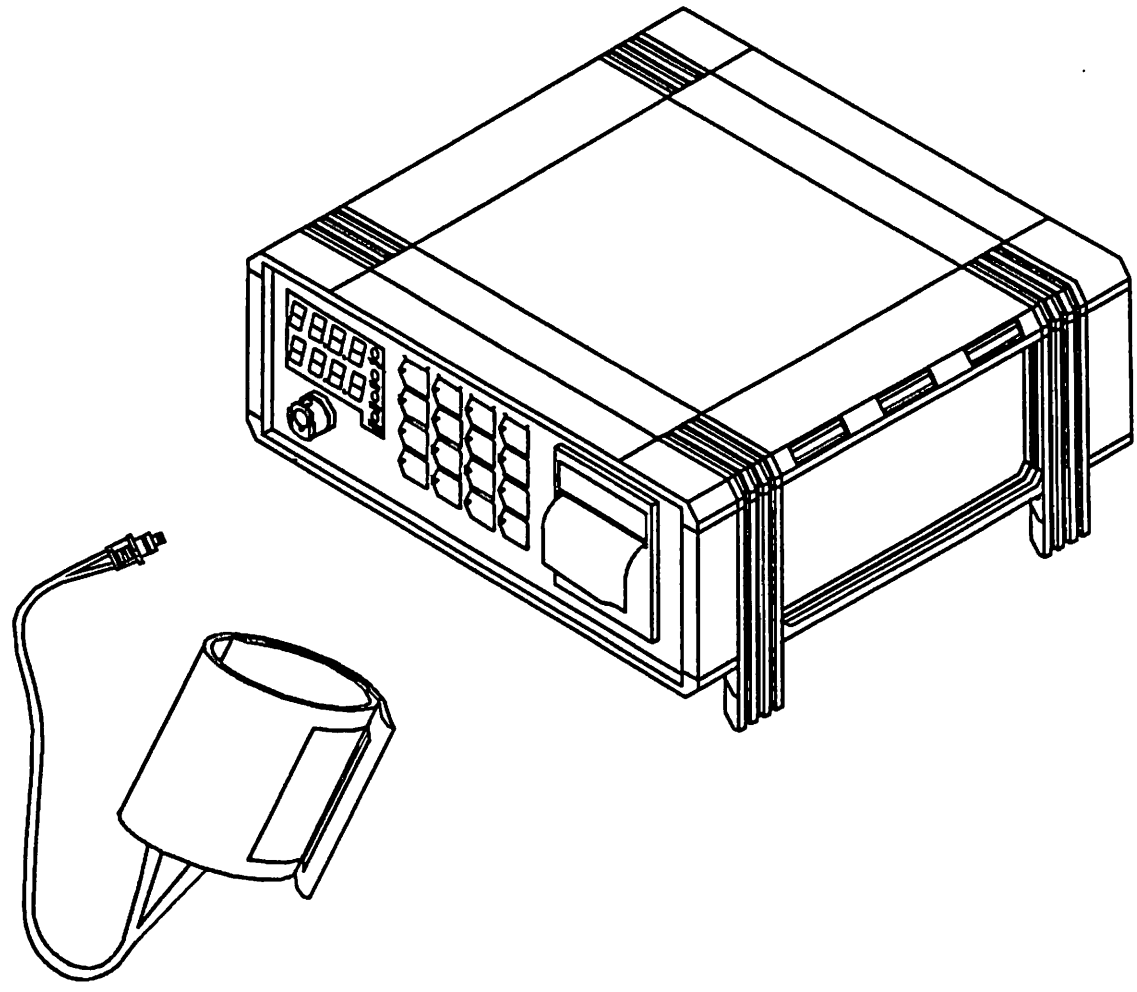
DEVICE DESCRIPTION

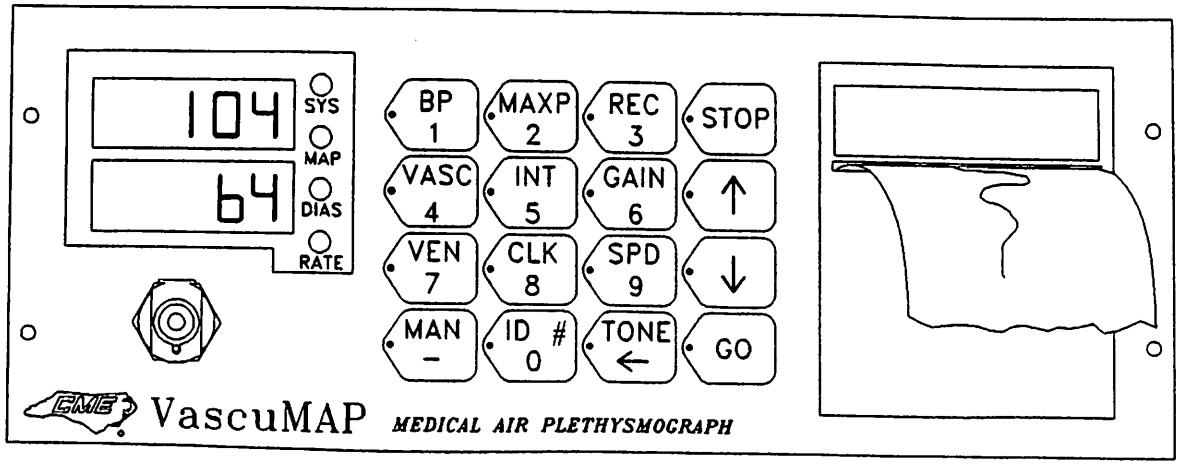
The VascuMAP is a multi-purpose diagnostic instrument based on the technology of high-resolution, high-bandwidth air plethysmography (APG) coupled with a precision positive-displacement volume calibrator. Its range of operation includes performing automatic and repetitive blood pressure measurements in humans and animals, acquiring and displaying arterial waveform patterns in both automatic and manual modes, and, in venous mode, observing and displaying venous volume changes. The only attachment to the subject under test is a standard blood pressure cuff. A wide variety of cuff sizes can be used on the device, as can disposable "single patient" cuffs. There are two tubing connections between the VascuMAP and the cuff. One tube fills and deflates the cuff under microprocessor command, while the other connection is dedicated to a pressure sensor within the VascuMAP. A special coaxial pneumatic connector is used to attach the cuffs to the instrument.



The VascuMAP unit is controlled by an 80C31 microprocessor (U1) which, after initial operator command, can automatically and repetitively perform blood pressure measurements through the oscillometric method and provide volume-calibrated pulse waveforms detected in the cuff. Interpretation of the oscillometric tracing for determination of the mean arterial pressure (MAP) and computation of the systolic and diastolic endpoints is done by the microprocessor using a specialized software algorithm developed by Carolina Medical.

Reporting of the systolic, diastolic, and mean pressures, as well as the subject's pulse rate, is done via two four-digit numeric LED displays which alternately display the four numbers. Another four discrete LEDs indicate which values are being displayed. These data are also reported on the chart recorder (if installed), along with arterial waveform tracings, pulse amplitude variation data (useful in predicting the reliability of BP measurements), time and date from the internal real-time clock, and the subject's identification number (if entered). Should the chart recorder become non-functional, the VascuMAP will continue to operate and display data via the numeric LED displays. The numeric display also shows, as needed, actual cuff pressure, cuff target pressure, time and date, chart recorder gain and speed, interval between repeat tests (in minutes), warning limits for all pressure and pulse readings, and patient's ID number.

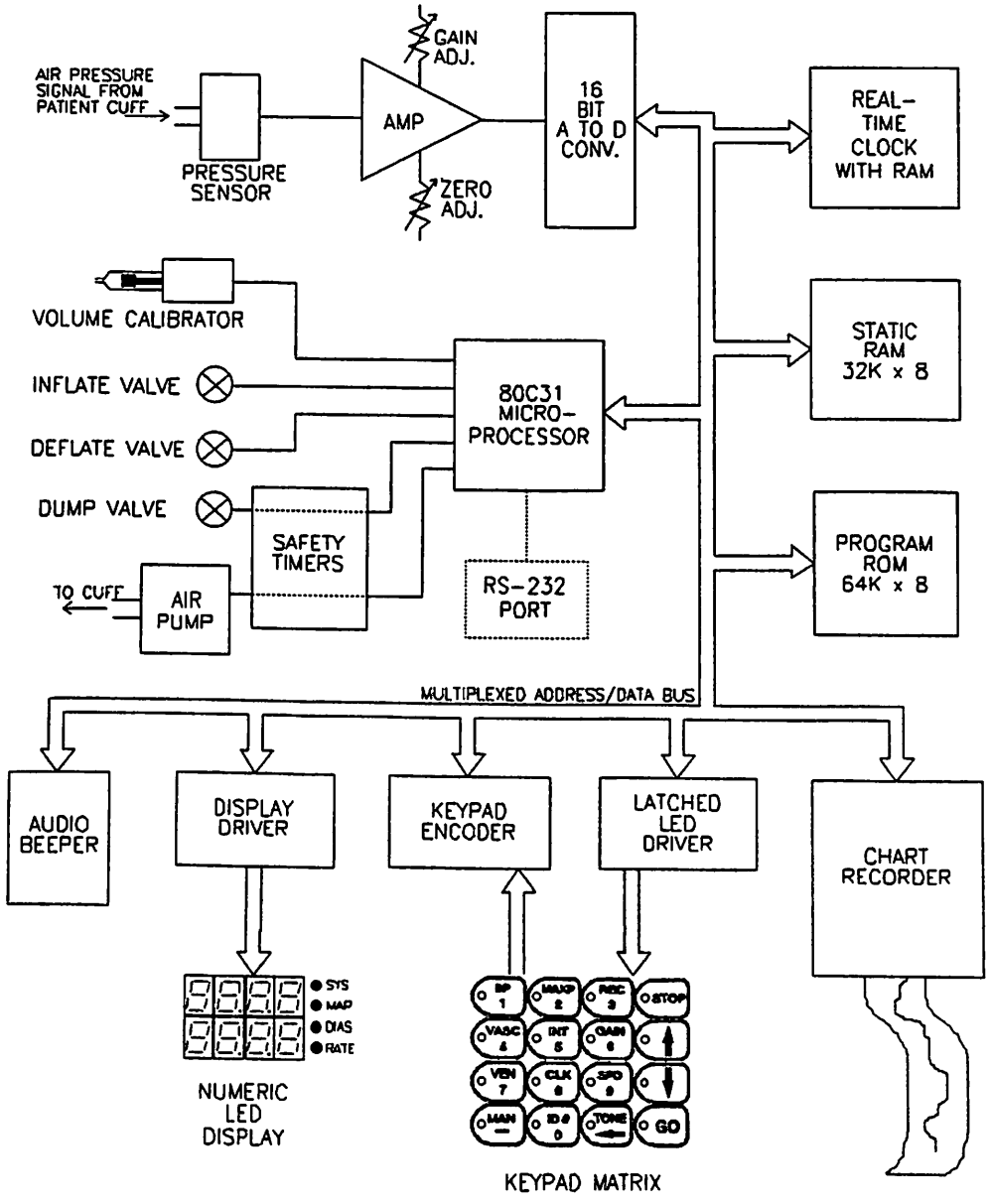
Operator control of the VascuMAP is done entirely through a 16-button lighted keypad front panel. The operator can select the test to be performed, the time interval between tests (such as repetitive blood pressure measurements), High and Low warning limits for Systolic, Diastolic, Mean Arterial Pressure (MAP) and Pulse rate during repetitive measurements, the reporting and display formats (BP, VASC, VEN, and MAN), and the maximum cuff inflation pressure. Also, the patient's ID may be entered, the clock set, the audible tone turned on or off, and the chart recorder gain, speed, and status controlled (during Manual functioning). One button, labeled "STOP", immediately deflates the pressure cuff when pushed. This button also exits a function entered in error.



DESCRIPTION OF THE CIRCUITRY

FOR REFERENCE: see the VascuMAP schematics in this manual.

CAUTION: Static Sensitive CMOS circuitry is used extensively throughout the VascuMAP and the AR-42 Chart Recorder. USE ANTISTATIC PROCEDURES when working on the VascuMAP circuitry.



The lights of the keypad are colored LEDs associated with each key. Each light is separate and under microprocessor control. During operation of the keypad, and at times during operation of the VascuMAP, these LEDS light or flash to prompt the operator for the next needed input. For instance, the "UP" and "DOWN" arrow keys light when the "MAX P" key is activated, as these raise or lower the pressure value displayed on the numeric LEDs.

THE KEY LIGHT CODE

10 Hz. FLASH RATE: INDICATES PRESENT FUNCTION

1 Hz. FLASH RATE: INDICATES FUNCTION RUNNING IN THE BACKGROUND

TRIPLE FLASH: THE ID# BUTTON FLASHES REPEATEDLY THREE TIMES WHEN THE VascuMAP IS IN KEYPAD LOCKOUT MODE.

OCCASIONAL FLASH: TONE BUTTON FLASHES WHEN PULSE DETECTED, GO BUTTON FLASHES WHEN PRESSURE ADJUSTED

LIT STEADILY: BUTTON IS ACTIVE IF PRESSED

NOT LIT: PRESSING BUTTON WILL HAVE NO EFFECT

To assure long-term accuracy, a manual calibration may be performed to check and adjust the VascuMAP's zero offset and gain against a known standard such as a mercury-column manometer.

Options to the basic VascuMAP Family (AP-102, AP-102R, and AP-102V) include a rugged Tilt Stand/Carrying Handle and a specially customized cart. An RS-232 port is an available option on special order. This DB-9 asynchronous serial port provides useful alphanumeric test and operational data at 9600 Baud (8 data bits, 1 stop bit, no parity).

POWER SUPPLY AND GROUNDING

The power supply is rated for 115 Vac 50/60 Hz, and is designed to meet UL-544 safety and leakage requirements. It consists of a Power Input Module (containing a power switch, fuse, EMI/RFI filter, and IEC power cord connector), a high-energy surge protector (Metal-Oxide Varistor), a low leakage 24 V-CT/2 Amp. transformer, full wave rectifier diodes, and hold-up capacitors for seven different voltage supplies: 16 V (unregulated) @8Amps (peak) for the pneumatic valves and the chart recorder print head, +12V @100mA (VR1), -12V @100mA (VR2), +5V @100 mA (VR6), and -5V @100mA (VR7) for the analog circuitry, +12 V @500 mA (VR3) for the front panel LEDs, and +5V @1Amp (VR4) for the digital circuits. Two non-adjustable analog reference voltages are used, +10V (VR5) and +2.5V (derived from +10V by R9, R10, and C23 and buffered by 1/4 of U10). Voltage and ripple specifications and testing locations for the power supplies appears in the appendix of this manual.

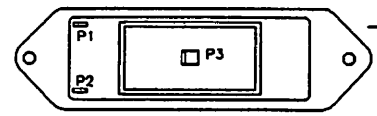
The Volume Calibrator is powered directly from 24 Vac, which is full-wave rectified to +33V and has its own "O V." ground level. (CAUTION: use only isolated instrument leads when testing this circuit). A 2 Ohm/2 Watt fusible resistor (R5) protects the solenoid coil from overheating if it is energized for approx 30 sec. +11V for the 555 timer (U1) is derived from the 33V supply via R4, D2, and C2.

No software control is used on the power supply. Automatic reset of the 80C31 occurs at power-up, as does reset of the AR-42 chart recorder.

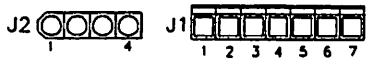
Standard "earth" ground is provided at the IEC power connector, with the rear panel of the cabinet being the common grounding point. The aluminum chassis plate is grounded to the rear panel. An electrostatic shield within the front panel membrane keypad connects to the two side panels at the four mounting screw sites.

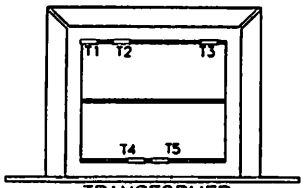
The center tap of the 24V power transformer is the meeting point common to the Analog and Digital grounds in the VascuMAP. A 10 Ohm resistor (R26) equalizes the two grounds on the motherboard for component protection when the power connector (J1) is not connected. A digital ground point (TP1) is provided on the VascuMAP motherboard for convenience in testing and troubleshooting.

The metal body of the Volume Calibrator is not grounded, although connecting it to ground does no harm. The Volume Calibrator circuitry inside the case should NOT be grounded, however (see above).



POWER INPUT MODULE

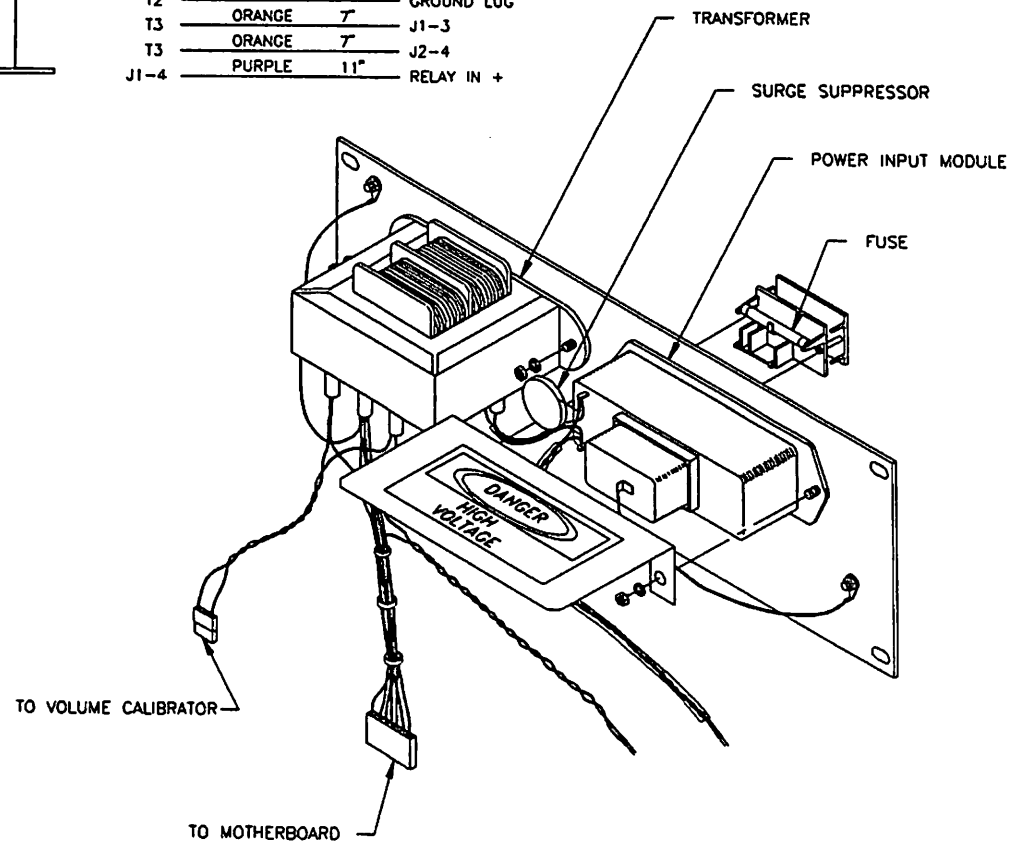




TRANSFORMER

WIRE RUN LIST

FROM	SURGE SUPPRESSOR		TO
P1			P2
P1	RED	6"	T5
P1	RED	9"	RELAY OUT
P2	BLACK	6"	T4
P2	BLACK	9"	TERMINAL LUG
P3	GREEN	7"	GROUND LUG
T1	ORANGE	7"	J1-5
T1	ORANGE	7"	J2-1
T2	WHITE	7"	J1-6
T2	BLUE	7"	J1-1
T2	BLUE	7"	J1-2
T2	BLUE	7"	J1-7
T2	GREEN	7.5"	RELAY IN -
T2	GREEN	7"	GROUND LUG
T3	ORANGE	7"	J1-3
T3	ORANGE	7"	J2-4
J1-4	PURPLE	11"	RELAY IN +



Rear Panel Wiring Detail

POWER AND GROUND SAFETY TESTING

Introduction

The VascuMAP is designed to the safety specifications of Underwriters' Laboratories UL-544 for Medical and Dental Equipment, and should be tested with calibrated equipment which can verify that the VascuMAP meets that specification. As there are many such instruments available, the technician is advised to follow the instructions of the particular analyzer(s) to be used in testing the following specifications to assure patient and electrical safety.

Chassis-to-source-ground impedance: LESS THAN 100 milliOhm (0.1 Ohm), max.

Line-to-source-ground breakdown voltage: GREATER THAN 1500 Volts,rms, 50-60 Hz, sinusoidal.

Source ground leakage current at the rated source voltage (120 or 240 Vrms), 50-60 Hz, sinusoidal: LESS THAN 50 microAmps, max.

(NOTE: As the VascuMAP has no external electrical connection other than line power and ground, the UL-544 specification requiring a minimum 2500 Vrms breakdown voltage between the power line input and any external electrical connection need not be tested.)

Testing Procedure:

Equipment Required;

1) VascuMAP Model AP-102x with power cord

2) Safety Analyzer(s) with instruction manual(s) to test device ground impedance, current leakage, and voltage breakdown per UL-544 Specification

3) Power source to supply the VascuMAP's rated voltage and current (may be wall power plug or special power generator).

Ground Impedance Verification:

A) Connect the VascuMAP to the Safety Analyzer using the VascuMAP's power cord. Some analyzers have a standard power plug for this connection, others have an alligator clip which is used to connect to the ground pin on the VascuMAP's power cord.

B) Connect the ground testing lead from the Safety Analyzer to the rear panel of the VascuMAP. Because this metal panel is anodized aluminum, it may be necessary to scratch the panel surface to make good electrical contact. If scratching the outside surface is not acceptable cosmetically, the top of the VascuMAP may be removed and the inner surface of the rear panel used for the test.

C) Once connections (A) and (B) have been established, use the protocol outlined in the instructions for the Safety Analyzer to measure the ground impedance. Turning the VascuMAP's power switch ON or OFF should have no effect on this measurement. Ground impedance must measure 0.1 Ohm or less to pass this test.

D) Remove the ground testing lead from the VascuMAP and close the top cover if it was opened for the test.

Line-to-Ground Breakdown Verification:

A) Plug the VascuMAP into the Safety Analyzer's test plug using the VascuMAP's power cord.

B) Using the protocol outlined in the Line-to-Ground Voltage Breakdown instructions for the Safety Analyzer, gradually apply up to 1500 Volts, rms, 50-60 Hz (sinusoidal) between the two power leads and the ground lead of the power cord. Breakdown should NOT occur for the VascuMAP to pass this test.

Source Ground Leakage Verification:

A) Ground Impedance must be verified first before this test is performed.

B) Plug the VascuMAP into the testing plug on the Safety Analyzer using the VascuMAP's power cord. Connect the analyzer to a power source that is correct for the VascuMAP (either 120V or 240V, 50-60 Hz). Be sure the Analyzer is set for this same power source voltage if required in the Analyzer's instructions.

C) Some analyzers have a test lead that must be connected to the VascuMAP's rear panel for this test. Connect this lead as outlined in step (B) of the Ground Impedance Verification (see above).

D) Using the protocol in the instructions for the Safety Analyzer for ground leakage testing, measure the ground leakage current with the VascuMAP turned ON. Leakage measurements must be made with the power leads correct, with the power leads reversed, with the neutral power lead open circuited, and with the safety ground in the power cord intact and open circuited. Ground leakage current must be less than 50 MicroAmps, rms under all of these conditions for the VascuMAP to pass this test.

POWER SUPPLY TROUBLESHOOTING NOTES

THE BLOWN FUSE:

The VascuMAP is equipped internally with a 150 Vrms surge suppressor (MOV-1). If a voltage surge occurs on the power input when the unit is ON, the suppressor will short the surge across the two power inputs (hot and neutral). The surge is NOT shunted to protective ground. Note that the fuse is located between the power input (hot) and the MOV.

If the surge suppressor shorts out a large voltage spike, the fuse may blow. This protects the internal circuitry. When replacing a fuse that blows repeatedly, the VascuMAP case should be opened and the MOV inspected for external signs of damage. If damaged, the MOV should be replaced before returning the unit to service.

If there is no visible damage inside the VascuMAP, and the fuse continues to blow, a systematic checkout of all the power circuitry is necessary.

ELECTRO-PNEUMATIC SYSTEM

Five electro-pneumatic devices are used to control cuff inflation and deflation and to provide volume calibration pulses (see the diagram of the Pneumatic System). When the instrument is idle between tests, all five devices are de-energized.

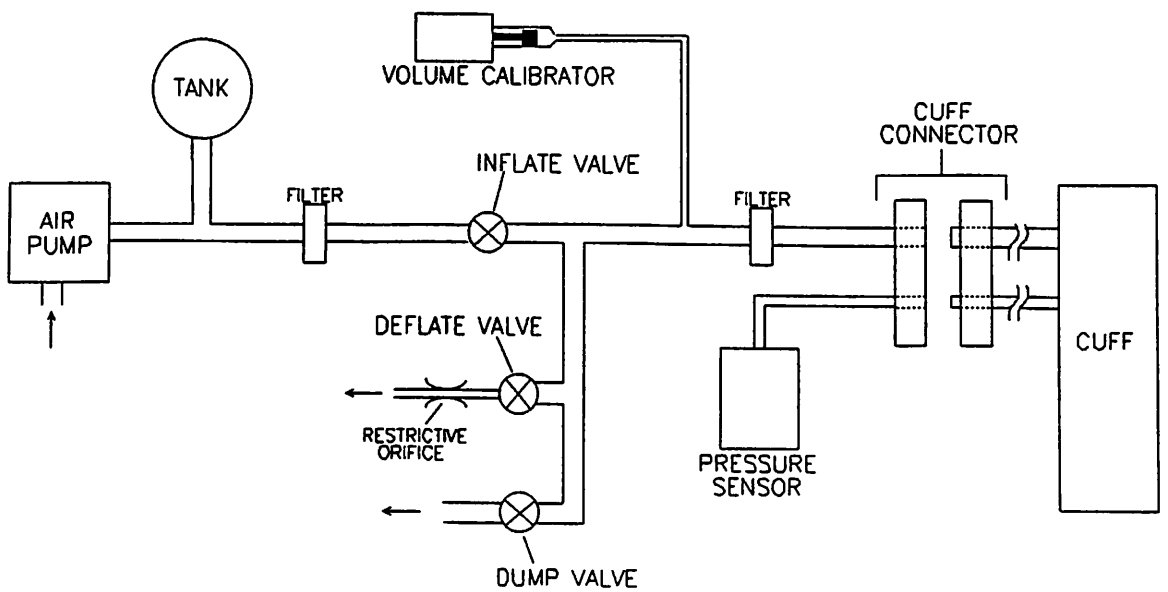
1) The AIR PUMP is powered with 115 Vac 50/60 Hz switched by a normally-open opto-isolated solid state relay (RLY1). This relay is controlled with a "watchdog" timer (1/2 of U22) which must be refreshed by software pulsing the PUMPON line high for 1 us at intervals not greater than 30 milliseconds. This keeps the PUMPSIG signal at +5 Volts, turning the relay ON.

2) The INFLATE VALVE is a normally-closed pneumatic valve between the accumulator tank and the cuff. Software opens this valve during cuff inflation by driving the INFLT line high, or by "pulsing" it with a variable duty cycle for controlled inflation. During patient cuff pulse waveform acquisition, this valve is closed.

3) The DEFLATE VALVE is a normally-closed pneumatic valve that deflates the cuff to atmospheric pressure through a restrictive orifice when activated. Software opens this valve during slow cuff deflation by driving the DEFLT line high. Otherwise, this valve remains closed during a test. For very slow deflation, this valve may be "pulsed" by software for several milliseconds at a time, allowing time between pulses for the cuff pressure to settle. The 0.005" restrictive orifice of the DEFLATE Valve gives a flow rate about 50 times less than the DUMP valve.

4) The DUMP VALVE is a normally-open pneumatic valve that rapidly deflates the cuff to atmospheric pressure if power is not supplied. This "dump" valve is powered by a watchdog timer (1/2 of U22) that must be refreshed by writing a 1 us high pulse to the DUMPOUT line at intervals of up to 30 ms or the valve will open and the cuff will be deflated. A diode gate also allows the 80C31 to open this valve at any time by holding DUMPOUT low. The DUMP valve is opened by software to deflate the cuff at the end of a test.

5) The VOLUME CALIBRATOR (optional) consists of a precision custom metal bellows which is actuated by a solenoid. When the 80C31 drives the VOLCAL line HIGH, the solenoid is energized for approx 110 ms by the 555 capacitively-triggered monostable timer (U1) in the Volume Calibrator circuit, drawing 0.5 cc of air OUT of the air cuff. A return spring then pushes the air back into the cuff, completing one calibration pulse. A precision Orifice Restrictor prevents pneumatic "ringing" when this calibration pulse occurs.



ANALOG FRONT END CIRCUITRY

The analog front end amplifies the cuff air pressure signal from the piezoresistive pressure sensor (XD-1) by a factor of 33 in the AD624 Instrumentation Amplifier. Zero offset is adjustable at this stage by adjusting R1. The signal is then processed through a 20 Hz single pole low-pass filter (R4 & C8) and passed to a non-inverting gain stage (1/4 of U10), which may be adjusted via R5 to amplify the signal so that +2.5 volts appears at the input of the A to D Converter (U13) when 317+ mmHg pressure is detected by the pressure sensor. This voltage should be 0.0 Volts when the pressure at the sensor is zero.

Calibration of the analog front end is advisable at least annually to assure that the VascuMAP is showing pressures accurately. This is done in Manual Mode. In this mode, software displays the pressure reading of the pressure transducer constantly to 0.1 mmHg accuracy. First, the cuff connector on the unit is left open to the atmosphere and the display reading adjusted to read just below 0.1 mmHg via the ZERO ADJ control. Then a calibrated pressure gauge (mercury manometer or other) is attached to the cuff port using the adapter supplied with the VascuMAP, and the pressure raised to near 250 mmHg. Once the reading has stabilized, the GAIN ADJ control is used to make the display read the same value as the calibrated pressure standard. See the CALIBRATION Section for more details on this procedure.

ANALOG TO DIGITAL CONVERTER

16-bit analog to digital conversion is accomplished via an AD7701/CS5501 Delta-Sigma converter (U13). This device is supplied with a stable +2.5 volt reference, an 11 MHz clock derived from the 22 MHz system clock (CLK1) via 1/2 of U9, and a latched convert signal (1/2 of U9). At power-up, the converter also performs a self-calibration routine via the CALADC command from the 80C31 Microprocessor. This calibration, which takes 1/2 second to perform, assures monotonicity of the digital output from the converter, thus providing pulse waveform definition of the highest quality.

The A to D Converter is very susceptible to lock-up if voltage on any pin goes out of range, especially at power-up. To prevent this, all its power (and the power of all inputs) comes from the same source (analog +5V and -5V). The analog pressure signal voltage is prevented from going below the ground reference voltage by the Shottky diode (D15).

Output from the converter is in serial format, with the sixteen bits of data appearing with the most significant bit first. This serial data stream is converted to two 8-bit parallel bytes via two 74HC299 universal shift registers (U11 & U12). Once these registers are loaded with all 16 bits of data, they are read by the 80C31 microprocessor.

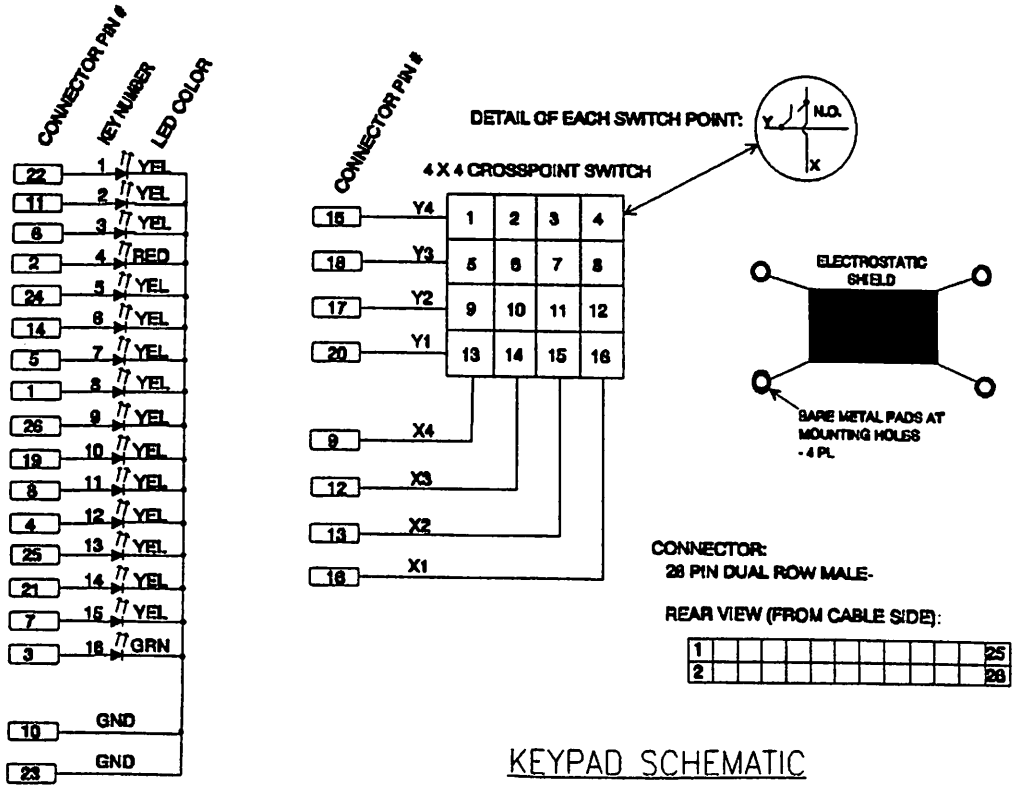
The microprocessor performs A to D conversion 256 times a second, timed by an interrupt from the DS1287 real-time clock (U2).

KEYPAD SWITCH INTERFACE

The 16 keys of the keypad are connected in 4x4 crosspoint array to an MM74C922 Keypad Encoder chip (U20). This device automatically scans the keys and performs debouncing functions on key press and release. Only one key may be pressed at a time. If one key is pressed, all others are ignored. When a key is pressed, the KDA (Keyboard Data Available) line to the 80C31 is driven high. This line is polled at 0.1 second intervals to detect a key press. Software can then read the 4-bit key data by driving RDKEY high, enabling the encoded output to appear on the data bus.

KEYPAD LIGHT INTERFACE

The 16 LEDs (one with each of the keyboard keys) are driven by two UCN-5815A latched driver devices (U17 & U18), each one controlling 8 of the lights. Two 470 Ohm resistor networks (RP2 and RP3) limit the current to the LEDs. These LEDs have their own +12V power supply (VR3).



KEYPAD SCHEMATIC

7-SEGMENT LED DISPLAY INTERFACE

There are two banks of four 7-segment LED displays located on a small LED Display daughterboard which plugs directly into the motherboard. The middle two digits of each bank are equipped with a trailing decimal point (the decimal point drivers of the outer digits are used to light the Discrete Annunciator LEDs on the daughterboard). The 80C31 drives the display via an ICM7218D Latched LED Driver (U19) which allows any digit to be changed independently. No series resistors are required, as U19 has current-controlled outputs. The display may show 0,1,2,3,4,5,6,7,8,9,-,E,H,L,P, and Off (blank). In addition to the Numeric LEDs, the four discrete LEDs annunciate which values are being displayed.

AUDIO TONE GENERATOR

A 100ms burst of 500 Hz square wave tone is produced via a 556 Dual Timer chip (U23) which drives a miniature electromagnetic audio transducer (SP1) mounted on the printed circuit board. To sound this tone, software must toggle the !BEEP address line low. Beep amplitude is not adjustable.

CHART RECORDER

Hard-copy output for the VascuMAP is provided through a Thermal Array Recorder (AR-42 by General Scanning, Inc.). The recorder is entirely controlled through software commands, and all data is entered digitally. The AR-42 also provides a readback function (via Octal Latch U24) so the 80C31 can read its control and data buffers during operation.

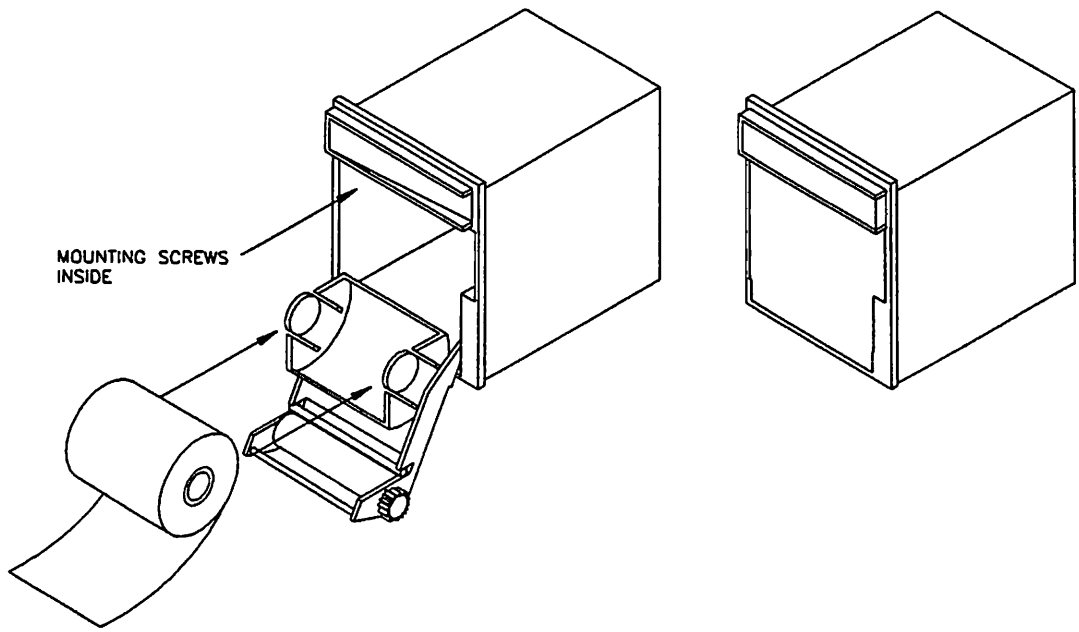
Power to the recorder consists of unfiltered +16V for the print head and +5V for the CMOS digital circuitry. All power, ground, and signal connections are made through a single 50-pin high-density connector.

CAUTION: TO PROTECT THE RECORDER, ALWAYS MAKE SURE THE POWER TO THE VascuMAP IS OFF BEFORE CONNECTING OR DISCONNECTING THE RECORDER CABLE.

A "hardware reset" line (!ARRST) is provided for reset of the recorder at any time. To perform a reset, this line must be pulled LOW, then taken HIGH. The recorder also resets automatically on power-up.

Mechanically, the AR-42 is designed for easy replacement of the recorder. The two mounting screws are captive type and are accessible by opening the paper loading door. Unplug the ribbon connector on the rear of the recorder and pull the unit out through the opening in the front panel.

The THERMAL PRINTHEAD is mounted on the spring-loaded assembly that presses the chart paper against the large rubber roller in the paper door. If the printhead is dirty, the recorder will print but portions will be missing. The printhead may be cleaned using a cotton swab moistened with alcohol.



OPENING THE VascuMAP CASE

Equipment Needed:

Medium Phillips Screwdriver

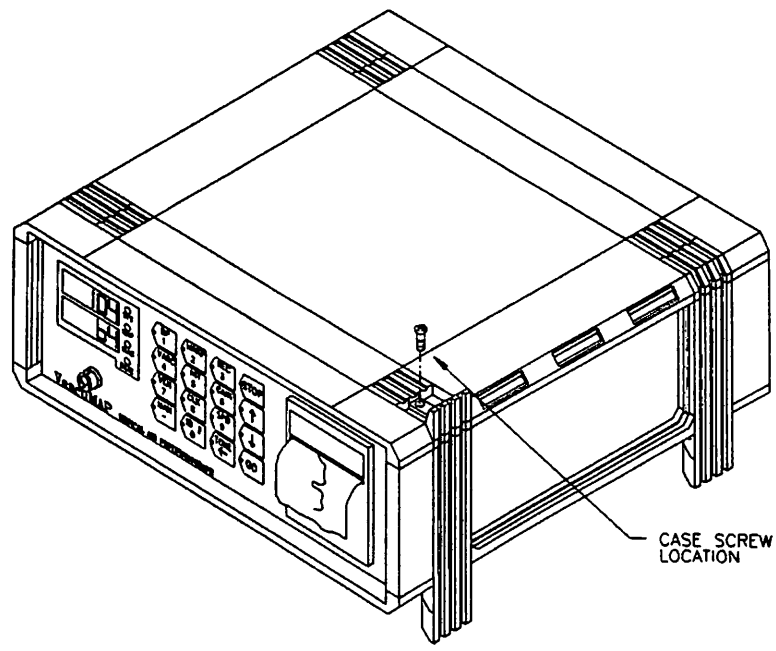
WARNING: SHOCK HAZARD! DANGEROUS VOLTAGES INSIDE. THIS PROCEDURE SHOULD BE DONE BY PROPERLY TRAINED PERSONNEL ONLY.

CAUTION: CMOS CIRCUITRY INSIDE. USE ANTISTATIC PRECAUTIONS WHENEVER WORKING ON THE VascuMAP CIRCUIT.

Procedure:

1) Unplug the unit.
2) Using a Phillips screwdriver, remove the four screws that hold down the top of the case. These screws are located under four small ribbed plastic inserts. With a flat-bladed screwdriver, pry up the edge of each insert which will hinge outward easily, exposing the screws.
3) Remove the top of the case by lifting it straight up.

NOTE: When CLOSING the case, be sure the small foam block just under the front edge of the cover is in proper location to hold down the LED Display Board (it is possible to replace the cover backwards).



PRESSURE CALIBRATION PROCEDURE

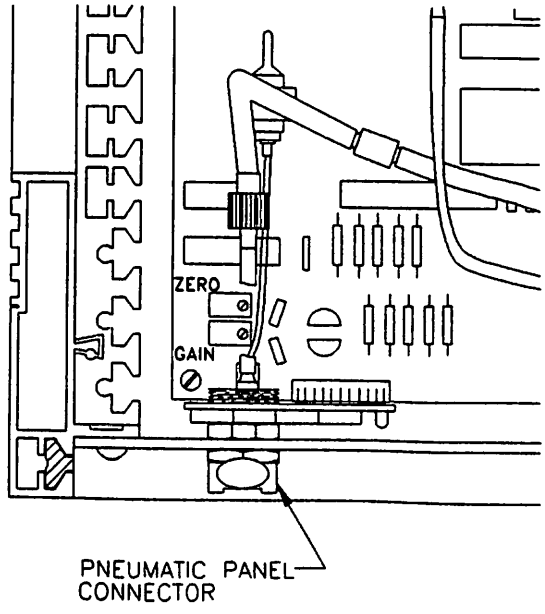
Calibration of the analog front end at least annually is advisable to assure that the VascuMAP is indicating pressures accurately. This is done in Manual Mode. In this mode, the upper display shows the pressure reading of the pressure transducer constantly to 0.1 mmHg. By applying known pressures (about 10 mmHg and 245 mmHg) the two ends of the pressure scale are checked for accuracy and adjusted if necessary.

Equipment Needed:

Medium Flat Blade Screwdriver
Small insulated flat blade screwdriver
VascuMAP Test Adaptor or Test Canister
Calibrated Pressure Standard with male Luer connector
(mercury manometer or other standard)

To perform calibration it is necessary to open the top of the VascuMAP case (see above). Then follow the step-by-step instructions below:

1) Look in the case and locate the two adjustments labeled ZERO ADJ and GAIN ADJ. These are found on the main circuit board near the cuff connector at the front of the unit.
2) Plug in and turn on the unit. SEE WARNING ABOVE!
3) After the Startup Routine, press GO and then MAN to begin the Manual Test Mode. Check "INT" to be sure it is zero (0).



4) Now plug the Test Adaptor into the Cuff Connector. Attach the calibrated pressure standard to the Luer end of the adaptor.
5) Using the Arrow Keys, adjust the Target Pressure to 8 mmHg. Press GO. The pressure will increase and then stabilize (settle) over 20-30 seconds. You may have to press GO several times to obtain a stable reading between 5 and 10 mmHg. If settling continues and will not stop, check all tubing connections for leaks.

NOTE: Atmospheric Pressure may be used as the low pressure reference standard by unplugging the Test Adaptor and adjusting the VascuMAP display to read just under 0.1 mmHg as per step #6.

6) Using the insulated Adjustment Tool or a small insulated screwdriver, turn the ZERO ADJ control so that the pressure indicated on the display reads the same as the reading on the pressure standard.
7) Using the UP Arrow Key, now set the Target Pressure (seen on the lower display) to 245 mmHg.

NOTE: Be sure the value of MAX-P is 245 mmHg or greater, as the Target Pressure cannot be set higher than MAX-P.

8) Press GO. The pump will start, and the indicated pressure will rise and then partially settle (due to thermal settling). You may have to press GO several times to get a stable reading above 240 mmHg on the pressure standard. If settling continues and will not stop, check all tubing connections for leaks.
9) When a stable reading above 240 mmHg is obtained, check to see if the reading on the upper display of the VascuMAP reads the same as the pressure standard. If the readings are different, slowly turn the GAIN ADJ control using an insulated tool until the readings match.
10) Decrease the Target Pressure back to 8 mmHg and press GO (or remove the Test Adaptor, see note, step #5). When the pressure is stable between 5 and 10 mmHg, check to see if the VascuMAP display pressure is the same as that shown on the pressure standard. If not, use the ZERO ADJ control to make the two equal.
11) Increase the Target Pressure back to 245 mmHg and press GO. When the pressure is stable again above 240 mmHg, compare the displayed pressure to that shown on the pressure standard. It should be very close. If needed, use the GAIN ADJ control to make the two readings the same.

12) If the VascuMAP is equipped with a Chart Recorder, a record of this calibration may be obtained if desired. Set the recorder GAIN to 20 cm/mmHg and the SPEED to 10 mm/sec. After any pressure settling has stopped, start the recorder by pressing REC. After 2 to 3 seconds, press REC again to stop the recorder and automatically record the pressure scale and footer information. Write the pressure shown on the pressure standard in the section of the footer labeled "Notes". Then lower the Target Pressure to the low reference level, and, when the pressure is stable, proceed as above to obtain a record of the low pressure adjustment.

13) Finally, unplug the unit for safety and replace the top cover with the four screws removed earlier (see above note on replacing the cover). The VascuMAP is now pressure-calibrated and ready to return to service. Be sure to store the Test Adaptor, Adjustment Tool, and a copy of this Calibration Procedure in a safe place for future use.

THE VascuMAP PNEUMATIC SYSTEM

FOR REFERENCE: See the VascuMAP Pneumatic Diagram on page 10.

CAUTION: DELICATE PNEUMATIC DEVICES. PREVENT DIRT AND LIQUID FROM ENTERING THE SYSTEM WHEN PERFORMING ASSEMBLY OR REPAIRS.

MAKING PNEUMATIC REPAIRS

1) 1/8" Barbed Tubing connections should be replaced rather than reused. It is difficult to disassemble these connections without damaging the connector and causing leaks on re-assembly. 1/16" connections may be reused if disassembly can be accomplished by slipping the tubing off.
2) When using pliers or clamps to grip or occlude tubing, slip sections of tubing over the jaws of the tool to protect the VascuMAP's tubing.
3) Do not use thread sealant or glue on barbed tubing connections. These may cause leaks by being incompatible with the tubing plastics.
4) Use suitable thread sealant when assembling ALL threaded fittings. Oatey pipe joint compound is good. Teflon tape works well, but is difficult to handle. Gasket compounds such as Permatex do NOT work.
5) A small amount of mineral oil makes assembly of tubing to barb fitting much easier. But NEVER allow excess liquid (visible droplets) into the pneumatic system. Do not use silicone or other lubricants on internal connections.
6) Locating leaks is first done by isolating the leak with a clamp (see #2). Work backwards from the pressure sensor tubing, check both tubes to the cuff or test canister, and then check the output manifold. If the clamp is placed between the pressure sensor and the leak, the downward drift of pressure will stop or slow considerably. Leaks are usually at the connectors.

When the leak has been approximately located, perform a bubble test by carefully swabbing the suspected connections with a weak solution of dish detergent and water. Use a cotton-tipped applicator to apply the solution. **BE SURE TO PROTECT THE CIRCUIT BOARD BY PLACING A DRY SPONGE UNDER THE AREA BEING CHECKED.** A leak will show as a tiny collection of bubbles at the site.

If the leak is isolated to a valve and its connector, and the connector is OK, the leak may be in the valve seat. Try plugging or clamping the other ports of the valve. If this stops the leak, the valve seat is leaking, and the valve will have to be replaced.

LEAK TESTING PROCEDURE

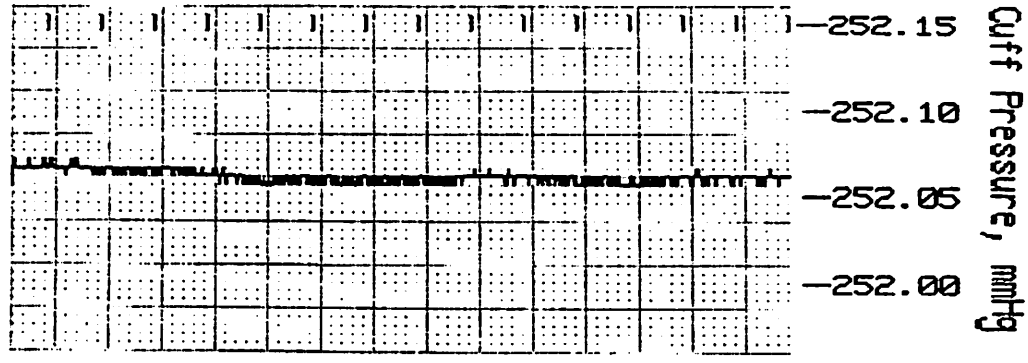
This sensitive leak test may be performed on completed VascuMAP instruments or on assembled Motherboard/Pneumatic Logic Assemblies.

Equipment Needed:

VascuMAP 250 cc Test Canister (#19939)
(or 12 cm "Adult" cuff on suitable rigid jig)
Pressure-Calibrated board assy or VascuMAP

Procedure:

1) Apply power to unit under test.
2) Enter VascuMAP serial number as ID number.
3) Start Manual (MAN) Mode.
4) Set Target Pressure at 250 mmHg (Note: MAX-P must be set at 250 or greater for this).
5) Set GAIN at 20 cm/mmHg and SPD at 5 mm/sec.
6) Plug test canister into CUFF connector.
7) Press GO to pressurize canister.
8) "Top up" pressure by pressing GO over 15 seconds.
9) Wait 1 to 10 minutes for thermal settling to stop.
10) If pressure now less than 235 mmHg - unit FAILS
11) If pressure OK, proceed as follows:
    a) No Recorder: Observe pressure readout. The time required to drop 0.1 mmHg must be longer than 30 (thirty) sec. If LESS THAN 30 sec, unit FAILS.
    b) Recorder Connected: Start recorder and run it for 15 - 20 seconds. Stop recorder and observe tracing. Downward drift must be LESS THAN 0.025mmHg (1 large chart division) over a 10 (ten) second period. If GREATER, unit FAILS. (This acceptable leak rate corresponds to approx 0.0005 cc/sec.)
12) Disconnect test canister and record test results.



EXAMPLE OF ACCEPTABLE LEAK RATE

GENERAL DESCRIPTION OF THE PNEUMATICS

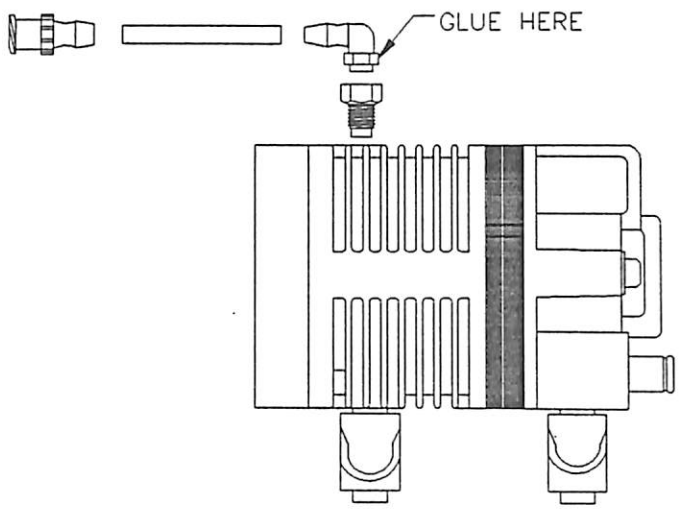
The VascuMAP Pneumatic System consists of five sub-assemblies which disconnect using Luer-Lock connectors for the 1/8" tubing, and 1/16" slip-on connections for the pressure sensor (XD1) and the Volume Calibrator (if installed). These sub-assemblies are:

The Pressure Pump
The Accumulator Tank
The Pneumatic Logic Assembly (valves, etc.)
The Front Panel Connector
The Volume Calibrator (AP-102V only)

PRESSURE PUMP ASSEMBLY

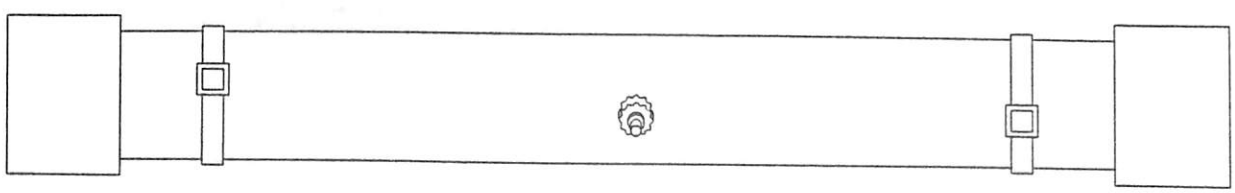
The PRESSURE PUMP is a single-piston type that generates pressure via a spring driven return stroke. Thus it is inherently pressure-limited, generating approximately 450 mmHg (8.5 psi) pressure, maximum. This maximum pressure can be checked by attaching a suitable pressure gauge to the pump via its Luer connector and EITHER powering the pump by using a jumper lead between the output terminals of the solid-state relay (WARNING! HIGH VOLTAGE CONNECTION - DISCONNECT POWER BEFORE MAKING CONNECTION), OR starting a VascuMAP program that will inflate a cuff (such as BP or MAN Modes). The MINIMUM PRESSURE generated (at no flow) must be 350 mmHg (6.8 psi) for proper instrument operation. The tubing and connections should show no gross leaks when bubble tested at full pump pressure.

CONNECTOR NOTE: The "ell" connector at the top of the pump consists of two pieces. If replacement is needed, first screw in the threaded portion using a suitable thread sealant (do not overtighten as this will weaken the neck of the fitting), then align and glue the barbed fitting correctly in the threaded section using a cyanoacrylate "super" glue.



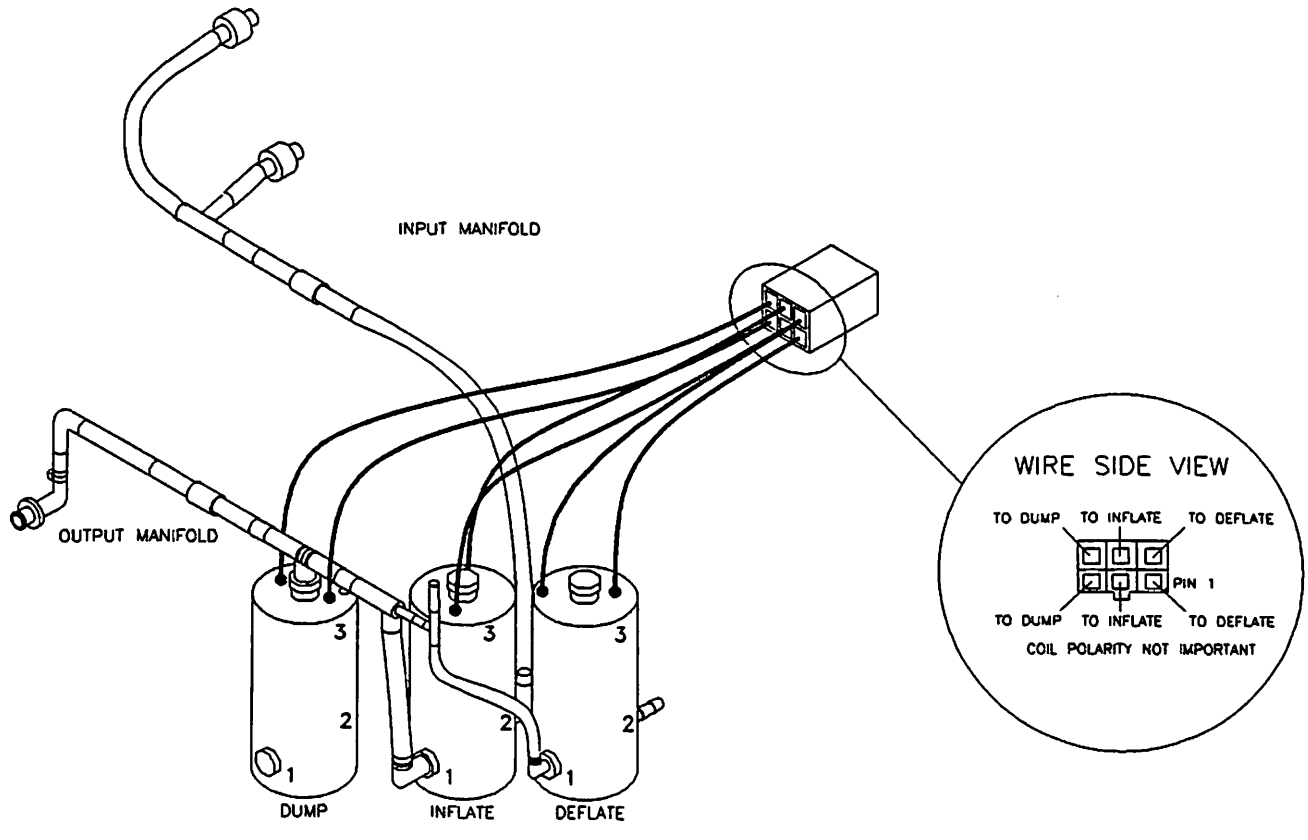
ACCUMULATOR TANK ASSEMBLY

The ACCUMULATOR TANK "smoothes out" any pressure pulsations from the pressure pump. It has its own threaded Luer connection, and is tee'd into the 1/8" tube from the Pressure Pump to the Inflate Valve. Its connector should show no signs of damage and the assembly should have no gross leaks when bubble tested at 250 mmHg pressure.



PNEUMATIC LOGIC ASSEMBLY

The PNEUMATIC LOGIC ASSEMBLY consists of a filtered input manifold with two male Luer connectors, three electropneumatic three-way valves (one with a restrictive orifice), and a filtered output manifold with a female Luer connector.



REMOVING THE PNEUMATIC ASSEMBLY is done by first removing the VascuMAP Motherboard from the cabinet, disconnecting the 6-pin valve connector, and removing the six screws that hold the valves to the motherboard. Once removed, caution must be taken in handling as the assembly is floppy. It is recommended that the valves be mounted on a narrow jig or on the motherboard while repairing the assembly.

The INPUT MANIFOLD connects the PUMP and ACCUMULATOR TANK to the INPUT VALVE. A 43-micron screen filter in a barbed inline housing protects the valve seats from particulate matter which could cause leaks. Air does NOT flow backward through this filter on cuff deflation. If it is necessary to clean this filter because of low flow on cuff filling (test: the 250 cc VascuMAP Test Canister should fill to 250 mmHg in under 5 seconds), unscrew the threaded fitting at the input valve and GENTLY blow compressed air back through the manifold (do NOT use high pressure as this could displace the filter screen). When in doubt, it is best to replace the filter.

All VALVES are the same basic three-way type, with a coil resistance of about 220 Ohms. They should actuate when 12 Volts DC at 55 mA is supplied in either polarity. The INPUT VALVE and the DEFLATE VALVE are normally closed when no coil voltage is applied. The DUMP VALVE is pneumatically connected to be normally open, and must be supplied with current to close the valve (this is so the cuff will deflate in the event of power failure). A 6-pin polarized plug connects the valve solenoids to the VascuMAP motherboard. Individual solenoid coil polarity is not important.

When replacing a valve in the assembly, be sure that the port numbers are in the correct locations. All the valves are aligned the same. Port #1 faces the front of the completed unit, Port #2 faces the back, and port #3 is the connection at the top of the valve. The valve will not work properly if ports #1 and #2 are reversed.

The threaded plastic plugs in the valves must be replaced using thread sealant if they are removed.

The OUTPUT MANIFOLD is a critical assembly in that it must be completely leak-tight (see section on Leak Testing), and must be made to the correct dimensions to fit without tube kinking. If it is necessary to replace any portion of the 1/8" tubing or components in this assembly, it is recommended that the entire assembly be re-built with new parts. See the accompanying diagram for proper parts alignment and dimensions.

When re-building the output manifold or replacing a valve, first install the threaded fittings to the valve(s) as required using thread sealant. Then mount the valves on a suitable jig (or back on the motherboard) and install the tubing components.

When replacing the Luer elbow which connects to the Front Panel Connector, use heat if necessary to slide the 1/8" tubing completely over the single barb on the male end of the connector, then apply a small tie wrap over the end of the tubing to hold it firmly on the barb.

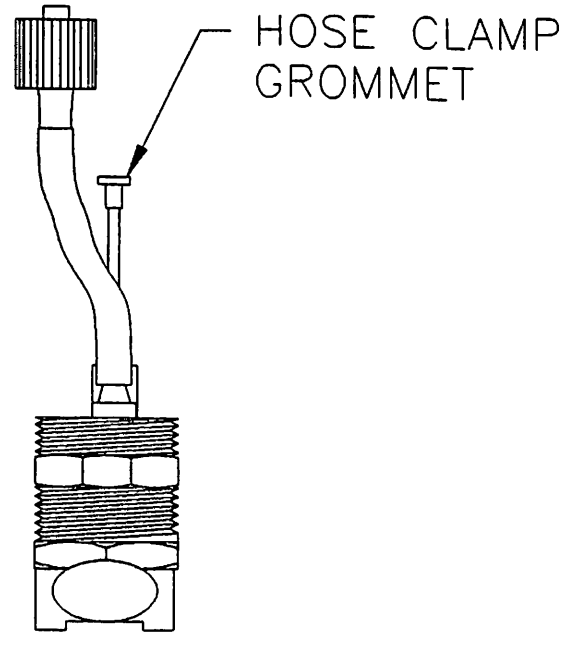
The filter in the Output Manifold is identical to the one in the Input Manifold. Air flows both directions through this filter, however. Plugging of the output filter is caused by material entering through the Cuff Connector, and causes slow cuff deflation (test: inflate a 250 cc VascuMAP Test Canister to 250 mmHg in Manual Mode, then press STOP. The canister should deflate to less than 20 mmHg in under 4 seconds). Try to dislodge any occlusion by starting cuff inflation with no cuff attached, and quickly clamping and releasing the 1/8" line between the input filter and the inflate valve. If the filter remains plugged, replacing it (and the output manifold assembly) is recommended.

When RE-MOUNTING the PNEUMATIC LOGIC ASSEMBLY on the VascuMAP MOTHERBOARD, replace the rubber sound-damping grommets if they are stiff. Use threadlock compound on the mounting screws, and tighten the screws to only slightly compress the grommets.

THE FRONT PANEL CONNECTOR

The FRONT PANEL CONNECTOR ASSEMBLY provides for convenient attachment of the testing cuffs to the Pneumatic Logic Assembly and the Pressure Sensor on the VascuMAP Motherboard. This assembly must be leak-tight for proper performance (see section on Leak Testing and Locating). Be sure that its inner bore is clean, smooth, and free of gouges and that the tubing connections are installed on the barbs fully.

To disconnect the Front Panel Connector from the rest of the pneumatic system, first remove the LED Display Board for more room. Then disconnect the 1/8" Luer connector to the Pneumatic Logic Assembly. Slide the 1/16" Hose Clamp Grommet back from the Pressure Sensor CAREFULLY. CAUTION: The leads of the sensor are brittle and tend to break. Do not bend the sensor's leads. Once the Grommet has been pushed back, gently slide the tubing off the un-barbed Pressure Sensor connection. Be sure not to scratch the surface of the Pressure Sensor's connector. The entire assembly may now be removed through the front panel mounting hole by unscrewing the 13/16" mounting nut.

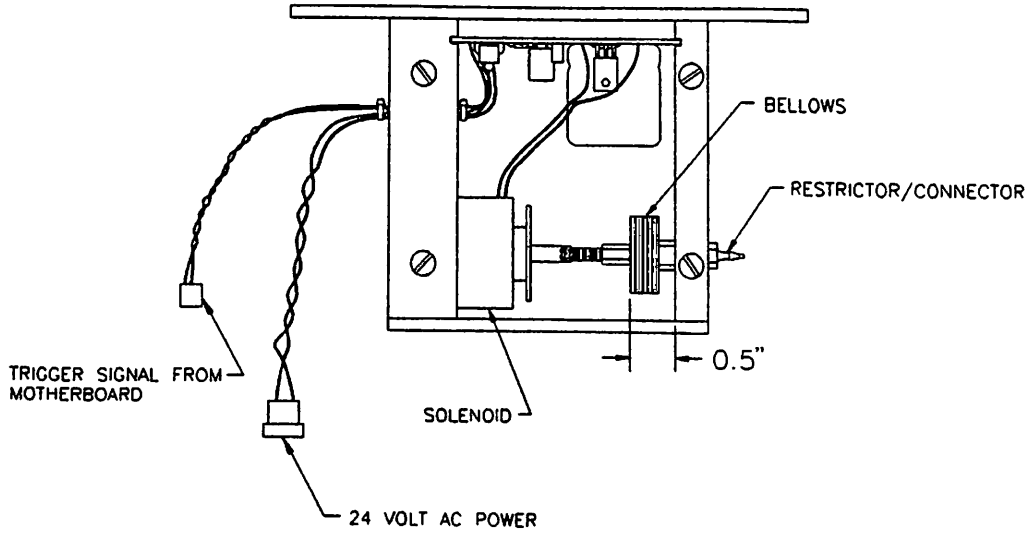


When re-mounting the Front Panel Connector, tighten it into the front panel with the release tab UP (the 1/8" tube should be above the 1/16" tube). Be sure the Grommet is in place on the 1/16" tubing with the flange toward the sensor. CAREFULLY slip the hose on to the sensor as far as it will go, then slide the Grommet down toward the Sensor firmly. Reconnect the Luer connection.

THE VOLUME CALIBRATOR (AP-102V MODELS ONLY)

The VOLUME CALIBRATOR ASSEMBLY provides a precisely-timed 0.500 cc increase in closed system volume on microprocessor command. Pneumatic components to this system are a precision metal bellows and a precision restrictive orifice (located within the 1/16" barbed connector on the Volume Calibrator). The Calibrator is connected to the Pneumatic Logic Assembly Output Manifold via 1/16" tubing. The assembly must be leak-tight (see section on Leak Testing and Locating)

To remove the Volume Calibrator, carefully disconnect the 1/16" tubing at the barbed connector on the unit (the tubing may be plugged with a 1/16" barbed plug if the VascuMAP is to be used without the Calibrator). Unplug the small 3-pin header from the Motherboard, and disconnect the in-line power connector at the back of the unit. Then ease the Calibrator straight up. The two slide-type mounting strips will come up and out with the unit. Marking the grooves used by the slide strips will aid in device replacement.

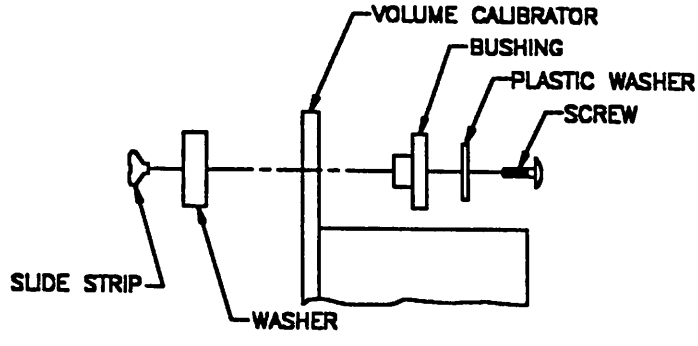


Removal of the Bellows is done as follows: Remove the top and bottom covers of the Calibrator unit. Now remove the four flathead screws that fasten the aluminum plate that mounts the Bellows (CAUTION: the Bellows is delicate and can be overstretched or permanently deformed). Rotate the armature of the Solenoid to unscrew the Bellows Shaft. When the Bellows is free, the 10-32 threaded fitting that holds it on the mounting plate can be unscrewed using a 1/4" wrench. The orifice of the precision restrictor should be checked for contamination at this step.

To replace the Bellows, First screw it on to the mounting plate using thread sealant. Screw the 4-40 threaded rod in place fully. With the mounting plate in approximate position, rotate the Solenoid armature to join the bellows and solenoid. Replace the four flathead case screws using thread lock compound. Then, by rotating the solenoid armature, adjust the Bellows so that it is compressed to 0.50" from the solenoid mounting plate, see diagram. When the position is satisfactory, secure both ends of the shaft using thread lock compound. The Solenoid should actuate the Bellows 0.127".

To replace the Volume Calibrator Assembly back in the VascuMAP, slide the two mounting strips back in their grooves, using moisture on the rubber bushings to act as lubricant if necessary. NOTE: The bushings should be replaced if they are torn or hardened. Thread lock should be applied to the two mounting screws before sliding the slide strips back into place.

Once the Calibrator is mechanically in place, re-connect the power connector, the 1/16" tubing, and the 3-pin connector on the motherboard (this last plug may be inserted either way).



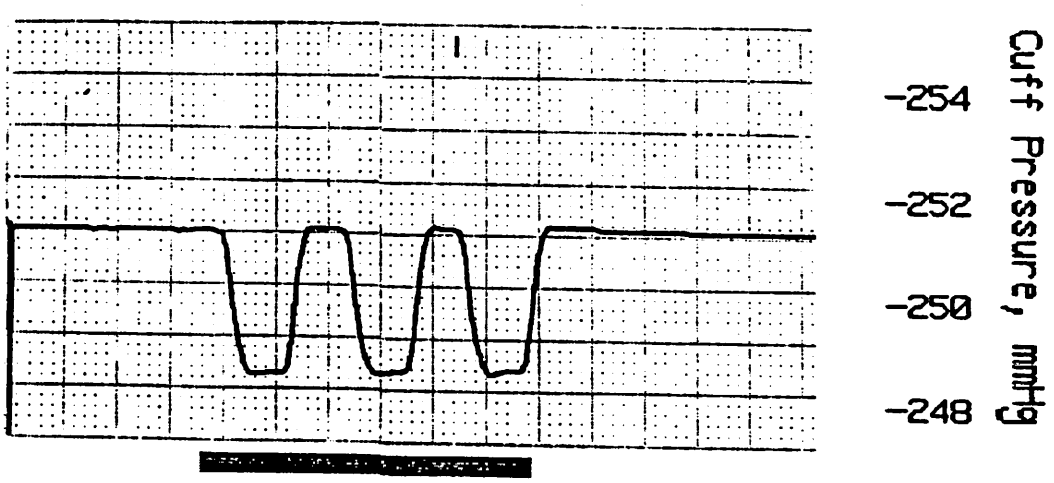
VOLUME CALIBRATOR SIGNAL TESTING

The Volume Calibrator pulse signal should have a fast fall time, and should show no signs of ringing on the bottom of the pulse. A clogged Volcal orifice or one that is too small will cause a prolonged fall time. Too large an orifice will cause ringing. Non-standard cuff tubing may also cause these problems. Generally, the VascuMAP software will flag problems with the message "Volume Calibration in Question."

To observe the Volcal pulse, perform the following test:

1) plug a Test Canister (#19939) into the cuff port
2) Turn on and set up the VascuMAP as follows:
    a) MAN Mode
    b) TARGET PRESSURE = 150 mmHg
    c) GAIN = 0.5 cm/mmHg
    d) SPD = 50 MM/sec
3) press GO to pressurize the canister to 150 mmHg
4) press REC to start the recorder
5) press TONE to fire the Volume Calibrator
6) press REC to stop the recorder
7) observe the tracing
8) press STOP if tracing satisfactory

To evaluate the tracing, look at the LEADING EDGE of the pulse, the fall time of this edge should be no greater than 0.06 sec (3 mm horizontally on the chart). Following this falling edge, there should be NO discernible ringing on the bottom of the pulse. Ringing after the RISING edge of the pulse is not a problem.



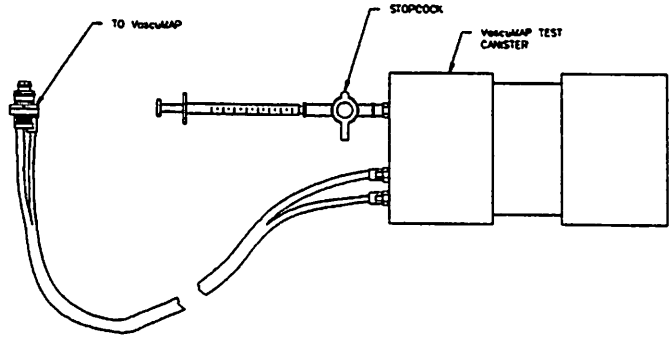
CHECKING VOLUME CALIBRATOR DISPLACEMENT

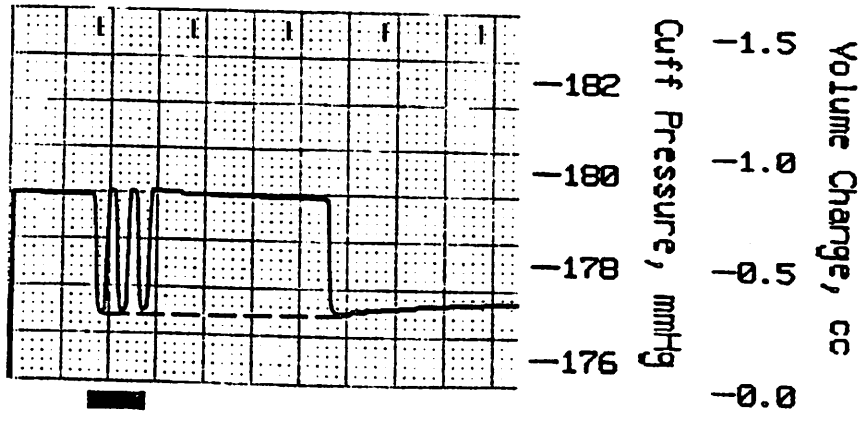
The Volume Calibrator should displace 0.5cc +/-2% of air with each pulse. To check this with a known standard, connect a one-way stopcock and a precision 0.5 cc syringe to the VascuMAP Test Cannister (#19939) as shown. Then proceed as follows:

1) push the syringe plunger all the way in to 0.0 cc.
2) open the stopcock.
3) pressurize the canister using MAN Mode.
4) start recorder and do a volume calibration.
5) close the stopcock.
6) pull the plunger back to 0.5 cc. Hold with clamp.
7) open stopcock quickly.
8) stop recorder and observe tracing.
9) press STOP if tracing satisfactory.

Interpretation: The pressure drop caused by opening the stopcock should equal the pressure drop seen at each Volume Calibration pulse. Use calipers for accurate comparison. If the test results are bad, check the linear throw of the solenoid, which should be 0.127" with no binding.

NOTE: The syringe and stopcock must be absolutely leak-tight for this test to be valid.





VascuMAP MOTHERBOARD JUMPER SETTINGS

Refer to the drawing labeled "JUMPERS AND CONNECTORS LOCATION" in this manual for more information.

J6 - VOLUME CALIBRATOR SELECT JUMPER

Description: 2-pin male header

Condition	Setting
Volume Calibrator installed -	no jumper
No Volume Calibrator -	short with jumper

J9 - SERIAL PORT RXD JUMPER

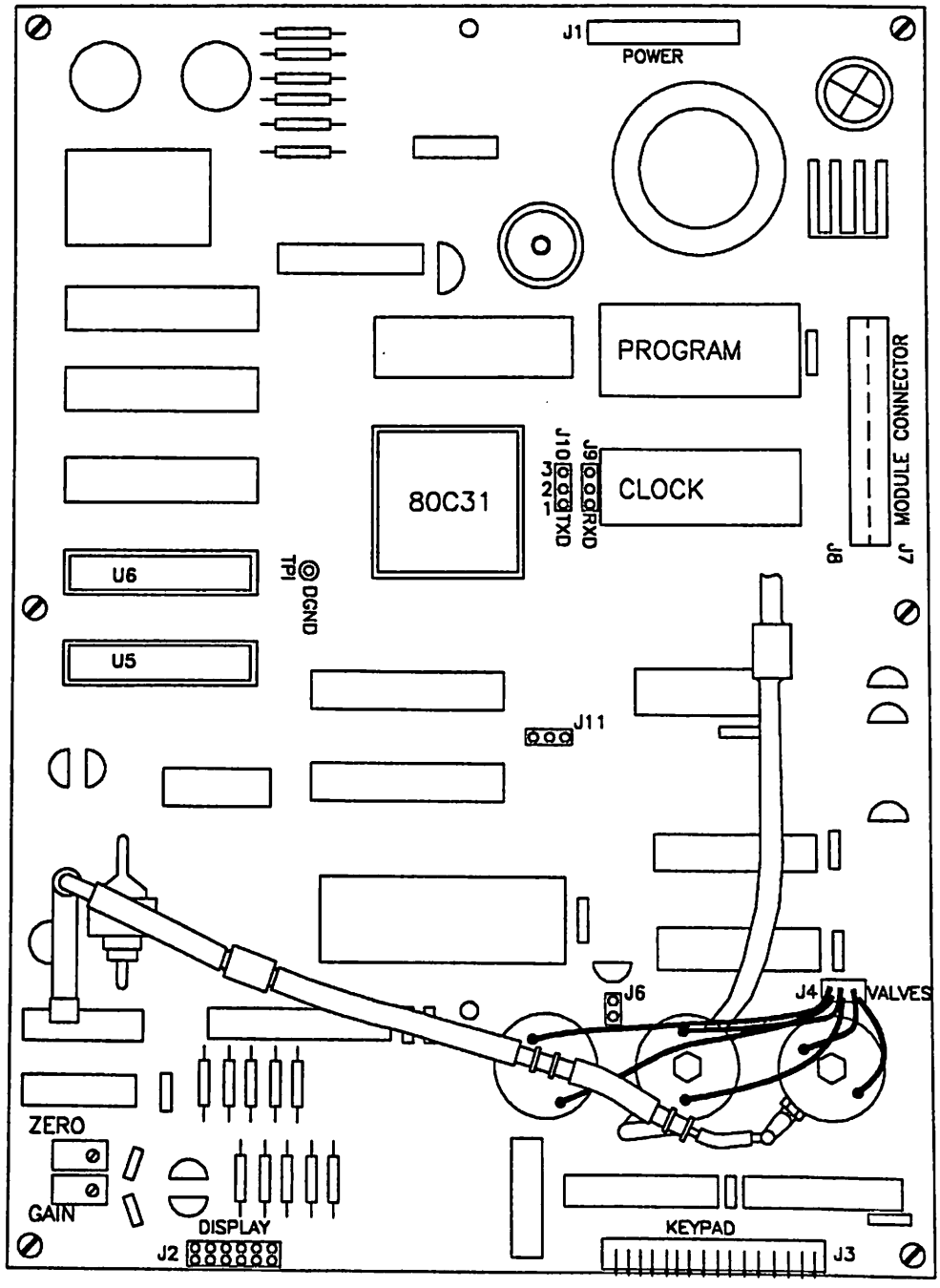
Description: 3-pin male header
Circuit Connections: See Schematic Diagram
Setting: Short J9-2 to J9-3 with shorting jumper

J10 - SERIAL PORT TXD JUMPER

Description: 3-pin male header
Circuit connections: See Schematic Diagram
Setting: Short J10-2 to J10-3 with shorting jumper

J11 - VOLUME CALIBRATOR SIGNAL CONNECTOR

Description: 3-pin male header
This header provides connection for the Volume Calibrator (if installed). The three-pin plug from the calibrator may be installed on J11 either way (see schematic for details). No shorting jumper should be used on J11, though it will cause no harm if placed by mistake.



JUMPER AND CONNECTOR LOCATION

VascuMAP BURN-IN TEST PROCEDURE

CAUTION: Electrical Burn-In always carries the risk of fire or smoke emission. USE A FIREPROOF AREA WHEN PERFORMING BURN-IN.

NOTE: Burn-in should be performed at room temperature with the VascuMAP cabinet closed fully.

Equipment Needed:

Complete VascuMAP instrument
250 cc Pneumatic Test Canister (#19939)
Suitable burn-in test area

1) Plug in the VascuMAP, turn it ON, and observe for proper startup routine (see Operator's Manual).
2) Attach the Pneumatic Test Canister to the front panel Cuff Connector.
3) Set up the VascuMAP as follows:
   a) Mode = MAN
   b) MAX P = 300
   c) INT = 1
   d) GAIN = 20
   e) TONE = ON (KEY LIT)
   f) Remove paper from recorder and shut recorder door.
4) Press GO twice. The VascuMAP should pressurize the Test Canister for 20 sec, deflate, then repeat this cycle every minute. If the unit is an AP-102V, the Volume Calibrator will snap 3-4 times during each inflation.
5) Continue this burn-in for eight (8) hours.
6) After burn-in, recheck all screws, connectors, power supply voltage and ripple levels, recalibrate the pressure sensing system (zero and gain), and perform leak testing.

VascuMAP PARTS LIST

QUAN	PART #	DESCRIPTION AND DESIGNATORS	
19609 VascuMAP MOTHERBOARD:			
RESISTORS:			
1	19265	1 OHM/2WATT LEAD MOUNTED.	R8
3	10952	10 OHM/5%	R24,25,26
3	10368	1K/5%	R7,23,27
2	18346	1.21K/1%	R3,12
1	16631	4.99K/1%	R6
3	10314	10K/5%	R20,R21,R22
1	18553	10K/1%	R11
1	18567	12.1K/1%	R10
1	25370	11K/1%	R18
3	10378	20K/5%	R13,16,28
2	18565	20K/1%	R2,17
1	16191	33K/5%	R15
1	18592	36.5K/1%	R9
1	18894	75K/1%	R4
2	10304	100K/5%	R14,27
2	19267	470 x 8 16-PIN DIP	RP2, RP3
2	18881	5K-15T TRIM, TOP ADJ	R1,5
CAPACITORS:			
3	17292	0.001UF/50V	C55,57,58
1	17291	0.01 UF/50V	C30
1	25560	.033 UF/50V/5%	C31
24	17539	0.1 UF/ 0.3" BYPASS	C1-4,10,25,32-37,40,42-50, 53,54
13	17290	0.1 UF/ 0.1" DISC	C5-7,9,11-13, 15,16,18,21-23,31
1	10322	0.1 UF/5% FILM	C8
1	16148	0.47 UF FILM	C5
2	5190	1.0 UF TANT.	C26,28
2	19268	4.7 UF TANT.	C27,29
1	19269	220 UF/25 V/'LYTIC RADIAL	C19
2	19271	1000 UF/35 V/ " "	C17,20
1	19270	12,000 UF/35 V " "	C14

QUAN	PART #	DESCRIPTION AND DESIGNATORS	
INTEGRATED CIRCUITS:			
1	19272	80C31-25 MHZ uPROCESSOR	U1
1	18462	DS1287 REAL-TIME CLOCK	U2
1	19619	74HCT573 OCTAL BUS LATCH	U3
1	19610	VascuMAP PROGRAM ROM	U4
1	19567	PROGRAMMED PAL OSDCD2	U5
1	19566	PROGRAMMED PAL OSDCD1	U6
1	18448	uPD43256AC-15L 32Kx8 SRAM	U7
1	18870	AD624 INSTRUMENT AMP	U8
1	18627	74HC74 DUAL D FLIP-FLOP	U9
1	16597	TL074 QUAD OP AMP	U10
2	19605	74HC299 SHIFT REGISTER	U11,12
1	19575	AD7701 16-BIT A TO D CONV	U13
2	19274	74HCT574 OCTAL FLIP-FLOP	U16,24
2	19318	UCN-5815A LATCHED DRIVER	U17,18
1	19276	ICM7218D 8-DIG LED DRIVER	U19
1	19277	MM74C922 KEYPAD ENCODER	U20
1	18906	74HCT4538 RETRIG TIMER	U22
1	19278	TLC556 DUAL TIMER	U23
1	19908	22 MHZ TTL CLOCK	CLK1
VOLTAGE REGULATORS:			
1	19012	78L12A 12V/5%/100mA REG	VR1
1	19081	79L12 -12V/100mA REG	VR2
1	16471	78M12 12V/500 mA REG	VR3
1	10422	7805 5V/1 AMP REG	VR4
1	16612	AD581 10V REFERENCE	VR5
1	10907	78L05 5V/100MA REG	VR6
1	17198	79L05 -5V/100MA REG	VR7
TRANSISTORS:			
4	19279	MPSA13 DARLINGTON T0-92	Q1,2,3,4
2	18531	VN1210L N-CH MOSFET	Q6,Q7
DIODES:			
12	18640	1N4007 RECTIFIER	D1-6,9-12,14,17
1	7890	1N914 SMALL SIGNAL DIODE	D16
1	18546	HP5082-2835 SHOTTKY	D15
TRANSDUCERS:			
1	19281	17PC05GF or DF 0-5 PSI PRESSURE	XD1

QUAN	PART #	DESCRIPTION AND DESIGNATORS	
CONNECTORS:			
2	18593	I.C. SOCKET, 20 PIN	FOR U5,6
1	17769	I.C. SOCKET, 24 PIN	FOR U2
1	18298	I.C. SOCKET, 28 PIN	FOR U4
1	18437	PLCC SOCKET, 44 PIN	FOR U1
1	16671	7 PIN MOLEX HEADER	J1
1	19282	18 PIN DUAL ROW FEMALE SOCKET STRIP	J2
1	19284	26 PIN DUAL ROW FEMALE SOCKET STRIP	J3
1	19323	6-PIN LATCHING MALE HEADER	J4
1	17317	2-PIN MALE HEADER	J6
3	17316	TEST JUMPER	FOR J6,9,10
1	19285	50 PIN HIGH DENSITY	J7&J8
9	19971	SNAP HEADER -3 PINS EACH	J9,10,11
HARDWARE:			
14	10134	1/4" RUBBER GROMMET	
6	2545	6-32 x 3/8" BHMS	
1	2540	6-32 x 1/4" BHMS	
1	7722	HEAT SINK PAD	
qs	3675	#290 THREAD LOCK	
HEAT SINKS:			
1	19286	HEAT SINK	ON VR4
SPEAKERS:			
1	19288	AUDIO TRANSDUCER	SP1
PRINTED CIRCUIT BOARD:			
1	19315	VascuMAP MOTHERBOARD, BARE	
19565 DISPLAY BOARD SUB-ASSEMBLY:			
LIGHT EMITTING DIODES:			
8	19289	0.56" ORANGE 7-SEG LED DISPLAY	LED1-8
1	19290	RED LED	LED9
1	19291	GREEN LED	LED10
2	19292	YELLOW LED	LED11,12
CONNECTOR:			
1	19283	18 PIN MALE DUAL ROW RT ANGLE TERMINAL STRIP	P2
PRINTED CIRCUIT BOARD:			
1	19316	LED DISPLAY BOARD, VascuMAP	

QUAN	PART #	DESCRIPTION AND DESIGNATORS	
19322 PNEUMATIC LOGIC SUB-ASSEMBLY:			
PNEUMATIC VALVES:			
3	19296	12VDC, 3-WAY MINIATURE VALVE	
TUBING CONNECTORS:			
1	19305	1/8-1/8-1/8 BARBED TEE	
1	19306	1/8-10/32-1/8 TEE ADAPTOR	
3	19307	10-32 THREADED PLUG	
2	19308	1/8 TO 10-32 ELL ADAPTOR	
1	19606	1/16 TO 10-32 ELL ADAPTOR	
1	19774	1/16 BARBED TEE CONNECTOR	
1	19607	1/16 BARBED ELL CONNECTOR	
1	19608	1/8-1/8-1/16 REDUCTION TEE CONNECTOR	
2	19331	1/8 BARB TO MALE LUER LOCK	
1	19310	1/8 BARBED ELL CONNECTOR	
1	19772	FEMALE LUER ELL ADAPTOR	
1	2196	TIE WRAP, SMALL	
1	19309	0.005" ORIFICE, 10-32 THD	
2	19304	43 MICRON FILTER, 1/8 BARBED	
2'	19312	1/8" PNEUMATIC TUBING	
8"	19313	1/16" PNEUMATIC TUBING	
qs	19771	PST PIPE SEALANT	
ELECTRICAL CONNECTORS:			
1	19300	6-PIN POLARIZED HOUSING	P4
6	16315	FEMALE PINS FOR ABOVE	
19732 VOLUME CALIBRATOR CIRCUIT BOARD			
1	19831	2 OHM/2W FUSABLE	R5
1	10314	10K/0.125W	R4
1	10304	100K/5%	R1
1	18637	1MEG/1%	R2
1	10127	1 MEG/5%	R3
1	18866	2700uf/35V 'LYTIC	C4
1	19269	220uF/35V 'LYTIC	C2
1	4870	.001uF	C1
1	10350	.01uF	C3
1	10322	0.1uF/1%	C5
6	18640	1N4007	D3-8
1	7890	1N914	D1
1	7860	1N4741 11V ZENER	D2
1	17099	IRF620 N-MOSFET, Vds=200V	Q1
1	19776	4N32 OPTOISOLATOR	U2
1	17460	TLC555CP TIMER	U1
1	19731	VOLCAL CIRCUIT BOARD, BARE	

QUAN	PART #	DESCRIPTION AND DESIGNATORS
19763	**MODIFIED SOLENOID SUB-ASSEMBLY:**	
1	19752	SOLENOID, LOW-PROFILE
1	19753	SHAFT COLLAR, 3/16"
1	19742	DOWEL PIN, 3/32" x 3/8"
19764	**SOLENOID MOUNT SUB-ASSEMBLY:**	
1	19737	CASE, SOLENOID END
1	19763	MODIFIED SOLENOID SUB-ASSY
1	19754	COMPRESSION SPRING
2	19825	#5-40 NUT
2	19826	#5 EXTERNAL STAR WASHER
19765	**VOLCAL MECHANICAL SUB-ASSEMBLY:**	
1	19764	SOLENOID MOUNT SUB-ASSY
1	19738	CASE BELLOWS END
1	19740	LONG SIDE
1	19739	SHORT SIDE
8	10393	SCREW, 8-32 x 1/2" FHMS
1	19988	4-40 x .625" THREADED ROD
1	19818	VOLCAL BELLOWS
1	19811	BRASS ORIFICE (IN 10-32 TO 1/16 BARB HOUSING)
19904	**VOLCAL FINAL ASSEMBLY:**	
1	19765	VOLCAL MECHANICAL SUB-ASSY
1	19732	VOLCAL CIRCUIT BOARD - ASSEMBLED
2	19741	TOP/BOTTOM COVER
8	10523	SCREW, 6-32 x 3/8" FHMS
12"	4564	WIRE, 24 GA STRANDED, ORANGE
9"	4558	WIRE, 24 GA STRANDED, YELLOW
9"	4568	WIRE, 24 GA STRANDED, VIOLET
2	2196	TIE WRAP, SMALL
1	10625	3-PIN BERG HOUSING
3	16315	BERG PINS, FEMALE
1	16707	4 POS PLUG SHELL, MOLEX
2	16125	MALE PIN, MOLEX
19333	**PRESSURE PUMP SUB-ASSEMBLY**	
1	19295	AIR PRESSURE PUMP PUMP1
1	19334	M6 THREAD TO BONDABLE FITTING
1	19336	1/8 BARB ELL BONDABLE JUNCTION
1	19332	1/8 BARB TO FEMALE LUER
3"	19312	1/8" PNEUMATIC TUBING
19321	**PRESSURE TANK SUB-ASSEMBLY:**	
1	19311	FEMALE LUER TO 10-32 THD ADAPTOR
1	19614	PRESSURE TANK BODY
2	19615	3/4" PVC PIPE CAPS

QUAN	PART #	DESCRIPTION AND DESIGNATORS	
19330 PNEUMATIC PANEL CONNECTOR SUB-ASSEMBLY			
1	19301	COAXIAL PNEUMATIC CONNECTOR, PANEL MOUNT	
1	19331	1/8 BARB TO MALE LUER	
4"	19312	1/8" PNEUMATIC TUBING	
3"	19313	1/16" PNEUMATIC TUBING	
19728 REAR PANEL SUB-ASSEMBLY:			
1	19934	REAR PANEL, MODIFIED	
1	19298	POWER INPUT MODULE	PIM1
1	19846	WARNING LABEL INSULATING BRACKET	
1	19847	SHOCK HAZARD LABEL	
1	19299	V150LA20 A or B	MOV1
1	3715	1 AMP SLOW-BLOW FUSE	
1	16703	7-PIN MOLEX CONNECTOR	
7	16121	MOLEX PINS, FEMALE	
1	19294	24 V-CT, 2.4 AMP XFMR, LOW-LEAKAGE, 2500V ISOL'N.	T1
1	16709	4 POS SOCKET, MOLEX	
2	16012	FEMALE PINS, MOLEX	
4	10246	FLATWASHER #6	
6	2605	NUT, 6-32	
2	3110	SOLDER LUG, #6	
6"	17060	3/16" SHRINK TUBING	
3	2196	TIE WRAP, SMALL	
2'	4740	PVC-105-10 TUBING	
	4550	WIRE, 24 GA STRANDED, WHITE	
	4552	WIRE, 24 GA STRANDED, BLACK	
	4554	WIRE, 24 GA STRANDED, RED	
	4556	WIRE, 24 GA STRANDED, GREEN	
	4560	WIRE, 24 GA STRANDED, BLUE	
	4564	WIRE, 24 GA STRANDED, ORANGE	

QUAN	PART #	DESCRIPTION AND DESIGNATORS
AP102V FINAL ASSEMBLY:		
1	19724	VascuMAP CASE
1	19733	AR-42 RECORDER BRACKET SUB-ASSEMBLY
1	19333	PRESSURE PUMP SUB-ASSEMBLY
1	19803	VascuMAP MEMBRANE KEYPAD
1	19900	KEYPAD CABLE
1	19330	PNEUMATIC PANEL CONNECTOR SUB-ASSEMBLY
1	19321	PRESSURE TANK SUB-ASSEMBLY
2	4770	TIE WRAP, LARGE
1	19775	1/16" HOSE CLAMP GROMMET
1	19297	SOLID STATE RELAY RLY1
1	19302	AR-42 THERMAL RECORDER
1	19324	AR-42 CABLE
1	19612	TESTED VascuMAP MOTHERBOARD
1	19904	VOLUME CALIBRATOR UNIT, TESTED
2	19617	10-24 x 3/4" THMS
2	18891	PLASTIC WASHER, .687" DIAM.
2	19905	WB1-050 RUBBER BUSHING
2	19906	WR1-050 RUBBER WASHER
2	19907	VOLCAL SUPPORT SLIDE STRIP
1	19901	VOLCAL SUPPORT RAIL
2	10537	STANDOFF #6 x 1" M/F
2	2545	SCREW, #6 x 3/8 FHMS
1	19880	EDPA-050 SOUND INSULATION
1	19902	FOAM HOLD-DOWN FOR DISPLAY
10	2545	6-32 x 3/8" BHMS
4	2550	6-32 x 1/2" BHMS
2	2525	4-40 x 3/8" BHMS
4	19903	6-32 x 3/8" BHSCS, BLACK
1	19108	MINIATURE TERM. STRIP, SINGLE
1	19728	REAR PANEL ASSEMBLY
X	19768	SCREW, M5 x 0.8 x 25mm CHMS, METRIC (case screws for lost, damaged)

ELECTRICAL AND MECHANICAL SPECIFICATIONS

Pneumatic System:
- Maximum Pressure: 7.5 PSI, typ., limited by pump design
- Flow Rate: 0.2 CFM (5 Liters/min) at 100 mmHg, typ.
- Accumulator Tank Volume: 100 cc., max.
- Tank Bursting Pressure: 100 PSI, min.
- Safety Features:
  - Automatic cuff deflation if power fails
  - Automatic pump stop if microprocessor fails
  - Automatic cuff deflation if microprocessor fails
  - Automatic cuff deflation on overpressure of 10 seconds duration
  - Automatic pump stop if no cuff connected
  - Maximum cuff inflation pressure is user selectable
  - Coaxial pneumatic connector prevents connection error

Pressure Sensing System:
- Separated from fill/deflate system with two-tube design
- Range: 0 to 325 mmHg
- Zero Offset: adjustable to less than +/- 0.1 mmHg.
- Full-Scale Gain: adjustable to pressure standard +/-0.1 mmHg
- Linearity: +/- 0.5% of full scale (+/- 1.3 mmHg, worst case)
- Drift over Operating Temperature: +/- 0.5 mmHg, max.
- System Bandwidth (cuff to recorder output): 0 to 20 Hz, min.
- Sensitivity: 0.005 mmHg, min, limited by LSB size
- Zero Offset and Gain adjustments for field calibration

Analog to Digital Conversion:
- 16-Bit A to D Converter with no missing codes.
- Conversion Factor: 1 bit = 0.005 mmHg pressure
- Sampling Rate: 256 samples/sec.
- Total System Noise: 2 LSB RMS Noise, Max., measured over 30 seconds.

Digital Circuitry:
- CPU: 80C31 Microprocessor running at 22 MHz
- Field-replaceable program ROM for software updates
- Socketed clock chip with integral 10-year battery for time and setting storage

Operator Controls:
- 4 by 4 custom lighted push-button matrix.
- Power Switch on rear panel
- Replaceable Fuse
- Coaxial Cuff Connector

Display Output:
- Two rows of four 0.5 inch 7-Segment Light Emitting Diodes (LEDs) with trailing decimal points on middle digits.
  - Character Set: 0,1,2,3,4,5,6,7,8,9,E,H,L,P,-, and Off.
- Four discrete LEDs labeled "SYS", "DIAS", "MAP", and "RATE"

Chart Recorder Output (AP-102R and AP-102V):
- Recorder Location: internal, front panel mounted
- Paper: 2 inch (48 mm) thermal roll type
- Trace Resolution: 200 dots/inch (8 dots/mm), min.
- Character Set: 137 characters including standard ASCII set Print Speeds: 1, 2, 5, 10, 25, and 50 mm/sec
- Vertical Gain: 0.01 to 20 cm/mmHg in 1-2-5 sequence
- Trace Grid: printed real-time during trace printing
- Data Output Format: includes testing date and time from internal real-time clock, 20-digit patient ID number(if entered), full alphanumeric test results and warning messages, and tracing of the cuff waveform with pressure data.

Positive-Displacement Volume Calibrator (AP-102V only)
- Displacement Volume: 0.500 cc +/- 2.5%, Unit to Unit
- Displacement Output Rate: 4 pulses per second up to 16 total

Cuff Set:
- Twenty-four (24) cuff types presently available, all with Velcro fasteners
- Cuff Widths: 2 through 21 cm (fits digit to thigh sizes)
- Cuffs use dual-lumen connection tube and coaxial connector

Power Requirements:
Voltage: 105 to 125 Volts or 210-250 Volts, AC only.
Frequency: 50 to 60 Hz.
Supply Current: less than 0.4 amp at 60Hz/120V.
Power Consumption: 35 Watts, Max. with pump running
Power Connector: Standard 3-Conductor IEC recessed male
Fuse: 1 Amp, slow-blow

Environmental Requirements (Operating):
Temperature: +10 to +38 Degrees, Centigrade (50 to 100F)
(when calibrated at 23C [75F])
Humidity: 20 to 90% RH, noncondensing
Shock and Vibration: Withstands normal clinical and transportation stresses

Storage Conditions:
Temperature: -20 to +45 Degrees, Centigrade (-5 to 115F)
Humidity: 5 to 90% RH, noncondensing

Electrical Safety Specifications:
(measured per UL-544)
Breakdown Voltage, line to ground: 1500 Volts, min.
AC Leakage Current: 50 microamps, max.
DC leakage Current: 50 microamps, max.
Chassis to Line Ground Resistance: 0.1 Ohm, max.
Electrical Connection to Patient: None

Mechanical Specifications:
Case Size: 12.7" W x 5" H x 11.9" D
Weight: Approx. 13 Lb. (15 Lb for AP-102V)
Case material: Aluminum and high-density plastic, rated UL94 V-0

VERSION 2.0 SOFTWARE OPERATIONAL SPECIFICATIONS

Power-up Reset:

- Exercises all lights and annunciator
- Determines presence of Chart Recorder
- Determines presence of Volume Calibrator
- Calibrates A to D Converter
- Checks memory battery
- Checks for stuck keyboard keys
- Checks ROM version against version stored in memory
- Enters operation mode in effect at power-down

Identification Number Entry:

- Stores up to 20 digits in non-volatile memory
- Numbers and dashes may be entered
- Number changeable via embedded keypad on front panel
- ID number retained in memory during power-down
- ID number printed on all tracing footer blocks
- Special ID entry to "lock" operating mode

Clock Functions:

- On-board quartz time clock with 10 year lithium battery
- LED clock display in 24 hour format
- Time printed on all footer blocks in AM/PM format
- Clock settable via front panel keypad

Annunciator Tone:

- 0.1 second 500 Hz fixed volume tone
- Tone switchable on-off via front panel keypad
- TONE key flashes to signal tone when annunciator off

Interval (INT) Functioning:

- BP, VASC, and MAN Modes automatically repeat at Interval setting in minutes
- Tests repeatable at 1 to 60 minute intervals
- Repeat function may be turned off
- INT Button flashes slowly when activated

Parameter Warning Limits:

- Functional during Interval (INT) testing
- Systolic, Diastolic, Mean Pressure, and Pulse Rate warnings available in BP and VASC Modes
- High and low limits adjustable independently for each parameter in each mode
- Warning limit settings retained in memory during power-down
- LEDs indicate out-of-range values with an "H" or "L"
- Printer documents out-of-range values as "H" or "L"
- Annunciator sounds if any value outside of set range

Maximum Pressure (MAXP) Setting:

- Individually adjustable for each of the four operating modes
- Sets automatic cuff inflation pressure in BP, VASC, and repeating MAN Modes Limits maximum pressure obtainable via operator command in MAN and VEN modes
- Self-adjusting if too low or too high in BP and VASC
- Settings retained in memory during power-down

Blood Pressure (BP) Mode:

- Inflates cuff to MAXP-BP pressure value
- Obtains pulse samples at pressures decreasing in 10mmHg steps
- Deflates cuff when diastolic pressure reached
- LEDs display Systolic/Diastolic pressures and Mean Arterial Pressure/Pulse Rate alternately
- LEDs flash if results may be inaccurate
- Printer output contains
  - ID Number
  - Date and Time
  - Systolic/Diastolic Blood Pressure
  - Pulse Rate per minute
  - Mean Arterial Pressure (MAP)
  - Percent Average and Maximum pulse height variation from a smooth oscillometric curve
  - Error warning messages (if any)
- Printer output is in condensed form if multiple tests are run without changing ID number

Vascular (VASC) Mode:

- Inflates cuff to MAXP-VASC pressure value
- Obtains pulse samples at pressures decreasing in 10 mmHg steps
- After determining MAP, cuff re-inflates to MAP pressure and obtains waveform sample (Volume-calibrated automatically if Model AP-102V)
- Systolic pressure value recordable on operator command
- LEDs display Mean Arterial Pressure and Pulse Rate
- LEDs flash if results may be inaccurate
- Printer output contains
  - Waveform tracing and pressure scale at MAP point (also volume scale if AP-102V)
  - ID Number
  - Date and Time
  - Psys, Pdias, and MAP (oscillometric)
  - Pulse Rate per minute
  - Systolic Pressure via operator input
  - Percent Average and Maximum pulse height variation from a smooth oscillometric curve
  - Segmental Index, if Brachial Psys entered
  - Error warning messages (if any)

Manual (MAN) Mode:

- LEDs display actual cuff pressure and target pressure simultaneously
- Target pressure is operator-adjustable up to MAXP-MAN value
- Tracing Gain is manually adjustable (GAIN setting is time holdoff in seconds when in INTERVAL Mode, as Gain is automatic in this mode).
- Tracing Speed is manually adjustable
- REC button turns recorder on and off
- STOP button turns recorder off and deflates cuff
- TONE button triggers volume calibration in AP-102V
- Tracing automatically re-centers if it goes off scale
- Printer output contains:
  - real-time tracing of cuff pressure waveform with one second timing marks and pressure scale (and volume scale if AP-102V)
  - ID Number
  - Date and Time
  - Tracing Gain and Speed
  - Space for operator's notes

Venous (VEN) Mode:

LEDs display actual cuff pressure and target pressure simultaneously
Target pressure is operator-adjustable up to MAXP-VEN value
Initial Tracing Gain is manually adjustable
Initial Tracing Speed is manually adjustable
Gain and Speed are fixed while recorder running
Tracing does NOT re-center if off scale
INT Button adjusts Zero Baseline above bottom of trace grid (measured in mm.)
REC Button starts recorder and resets elapsed time
REC Button stops recorder and prints pressure scale
STOP Button stops recorder, deflates cuff, and gives complete footer
TONE button triggers Volume Calibrator (AP-102V)
DOWN ARROW Button changes recorder speed to 25 mm/sec and prints elapsed time since last REC command (also triggers volume calibration in AP-102V)
Complete footer contains:
Identification number
Time and date
Tracing Gain
Initial Chart Speed
Zero Baseline level (in mm.)
Segmental Venous Capacitance (SVC) *
Space for Maximum Venous Outflow in mm/1sec *
Space for Occlusion Pressure in mmHg *
Space for operator's notes

*printed only if DOWN ARROW command given

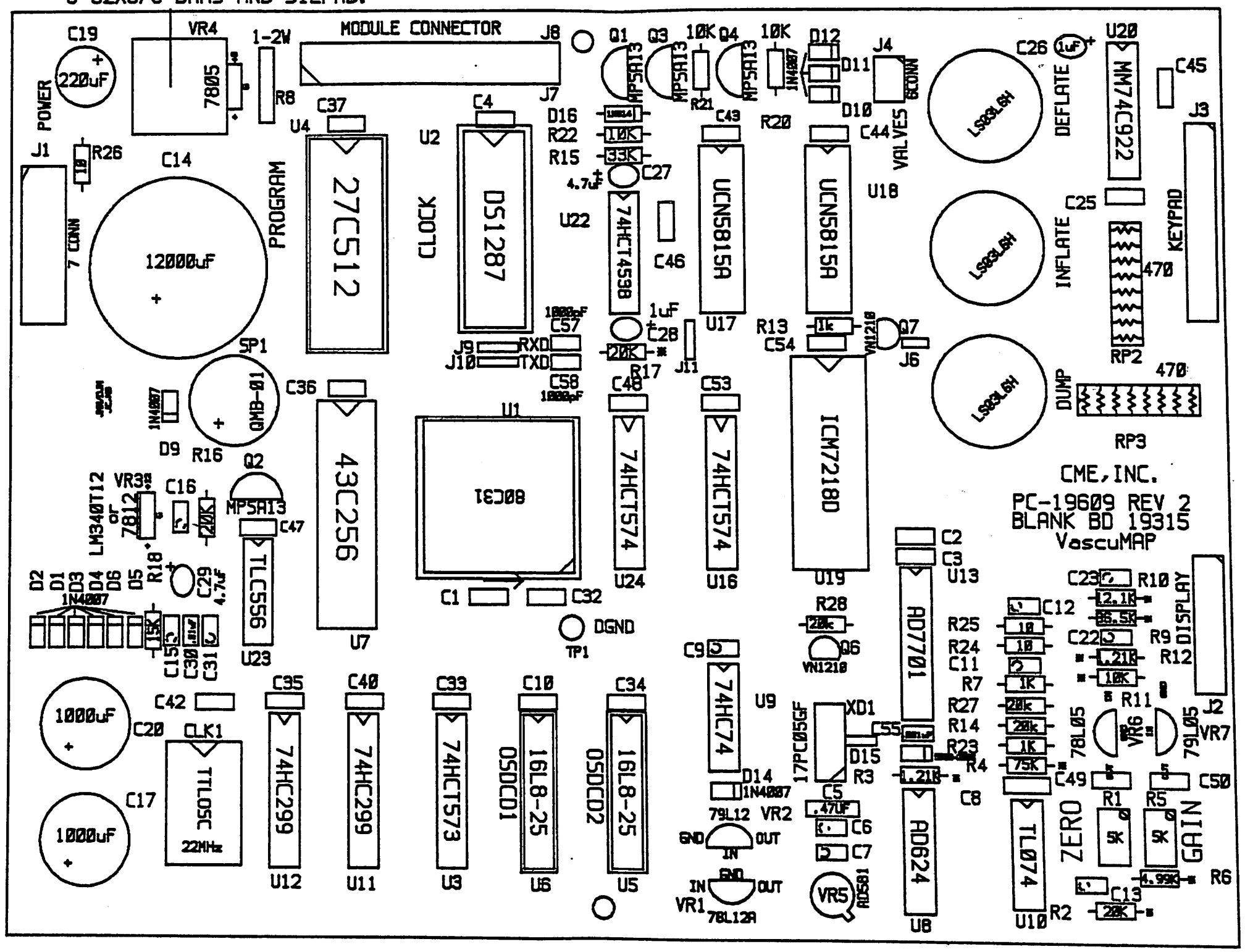
APPENDIX A

PARTS LAYOUT DIAGRAMS

Carolina Medical

VascuMAP®

INSTALL HEATSINK CME #19286 USING THE FOLLOWING:
6-32X3/8 BHMS AND SILPAD.



NOTES:

1) INSTALL XD1 LAST, MOUNTED 1/4" ABOVE PCB.

2) INSTALL VALVES WITH #2545 SCREWS 6 PLCS.

3) INSTALL IC SOCKETS FOR U1,U2,U4,U5 AND U6.

4) UNMARKED CAPS ARE .1UF. WIDE BODY ▭ IS CME# 17539, NARROW BODY ▯ IS #17290.

5) COMPONENTS MARKED WITH A * ARE 1%.

ISSUE	DATE	INIT	CAROLINA MEDICAL ELECTRONICS INC.
1	12/19/90	JMM	VASCUMAP REV 2
2	11-18-91	DJM	PART LAYOUT
3	5-22-92	DJM	
4	4-21-94	DJM	
5			SH 1 OF 1
DISK:		APP.	DRW. PC-19609
FILE: 19609.PCB		SCALE 1:1	

APPENDIX B

SCHEMATIC DIAGRAMS

Carolina Medical

VascuMAP®

R13 10 5% 18952

J11 17587

Q7 VN02NL 18591

VOLCAL2

J6 17917

NOTE: SHORT IF VOLUME CALIBRATOR NOT INSTALLED

C42 0.1uF 80% 17539

CLK1 N/C +5V GND OUT 16MHZ 18191

16MHZCLK TO SH 6

C1 0.1uF 80% 17539

U1 80C31BH PLCC 19272

XTRL2 XTRL1 NC P1.0 P1.1 P1.2 P1.3 P1.4 P1.5 P1.6 P1.7 RST P3.0/RXD P3.1/TXD P3.2/INT0 P3.3/INT1 P3.4/T0 P3.5/T1 P3.6/ WR P3.7/ RD N/C VSS NC VCC P0.0 P0.1 P0.2 P0.3 P0.4 P0.5 P0.6 P0.7 EA ALE PSEN P2.7 P2.6 P2.5 P2.4 P2.3 P2.2 P2.1 NC P2.0

TO SH 4 PUMPON
TO SH 4 DUMPOUT
FROM SH 3 KDA
TO SH 5 ARRST
TO SH 6 CALADC
TO SH 6 CNVT
TO SH 3 VRTNUM
TO SH 5 RXD
TO SH 5 TXD
FROM SH 5 SYNC
INTT
TO SH 4 INFLT
TO SH 4 DFLT
WR
RD

TO U4

ADDR

DATA

C32 0.1uF 80% 17539

CLOCK DS1287 18462

DB7 DB6 DB5 DB4 DB3 DB2 DB1 DB0 SQW IRQ N/C N/C N/C N/C N/C N/C VSS VDD N/C MOT N/C AS R/W DS CS N/C N/C RESET

DATA INTT ALE VR RD RTCSEL

C4 0.1uF 80% 17539

U2

U3 74HCT573 ADDRESS DE-MULTIPLEXER 19619 DE CP D0 D1 D2 D3 D4 D5 D6 D7 Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7

ALE ADDR

C33 0.1uF 80% 17539

PROGRAM ROM U4

TMS27C512 18445

C37 0.1uF 80% 17539

OSDCD2 U5 16L8-Q25 ADDRESS DECODER 19557

A15 A14 A13 A12 VR RD A11 I0 I1 I2 I3 I4 I5 I6 I7 I8 I9 VCC O8 O1 O2 O3 O4 O5 O6 O7 GND

CBREAD TO SH 6
HBREAD TO SH 6
BEEP TO SH 4
LONUM TO SH 3
ROKEY TO SH 3

C34 0.1uF 80% 17539

OSDCD1 U6 16L8-Q25 ADDRESS DECODER 19566

RAMSEL
ARRD TO SH 5
ARWR TO SH 5
LOLITE TO SH 3
HILITE TO SH 3
RTCSEL
ARSTAT TO SH 5
ARSTAT TO SH 5

C10 0.1uF 80% 17539

U7 UPD43256AC 18448 32K X 8 SRAM

A14 A12 A7 A6 A5 A4 A3 A2 A1 A0 I/O1 I/O2 I/O3 GND VCC WE A13 A8 A9 A11 OE A10 CS1 I/O8 I/O7 I/O6 I/O5 I/O4

WR A13 A8 A9 A11 RD A10 RAMSET D7 D6 D5 D4 D3

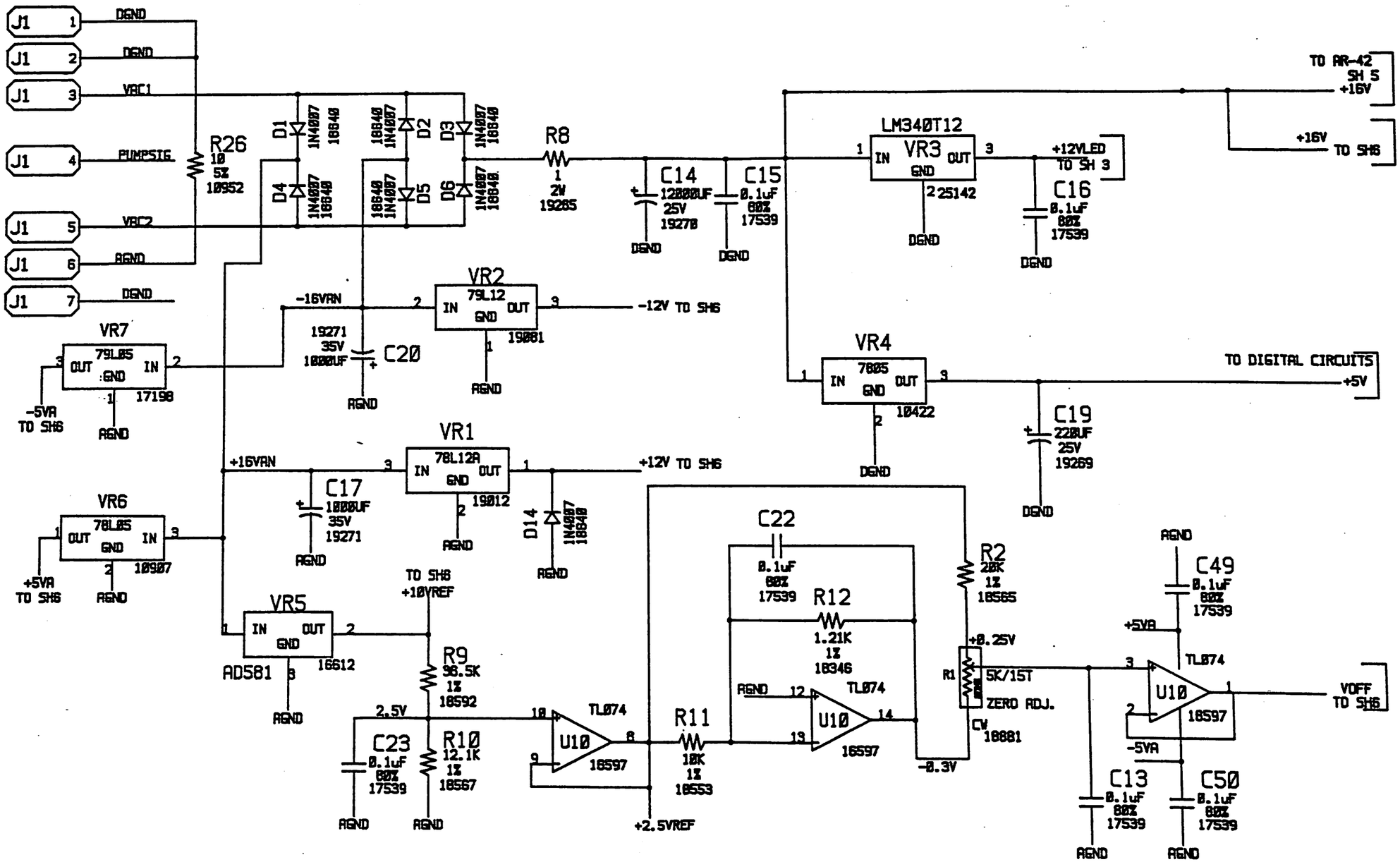
C36 0.1uF 80% 17539

ADDR TO SH 5

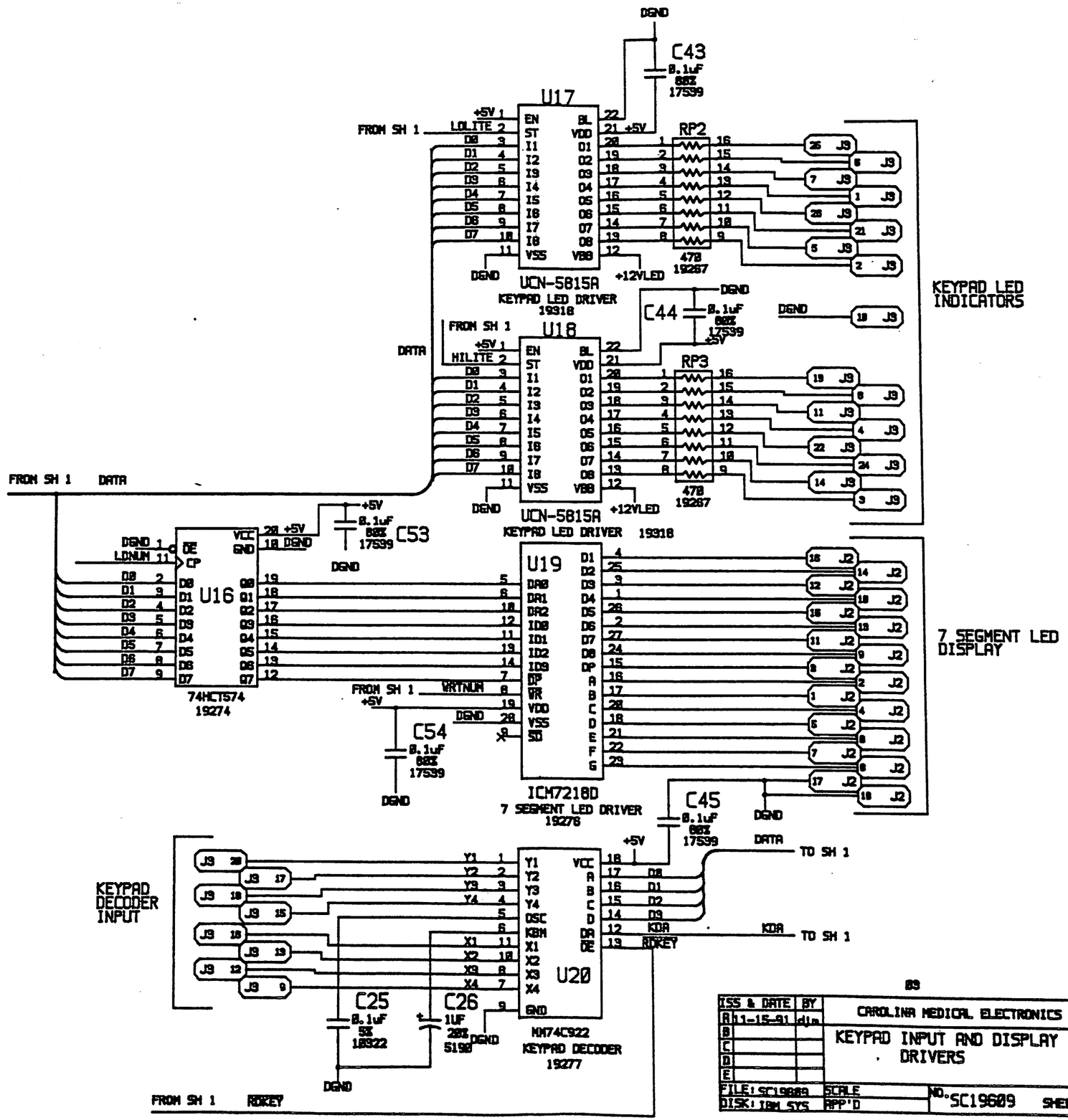
DATA TO SH 3,5,6

ISS & DATE	BY	CAROLINA MEDICAL ELECTRONICS INC.
1 11-15-91	dlm	MICROPROCESSOR, MEMORIES, AND CLOCK
2		
3		
4		
5		
FILE: 19609S1	SCALE	NO. SC19609 SH 1
DISK: VAXCLUSAP	APP'D	

01

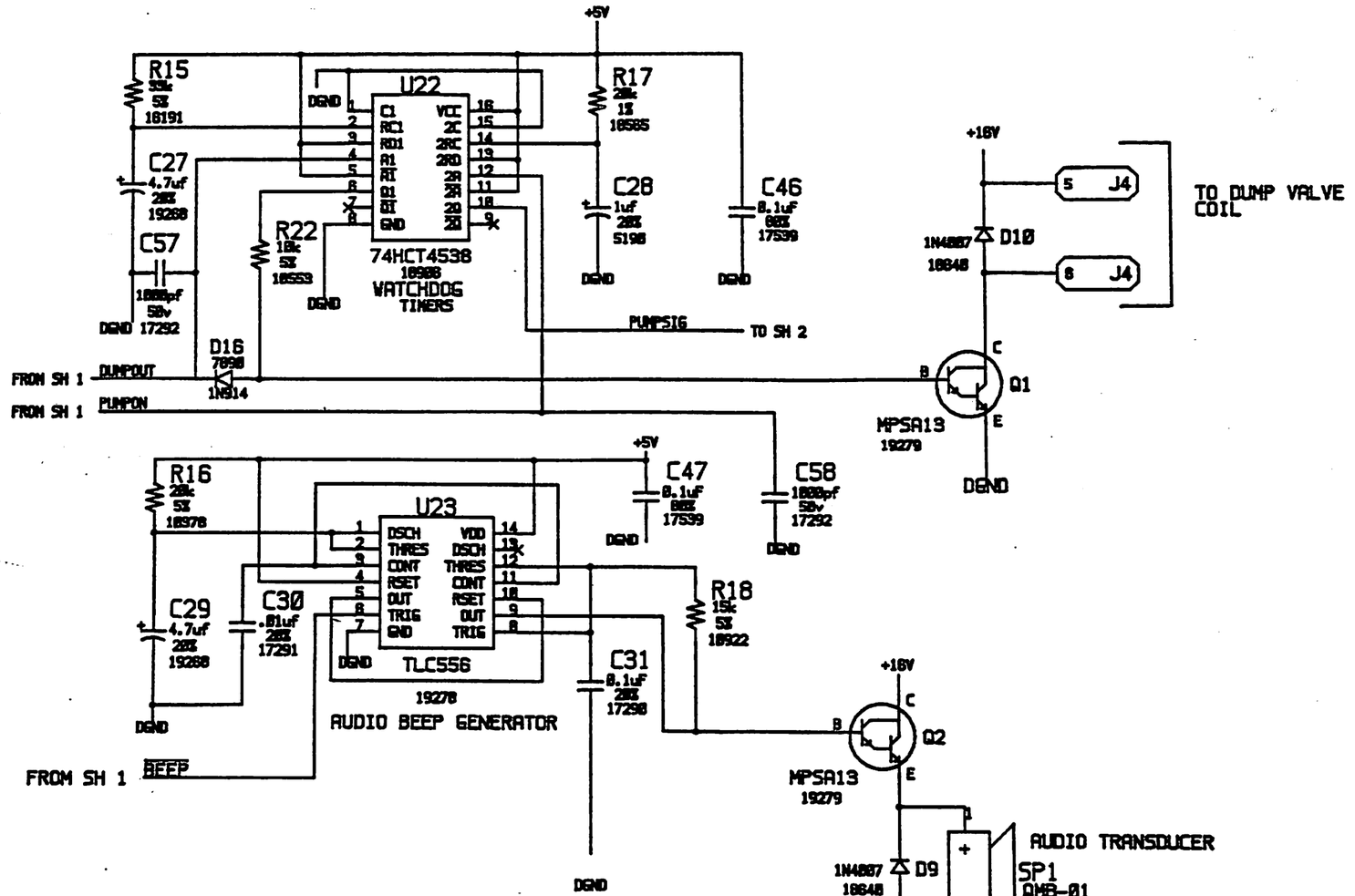


ISS & DATE	BY	CAROLINA MEDICAL ELECTRONICS INC.
1 11-15-91	DJM	
2 4-8-94	DJM	VOLTAGE REFERENCE GENERATORS AND POWER SUPPLIES
3		
4		
5		
FILE: SC19609		SCALE N/A NO. SC19609 SH 2
DISK: IBM SYS		APP'D



89

ISS & DATE	BY	CAROLINA MEDICAL ELECTRONICS INC.
A 11-15-91	djm	KEYPAD INPUT AND DISPLAY DRIVERS
B		
C		
D		
E		
FILE: SC19609	SCALE	NO. SC19609 SHEET 9
DISK: IBM.SYS	APP'D	



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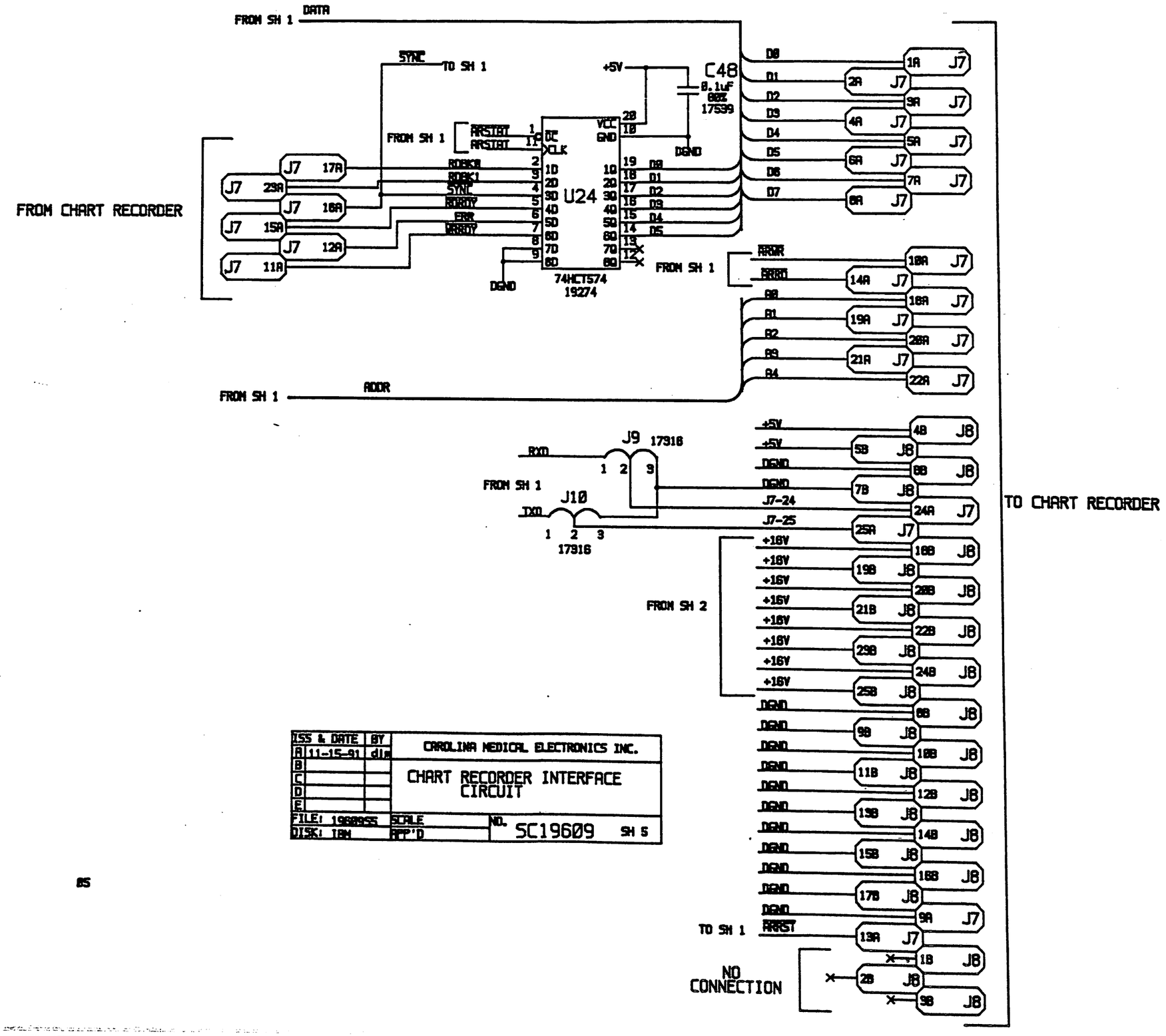
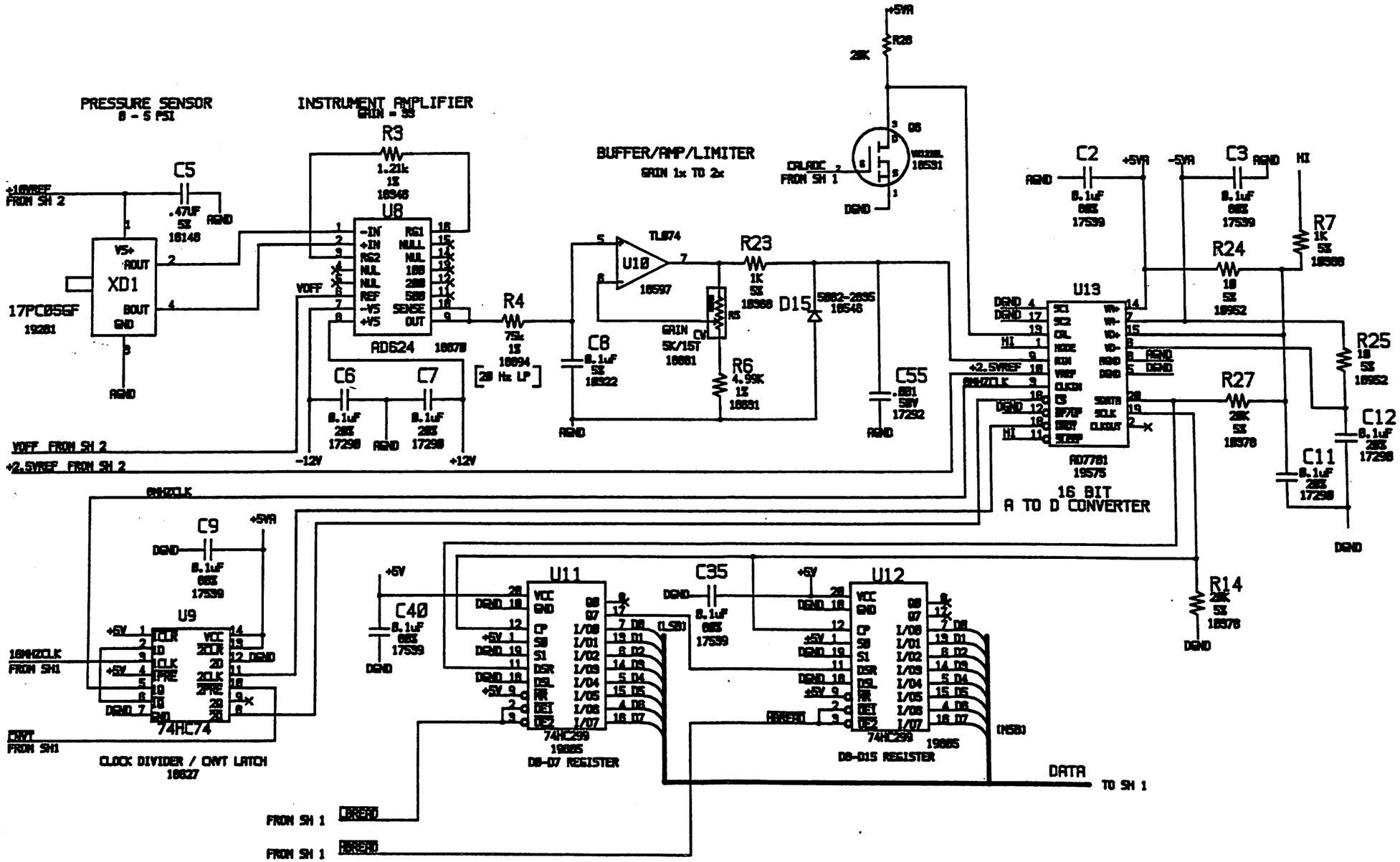
ISS & DATE	BY	CAROLINA MEDICAL ELECTRONICS INC.
A 11-15-91	dla	
B		PNEUMATIC CONTROL AND BEEPER CIRCUITS
C		
D		
E		
FILE: 1900954	SCALE N/A	NO. SC19609 SH 4
DISK: IAM	APP'D	



ISS & DATE	BY	CAROLINA MEDICAL ELECTRONICS INC.
A 11-15-91	dlm	CHART RECORDER INTERFACE CIRCUIT
B		
C		
D		
E		
FILE: 19809SS	SCALE	NO. SC19609 SH 5
DISK: IBM	APP'D	



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