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LITHIUM DRIFTED GERMANIUM SYSTEM

Series 1000
Model 6908A.

E. J. Fjarlie

FINAL REPORT
SEPTEMBER, 1969

Prepared for

NASA MANNED SPACECRAFT CENTER
SPACE SCIENCE PROCUREMENT BRANCH/BG931
HOUSTON, TEXAS 77058

Attention : Mr. T. Krenek
Bldg. No. 2, Room 362

under

CONTRACT NO. NAS 9-9377

RCA Research Laboratories

RCA Limited | 1001 Lenoir Street | Montreal 207, Que. | Canada

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Approved By: R M Green

Dr. R.M. Green, Director
Optical and Microwave
Physics Laboratory

Dated: September 1969

RCA Limited, 1001 Lenoir Street, Montreal 207, Quebec, Canada

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ABSTRACT

This report gives general characteristics of the lithium-drifted germanium photodiode - Dewar - preamplifier system and the particular operating instructions for the device together with some advice on what to do if difficulties occur.

1 GENERAL

When cooled, germanium photodiodes are excellent quantum detectors in the $\lambda 1$ to $1.5\ \mu m$ spectral region. The normal germanium photodiode consists of a wafer of p-type germanium into which a shallow layer of n-type impurity is diffused to form a junction. Radiation flux enters the device through the diffused layer and is absorbed in the junction depletion layer to create a hole-electron pair. At short wavelengths where the absorption coefficient is high, greater than $10^4 cm^{-1}$, the energy is absorbed in the diffused layer and recombination occurs before the signal is detected, at long wavelengths where the absorption coefficient is small, less than $10\ cm^{-1}$, most of the energy passes through the depletion layer to be absorbed in the undepleted part of the wafer or is transmitted completely through the detector. Typical depletion layers are about $50\ \mu m$ wide.

The technique of drifting lithium through the device widens the depletion layer in that the impurities in the material are compensated to effectively yield intrinsic material. Depletion layers up to 10 mm wide can be made with little difficulty. The p-n diode has become a p-i-n diode and the range of high quantum efficiency has been extended over a much broader range of absorption coefficients.

Radiation flux enters the lithium-drifted germanium detector in a direction parallel to the junction, thus there is little or no "dead" layer and almost all of the generated carriers are collected.

Because of the mobility of the lithium ions and of the possibility of precipitation or other chemical effects occurring at room temperature, the diode must be kept cooled to remain in good operating condition. Storage in a deep freeze (-40°C), at dry ice (196°K), or at liquid nitrogen (77°K) is necessary.

The noise performance of the system is a function of temperature. Noise contributions are made by the detector, the load, and the transistor (FET) in the preamplifier. Cooling the system decreases the noise contributions from all the components, but does make it more difficult for the FET to operate. Because the noise is system noise it is meaningless to convert the system noise equivalent power (NEP) to detectivity (D*).

The metal Dewar is demountable at the tail piece for access to the detector and preamplifier; the room temperature vacuum seal is a rubber O-ring. The detector and electronics are mounted on a plate which is in contact with the face plate of the cold finger of the Dewar. Thermal cooling of the components is effected by conduction from part to part. The heat inputs to the system via radiation, conduction, and convection are about equal.

2 SPECIFIC

The specific operating conditions for this particular detector are given in the attached appendices; that is, the detector bias, and the circuit bias voltage and current together with the circuit load resistor value. Simple batteries may be used as the power supplies; no special characteristics are required of the circuit load resistor, R.

Measured curves are included showing NEP as a function of wavelength, λ, and the noise voltage spectrum of the system. Measurements are made at 23 Hz and referred to a frequency bandwidth, Δf, of 1 Hz.

The responsivity of the system is given for one wavelength, the NEP curve may be converted to a spectral response curve by applying the responsivity value at the measured λ to see the variation in responsivity with wavelength.

The dynamic range limit of the system is also given in the data sheet for the detector. The mechanism of saturation is that the signal current into the diode load determines the dynamic resistance of the load. At high power levels the diode load resistance has decreased to about $10^9 \Omega$, thus the bias volts for the transistor is affected making the circuit nonlinear.

The coolant hold time for the Dewar is given for the case of the ion pump operating continuously, and for the case of the ion pump not operating at all.

The ion pump characteristics are given in a separate Appendix.

3 TECHNIQUES AND TROUBLES

If there is any question that the system is working improperly, a graph of current vs volts across R should trace the FET characteristic curve. The operating point for the circuit usually is on the plateau of the curve. If a straight line relationship is found, one of the junctions of the FET has been short circuited.

If an adverse result is found above, extreme care must be exercised if the user elects to replace the FET himself. While the circuit is being modified, the detector must be kept cold and, in addition, nothing must touch any of the detector surfaces except the two electrode surfaces. Furthermore, the polarity identification of the detector takes much experience so keep exact information on the orientation if such repair work is attempted.

Never open the vacuum compartment when the detector is cold, the resulting instant frost could permanently damage the detector. If it is desireable to enter the vacuum compartment, dump the liquid nitrogen and fill and empty the Dewar with warm water two or three times over a period of three to four hours before breaking the vacuum. It is a good idea as an extra safeguard to fill the vacuum side with dry nitrogen gas or helium before opening the Dewar. The detector can tolerate being at room temperature for a short time about 15 to 20 min before deterioration results. In replacing the detector, the vacuum compartment should be briefly pumped, about 10 min., before turning on the ion pump and cooling the system once more. Keep in mind that the detector is the last to warm up on increasing the temperature and the last to cool on decreasing the temperature.

There should be no sign of heating around the ion pump, the operating current should be in the region of 5 μA to 50 μA. If heating and higher currents or erratic current behaviour are noticed, it means that there is either a vacuum leak or that the pump has been contaminated and must be replaced.

When biassing the circuit, the voltage level is not too critical in that greater or smaller values may be used; however, if the current is allowed to increase too much, the FET may be damaged. The detector bias may be increased significantly, as much as a factor of three or so if desired.

There may be considerable difficulty with electrical "pick-up" with this system. Great care must be exercised with reference to ground loops.

(Don't forget there is an electrical common connection via the ion pump.) Disconnect any meters when measurements are made.

It is not necessary to keep the detector in the dark before using the system. When the detector is exposed to radiation flux (with bias volts applied) current is generated which can be either ac or dc depending on whether the flux was chopped or not. If a dc signal is generated which is appreciable, the detector noise could increase due to the increased current and the S/N ratio for the ac signal would be affected.

When the device is operated at high frequencies the system is in the f^{-1} frequency response condition. If wide frequency bandwidths are necessary, an equalizing network or compensating network is required before the signal is demodulated in order to balance the contribution from the sidebands.

Synchronous demodulation may improve the measured NEP; all the measurements have been made with a quadratic demodulator.

The long wavelength response of the detector may be significantly enhanced by operating the system at a higher temperature. Higher temperature will increase the absorption coefficient; for example, at $\lambda 1.65$ μm a change from liquid nitrogen to liquid oxygen would broaden the long wavelength response by $\lambda 150$ Å, and a change to solid CO_2 would give a further increase of $\lambda 1350$ Å to 1.78 μm before falling off with the same slope.

The Dewar has a very large heat capacity which means that if all the coolant boils off it would be several hours before the temperature of the detector reached a high enough level to affect the performance. Note that the measurements on the coolant hold times have been made in the laboratory under undisturbed conditions.

It is not obvious that the system NEP remains constant with increasing frequency. An examination of the noise spectrum shows the voltage falling as f^{-2}. There are peaks at 60 Hz and the first five harmonics of 60 Hz, but the general power spectrum is falling as f^{-2}. Signal falls at the same rate making the S/N ratio constant with frequency and hence making the NEP constant with frequency until the detector noise reaches the white noise of the following amplifier - at about 20 kHz or so. The output voltage at higher frequencies does fall placing a greater requirement on the following amplifier to handle signals of the order of 10 nV at 10^3 Hz operating frequency.

If the short wavelength response drops it means that there is a residual dead layer in the detector of between 0.1 and 1 μm thickness. There is no explanation of why this appears - it varies from detector to detector - and cannot be predicted or controlled in the fabrication process. The theory does not predict such a drop in response.

The boiling off action of the liquid nitrogen in the Dewar occurs at a uniform rate. If the system is to be operated in a reduced ambient pressure environment to force the boil off rate to increase it may produce a significant microphonic input to the electronics and the apparent noise performance may be degraded. However, the bubbling of the nitrogen can be completely eliminated by passing helium gas over the surface of the coolant or by bubbling the gas through the liquid nitorgen via a small capillary. There is then no microphonic input to the system via this cause; the system noise measurements reported have been made with the coolant in the unmodified condition.

The circuit for the detector and preamplifier is drawn assuming the FET is P-channel requiring negative bias for the FET and the photodiode orientation and battery connection shown. If the FET is n-channel, all the polarities are reversed and the diodes are reversed in their connections as well. The appropriate polarity is given in the specific data for the device.

Series 1000 6908A

Detector Description

Type	Lithium drifted germanium
Detector dimensions	1 cm × 1 cm × 3 cm long
Sensitive area (masked)	0.7 cm diameter
Window material	Quartz
Window thickness	2.0 mm
Window diameter (clear)	7/8 inch
Transistor type	2N3089A
Current output impedance	~ 500 Ω

Dewar Description

Coolant lifetime (ion pump operating)	> 5 days
Coolant lifetime (ion pump not operating)	~ 2 days
Coolant capacity	10 liters

Test Conditions

Source	Tungsten filament
Spectrometer	Barr and Stroud monochrometer
Line width at 1.6 μm	600 Å
Prism	Rock salt
Neutral density filter	Optic technology 1226
Chopping frequency	23.5 Hz
Noise bandwidth	1.0 Hz
Wave analyser	Hewlett Packard 302A
Low noise preamplifier	Tektronix 122
Ampient temperature	24°C
Background radiation or detector	297°K only
Standard thermopile	Hilger and Schwartz FT-20-301-55234
Calibration of thermopile and transformer	4.2 rms volt/rms watt cm^{-2}

Series 1000 6908A

Test Results

Transistor Current	0.25 mamp
Total volts V_b	+12.5 volts
Load resistance	33×10^3 Ω
Diode bias V_d	-90 volts
Wavelength of peak response λ_m	1.64 μm
Power on diode at λ_m	1.5×10^{-11} watt
Noise out at 23.5 Hz	1.0×10^{-6} $VHz^{-\frac{1}{2}}$
NEP at 23.5 Hz and λ_m	1.25×10^{-14} watt $Hz^{-\frac{1}{2}}$
Responsivity at 23.5 Hz and λ_m	$8.0 \times 10^{+7}$ volt $watt^{-1}$
Saturation	5×10^{-9} W total
Temperature of system	~ 77°K

DISTRIBUTION

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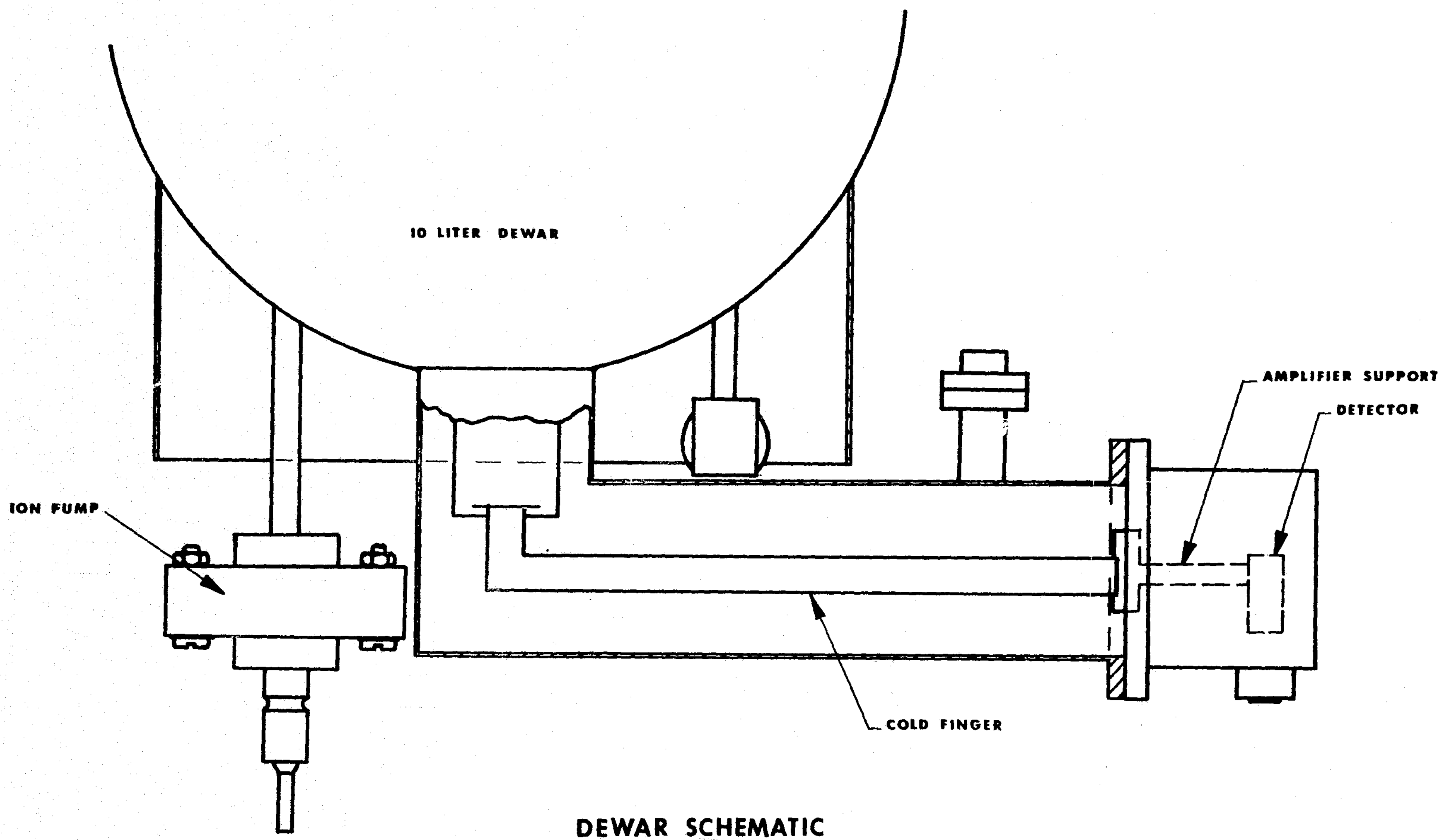
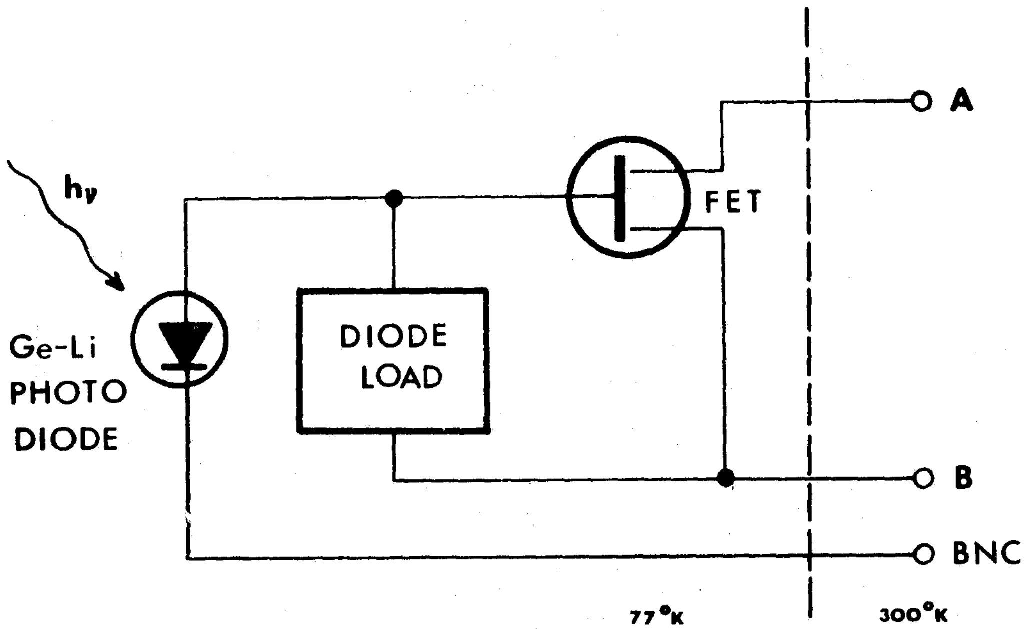
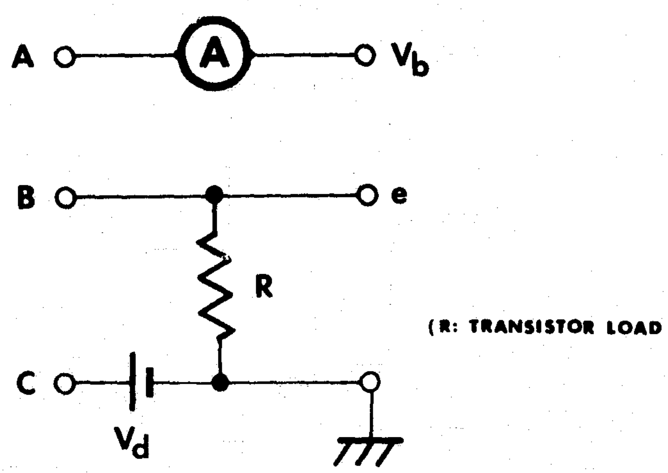


DEWAR SCHEMATIC

SYSTEM-6908A



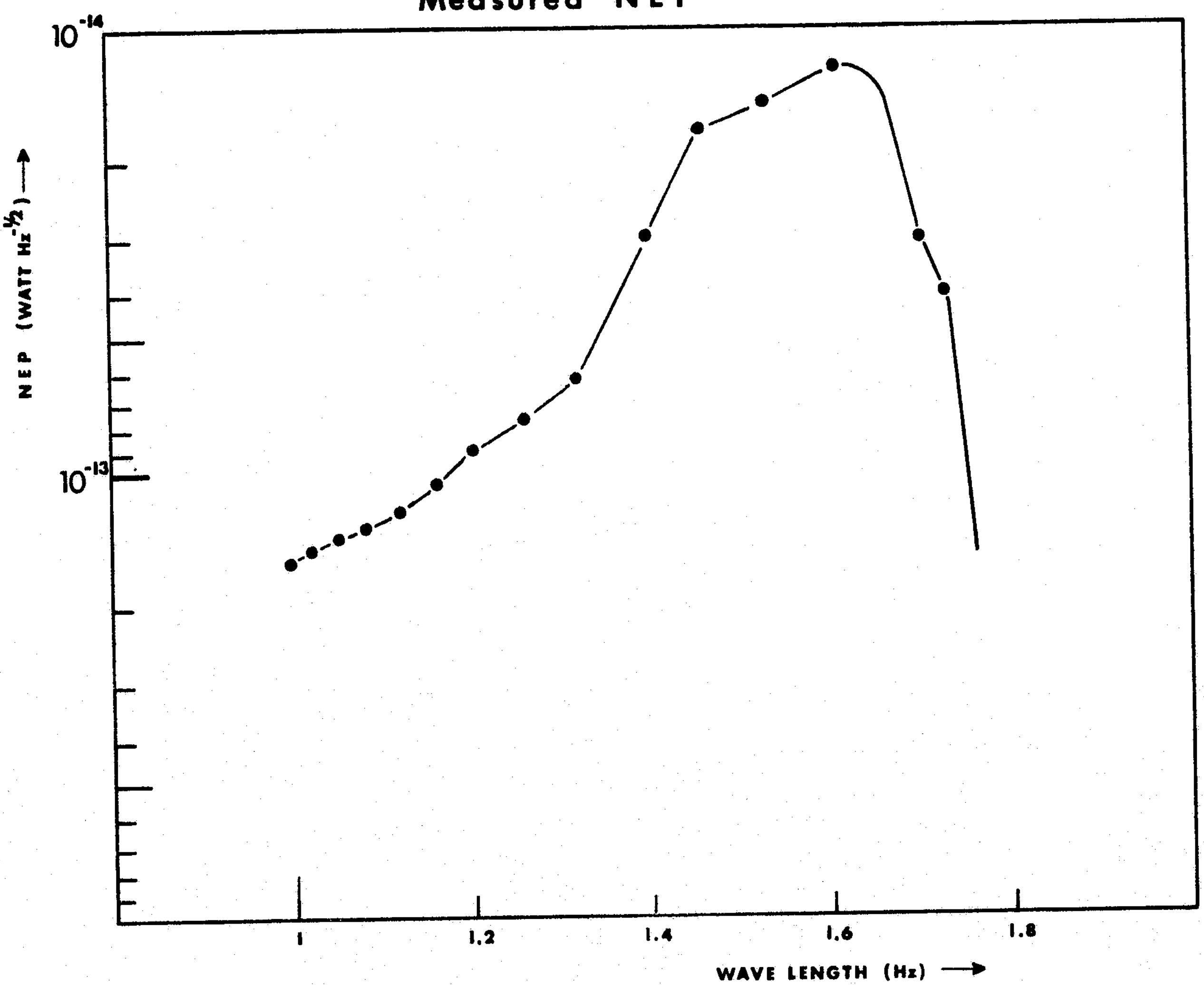
Cooled Preamplifier (IN DEWAR)

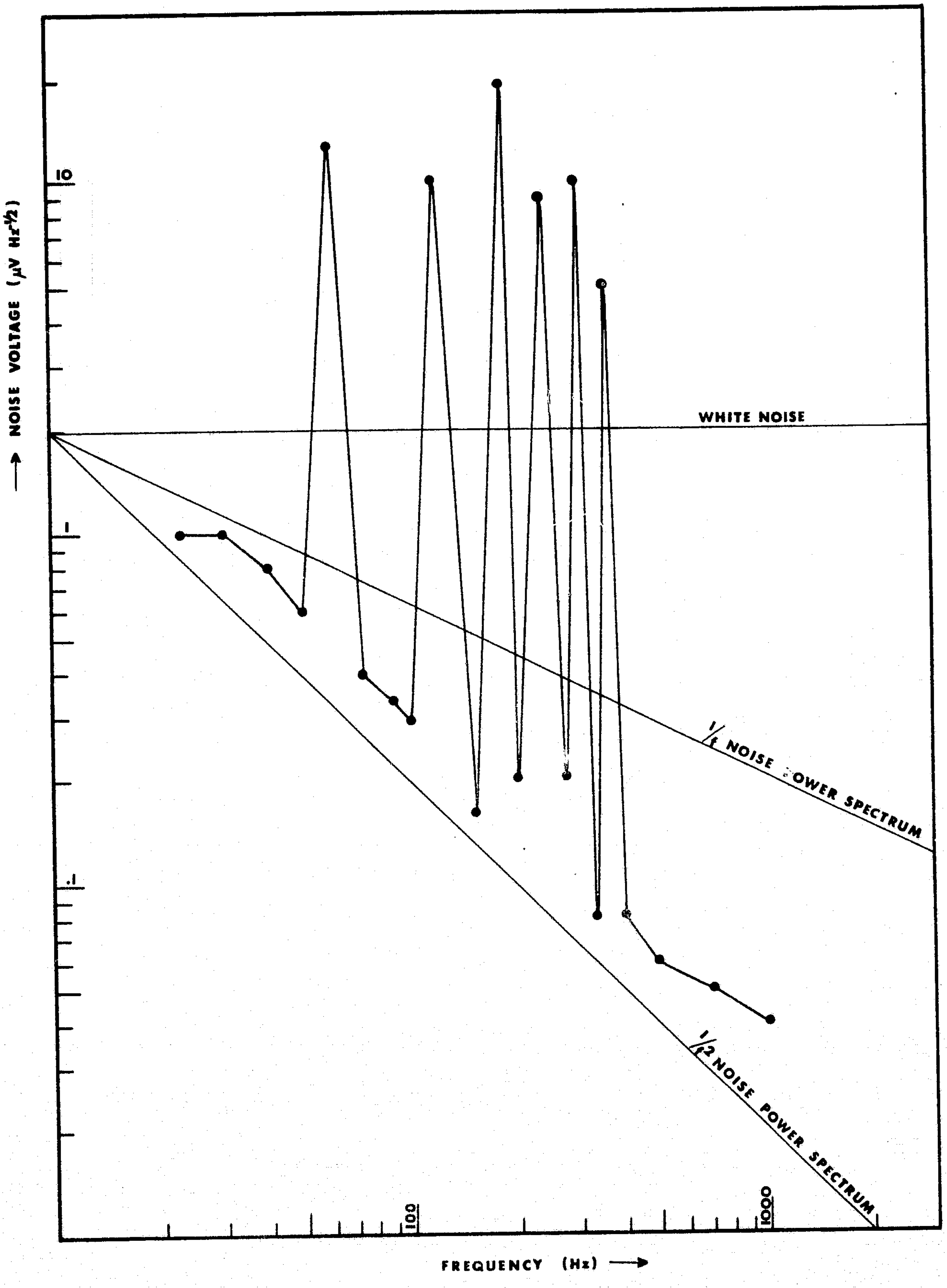


Electrical Connections To Dewar

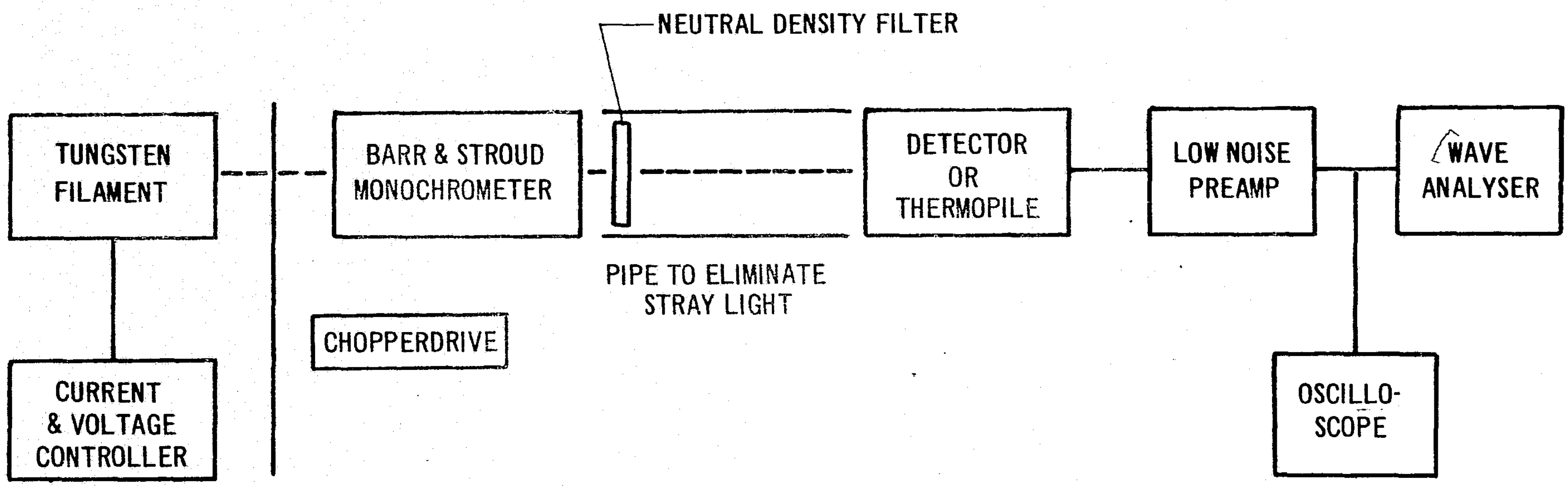
FIGURE ELECTRONICS

Measured NEP

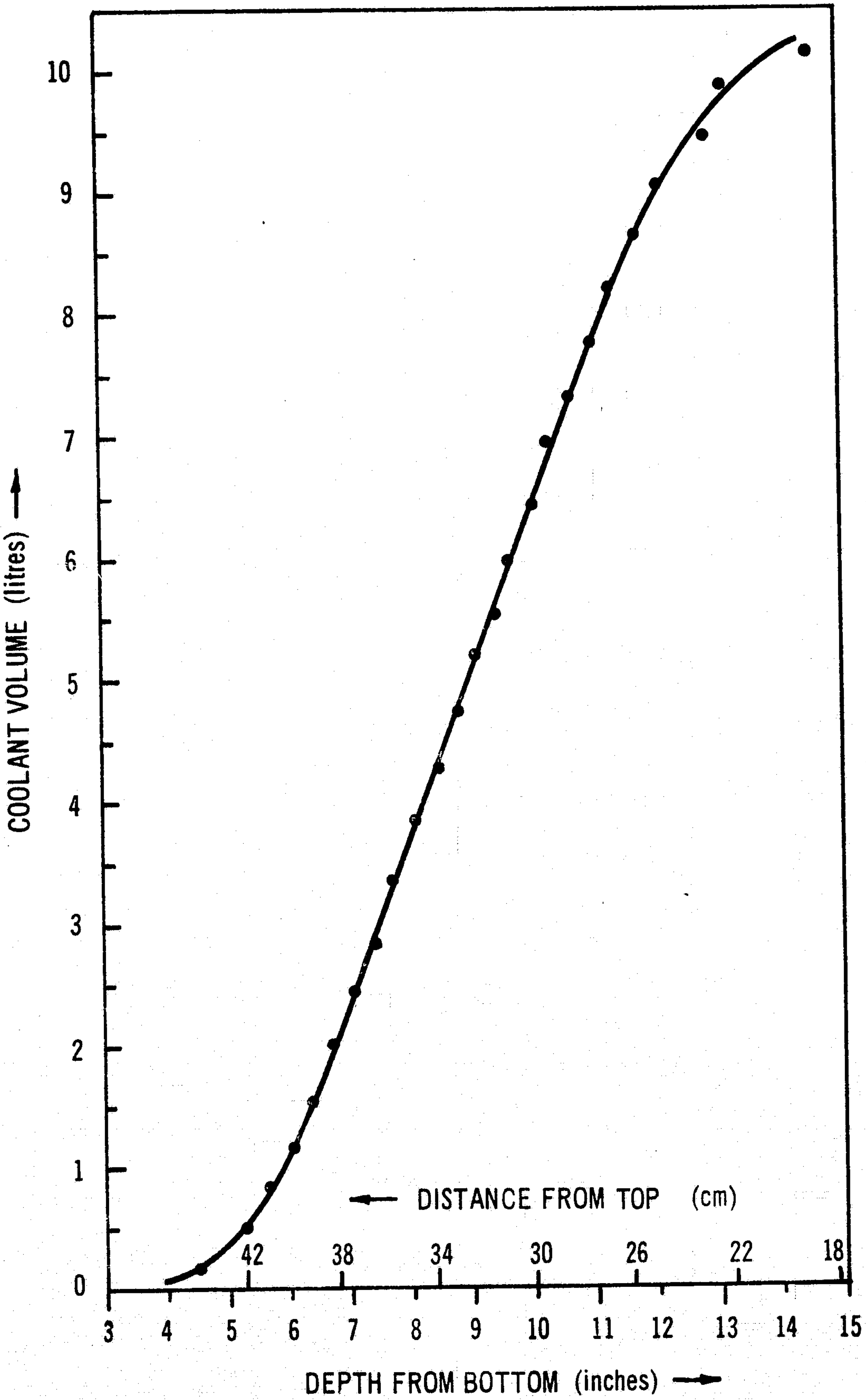




Noise Voltage Spectrum (SYSTEM 6908A)



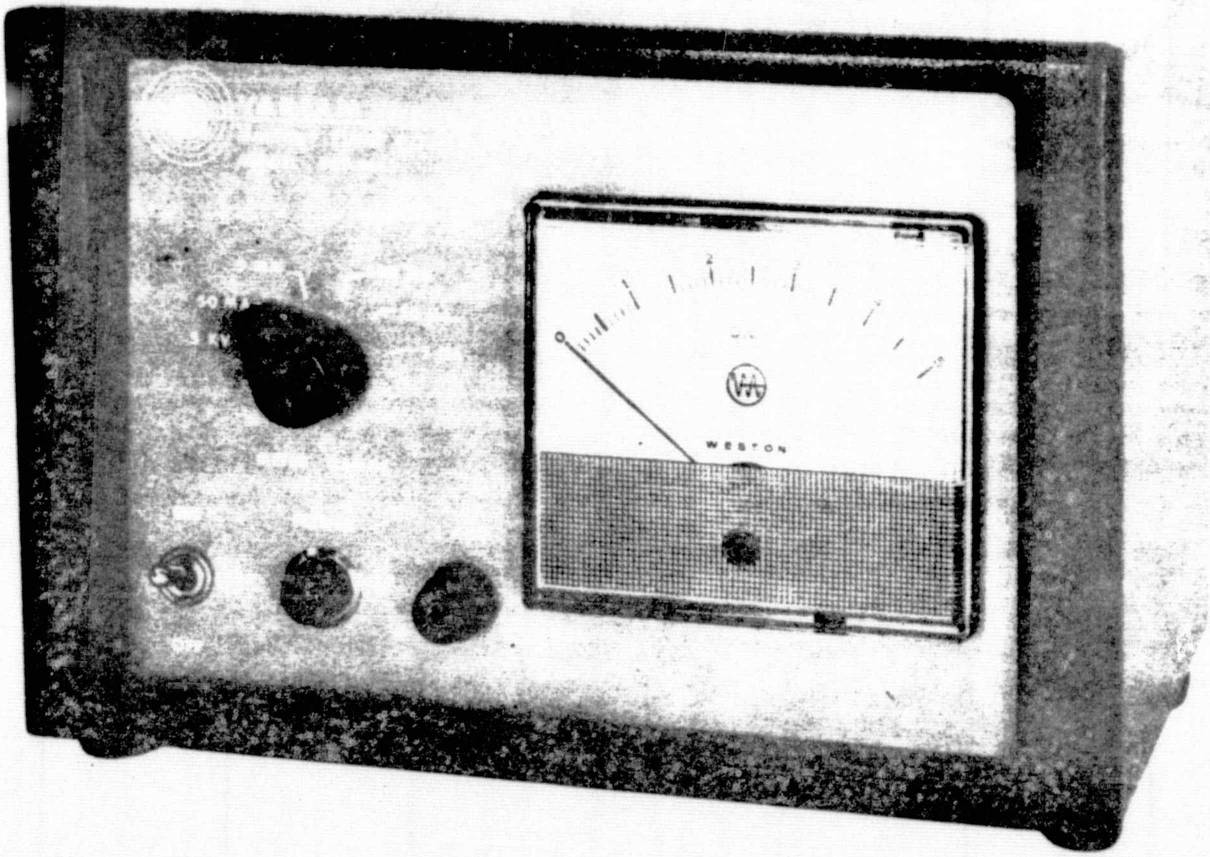
Block Diagram of Test Circuit



Liquid Depth vs Coolant Volume

87-400 075

MAY 1967



VacIon® PUMP CONTROL UNIT

MODEL NO. 921-0015

INSTRUCTION MANUAL

ORIGINAL PAGE
OF POOR QUALITY

CONTENTS

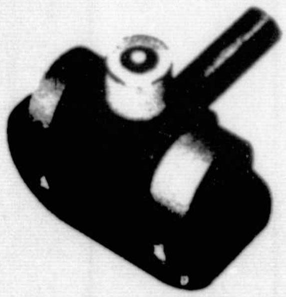
I. INTRODUCTION

The Varian Associates Model 921-0015 VacIon® Pump Control Unit starts and operates VacIon Pumps which have pumping speeds up to and including 8.0 liters per second. Larger VacIon Pumps requiring the same operating voltage can be operated also with this control unit; however, first the VacIon Pump must be started and pumped to a sufficiently low pressure with an appropriate control unit. The control unit output current or voltage is read on the front panel meter by setting the selector switch. Pressure in the VacIon Pump is determined by converting the current reading with the curves for Current vs Pressure on page 17. Recorder jacks on the rear of the chassis allow continuous monitoring of the pump current by a recorder. The control unit is housed in a case but it can be panel mounted if desired.

The control unit high voltage outlet is connected to a VacIon Pump by a high voltage coaxial cable and connector assembly. Three types of high voltage cables are used depending on the size of the VacIon Pump to be operated. High voltage cables must be ordered separately.

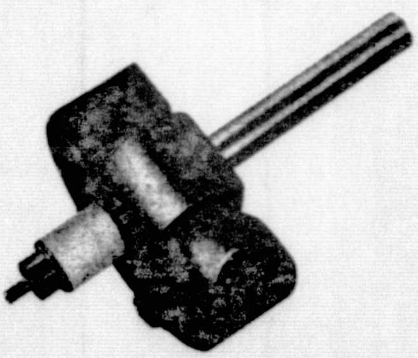
The control unit will operate from a single phase 115-volt or 230-volt, 50-or 60-cycle power source. It is connected for 115-volt operation when shipped from the factory. For changeover to 230-volt operation see page 8.

A description of the VacIon Pumps normally operated with this control unit follows.



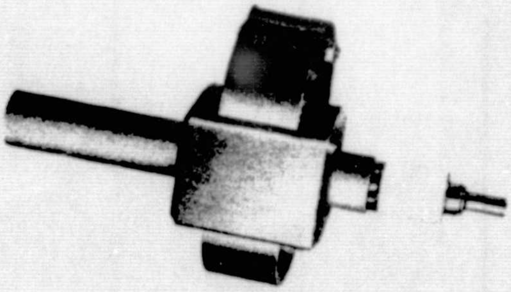
0.15 ℓ/S PUMP

PUMP SPEED (LITERS/SEC.)	DESCRIPTION	MODEL NO.	REQUIRES MAGNET NO.
0.15	7052 Glass Tubulation	913-0024	913-0021
0.15	Copper Tubulation	913-0018	913-0021
0.15	Stainless Steel Tubulation	913-0019	913-0021



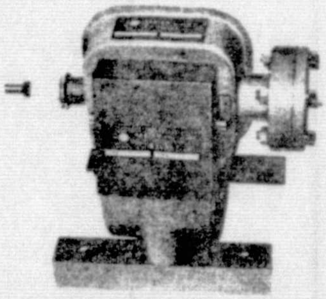
0.2 ℓ/S PUMP

PUMP SPEED (LITERS/SEC.)	DESCRIPTION	MODEL NO.	REQUIRES MAGNET NO.
0.2	Copper Tubulation	913-0002	913-0003
0.2	Stainless Steel Tubulation	913-0005	913-0003
0.2	7052 Glass Tubulation	913-0025	913-0003



1.0 ℓ/S PUMP

PUMP SPEED (LITERS/SEC.)	DESCRIPTION	MODEL NO.	REQUIRES MAGNET NO.
1.0	Copper Tubulation	913-0007	913-0011
1.0	Stainless Steel Tubulation	913-0008	913-0011
1.0	Pyrex Tubulation	913-0009	913-0011
1.0	7052 Glass Tubulation	913-0010	913-0011



5.0 ℓ/S AND 8.0 ℓ/S PUMP

PUMP SPEED (LITERS/SEC.)	DESCRIPTION	MODEL NO.	REQUIRES MAGNET NO.
5.0*	Standard VacIon Pump	911-1402	911-0001
8.0	Standard VacIon Pump	911-5000	911-0001
8.0	Standard VacIon Pump, Tee Style	911-5001	911-0001
8.0	Super VacIon Pump**	911-5014	911-0001

* 5 ℓ/s VacIon Pumps are equipped with old-style Varian Flanges. Adapters are available to mate the old-style flange with the new ConFlat® Flanges.

** Super VacIon Pumps have slotted cathodes which provide stable pumping against a constant air leak.

II. OPERATING SPECIFICATIONS

Power	60 Hz - 115 volts, 0.9 ampere 60 Hz - 230 volts, 0.45 ampere 50 Hz - 115 volts, 0.7 ampere 50 Hz - 230 volts, 0.35 ampere	Note: Control unit is delivered ready to operate on 115 volts. For changeover to 230-volt operation see page 8.
Fuse	115-volt input - 1 ampere slo-blo 230-volt input - 1/2 ampere slo-blo	
Output	60 Hz, 115-volt or 230-volt input 50 Hz, 115-volt or 230-volt input	- Open circuit 3500 Vdc ± 10% Short circuit 43 mAdc ± 10% - Open circuit 3500 Vdc ± 10% Short circuit 36 mAdc ± 10%
Metering	Current ranges - 5 μA, 50 μA, 500 μA, 5 mA, and 50 mA with an accuracy of ± 10% of full scale in each range. Voltage range - 5 kilovolts with an accuracy of ± 10% of full scale.	
Leakage Current	High voltage cable removed from control unit - 0.2 μAdc maximum.	
Recorder Output	Negative 100 millivolts output (with respect to chassis ground) corresponds to full scale meter deflection for all current ranges.	
Duty Cycle	Continuous under any normal load condition.	
Ambient Temperature	Operation - 32°F to 105°F (0°C to 41°C) Storage - 0°F to 150°F (-32°C to 66°C)	
Altitude	Sea Level to 15,000 feet (4570 meters)	
Size	With cabinet - Width - 11-1/2 inches (29.2 cm) Height - 8 inches (20.3 cm) Depth - 8-1/4 inches (21.0 cm) Note: For panel mounting see page 9.	
Weight	Actual - 14 pounds (6.4 kg) Shipping - 18 pounds (8.2 kg)	

III. PRINCIPLE OF OPERATION

Model 921-0015 VacIon Pump Control Unit will supply, regulate and monitor the power that is applied to a VacIon Pump. The output capability of a VacIon Pump Control Unit, for use with a specific pump, provides sufficient voltage and current to start the pump at its recommended starting pressure in a practical time and never exceeds the power dissipation limit of the pump. A high voltage potential above 3000 volts is needed by a pump to provide pumping action over most of its functional range. The high voltage requirement necessitates the use of a power transformer in the control unit. The voltage from the transformer secondary is rectified in a voltage doubler circuit to provide d-c voltage and current. Current limiting is necessary to prevent excessive power being applied to the pump at high pressures (above 10^{-4} torr) and during the starting condition. Current limiting is accomplished by capacitive reactance. Filtering is provided for low currents at high voltages.

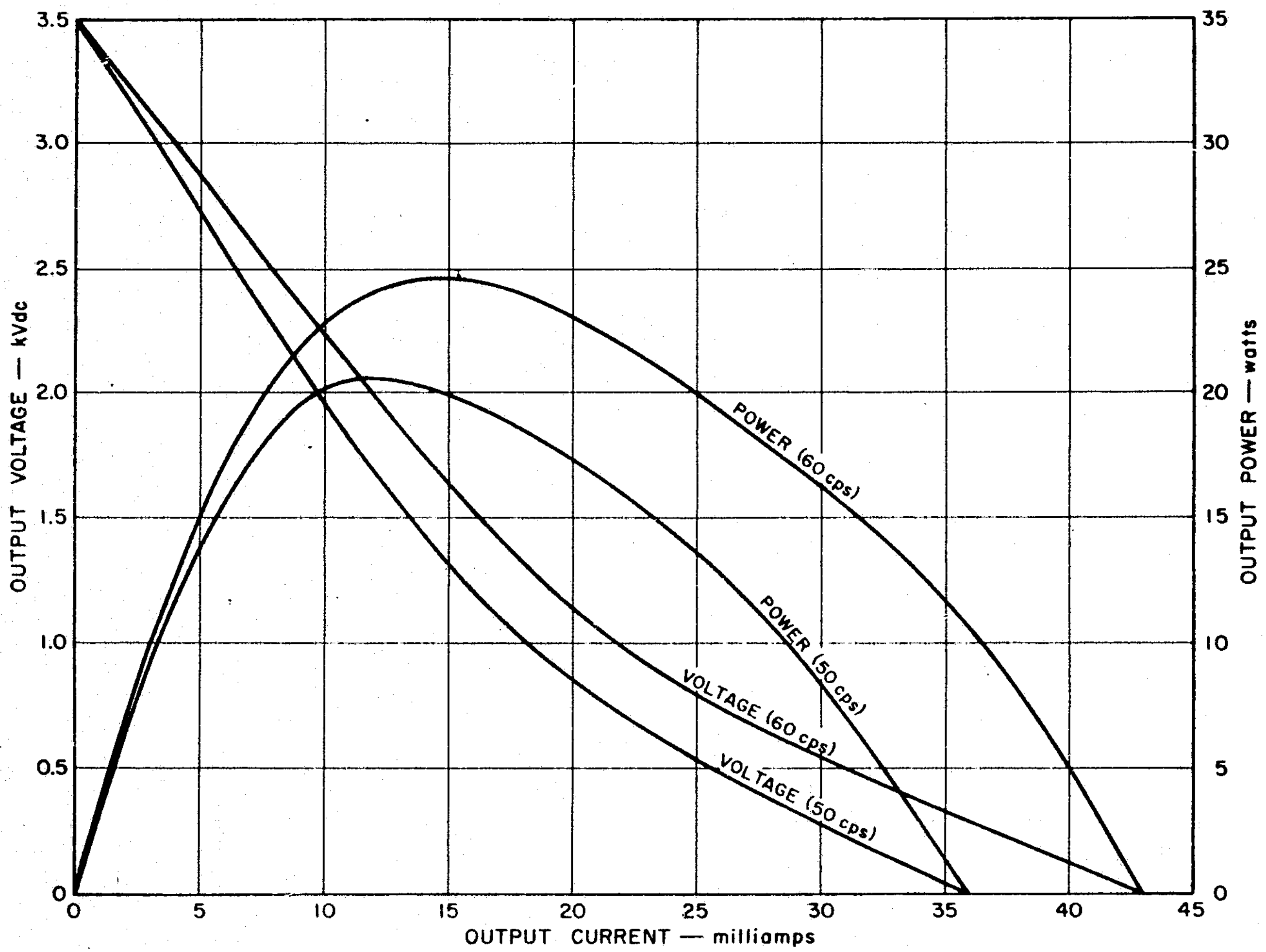
A unique design feature of the VacIon Pump Control Unit is that it has a falling Voltage vs Current (soft supply) characteristic, as shown by the curves on page 7. With increasing load the d-c output voltage falls from a maximum value at no load to zero volts at short circuit. At the same time the output current increases from zero amperes at no load to a maximum short circuit current which is limited by the internal impedance of the control unit. The resulting power output of the control unit rises from zero power at no load to a maximum value established by the dissipation limit of the smallest VacIon Pump which the control unit is intended to operate, and then decreases to zero power at short circuit. This type of regulation in the high voltage supply is necessary because the impedance of the electrical discharge in the VacIon Pump varies from several hundred ohms at the starting pressure to several thousand megohms at low pressures.

When a VacIon Pump is connected to the control unit, the output voltage will vary with the pump current. The doubler circuit supplies an increasing current demand up to the point where the output is shorted to ground. When a VacIon Pump is at a high pressure (1×10^{-2} torr), such as in the starting condition, the unconfined glow discharge in the pump approaches a short circuit, or low impedance condition, and the potential across the pump is 300 to 400 volts. As the VacIon Pump reduces the pressure, the pump current will decrease and the voltage will rise accordingly.

Current drawn by a VacIon Pump is proportional to the pressure in the pump. Therefore, the pump acts as its own pressure gauge. The pressure can be determined by converting the current reading with the curves provided on the Current vs Pressure chart on page 17. The accuracy of such a determination is comparable to that of a good ionization gauge.

The control unit voltage and current are metered in low voltage circuits for safety. The meter is placed in the negative or ground side of the control unit circuitry. The meter movement has a five-microampere full-scale deflection in each range, and it is protected from surge currents by a special protection diode. The accuracy of a current or voltage reading is within $\pm$ 10% of full scale in each range.

The output signal provided for recording is taken from the negative side of the current metering circuit. For an equivalent full scale meter deflection in any current range, a negative (with respect to the chassis) 100-millivolt signal provides full span deflection for a recorder. As VacIon Pump pressure decreases, the pump current decreases and the recorder output signal decreases in magnitude.



ELECTRICAL CHARACTERISTICS OF VacIon® PUMP
CONTROL UNIT MODEL NO. 921-0015

IV. INSTALLATION

WARNING

THE VOLTAGES DEVELOPED IN THIS CONTROL UNIT ARE DANGEROUS TO LIFE. USE CAUTION DURING INSTALLATION, OPERATION AND MAINTENANCE. ADHERE STRICTLY TO THE GROUNDING PROCEDURE GIVEN IN THESE INSTRUCTIONS.

Power Requirements

The Model 921-0015 control unit will operate from a single phase 115-volt or 230-volt, 50- or 60-cycle power source. The control unit leaves the factory connected for 115-volt operation.

FOR PERSONNEL SAFETY IT IS ABSOLUTELY NECESSARY THAT THE GROUND PIN OF THE INPUT POWER PLUG BE CONNECTED TO EARTH GROUND THROUGH THE MATING FEMALE POWER LINE RECEPTACLE.

Voltage Changeover

If an operating voltage change is desired, proceed as follows:

1. Disconnect the unit from the power source. Wait 30 seconds for the capacitors to discharge.

2. Remove the four screws in the rubber feet on the bottom of the case and remove the chassis assembly from the case.

3. Discharge all capacitors completely by shorting their terminals.

4. Locate terminal board TB101, on the side opposite the transformer, with terminals numbered 1 through 4.

5. For 115-volt operation - On TB101, connect jumper strap E101 between terminals 1 and 2 and jumper strap E102

between terminals 3 and 4. Use P101 plug on power cord or use A101 Power Cord Set for 115 volts.

6. For 230-volt operation - On TB101, connect both jumper straps E101 and E102 between terminals 2 and 3. Use P102 Plug on power cord or use A102 Power Cord Set for 230 volts. Replace the terminal screws in terminals 1 and 4.

7. Place the chassis assembly in the case and replace the four screws in the rubber feet on the bottom of the case.

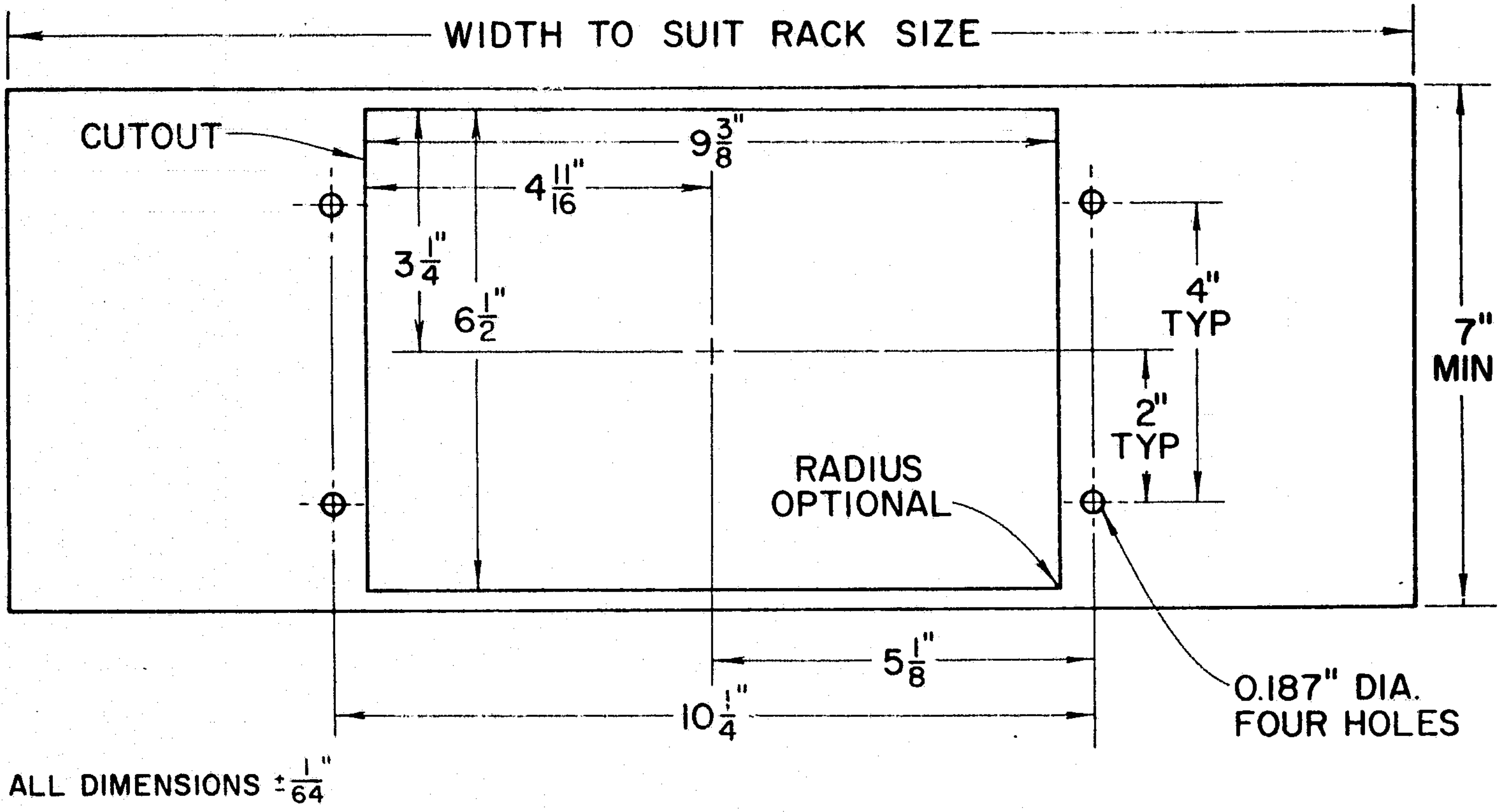
8. Install the proper fuse for the voltage being used.

Location

The control unit should be positioned to accommodate the high voltage cable length of the VacIon Pump it is to operate. The normal cable length is 8 feet for the 0.15 ℓ/s and 0.2 ℓ/s pumps and 14 feet for larger pumps. However, distances up to 50 feet are practical if additional leakage current can be tolerated. The control unit should be kept away from ventilation outlets which are contaminated with dust or corrosive and conductive agents. Extremely humid locations should be avoided. The ambient operating temperature range is 32° F to 105° F.

Panel Mounting

For panel mounting, the diagram on page 10 of a cutout and bolt hole pattern can be used. To panel mount the control unit, remove the chassis from the case by removing the four screws in the rubber feet on the bottom of the case. Remove the four screws and nuts which hold the front panel to the chassis. Place the chassis and front panel behind the mounting panel and attach with four screws and nuts through the mounting panel, control unit front panel and chassis.



MOUNTING PANEL LAYOUT FOR MODEL NO. 921-0015 CONTROL UNIT

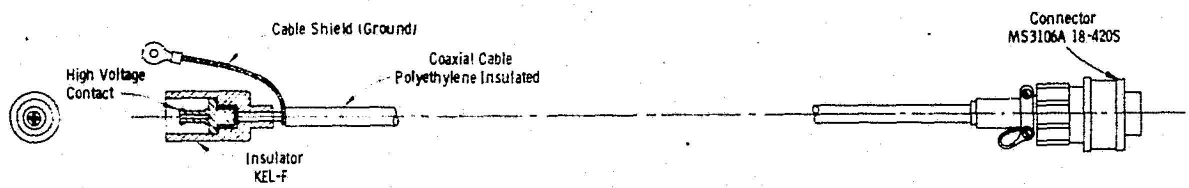
V. CONNECTION TO THE VacIon PUMP

A VacIon Pump is connected to the control unit high voltage outlet by one of three different types of coaxial high voltage cable assemblies, depending on the pump size. The cable assemblies shown in the accompaning figures must be ordered separately. The cable assemblies are identical except for the connector on the VacIon Pump end. The insulated center conductor furnishes the positive high voltage to the VacIon Pump. The braided outer shield conductor is the negative electrical connection to the VacIon Pump and is also the ground lead from the pump case. For all the cable assemblies, connection to the HIGH VOLTAGE receptacle on the rear of the control unit is made with an MS (Military Specification MIL-C-5015) type connector.

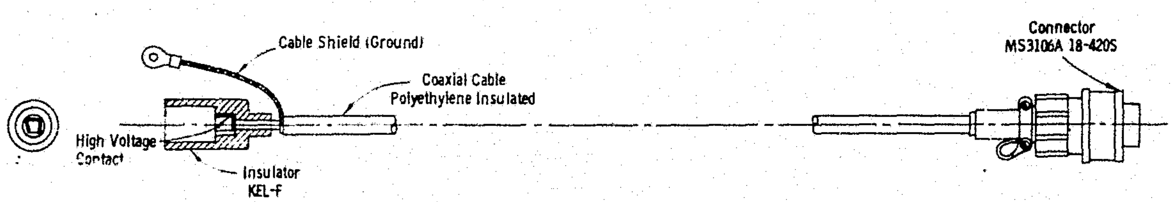
REAR VIEW OF MODEL 921-0015 CONTROL UNIT

0.15 L/S and 0.2 L/S VacIon Pumps

The cable assemblies for 0.15 ℓ/s and 0.2 ℓ/s VacIon Pumps have a miniature size (9/16-inch OD) high voltage connector which mates with the pump. Although the two connectors are identical in external appearance, they are not interchangeable due to different internal contacts. The plastic connector is molded onto the contacts and center conductor of the coaxial cable. The outer shield of the coaxial cable is brought out of the cable near the connector and is provided with a terminal lug.



MINIATURE SIZE HIGH VOLTAGE CONNECTOR WITH 8' CABLE
FOR 0.15 ℓ/S VacIon PUMPS - MODEL NO. 924-0020



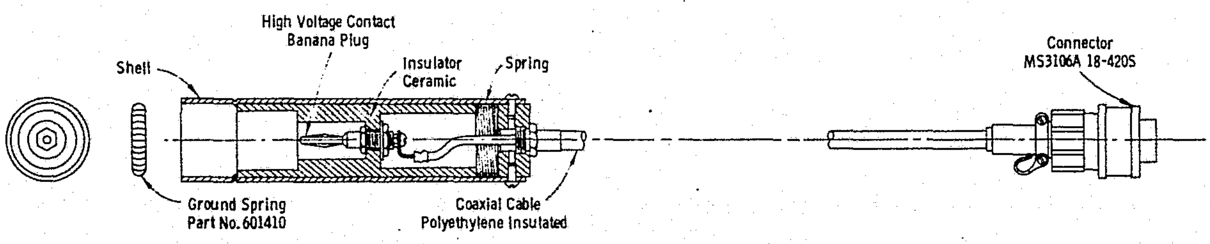
MINIATURE SIZE HIGH VOLTAGE CONNECTOR WITH 8' CABLE
FOR 0.2 ℓ/S VacIon PUMPS - MODEL NO. 924-0021

To install a miniature size high voltage connector on a VacIon Pump:

1. Place the plastic connector on the pump high voltage insulator and push into place.
2. Attach the shield lead to the pump body under a magnet mounting bolt head. Be sure good mechanical and electrical contact is made.
3. Attach the braided ground lead from the control unit to the pump body.

1.0 L/S and Larger VacIon Pumps

The cable assemblies for 1.0 ℓ/s and larger VacIon Pumps have a standard size (1-inch OD) high voltage connector which mates with the pumps. The center conductor of the coaxial cable is connected to a banana plug inside the connector housing. The outer shield of the coaxial cable is internally attached to the connector housing. This arrangement necessitates the use of a ground spring for contact between the connector housing and the base of the pump high voltage insulator.



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STANDARD SIZE HIGH VOLTAGE CONNECTOR WITH 14' CABLE FOR 1.0 ℓ/S AND LARGER VacIon PUMPS - MODEL NO. 924-0022

To install a standard size high voltage connector on a VacIon Pump:

1. Place the ground spring in the recess on the pump high voltage insulator.
2. Place the connector on the pump high voltage insulator and with a quarter turn rotary motion push the connector as far as it will go. Make certain that the ground spring is not displaced.
3. Attach the braided ground lead from the control unit to the pump body.

<u>Grounding</u>

It is extremely important that the ground spring be employed and properly installed. The ground return for the high voltage circuit is completed through this spring. As a safeguard against possible malfunction of the ground spring or a broken ground connection, an auxiliary ground lead is placed between the control unit and the VacIon Pump. This lead is the uninsulated braided cable which leaves the rear of the control unit chassis through the rubber grommet. It is connected to the power line ground inside the control unit.

VI. OPERATION

The 921-0015 control unit starts and operates VacIon Pumps which have pumping speeds up to and including 8.0 ℓ/s. However, at high pressures this control unit does not have sufficient power to maintain the rated pumping speeds of pumps larger than 1.0 ℓ/s. VacIon Pumps larger than 8.0 ℓ/s which require the same operating voltage can be operated at low pressures with this control unit. Larger pumps require special considerations which are discussed later in this section under "Control Unit Capability."

Controls

ON/OFF Toggle Switch - This is the main power switch. When turned ON the indicator light will glow. High voltage is then immediately available at the HIGH VOLTAGE outlet on the rear of the chassis. No warm-up period is required.

METER RANGE Selector Switch - This switch is used to select any of five current ranges, or voltage, for display on the meter. The current and voltage indicated are for the output of the control unit.

Operating Instructions

Before operating the control unit, all steps in Sections IV and V should be completed. Particular attention should be given to the grounding procedure.

1. Connect the power cord to the power source receptacle.
2. Place the main power toggle switch in the ON position. (For details of VacIon Pump starting and operating characteristics, consult the appropriate VacIon Pump instruction manual.)
3. To monitor the control unit output voltage, place the METER RANGE switch in the 5-KV position.

4. To monitor the VacIon Pump current, place the METER RANGE switch in an appropriate current range so that the meter indication can be read.

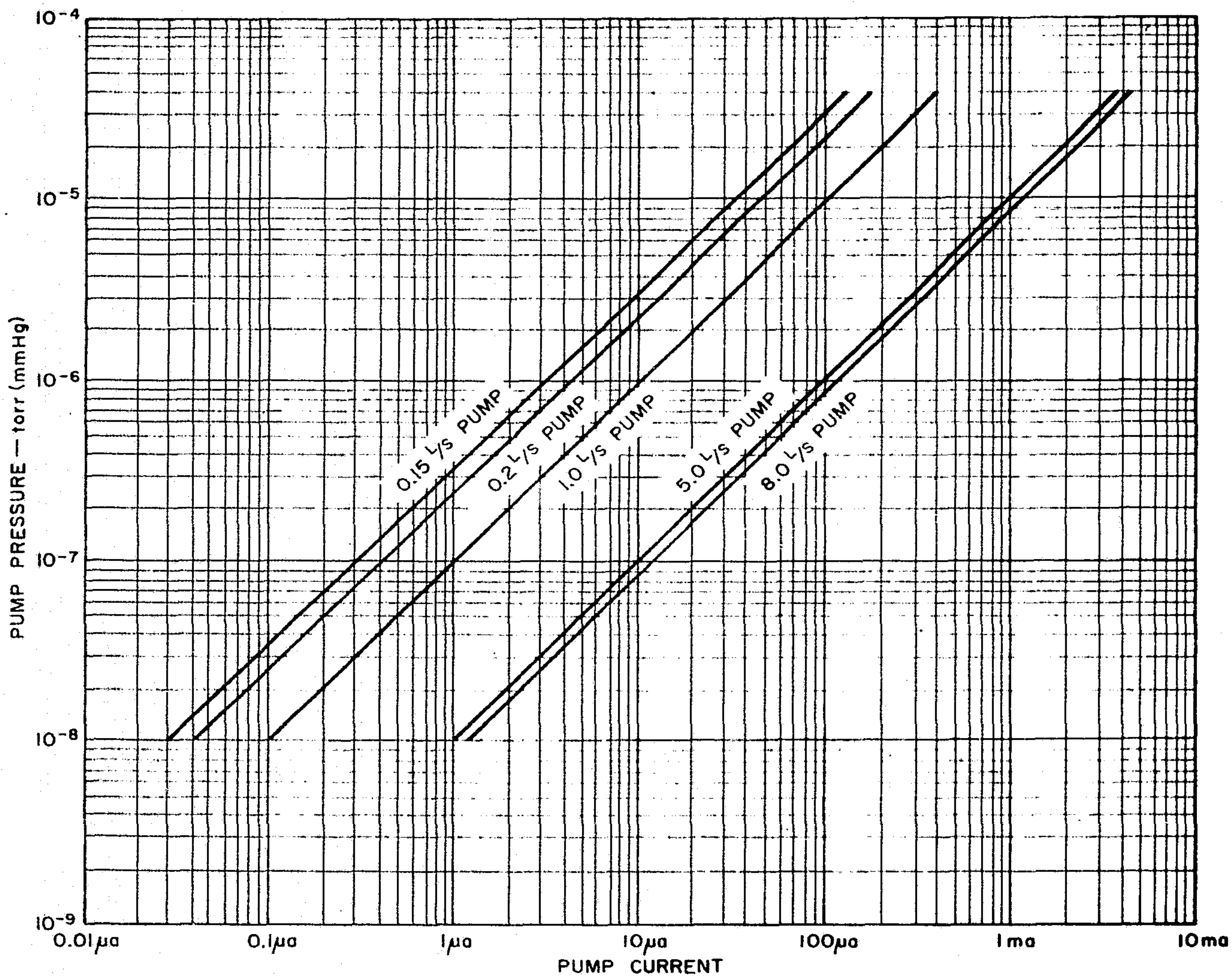
Pressure Determination

Pressure at the inlet flange of a VacIon Pump is proportional to the current drawn by the pump. The Current vs Pressure curve for each pump normally operated by this control unit is shown on page 17. To determine the pressure at the inlet flange of the VacIon Pump, read the current displayed on the control unit meter and find the corresponding pressure value from the curve for the particular pump. The accuracy obtained is comparable to that of a good ionization gauge.

The pressure in a VacIon Pump is proportional to the ion current flowing in the pump. An additional current flow due to electrical leakage or field emission can occur and will result in pressure determinations which are high. Electrical leakage currents often associated with high voltage circuits can be caused by the accumulation of dirt, moisture or insulation degradation. Field emission currents are associated with the build-up of minute sharp points within a VacIon Pump. These currents are only of concern where it affects the accuracy of pressure determination. For evaluation of electrical leakage and field emission currents, see page 33.

Use of a Recorder

The control unit has recorder output connections to provide a continuous permanent record of VacIon Pump current. Two standard banana jacks to accommodate a dual banana plug (General Radio No. 274-MB) are mounted on the rear of the chassis on 3/4-inch centers. The black jack is grounded to the control unit chassis. The voltage on the red jack varies from 0 to negative 100 millivolts with respect to the grounded black jack. The negative 100 millivolts correspond to full scale meter deflection for all current ranges. The maximum impedance looking into the recorder jacks is 20 kilohms. It is recommended that the input impedance of the recorder be



CURRENT VS PRESSURE
(Pressure Indication Over This Range is Comparable to That
of Good Ionization Gauges)

at least 100 kilohms. Varian recorders G-10, G-11A, G-14, or dual channel G-22A are compatible with this control unit.

Control Unit Capability

From the Electrical Characteristics curves on page 7, it can be seen that the power output of the control unit reaches a maximum value when the current demand is 15 milliamperes. The throughput of the VacIon Pump (Q, in torr-liters/second*) will also be a maximum when the power output of the control unit is highest. At this point an increase in pressure in the pump will cause the current to increase, but the power will decrease. Therefore, the throughput of the pump will decrease when the pump pressure rises above the maximum power point of the control unit.

The practical requirement for operating pumps larger than 1.0 ℓ/s up to and including 8.0 ℓ/s is that the current demand on the control unit should not exceed 15 mA when a gas evolving process is at its maximum. That is, a pump can handle a gas load which results in a pressure corresponding to a current demand of 15 mA on the Current vs Pressure curve. For example, an 8.0 ℓ/s VacIon Pump draws 15 mA at a pressure of 1.2×10^{-4} torr. If gas evolution forces the pressure higher, the gas evolving process must be slowed down or stopped until the pump brings the pressure down again.

VacIon Pumps larger than 8.0 ℓ/s which require approximately 3000 volts can be operated satisfactorily at low pressures with this control unit. However, it is usually desirable to start the pump with its appropriate control unit. These larger pumps should only be expected to pump gas loads that result in pump pressures that correspond to a current demand which lies to the left of the 15 mA line on its Current vs Pressure curve. For example, to operate a 40 ℓ/s VacIon Pump, the pressure should remain less than about 2.5×10^{-5} torr.

----

* Q is defined as throughput in pressure-volume units, per unit time. Example: At 2×10^{-6} torr and with a pumping speed of 8 liters/second, $Q = 2 \times 10^{-6}$ torr x 8 liters/second = 1.6×10^{-5} torr-ℓ/s.

VII. CIRCUIT DESCRIPTION

Power Supply Circuit

The power supply circuit of Model 921-0015 control unit consists of a transformer and a half-wave voltage doubler circuit to provide d-c power for the VacIon Pump. Refer to the accompanying schematic diagram. Line power is supplied to the dual voltage primary of transformer T101 by a three-conductor power cord from Plug P101. The black and the white insulated conductors in the cord are for power, and the green conductor is for grounding. The power to the transformer primary is controlled by the ON/OFF toggle switch S101. Fuse F101 is a one-ampere slo-blo fuse which provides overload protection. For 115-volt operation the primary coils of the transformer are connected in parallel and for 230-volt operation the primaries are connected in series. For voltage changeover procedure see page 8.

The half-wave voltage doubler circuit consists of capacitors C102, C103, C104, and diodes CR101 through CR114. The transformer secondary voltage is 1250 volts at no load. The voltage doubler circuit provides a positive 3500 volts dc ± 10% with respect to chassis ground at high voltage outlet J101 when no load is applied. The voltage doubler circuit will supply a short circuit current of 43 milliamperes ± 10%. When operated from a 50-Hz power source the open circuit voltage and short circuit current values will be slightly lower than those given above for 60-Hz operation. However, a VacIon Pump will operate equally well from this control unit when it is powered from a 50-Hz source. Specific values for 50-Hz operation are given on page 4.

The secondary voltage of the transformer is established by the open circuit d-c voltage requirement. The short circuit current value is mainly determined by the reactance of C102. A low ripple d-c output voltage at low current is obtained by the filtering action of C103 and C104. Resistor R106 is used to limit the peak surge currents that C103 and C104 can supply when a heavy load is suddenly placed on the control unit. The peak current values are then low enough to be conducted safely by the meter diode CR115. Resistors R105, R107, R108, R109 and R110 form the power supply bleeder to discharge C102, C103 and C104 within 30 seconds after the main power switch S101 is opened. These resistors are also used to divide the d-c output voltage equally across C103 and C104 to assure that their rated working voltage is not exceeded.

Meter Circuit

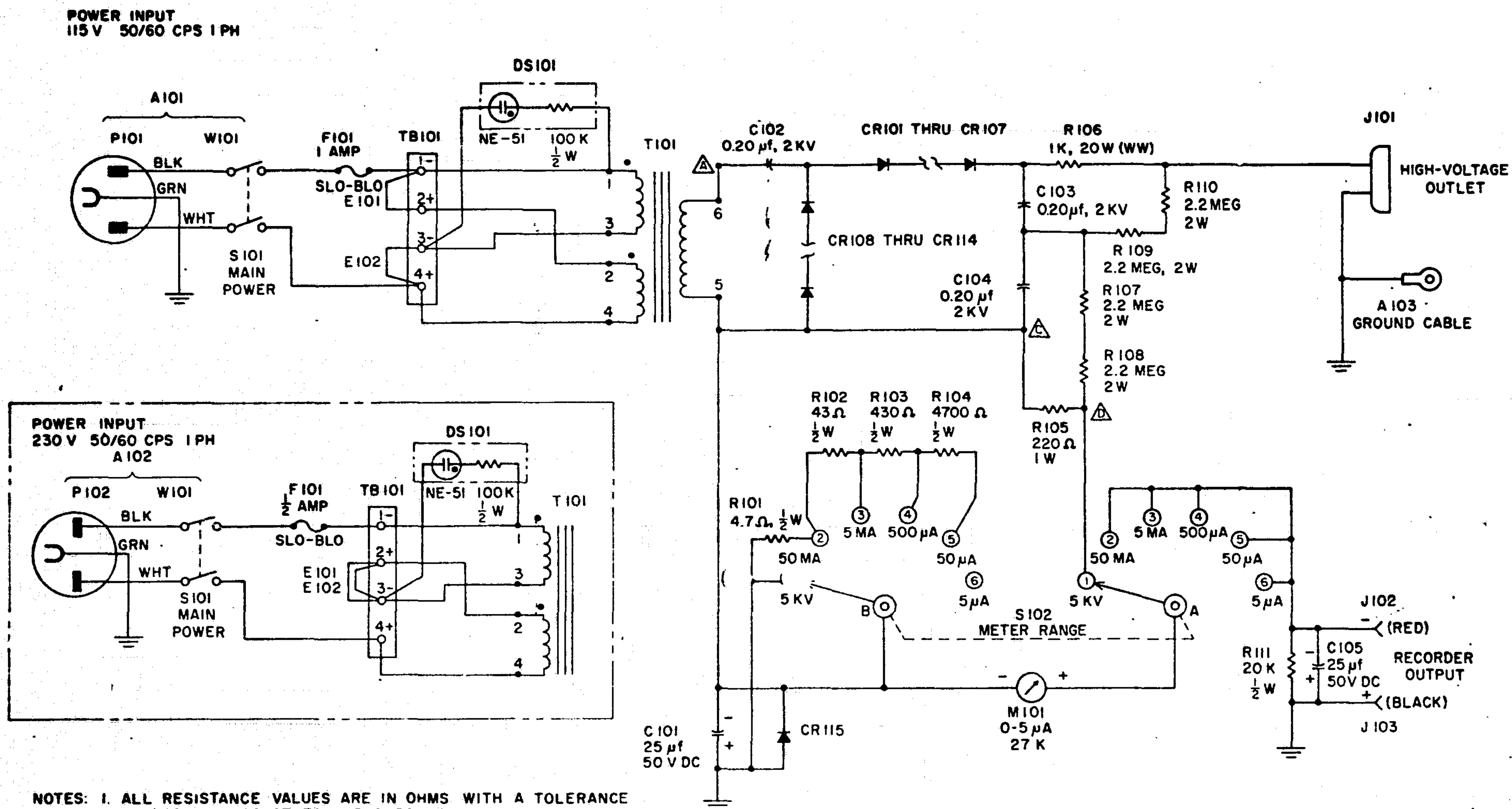
The control unit meter M101 has a five-microampere full-scale movement. Currents from 0.05 microampere to 50 milliamperes can be read. The METER RANGE selector switch S102 is used to select the proper shunt resistors R101 through R104 so that the current can be displaced in decade increments on the meter. For safety, all current and voltage measurements are made in circuits with voltages less than one volt from chassis ground.

The current to the VacIon Pump is metered between the negative terminal of the power supply and its connection to ground. Filter capacitor C101 and meter-protect diode CR115 are connected in parallel with M101 for all current ranges. C101 minimizes the a-c ripple and current surges that are applied to M101. The exponential voltage versus current characteristic of CR115 is used to prevent excessive currents in M101. CR115 has less than 0.1-microampere forward current at 250 millivolts and less than 1 volt across it at 3/4-ampere forward current. During normal operation, CR115 has 235 millivolts across it for full-scale meter deflection and its forward current is negligible in any current range. Any surge current up to 3/4-ampere will produce less than one volt across the parallel combination of CR115, C101, and M101 in series with R111, because CR115 goes into heavy conduction. With one volt across the series combination of M101 and R111, the total current is limited to 4.25 times full-scale deflection current. During normal operation the current through M101 will not exceed three times full-scale even if it is on the five-microampere range and there is a short circuit current of 43 milliamperes.

The voltage applied to the VacIon Pump is indicated on M101 when the METER RANGE switch S102 is in the 5-KV position. M101 is then connected in parallel with R105 by S102. For a 3500-volt output, the voltage across M101 and R105 will be 94.5 millivolts.

Recorder Circuit

A permanent record of VacIon Pump current can be made by connecting a recorder to jacks J102 and J103. J102 is red and varies linearly from 0 to negative 100 millivolts with respect to ground for a zero to full-scale meter deflection in any current range. J103 is black and is grounded to the chassis. Then a full-scale current of five microamperes flows through M101 and R111 which are in series, negative 100 millivolts is developed across R111 in each current range. C105 is connected across R111 to reduce the a-c ripple and noise at the recorder jacks. The maximum impedance looking into the recorder jacks is 20 kilohms. The input impedance of the recorder should be at least 100 kilohms to minimize errors due to its shunting effect on R111.



NOTES: 1. ALL RESISTANCE VALUES ARE IN OHMS WITH A TOLERANCE OF ±5% UNLESS OTHERWISE SPECIFIED.

2. DIODE ORIENTATION BLACK → BLUE (CATHODE)

3. SWITCH S102 IS SHOWN IN CCW POSITION WHEN VIEWED FROM PANEL FRONT. THE "A" WAFER IS NEAREST THE FRONT PANEL.

4. SYMBOL ⓧ CORRESPONDS TO CONTACT NUMBERS ON SWITCHES

5. SYMBOL △ CORRESPONDS TO LETTERS ON PRINTED CIRCUIT BOARD

Continuous product improvement may render the schematic diagram in this instruction manual obsolete. To facilitate maintenance, the schematic diagram and printed circuit board component layout which were used during manufacturing of this control unit are included with the unit.

SCHEMATIC DIAGRAM
VacIon® VACUUM PUMP CONTROL UNIT
MODEL № 921-0015

VIII. MAINTENANCE

This section describes routine maintenance such as cleaning, trouble shooting, meter tests and electrical leakage determination. If service is necessary, contact the nearest Varian Associates Vacuum Products District Office.

Continuous product improvement may render the schematic diagram in this instruction manual obsolete. To facilitate maintenance the schematic diagram, printed circuit board assembly and parts list which were used during manufacturing are included with the control unit.

> WARNING
>
> THE VOLTAGES DEVELOPED IN THIS CONTROL UNIT ARE DANGEROUS TO LIFE. UNPLUG THE CONTROL UNIT AND WAIT 30 SECONDS BEFORE REMOVING THE CHASSIS FROM THE CASE. SHORT ALL CAPACITORS AND MAKE ALL TESTS WITH AN OHMMETER UNLESS DIRECTED OTHERWISE.

Cleaning

More than a normal amount of dust particles can be collected on the high voltage components of the control unit because of electrostatic precipitation. The dust particles can adsorb vapors from the air which will cause electrical leakage and arc-over. To prevent this, it is necessary to keep all the high voltage components clean. Periodic routine dusting or vacuuming is recommended.

Trouble Shooting

Refer to schematic diagram for circuit layout.

	SYMPTOM	POSSIBLE CAUSE	REMEDY
1.	DS101 won't light when S101 is ON and P101 is plugged into power source.	F101 is blown.	Replace.
		No source power.	Check power fuse or circuit breaker.
		DS101 defective.	Replace.
		S101 defective.	Replace.
		Open in power cord.	Repair or replace.
		Open in wiring between S101 and T101.	Repair.
		E102 loose on TB101.	Tighten screws.
2.	F101 blows repeatedly.	T101 primary or secondary windings shorted or shorted to each other and/or to chassis.	Confirm with ohmmeter and replace.
		T101 primaries phased incorrectly.	Check connections and phasing against schematic and wire correctly.
		Shorted or grounded wiring between F101 and T101.	Repair or replace.
		C102 shorted or grounded to chassis.	Replace.
		High voltage wire from T101 to C102 grounded.	Replace.
3.	Power source circuit breaker opens or fuse blows, but F101 doesn't blow.	Short or ground in P101, power cord, S101, or wire to F101.	Confirm with ohmmeter and repair or replace.
		Replacement line power plug wired incorrectly.	Confirm with ohmmeter and correct.
		Wire between terminal 4 of T101 and P101 grounded and "hot" side of power source connected to "low" terminal of source receptacle or power extension cord.	Check T101 terminal 4 for ground and rewire receptacle or power extension cord.

SYMPTOM	POSSIBLE CAUSE	REMEDY
4. T101 overheats on 115 or 230 Vac while furnishing short circuit current, but F101 doesn't blow.	One primary winding open.	Confirm with ohmmeter and replace.
	E101 or E102 loose on TB101.	Tighten screws.
	Open wiring between TB101 and T101.	Repair or replace.
	T101 windings partially shorted.	Replace.
5. DS101 lights, but M101 indicates zero voltage and current when high voltage cable is connected to J101 but not to VacIon Pump.	C102 open.	Replace.
	T101 primary or secondary windings open.	Confirm with ohmmeter and replace.
	CR101 through CR107 open.	Replace. Page 32.
	CR108 through CR114 shorted.	Replace. Page 32.
	M101 open or shorted.	Repair or replace. Refer to Meter Tests, Page 29.
	High voltage cable shorted and CR115 or C101 shorted.	Repair or replace. (Disconnect M101 before testing.)
	R106 open.	Replace.
	R107 through R110 open.	Replace.
	R105 shorted.	Replace.
6. DS101 lights and M101 indicates 3.5 kv but no current on any range.	VacIon Pump is at a very low pressure corresponding to less than 0.1 microampere. This is a satisfactory condition indicating high vacuum in pump.	To confirm, turn S101 OFF and allow pressure to rise. After several minutes turn S101 ON and note current decreased.
	VacIon Pump at high or atmospheric pressure.	Check pump pressure and rough pump system to 10 microns or lower.

SYMPTOM	POSSIBLE CAUSE	REMEDY
	CR115 shorted.	Replace. (Disconnect M101 before testing.)
	C101 shorted.	Replace. (Disconnect M101 before testing.)
	R111 open.	Replace.
	Open contacts on S102A.	Replace.
	Open circuit in high voltage cable.	Repair or replace.
7. M101 gives a voltage and current indication, but one or both are suspected of being wrong.	Confirm by comparing M101 voltage and current readings to Voltage vs Current curve. The difference between two corresponding values of current or voltage should not exceed the average value of the two readings by more than 20 per cent.	Test M101 per Meter Tests, Page 29. Repair or replace.
	Excessive leakage current in high voltage circuit, connector, cable or VacIon Pump.	Test for electrical leakage, Page 32, and clean or replace.
8. M101 reads short circuit current but zero volts (M101 should read several hundred volts during normal starting condition.)	Short in VacIon Pump.	Remove connector from pump. M101 should read open circuit voltage and zero current. Test pump with ohmmeter.
	Short in high voltage cable.	Remove cable from control unit. M101 should read open circuit voltage and zero current. Test cable through to pump with ohmmeter.
	J101 or connecting lead grounded.	Replace.
	C103 grounded to chassis.	Replace.

	SYMPTOM	POSSIBLE CAUSE	REMEDY
9.	M101 indicates zero voltage but correctly on all current ranges.	C104 shorted.	Replace.
		R107 through R110 open.	Replace.
		R105 shorted.	Replace.
		S102A(1) open.	Replace.
10.	M101 indicates low voltage but correctly on all current ranges.	R107 through R110 increased in resistance.	Replace as required.
		R105 decreased in resistance.	Replace.
		C103 leaky.	Replace.
		Source voltage high.	Check. Not probable if short circuit current is correct.
11.	M101 indicates off scale or higher than rated voltage but correctly on all current ranges.	R107 through R110 decreased in resistance.	Replace as required.
		R105 increased in resistance.	Replace.
		C103 shorted or leaky.	Replace.
		Source voltage high.	Check. Not probable if short circuit current is correct.
12.	M101 indicates voltage correctly but all current ranges are high. Recorder output low or zero.	R111 decreased in resistance.	Replace.
		C105 shorted or leaky.	Replace.
13.	M101 indicates voltage correctly but all current ranges are low. Recorder output low.	C101 leaky.	Replace.
		CR115 changed characteristics.	Replace.

SYMPTOM	POSSIBLE CAUSE	REMEDY
14. M101 indicates voltage correctly but all current ranges except 5-microampere range are incorrect.	R101 through R104 incorrect resistance.	Replace as required.
	S102B has high resistance contacts.	Replace
15. M101 indicates incorrectly on all current and voltage ranges.	M101 defective. Accumulative problems.	Repair or replace.

Meter Tests

DO NOT test meter M101, or circuit to which M101 is connected, with an ordinary ohmmeter. Test current from a typical ohmmeter greatly exceeds five microamperes and M101 would be seriously damaged. Before making test connections, turn control unit OFF and unplug from power source. Remove high voltage cable. Wait 30 seconds and ground high voltage receptacle J101. Remove the lead used for grounding before tests. Tolerance on control unit voltage and current values are ± 10% of full scale.

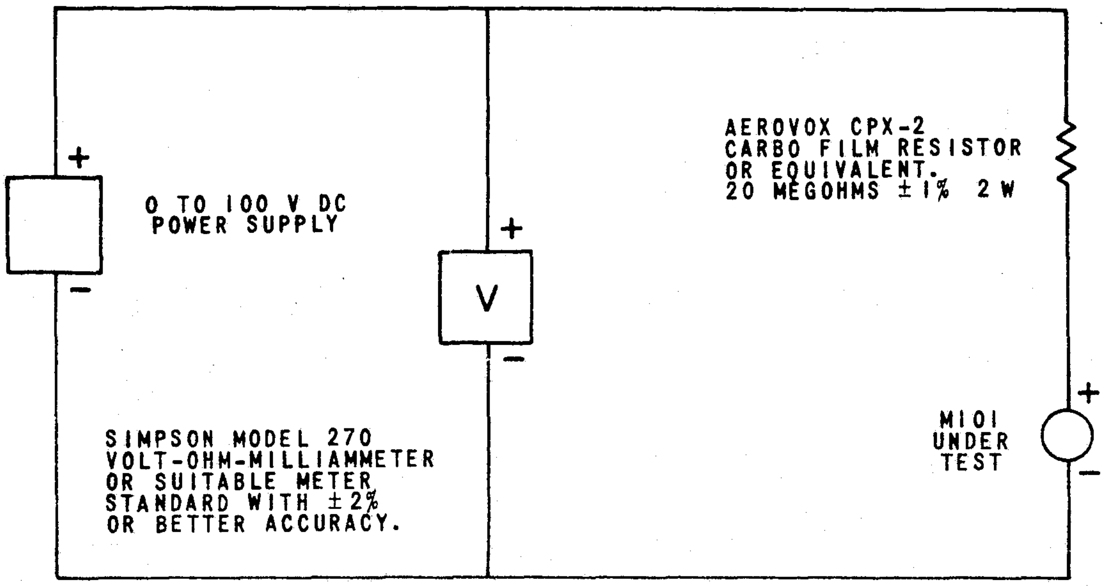
CONTROL UNIT			METER-STANDARD *	
Meter Range	Test Condition	Meter 101 Should Read	Range	Reading
	Connect meter-standard positive lead to high voltage contact of J101 and negative lead to braided ground lead. Supply input voltage from a variable transformer.			
5 kV	J101 open: 115/230-V 60/50-cps input	3.5 kV	5 kVdc	3.5 kV ± 10%
50 mA	J101 shorted: 115/230-V 60-cps input	43 mA	100 mAdc	43 mA ± 10%
	50-cps input	36 mA	100 mAdc	36 mA ± 10%

CONTROL UNIT			METER-STANDARD*	
Meter Range	Test Condition	Meter 101 Should Read	Range	Reading
5 mA	Increase input voltage from zero until meter-standard reads 5 milliampere.	5 mA	10 mAdc	5 mA
	Connect meter-standard positive lead through a 1-megohm 2-W (for the voltage rating) composition resistor to the high voltage contact of J101, and the negative lead to the braided ground lead.			
500 μA	Increase input voltage until meter-standard reads 500 microampere.	500 μA	1 mAdc	0.5 mA
	Same procedure as above except use a 10-megohm 2-W composition resistor.			
50 μA	Increase input voltage until meter-standard reads 50 microamps.	50 μA	50 μA	50 μA
	Same procedure as for 500-microampere range except use five 20-megohm 1-W composition resistors in series.			
5 μA	Increase input voltage until meter-standard reads 5 microampere.	5 μA	50 μA	5 μA

*Simpson Model 270 recommended or a voltmeter with 20,000 ohms per volt d-c sensitivity is suitable.

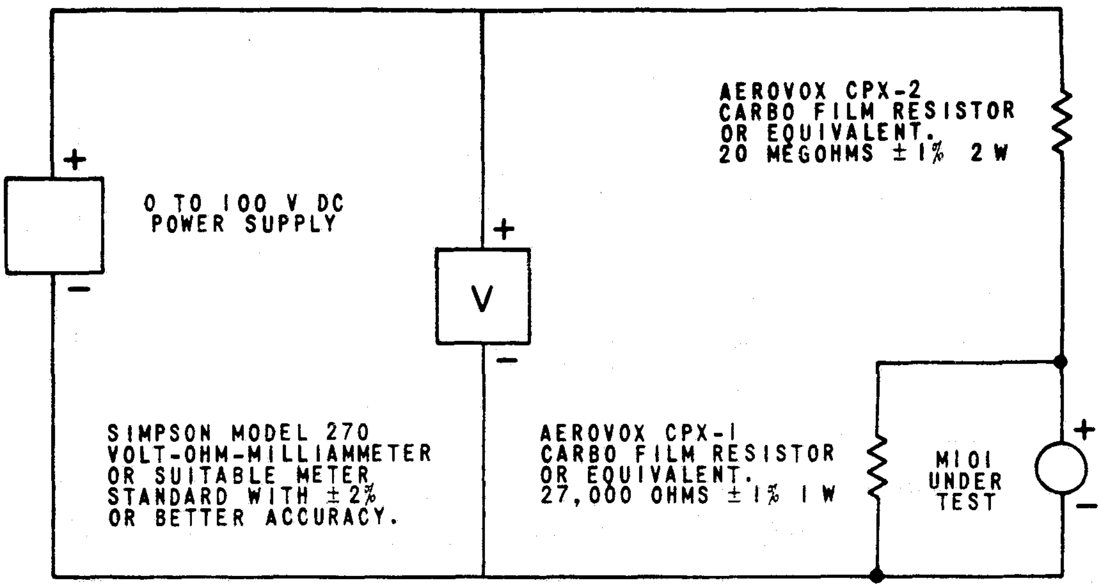
Meter Movement Tests - The meter has a full-scale deflection current of five microamperes ± 2% and a terminal resistance of 27,000 ohms ± 1%. These tolerances can be determined only if tests on M101 are made with laboratory equipment and at 25°C ± 10°C. A satisfactory practical test without the aid of laboratory equipment can be made as follows.

To check full-scale deflection current, connect M101 as shown below. Make all connections with the d-c power supply OFF. Starting at zero, adjust the d-c power supply for 100 volts on the meter-standard. At 77° F, M101 should read five micro-amperes ± 5%.



METER FULL SCALE DEFLECTION CURRENT TEST

To check the terminal resistance, connect M101 as shown below. Make all connections with the d-c power supply OFF. Starting at zero, adjust the d-c power supply for 100 volts on the meter-standard. At 77° F, M101 should indicate on the meter between 2.3 and 2.7 with a nominal half-scale reading of 2.5 when the terminal resistance is 27,000 ohms. If M101 reads above half-scale, the terminal resistance is below 27,000 ohms and vice versa. Do not remove the meter-standard during the above tests.



METER TERMINAL RESISTANCE TEST

Diode Tests

Meter Protection Diode Test - In order for CR115 to function properly, it must have a forward current of less than 0.1 microampere at 250 millivolts across the junction. The forward voltage drop should be less than one volt at 750 milliamperes and 77° F. If CR115 is suspected of excessive conduction and adequate test equipment is not available, it may be simply checked by performing the meter test for five-microampere current indication. If CR115 is conducting excessively, M101 will read appreciably lower than the meter-standard. The effect of CR115 conducting excessively is less pronounced in the higher current ranges. CR115 should have a forward resistance of about 7 ohms when tested with a Simpson Model 270 Volt-Ohm-Milliammeter. Other ohmmeters can give a different resistance because of different test currents.

Rectifier Diode Test - When measured with a Simpson Model 270 Volt-Ohm-Milliammeter, the diodes CR101 through CR114 should have a forward resistance of about 7 ohms and a backward resistance of infinity (60 megohms). The forward resistance may differ when measured with other ohmmeters because of different test currents. At 77° F, a good diode should have a reverse current of less than 10 microamps at 600 Vdc. The forward voltage drop should be less than 1.2 volts at 3/4 ampere.

Electrical Leakage and Field Emission

When electrical leakage and field emission currents are suspected, this evaluation can be made. The VacIon Pump pressure should be below approximately 1×10^{-6} torr. Turn the control unit OFF and remove the magnet from the pump. With the magnetic field removed, no pumping action will occur. Turn the control unit ON. The current indicated will be the accumulated leakage and field emission currents of the control unit, high voltage cable and VacIon Pump. Normally, the current for this combination should not exceed 0.3 microampere.

If the electrical leakage and field emission current is considered significant, its value can be subtracted from the indicated pump current (with the magnet in place on the pump) to obtain the pump ion current for pressure determination. However, this approach will yield only a close approximation of the actual ion current in the pump, because the field emission current value can change when the magnetic field is removed from the pump.

If the undesirable current is excessive and it is considered necessary to reduce it, these steps will locate the source of the current. Turn the control unit OFF and remove the high voltage cable assembly from the control unit. Turn the control unit ON and observe the current. Normally, the indicated current should be no greater than 0.2 microampere for the control unit alone. If the leakage current for the control unit is normal, any undesirable current flow is in the high voltage cable and/or the VacIon Pump. If this is the case, turn the control unit OFF, connect the high voltage cable to the control unit and remove the high voltage connector from the VacIon Pump. Turn the control unit ON and observe the current. If the current indication is higher than the previous reading, the difference is the current in the high voltage cable. If the current indication is the same as in the previous test or less than in the original test, the excessive current is in the VacIon Pump.

If excessive leakage current is found in the control unit, the leakage to ground from C102, C103, C104, J101, T101 and the associated wiring and terminal boards can be eliminated by cleaning or replacement. Turn the control unit OFF and remove from the power source. Remove the chassis from the case by removing the four screws in the rubber feet. Discharge all capacitors. Unsolder all leads to the printed circuit board. Use care not to loosen the printed circuitry from the circuit board. Remove the leads from the high voltage connector J101 and remove the connector. Remove the six screws holding C102, C103 and C104 to the rear of the chassis and lift out the printed circuit board and C102, C103 and C104.

Wash the printed circuit board and capacitor insulators with acetone. Take care to keep the solvent off of the paint on the capacitors. Thoroughly dry the circuit board in air or bake in an oven at 150° F for two hours.

Disassemble and wash the connector with methol alchohol. Bake the phenolic parts at 250°F for two hours. Do not blow on these parts with an air hose, because most air lines contain oil vapor, water vapor and other contaminants. Do not contaminate the clean high voltage components by touching them with bare fingers. Install and connect the cleaned components; test for leakage current.

If the undesirable current is determined to be in the high voltage cable or VacIon Pump, consult their respective instruction manuals for corrective procedure.

IX. PARTS LIST

Model 921-0015 VacIon Pump Control Unit

Final Assembly No. 606285

Schematic Diagram No. 606281

SYMBOL NO.	DESCRIPTION	MFG. AND CATALOG NO.	VARIAN PART NO.
A101	Power Cord Set for 115 V, 6 ft. No. 18-3, Type SJ cord. 125 V, 15A, 3 contact molded plug.	Varian Associates	611635
A102	Power Cord Set for 230 V, 8 ft. No. 18-3, Type SJ cord. 250 V, 15A, 3 contact molded plug.	Varian Associates	608797
A103	Braided Ground Cable Assembly, 10 ft.	Varian Associates	607238
A107	Switch Assembly. Complete with C101, CR115, R101 thru R104, R111, and S102.	Varian Associates	606287
A108	Printed Circuit Board Assembly, PC101, complete with CR101 thru CR114 and R105 thru R110.	Varian Associates	606277
C101 and C105	Capacitor, Electrolytic. 25 uf, 50 WVdc.	Sangamo Electric Co., MT-0525	41-507-798
C102 thru C104	Capacitor, Oil filled. 0.20 uf $\pm$ 10%, 2000 WVdc.	Industrial Cond. Corp., No. 2678	41-499-892
CR101 thru CR114	Crystal Diode, Silicon. 600 piv, 750 mA.	Diodes Inc., DI-56	66-396-950
CR115	Crystal Diode, Silicon. 600 piv, 750 mA, Special Test.	Varian Associates	606463
DS101	Lamp, Neon Glow.	General Electric, NE-51	67-449-999
E101 and E102	Jumper Strap for TB101	Kulka, 601-J	56-999-981

PARTS LIST (Cont'd.)

SYMBOL NO.	DESCRIPTION	MFG. AND CATALOG NO.	VARIAN PART NO.
F101	Fuse, 1A, 125V, Slo-blo.	Bussman Mfg. Co. Type MDL	67-136-410
	Fuse, 1/2 A, 250 V, Slo-blo.	1/4" dia. x 1-1/4" long.	67-135-410
H101	Knob, Meter Range Switch	Raytheon Company, 90-5-2	23-509-980
J101	Connector, High Voltage Chassis receptacle.	Amphenol, MS-3102-A-18-420P	52-999-950
J102	Connector, Banana Jack, Red.	E. F. Johnson, 108-902	51-451-982
J103	Connector, Banana Jack, Black.	E. F. Johnson, 108-903	51-451-983
M101	Meter, 0-5 Microamp DC ± 2%. Special scale.	Varian Associates	606269
P101	Plug, Male, 3 contact. U. S. Standard 15A, 125V with "U" ground.	Hubble, No. 5266	51-133-991
P102	Plug, Male, 3 contact. U. S. Standard 15A, 250V with "U" ground.	Hubble, No. 5664	51-133-983
PC101	Printed Circuit Board	Varian Associates	606058
R101	Resistor, Fixed Composition. 4.7 ohms, 1/2 W, 5%.	Allen-Bradley, EB47G5	32-201-147
R102	Resistor, Fixed Composition. 43 ohms, 1/2 W, 5%.	Allen-Bradley, EB4305	32-201-243
R103	Resistor, Fixed Composition. 430 ohms, 1/2 W, 5%.	Allen-Bradley, EB4315	32-201-343
R104	Resistor, Fixed Composition. 4700 ohms, 1/2 W, 5%.	Allen-Bradley, EB4725	32-201-447

PARTS LIST (Cont'd.)

SYMBOL NO.	DESCRIPTION	MFG. AND CATALOG NO.	VARIAN PART NO.
R105	Resistor, Fixed Composition. 220 ohms, 1 W, 5%.	Allen-Bradley, GB2215	33-301-322
R106	Resistor, Fixed Wirewound. 1000 ohms, 20 W, 5%.	Ohmite Mfg. Company, 1821	35-489-410
R107 thru R110	Resistor, Fixed Composition. 2.2 megohms, 2 W, 5%.	Allen-Bradley, HB2255	34-401-722
R111	Resistor, Fixed Composition. 20,000 ohms, 1/2 W, 5%.	Allen-Bradley, EB2035	32-201-520
S101	Switch, Toggle, DPST, 6A at 125V, 3A at 250V.	Arrow-Hart and Hegeman, 81024-GB	71-139-990
S102	Switch, Rotary, 2 Section, 2 pole, 6 position, shorting.	Centralab, 1412	71-729-950
T101	Transformer, 115/230 V primary, 50/60 cps, 10 ohms per winding. Secondary: 1250 V at no load, 1150 V at 60 mA.	Varian Associates	C-617832
TB101	Terminal Board, 4 Terminal	Cinch-Jones Sales, 4-141	56-199-804
W101	Power Cord, No. 18-3, Type SJ, 7A, 300 V.	Cornish Wire Co., No. 3201	81-811-499
XDS101	Lampholder, Red Lens, with 100K, 1/2 W resistor.	E. F. Johnson, 147-1144-2	55-229-982
XF101	Fuseholder, 15A, 250 V.	Bussman Mfg. Div. HKP	55-198-999

X. WARRANTY

Products are warranted to be free from defects in material and workmanship. The liability of Varian Associates under this warranty is limited to servicing or adjusting the product and replacement of defective parts. The warranty is effective for one year after delivery of a new unit and only applies when the product becomes defective in material or workmanship through no fault of the user, as determined by Varian Associates. If defects result from misuse or abnormal operating conditions, there will be a charge for repairs. In this event, repair charges will be estimated and sent to you for authorization before work begins.

XI. SERVICE INFORMATION

To help you get the most out of your Varian vacuum equipment, we have established local service offices throughout the United States. These field service facilities, together with our complete laboratory in Palo Alto, provide prompt and thorough help whenever and wherever you need it.

Field Service

Skilled vacuum equipment Service Engineers are available in our Vacuum Products Division Field Offices to help you. We find that most field service calls are for:

1. New installation service - Engineering assistance is available during installation of vacuum systems to demonstrate proper operating techniques. No fee is charged for normal installation service.
2. Warranty - Service is provided without charge to fulfill the provisions of our warranty.
3. Special customer request - Service, repair or maintenance will be provided at your request. Service fees for this type of work are listed in the Vacuum Products Price List.

When you need assistance, please call the nearest Vacuum Products Division Field Office.

Factory Service

For warranty, maintenance or repair service which is more extensive than can be handled by a field office, the equipment should be returned prepaid to:

Varian Associates
Vacuum Division
611 Hansen Way
Palo Alto, California
Attention: Service Manager

When returning equipment, please include your purchase order number under which the equipment was purchased. This is needed before warranty repair work begins. Package equipment carefully to protect it from vibration damage during shipment.

A brief description of conditions of use and observations of unsatisfactory performance will help us to determine the cause and hasten the return or replacement of your equipment.

Exchange Service

When repairs or routine maintenance interrupt your vacuum equipment operation, we can quickly replace VacIon Pump Control Units on an exchange basis. If you return your original equipment to the factory within 30 days after receiving the exchange, only an exchange fee is incurred; thus interruptions can be minimized at a nominal cost. Equipment being returned under "exchange" agreements should be shipped in the container used to deliver the "replacement" equipment. Consult your Vacuum Division Field Office for detailed delivery and cost figures.

XII. ACCESSORIES

The following accessories are available:

DESCRIPTION	MODEL NO.
High Voltage Cable and Connector Assemblies	
for 0.15 ℓ/s VacIon Pumps	924-0020
for 0.2 ℓ/s VacIon Pumps	924-0021
for 1.0 ℓ/s and larger VacIon Pumps	924-0022
VacIon Pump Leak Detector, 60 Hz	975-0000
VacIon Pump Leak Detector, 50 Hz	975-0020
Pressure Sensitive Relay	924-0031
Ion Gauge with Kovar tubulation, UHV-12-K	971-0005
Ion Gauge with 2-3/4" OD ConFlat® Flange, UHV-12-KF	971-5005
Ion Gauge with Nonex Tubulation, UHV-12-N	971-0007
Ion Gauge with Pyrex Tubulation, UHV-12-P	971-0006
Nude Ion Gauge on 2-3/4" OD ConFlat Flange, UHV-14	971-5004
Nude Ion Gauge with double filament on 2-3/4" OD ConFlat Flange, UHV-24	971-5008
Ion Gauge Control Unit, 60 Hz	971-0003
Ion Gauge Control Unit, 50 Hz	971-0023
12' Ion Gauge Cable	971-0012
Ion Gauge Leak Detector	975-0010
Recorder, G11-A, with panel mounting case	924-0025
Recorder, G14, for bench top operation	924-0028
Recorder Chart Paper 5A (linear)	924-0017

XIII. ORDERING INFORMATION

Address orders or inquiries to the nearest Varian District Office nearest you or to Varian Associates, Vacuum Division, 611 Hansen Way, Palo Alto, California 94303. European orders should be addressed to Varian A. G., Baarerstrasse 77, Zug, Switzerland. Order all products by name and model number.

varian vacuum division district offices

BOSTON
Varian Associates
400 Wyman Street
Waltham, Massachusetts 02154
Phone: (617) 891-5750

CHICAGO
Varian Associates
Executive Plaza Office Building
205 West Touhy Avenue
Park Ridge, Illinois 60068
Phone: (312) 825-6656

CLEVELAND
Varian Associates
Suite 207
25000 Euclid Avenue
Euclid, Ohio 44117
Phone: (216) 261-2115

DALLAS
Varian Associates
First Bank and Trust Building
811 South Central Expressway
Richardson, Texas 75080
Phone: (214) 235-4586

DENVER
Varian Associates
Colorado Building, Room 403
14th and Walnut Streets
Boulder, Colorado 80302
Phone: (303) 444-0431

LOS ANGELES
Varian Associates
2901 Wilshire Boulevard
Santa Monica, California 90403
Phone: (213) 451-5731

NEW YORK
Varian Associates
2005 Route 22
Corner Fairway Drive
Union, New Jersey 07083
Phone: (201) 688-7474

PHILADELPHIA
Varian Associates
1500 North Kings Highway
Cherry Hill, New Jersey 08034
Phone: (609) 428-6110

SAN FRANCISCO
Varian Associates
4940 El Camino Real
Los Altos, California 94022
Phone: (415) 326-4000

SYRACUSE
Varian Associates
847 James Street
Syracuse, New York 13203
Phone: (315) 472-7051

TAMPA
Varian Associates
314 South Missouri Avenue
Clearwater, Florida 33516
Phone: (813) 446-5513

WASHINGTON, D.C.
Varian Associates
714 Church Street
Alexandria, Virginia 22314
Phone: (703) 549-7525

CANADA
Varian Associates of Canada, Ltd.
45 River Drive
Georgetown, Ontario, Canada
Phone: (416) 877-6901

AUSTRALIA
Varian Pty. Ltd.
38 Oxley Street, Crows Nest
Sydney, N.S.W., Australia
Phone: 43-0673

ENGLAND
Varian Associates, Ltd.
Russell House, Molesey Road
Walton-on-Thames
Surrey, England
Phone: 28-766

FRANCE
Varian SA
85 Rue Fondary
Paris 15e, France
Phone: 306-98-10

GERMANY
Varian GmbH
Breitwiesenstrasse 9
D-7 Stuttgart-Vaihingen
West Germany
Phone: 78-33-51/52

ITALY
Varian SpA
Strada del Barocchio
Ang. Via Boston
Turin, Italy
Phone: 32-17-17

NETHERLANDS
Varian Associates Holland N.V.
Atoomgebouw 112, Kamer 186
Amsterdam-Schiphol, Netherlands
Phone: 15-94-10

SWITZERLAND
Varian AG
Baarerstrasse 77
Zug, Switzerland
Phone: 042/4-45-55

SWEDEN
Varian AB
Skytteholmsvaegen 7D
Solna 8 (Stockholm), Sweden
Phone: 85-15-35

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