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SERIES 280

DIGITAL IONIZATION

GAUGE CONTROLLER

INSTRUCTION MANUAL

GRANVILLE-PHILLIPS

⚠ **WARNING** - Safe operation of vacuum equipment, including the 280 IGC, requires grounding of all exposed conductors of the gauges **and** the controller **and** the vacuum system. **LETHAL VOLTAGES** may be established under some operating conditions unless correct grounding is provided.

Research at Granville-Phillips has established that ion producing equipment, such as ionization gauges, mass spectrometers, sputtering systems, etc., from many manufacturers may, under some conditions, provide sufficient electrical conduction via a plasma to couple a high voltage electrode potential to the vacuum chamber. If exposed conductive parts of the gauge, controller, and chamber are not grounded, they may attain a potential near that of the high voltage electrode during this coupling. Potentially fatal electrical shock could then occur because of the high voltage between these exposed conductors and ground.

During routine pressure measurement, using ionization gauge controllers from **any** manufacturer, about 160V may become present on ungrounded conductors at pressures near 10^{-3} Torr. All isolated or insulated conductive parts of the controller, the gauge, and the vacuum system must be grounded to prevent these voltages from occurring.

Grounding, though simple, is very important! Please be certain that the ground circuits are correctly utilized on your ion gauge power supplies, gauges, and vacuum chambers, regardless of their manufacturer, for this phenomenon is not peculiar to Granville-Phillips equipment. Refer to Safety Instructions and Section 3, Installation, for additional information. If you have questions, or wish additional labels or literature, please contact one of our technical personnel.

SERIES 280

DIGITAL IONIZATION

GAUGE CONTROLLER

INSTRUCTION MANUAL

IT IS VERY IMPORTANT FOR YOU TO READ AND UNDERSTAND THE CONTENTS OF THIS MANUAL AS IT PERTAINS TO YOUR PARTICULAR INSTRUMENT BEFORE YOU ATTEMPT TO INSTALL OR USE YOUR INSTRUMENT.

This manual is to be used only with the following Series 280 Controller part numbers and options having a Serial Number of 1951 or greater. See Section 1.3 for part number explanations.

280001	280024
280002	280025
280003	280026
280004	280027
280005	280028
280014	280029
280015	280030
280017	280033

Instruction Manual P/N 280013
Granville-Phillips Co.
5675 E. Arapahoe Avenue
Boulder, Colorado 80303
(303) 443-7660
Revised August 1990

CERTIFICATION

Granville-Phillips Company certifies that this product meets its published specifications at the time of shipment from the factory.

LIMITED WARRANTY

This Granville-Phillips Company product is warranted against defects in materials and workmanship for 1 year from the date of shipment provided the installation, operating and preventive maintenance procedures specified in this instruction manual have been followed. Granville-Phillips Company will, at its option, repair, replace, or refund the selling price of the product if it proves to be defective in materials or workmanship during the warranty period, provided the item is returned to Granville-Phillips Company together with a written statement of the problem.

Defects resulting from or repairs necessitated by misuse or alteration of the product or any cause other than defective materials or workmanship are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. UNDER NO CIRCUMSTANCES SHALL GRANVILLE-PHILLIPS COMPANY BE LIABLE FOR CONSEQUENTIAL OR OTHER DAMAGES RESULTING FROM A BREACH OF THIS LIMITED WARRANTY OR OTHERWISE.

"WARNING"

SAFETY PAYS. THINK BEFORE YOU ACT. UNDERSTAND WHAT YOU ARE GOING TO DO BEFORE YOU DO IT. READ THIS INSTRUCTION MANUAL BEFORE INSTALLING, USING, OR SERVICING THIS EQUIPMENT. IF YOU HAVE ANY DOUBTS ABOUT HOW TO USE THIS EQUIPMENT SAFELY, CONTACT THE GRANVILLE-PHILLIPS PRODUCT MANAGER FOR THIS EQUIPMENT AT THE ADDRESS LISTED ON THIS MANUAL.

Explosive Gases

Do not use Series 280 instruments to measure the pressure of explosive or combustible gases or gas mixtures.

Implosion and Explosion

Glass ionization gauges if roughly handled may implode under vacuum causing flying glass which may injure personnel. If pressurized above atmospheric pressure, glass tubes may explode causing dangerous flying glass. A substantial shield should be placed around vacuum glassware to prevent injury to personnel.

DANGER "HIGH" VOLTAGE

Be aware that 180V is applied to the grid when the controller is turned on and the gauge tube is connected. Do not touch any gauge tube electrodes while the tube is connected to the controller.

System Grounding

When operating ionization gauges, some relatively common gas discharge conditions have been found to cause currents through the common ground between the vacuum chamber and the ionization gauge controller chassis. If this ground connection is open when the discharge occurs, nearly the full grid voltage (up to 160V) can appear between the ground of the controller chassis and the vacuum system. Human contact could be fatal. In this dangerous condition, the fuses and automatic turn-off circuits in the controller are not usually called to action. Thus, this dangerous voltage could remain between the vacuum system and ground for extended periods of time. Guaranteeing a good common ground for the vacuum chamber and gauge controller chassis can remove these dangers. It appears probable that all brands of gauge tubes and controllers can cause this hazard.

The safety ground on most electronics equipment does not carry continuous current. Thus its potential may differ by several volts from the ground of those vacuum systems which use the power common line as their ground. These two ground systems should have a common junction which is typically at the distribution breaker box. Even though the resistance between these two grounds may be very low, and thus correct, that voltage difference resulting from unbalanced current flow in the common lead complicates the use of the conventional ohmmeter for verifying that low resistance. The placement of a second ground wire between the vacuum chamber and the gauge controller chassis is not a safe answer, for large continuous currents could flow through it as a ground loop.

Refer to the installation instructions for the proper inspection procedure to determine if your system grounding is satisfactory.

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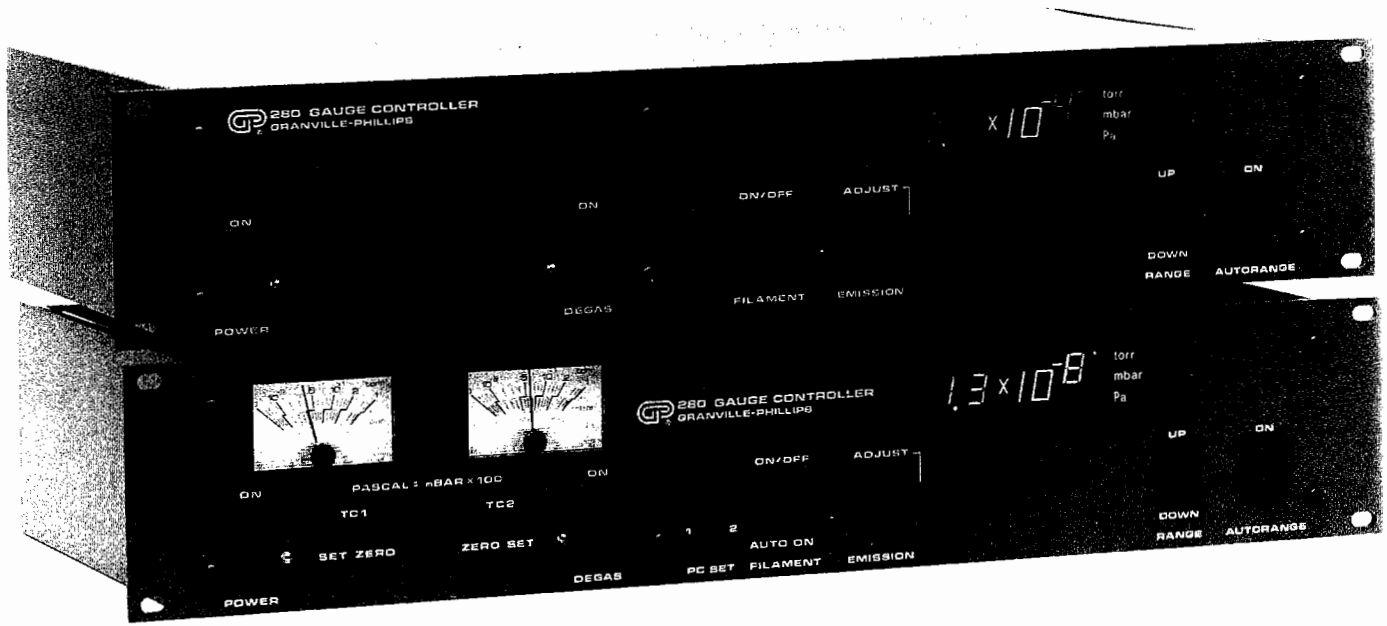


FIG. 1-1 THE 280001 & 280004 ION GAUGE CONTROLLERS

SECTION I

GENERAL INFORMATION

1.1 Description:

The 280 digital ionization gauge controller is a precision instrument designed to indicate vacuum pressures from 1 Torr to 10^{-8} Torr, 1 mbar to 10^{-8} mbar, and 100 Pascal to 10^{-6} Pascal, air equivalent. The basic unit is comprised of a power supply, electrometer, emission controller, converter, and display. Dual thermocouple gauge capability and process controls on the ion gauge and thermocouple gauges are included on some models. Recorder outputs provide capability for remote indication as well as continuous monitoring. A digital BCD output option may be added to any Series 280 digital controller. This option can be either installed at the factory or in the field.

In its basic form the 280 digital controller will display pressure data in five linear decades, 10^{-8} to 10^{-4} Torr. The range of displayed data is from 0.1×10^{-8} to 19.9×10^{-4} Torr. The controller is designed to utilize a Bayard-Alpert type transducer with sensitivity ranging from 8/Torr to 25/Torr, The unit is shipped pre-adjusted for directly indicating pressure of a gauge having a sensitivity of 10/Torr, corresponding to an emission current of 2 mAdc.

Degas is provided by conventional resistive (I^2R) heating of the grid surfaces with a nominal 80 watts of power. Ion gauge pressure measurements are not possible during degas.

Ion gauge process controls, when included, provide two independent set points which operate individual SPDT relay contacts. Set point adjustment over the entire measurement range is by means of recessed front panel controls. Interlocks are provided to allow operation only during autorange operation when the filament is on and the gauge has had sufficient time to stabilize.

The thermocouple section is comprised of two independent measuring circuits and, when included, extend the measurement range of the controller to 1 Torr or 1 mbar. Indication is provided by two 1½ inch taut band ruggedized meters. Recorder outputs are also provided for each of the thermocouple circuits. The thermocouple circuitry is designed to operate with Granville-Phillips 270006 or comparable transducers.

Thermocouple process controls, when included, provide an individual SPDT relay contact set point for each thermocouple gauge. Set point adjustment over the thermocouple's measurement range is adjustable by means of recessed front panel controls. The controller is wired such that the setpoint for thermocouple No. 2 can be used to switch the ion gauge filament on and off, thus allowing fully automatic operation.

All Series 280 controllers come with an automatic ranging feature which can be defeated placing the controller in a manual ranging mode. Autoranging points are preset to occur at $.95 \times 10^{-x}$ and 11.7×10^{-x}. While in the manual mode the controller is capable of readings from 0.0×10^{-x} to 19.9×10^{-x}. Autoranging eliminates troublesome range changing in a variable system and prevents unnecessary shutdowns due to momentary pressure bursts. The manual/auto range function is selected via a front panel switch.

The 280 digital ion gauge controller provides direct ion gauge pressure readout in either Torr, mbar or Pascal. The unit of measure is selectable by means of a slide switch inside the controller. The indicated measurement unit is displayed on the digital display via an indicator LED. The pressure signal is converted and displayed in the desired format, thus eliminating cumbersome conversion tables or calculations.

1.2 SPECIFICATIONS

NOTE

Full scale (FS) in this manual is defined to be a displayed reading of 10.0×10^{-x}

Pressure Range:

Ionization Gauge	Five decades of linear ranges from:
	10.0×10^{-8} Torr FS to 10.0×10^{-4} Torr FS
	10.0×10^{-8} mbar FS to 10.0×10^{-4} mbar FS
	10.0×10^{-6} Pa FS to 10.0×10^{-2} Pa FS
	Readable range of:
	1×10^{-9} Torr to 1.99×10^{-3} Torr
	1×10^{-9} mbar to 1.99×10^{-3} mbar
	1×10^{-7} Pa to 1.99×10^{-1} Pa

Specifications are for N_2 measured with a Bayard-Alpert type gauge having a sensitivity of 10/Torr with factory set emission current of 2 mAdc.

Thermocouple Gauge	10^{-3} Torr to 1 Torr
	10^{-3} mbar to 1 mbar
	10^{-1} Pa to 100 Pa (using mbar $\times 10^2$ factor)

Air equivalent pressure indicated on a non-linear meter scale using dual independent circuits.

Ambient operating temperature range	0 - +50°C
Degas	Power approx. 80 watt using resistive heating of the grid. Pressure measurements are not possible during degas.
Emission Current	Preset at 2.0 mAdc for Bayard-Alpert gauges with N_2 sensitivity of 10/Torr.
Emission current range	0.6 mA to 3 mA to accommodate gauge sensitivities between 25/Torr and 8/Torr.
Stability of ionization gauge meter zero (for zero current input to electrometer after a 10-minute warm-up).	With time: ± 0.25% FS/50h With temperature: ± 1%, FS, 0-50°C With line voltage: ± 0.25% FS
Stability of thermocouple circuit (not including transducer)	With time: ± 0.25% FS/50h With temperature: ± 2.25% FS, 0-50°C With line voltage: ± 0.5% FS

Recorder Output, Ion Gauge		1) 0 to -4V corresponding to front panel indication of 0 to 19.9 x 10^{-X}. Output impedance is 2 Kohm. 2) 0 to -5V corresponding to 1V/decade of pressure. Output impedance is 2 Kohms.
Recorder Output, Thermocouple		0 to 2V corresponding to 0 to 1 Torr (0 to 1.33 mbar) of air; output impedance is 1.86 Kohms ± 1%.
Automatic ranging	up down	117% FS 9.5% FS
Electrical Power Requirement		
Customer specified preset at factory via selector switch		105 to 125 VAC, 50-60 Hz, 100W 210 to 250 VAC, 50-60 Hz, 100W 90 to 110 VAC, 50-60 Hz, 100W
Electrical Characteristics		
Collector voltage to ground		0V
Grid voltage to ground		+180V nominal
Filament voltage to ground		+30V nominal
Filament power available		6 VAC, 6A
Degas power available		8 VAC, 10A (12A max)
Process control range, ionization gauge (each of 2)		3×10^{-9} Torr to 10×10^{-4} Torr 3×10^{-9} mbar to 10×10^{-4} mbar 3×10^{-7} Pa to 10×10^{-2} Pa
Process control range, thermocouple gauge (each of 2)		1×10^{-3} Torr to 1 Torr 1×10^{-3} mbar to 1 mbar 1×10^{-1} Pa to 100 Pa
Process control relay contact rating		SPDT, 4A at 115VAC, 2A at 230VAC, resistive load
Filament status relay contact rating		SPDT, 2A at 115VAC, 1A at 230VAC, resistive load
Thermocouple gauge mounting		1/8" NPT or .410 in. compression quick-connect or suitable weld connection.
Compatible Thermocouple Gauges		Hastings-Radist DV-6M, DV-6R, DV-36, and DV-20
Physical:		
Height		89 mm (3.5 in.)
Width		483 mm (19 in.) to fit standard 19 in. relay rack
Depth		292 mm (11.5 in.) required for mounting
Weight		5.3 kg (11.5 lb)
Shipping weight		7.5kg (16.5 lb)
Mounting Hardware Supplied		Four 10-32x½ in. screws and four nylon washers

BCD Option

Data Available	I. G. pressure, all digits D: DD.D x 10^{-D}, as displayed. I. G. process control status: 2 bits Filament status: 1 bit Data Valid Pulse: 4 Hz, 75% duty cycle
Numerical Data Format	Parallel, latched. 8421-BCD-Positive true logic
Status Data Format	Parallel, Real time Positive logic
Logic Levels, all outputs	"0" = 0 to 0.4 volts at 6 mA typ., 2.6 mA min. (sink). "1" = 2.5 to 5.25 volts at 2.5 mA typ., 1 mA min. (source). = 4.5 to 5.25 volts into high-Z CMOS input.

1.3 Controller Part Number Identification

This manual applies only to the Series 280 Ionization Gauge Controllers having the following part numbers with a Serial Number of 1951 or greater. Use only the information in this manual pertaining to the features furnished on your instrument.

Part Number	Descriptive Information		
Catalog No.	Voltage	Units	Features
280001 and 280030	115	Torr	IGC, Autoranging
280002 and 280029	115	Torr	IGC, Autoranging, Thermocouple Gauges
280003 and 280028	115	Torr	IGC, Autoranging, I.G. Process Control
280004, 280027, 280033	115	Torr	IGC, Autoranging, Thermocouple Gauges I.G. Process Controls, T.C. Gauge Process Controls, Automatic Filament
280014	230	mbar	IGC, Autoranging
280015 and 280026	230	mbar	IGC, Autoranging, Thermocouple Gauges
280017 and 280025	230	mbar	IGC, Autoranging, Thermocouple Gauges, I.G. Process Controls, T.C. Gauge Process Controls, Automatic Filament
280005	BCD Output Option		Fits all of above.
280024	230	Torr	IGC, Customer Special

NOTES

SECTION 2

INSPECTION

2.1 Receiving Inspection

Prior to using your controller for the first time, remove the two screws of the upper corners of the rear panel and take off the top cover. Visually inspect the unit for shipment damage. Especially check to see that all relays are seated in their sockets properly, that the relay retaining straps are in place, that the inter-connect cable between the two P.C. boards is properly seated, that the line voltage selector switches are in the proper position and finally that the proper fuse is provided. Following these preliminary inspection steps may save substantial time delays in putting your new unit into operation in the event of shipping damage or human error.

2.2 Domestic Shipments

Confirm that your shipment includes all material and options ordered. If materials are missing or damaged the carrier that made the delivery must be notified within 15 days of delivery in accordance with Interstate Commerce regulations in order to file a valid claim with the carrier. Any damaged material including all containers and packing should be held for carrier inspection. Contact our Customer Service Department, 5675 East Arapahoe Avenue, Boulder, Colorado 80303, (303) 443-7660 if your shipment is not correct for reasons other than shipping damage.

2.3 International Shipments

If items are missing or damaged the carrier making delivery to the customs broker must be notified within 15 days of delivery.

Example:

If an airfreight forwarder handles the shipment and their agent delivers the shipment to customs the claim must be filed with the airfreight forwarder.

If an airfreight forwarder delivers the shipment to a specific airline and the airline delivers the shipment to customs the claim must be filed with the airline, not the freight forwarder.

Any damaged material including all containers and packaging should be held for carrier inspection. Contact our Customer Service Department, 5675 East Arapahoe Avenue, Boulder, Colorado 80303, U.S.A. Telex 045 791 GPVAC Bldr or telephone (303) 443-7660 if your shipment is not correct for reasons other than shipping damage.

SECTION 3

INSTALLATION AND OPERATION

3.1 General Information

Rack mounting - 280 series controllers are designed to mount into a standard 19" relay rack. Four 10-32 x ½ in. screws and nylon washers are provided for this purpose. Caution should be exercised in rack mounting the 280 controller, that its ambient temperature does not rise above 50°C. This can be accomplished by providing adequate ventilation below and above the controller and by not mounting large heat sources below the controller.

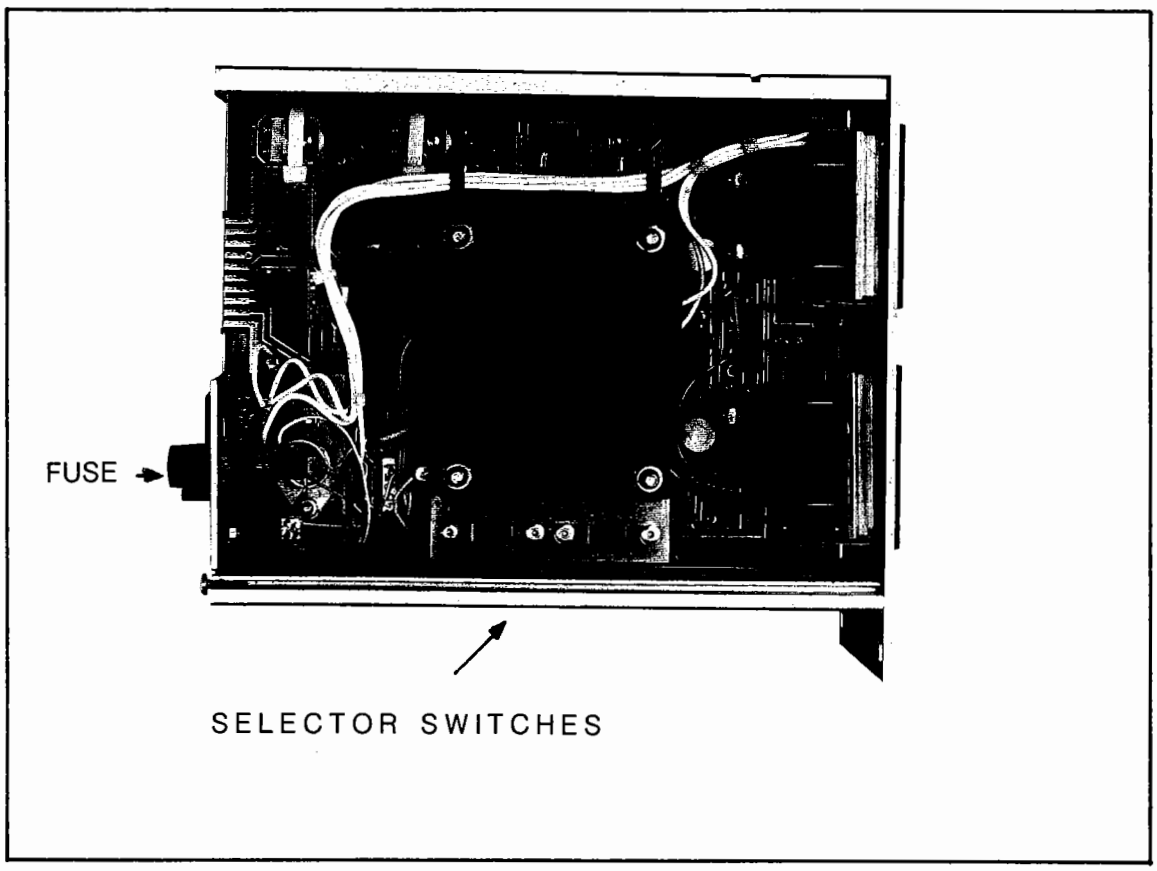


FIG. 3-1 LINE VOLTAGE SELECTOR SWITCH

Electric Power

The line power supplied to the Series 280 controller should be one of the following: 100V with a 1.25 amp fuse, 115V with a 1.25 amp fuse or 230V with a .5 amp fuse. 50 - 60 Hz single phase. Voltage selection switches, as shown in Fig. 3-1, are located inside the instrument next to the power transformer and must be set to correspond to the available supply voltage. Be sure that the controller is unplugged from the AC power (mains) source before setting voltage selection switches. Connect the power cable to the controller and to the appropriate source of AC power.

System Ground Test Procedure (Refer to the Safety Instructions for further information)

Procedure: Physically examine the grounding of both the ion gauge controller and the vacuum chamber. Is there an intentional heavy duty ground connection to the vacuum chamber? There should be. Note that a horizontal "O" ring or "L" ring gasket, without metal clamps, can leave the chamber above it electrically isolated. Power can be delivered to mechanical and diffusion pumps without any ground connections to the system frame or chamber. Water line grounds can be lost by a plastic or rubber tube interconnection. What was once a carefully grounded vacuum system can, by innocent failure to reconnect all ground connections, become a very dangerous device. Use the following procedure to test each of your vacuum systems which incorporates an ionization gauge.

This procedure uses a conventional Volt-Ohm Meter (VOM) and Resistor (10 ohm, 10 watt)

1. With the gauge controller turned off, test for both DC and AC voltages between the metal parts of the vacuum chamber and the gauge controller chassis.

2. If no voltages exist, measure resistance. The resistance should not exceed 2 ohms. Two ohms, or less, implies commonality of these grounds that should prevent the plasma from creating a dangerous voltage between them. This test does not prove that either connection is earth ground, only that they are the same. If more than 2 ohms is indicated, check with your electrician.

3. If AC or DC voltages exist and are less than 10 volts, shunt the meter with a 10 ohm, 10 watt resistor. Repeat the voltage measurement. With the shunt in place across the meter, if the voltage remains at 83% or more of the unshunted value, commonality of the grounds is implied. Repeat the measurements several times to be sure that the voltage ratio is not changing with time. If

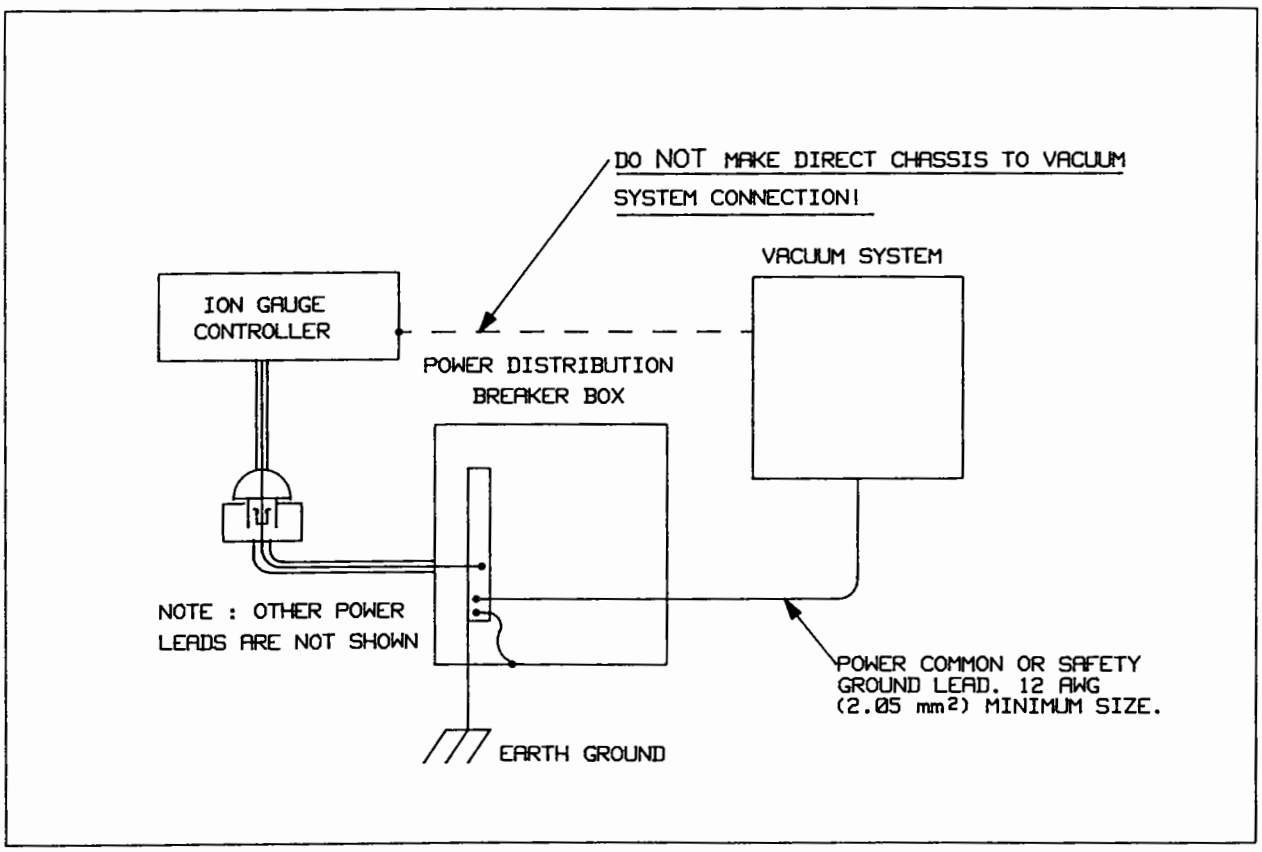
$$\frac{\text{Voltage (shunted)}}{\text{Voltage (unshunted)}} = .83 \text{ or more,}$$

this should prevent the plasma from creating a dangerous voltage between these grounds. If more than 10 volts exists between grounds, check with your electrician.

4. If the voltage change in #3 is greater than 17% due to the placement of the shunt, it complicates the measurement. The commonality of the grounds may be satisfactory and the coupling poor, or the commonality could be poor! Your electrician should be asked to check the electrical continuity between these two ground systems. The placement of a second ground wire between the vacuum chamber and the power supply chassis is NOT a safe solution. Large currents could flow through it. Professional help is recommended.

⚠ WARNING

AFTER EACH MAINTENANCE/SERVICE PROCEDURE AND BEFORE OPERATING THE CONTROLLER AND VACUUM SYSTEM MAKE SURE THAT YOUR VACUUM SYSTEM AND CONTROLLER ARE GROUNDED AS SHOWN IN THE FOLLOWING SCHEMATIC DIAGRAM. **FAILURE TO DO SO COULD BE FATAL.**



CORRECT SYSTEM GROUNDING

3.2 Ion Gauge Connections

WARNING

ALWAYS SHIELD GLASS IONIZATION GAUGE TUBES. ADVERSE SYSTEM CONDITIONS OR ROUGH HANDLING CAN CAUSE GLASS IONIZATION TUBES TO EXPLODE OR IMPLODE POSSIBLY CAUSING SERIOUS INJURY TO PERSONNEL.

Gauge types and mounting - Series 280 ionization gauge controllers are designed to operate with Bayard-Alpert type gauges such as the Granville-Phillips Series 274 gauges. The Series 280 controllers will also operate with other gauges whose voltage and current requirements are within the operating range of the controller. It is recommended that an iridium coated filament type gauge be used if the automatic filament turn on is to be utilized. Iridium filaments provide longer operating life during operation in the higher pressure ranges. Consideration should be given to where the gauge is connected to the system. If placed near the pump, the pressure in the gauge may be considerably lower than in the remainder of the system. If placed near a gas inlet or source of contamination, the pressure in the tube may be considerably higher than in the remainder of the system. If an unshielded gauge is placed near an electron beam evaporation source or used in a sputtering system, spurious electrons or ions may completely disturb the measurement. Screens or other shielding should be placed between the gauge and system if spurious charged particles are present. Consideration should also be given to electrostatic shielding of glass tubulated gauges when measuring pressures near their x-ray limit. **WARNING** - Ionization gauges are safe for use only if all exposed conductors on the gauge and on controller and on vacuum system are grounded.

WARNING

DO NOT ATTACH CABLES TO GLASS GAUGE PINS WHILE THE GAUGE IS UNDER VACUUM. ACCIDENTAL BENDING OF PINS MAY CAUSE GLASS TO BREAK AND IMPLODE. CABLES, ONCE INSTALLED, SHOULD BE SECURED TO THE SYSTEM PROVIDING STRAIN RELIEF FOR THE GAUGE TUBE PINS.

Ion gauge cable

Granville-Phillips offers two basic cable types for ion gauge operation. One has a standard connector for the Series 274 tubulated gauge tubes, the other has individual pin sockets for use will all nonstandard pin configuration as well as with Granville-Phillips "nude" tubes. There are a variety of lengths available for both types.

A 10-foot long ion gauge cable for standard Series 274 tubulated gauge tubes is provided with each Series 280 controller.

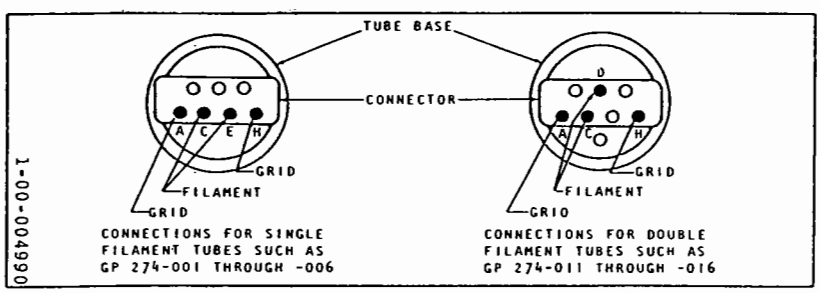


FIG. 3-2 DIAGRAM SHOWING STANDARD TUBE BASE CONFIGUATIONS

Figure 3-2 shows the configuration the tube elements must have if the tube is to mate directly to a standard cable assembly. Granville-Phillips catalog numbers 270007, 270008 and 270040 are standard cable assemblies with tube connection as shown in Fig. 3-2. These cables are designed to be used with gauges similar to the series 274 tubulated gauges, with either single or dual filaments. If one of these cables is to be used, connect the tube to the 7 contact connector. Be sure to provide strain relief for the tube connector and cable assembly so that the glass envelope will not break due to pin movement. Plug the plastic collector socket on the collector pin at the opposite end of the tube. Then plug the 6 pin connector into the rear of the controller marked "gauge". Connect the BNC plug into the jack marked "collector". Both are on the rear of the controller.

WARNING

REMOVE OR TURN OFF AC POWER WHEN MAKING GAUGE CONNECTIONS. 180 VOLTS IS APPLIED TO THE ION GAUGE GRID CONNECTIONS WHENEVER THE CONTROLLER POWER IS ON, EVEN WHEN FILAMENT IS OFF. THEREFORE, TO ELIMINATE POSSIBILITY OF ELECTRICAL SHOCK, MAKE GAUGE CONNECTIONS FIRST.

Gauge cable assemblies with catalog numbers 270009, 270010 and 270041 are designed to be used with gauges which do not have the standard base. If you are using one of these cables, connect the individual labeled sockets to the corresponding gauge pins. Connect the sockets labeled "pin cover" to any unused gauge tube pins. Now, plug the 6-pin connector of the gauge cable into the connector on the rear of the controller marked "gauge". Connect the BNC plug of the collector cable to the connector on the rear of the controller marked "collector".

Both of the above cable types may be obtained in lengths up to a maximum of 40 ft if desired. Refer to the data sheet for added information.

If the controller is to be used with gauges other than those supplied by Granville-Phillips, refer to the specifications section located in the front of this manual to assure that your tube specifications are compatible with the controller.

IG Accessory Connector (Refer to Fig. 3-3)

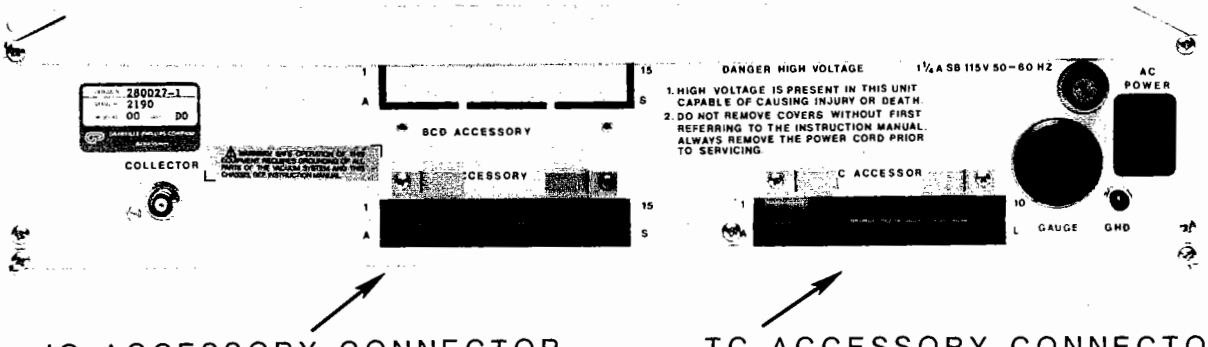


FIG. 3-3 SHOWING ACCESSORY CONNECTORS

The IG accessory connector as supplied is not prewired for use. See Fig. 3-3A for connector kit assembly. This connector is shipped in the bag marked "280" and has keys installed between pins 3 & 4 and 10 & 11. An explanation of each contact is as follows:

Pins	Function
1 & A	Chassis ground - used for grounding cable shields
2 & B	Recorder output, electrometer - 0 to 4V dc corresponding to the ion gauge meter information, 2Kohm impedance
3 & C	Recorder output, pressure - 0 to -5V dc corresponding to entire pressure range, 2Kohm impedance
4 & D	Common - filament status relay
5 & E	Normally open contact - filament status relay
6 & F	Normally closed contact - filament status relay
7 & H	Remote filament turn on - momentary contact to 9 or K energizes filament circuit
8 & J	Remote filament turn off - momentary contact to 9 or K de-energizes filament circuit
9 & K	Circuit ground - ground return for recorder output and filament control circuit
10 & L	Normally open contact - IG process control relay #1
11 & M	Common - IG process control relay #1
12 & N	Normally closed contact - IG process control relay #1
13 & P	Normally open contact - IG process control relay #2
14 & R	Common - IG process control relay #2
15 & S	Normally closed contact - IG process control relay #2

005943 100

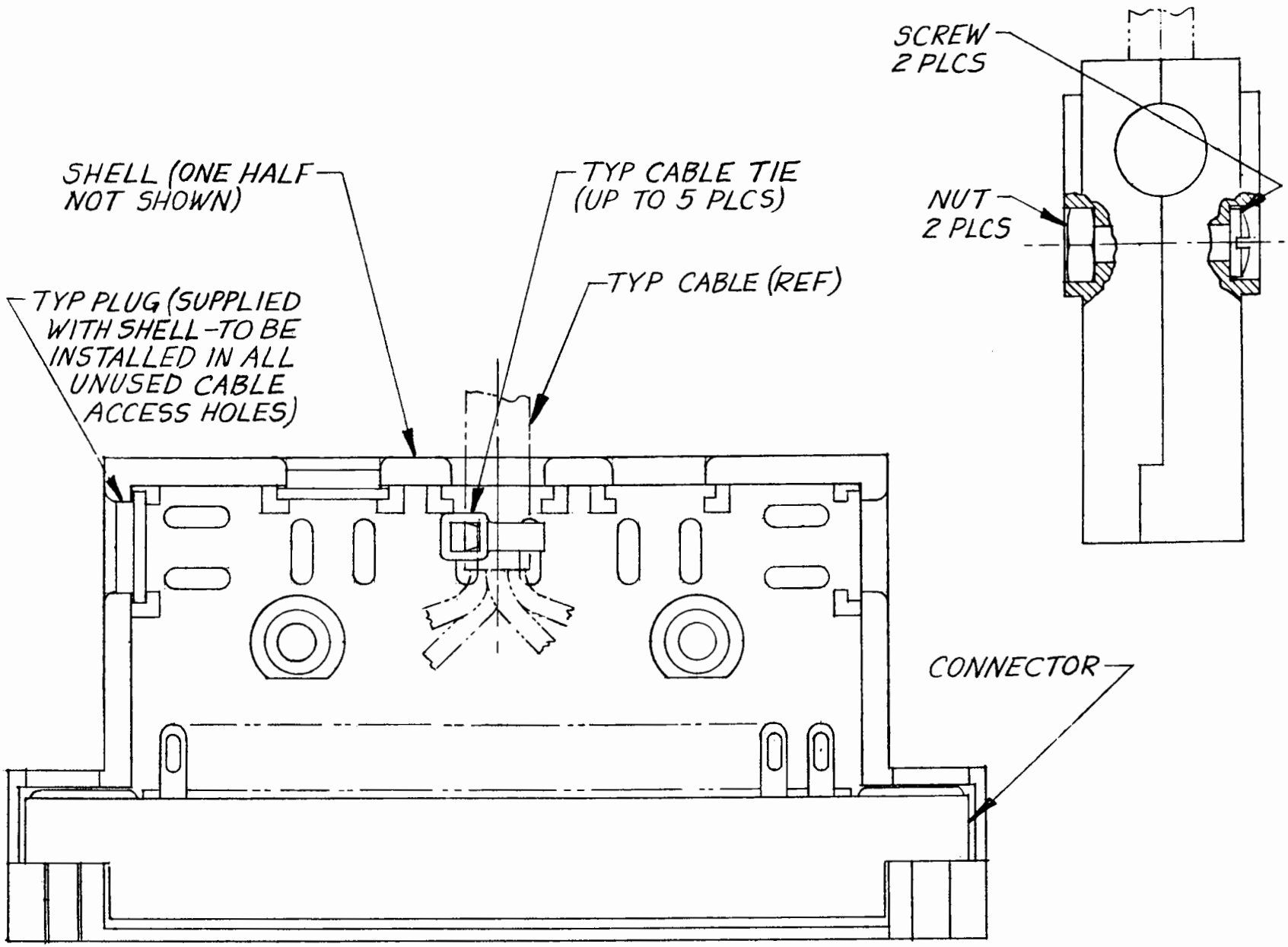


FIG. 3-3A CONNECTOR PICTORIAL

3.3 Protection of Controller from DC and RF Voltages

The controller is built to withstand shorts of the tube elements. In addition input protection is provided to help protect the electrometer from external high energy discharges. However, it is absolutely necessary to shield the IG tube any time the controller is used on systems where high voltage arcs may be present in the system. If not done, failures are to be expected. This shielding can include baffles in the tube inlet or fine screening. If the energy is external to the system, an additional RF shield around the tube will be required.

Note also, the use of a high frequency spark coil commonly used for leak testing glass systems can cause damage to the controller and as a result possibly burn out the tube. Always disconnect the cables from the tube before leak testing with a spark coil.

A ground lug is provided on the rear panel of the controller for use in high EMI and RFI environments. In such cases a good shield should be placed over the gauge tube and cable and grounded at the lug.

3.4 Thermocouple Gauge Tube Installation

The thermocouple gauge tubes may be installed anywhere in the system using a 1/8" NPT or .410 in. compression connection, or may be welded directly. Do not use compression fittings for positive pressure applications. If installed in an area where condensable vapors are present a mounting position with the open end pointing down should be utilized. If the automatic ion gauge control is to be utilized, TC #2 should be installed as close to the ion gauge as practical so that both devices see the same pressure. Under no circumstances should they be separated by any valving which might result in their measuring a different pressure.

The thermocouple gauge cable as received is prewired for the two gauge tubes. The connector to the controller, see Fig. 3-3, is also used for the TC recorder outputs and process control outputs. If either or both are to be used they should be connected at time of installation. An explanation of each usable contact of the TC accessory connector is as follows:

Pins	Function
A	Normally open contact - process control relay TC1
B	Common - process control relay TC1
C	Normally closed contact - process control relay TC1
1	Normally open contact - process control relay TC2
2	Common - process control relay TC2
3	Normally closed contact - process control relay TC2
5	Recorder output TC2 - 0 to +2V dc signal corresponding to meter information for TC2, 1.86 Kohm impedance
6	Recorder output TC1 - (same as above)
4 & D	Circuit ground - for use with recorder outputs
10 & L	Chassis ground - for grounding cable shields

3.5 Digital BCD Output Option

NOTE: Before installing the BCD option board check that there are no ac or dc ground potentials between the controller and the equipment you are interfacing.

The series 280 BCD output option circuit board has been designed so that installation into the 280 IG controller requires a Phillips screwdriver, a 3/8 in. wrench or nut driver, a standard slotted screwdriver and a heavy duty diagonal cutter. Refer to Fig. 3-4. Remove the back panel screws and ground lug nuts, then remove the rear panel. Remove the converter board retainers and slide the BCD circuit board into the same two slots that the converter board is in. The converter board to BCD board connector should engage as the board is pushed forward. Break out the BCD option slot cover from the rear panel using a diagonal cutter. Replace rear panel, screws and nuts.

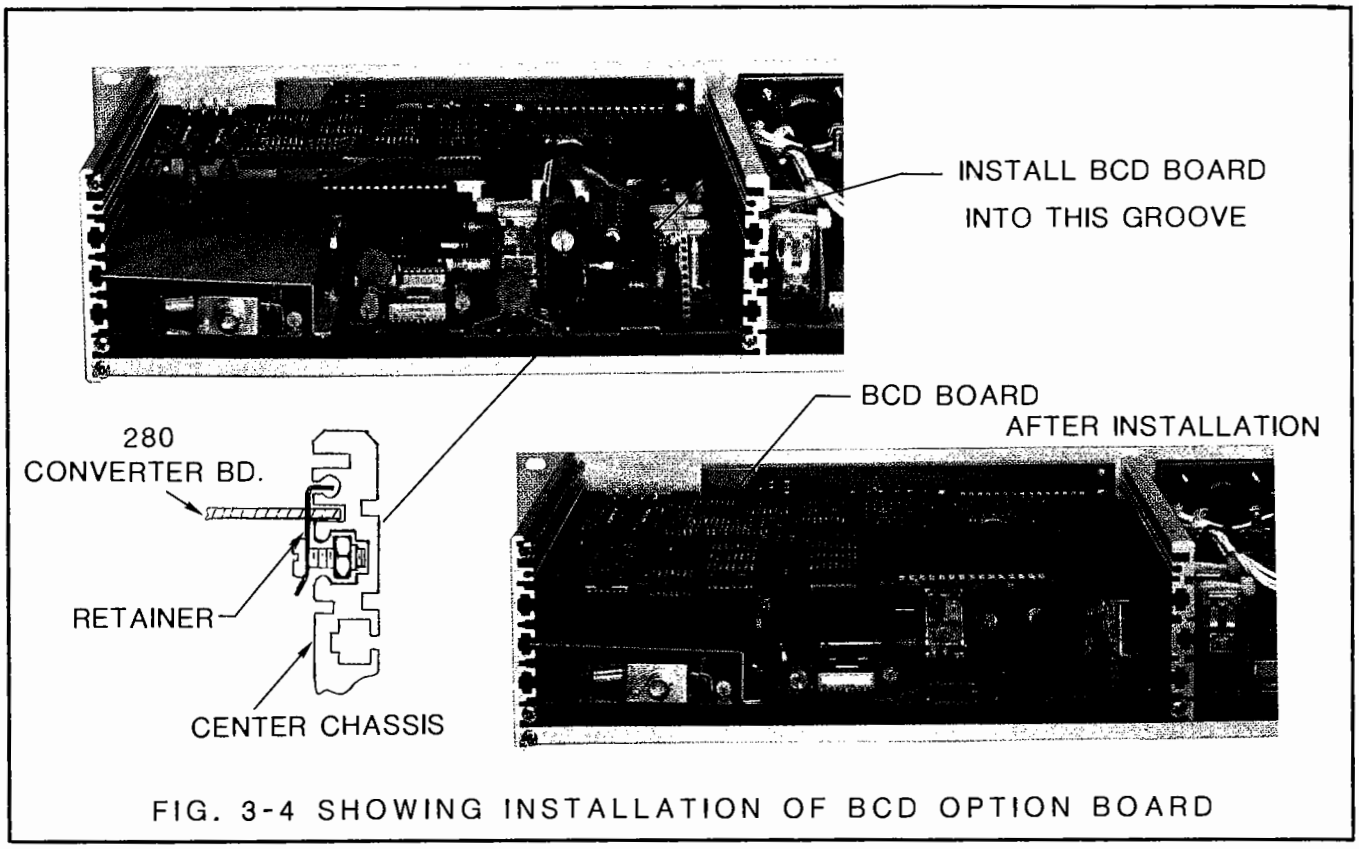


FIG. 3-4 SHOWING INSTALLATION OF BCD OPTION BOARD

Provided with the BCD option is a 15 position edge connector and housing for interfacing. This connector is shipped in the bag marked "BCD", and has keys installed between pins 2 & 3 and 14 & 15. The pins are identified as follows.

Pin	Function	Pin	Function
1	Data valid	A	N/C
2	1 - tens	B	Process control 2 status
3	8 - units	C	Process control 1 status
4	4 - units	D	Filament status
5	2 - units	E thru S	Ground
6	1 - units		
7	8 - tenths		
8	4 - tenths		
9	2 - tenths		
10	1 - tenths		
11	8 - range		
12	4 - range		
13	2 - range		
14	1 - range		
15	Ground		

For more detailed information on the logic levels and use of the specific lines, refer to Section 4.13. The format of the output has been made as simple as possible to allow easy interfacing to a wide range of digital systems. The outputs will directly interface with TTL or 5-volt CMOS inputs. All signals are positive true logic. When interfacing with other equipment it is very important that the grounds be connected and that they are at the same potential since there is no provision for isolation.

NOTES

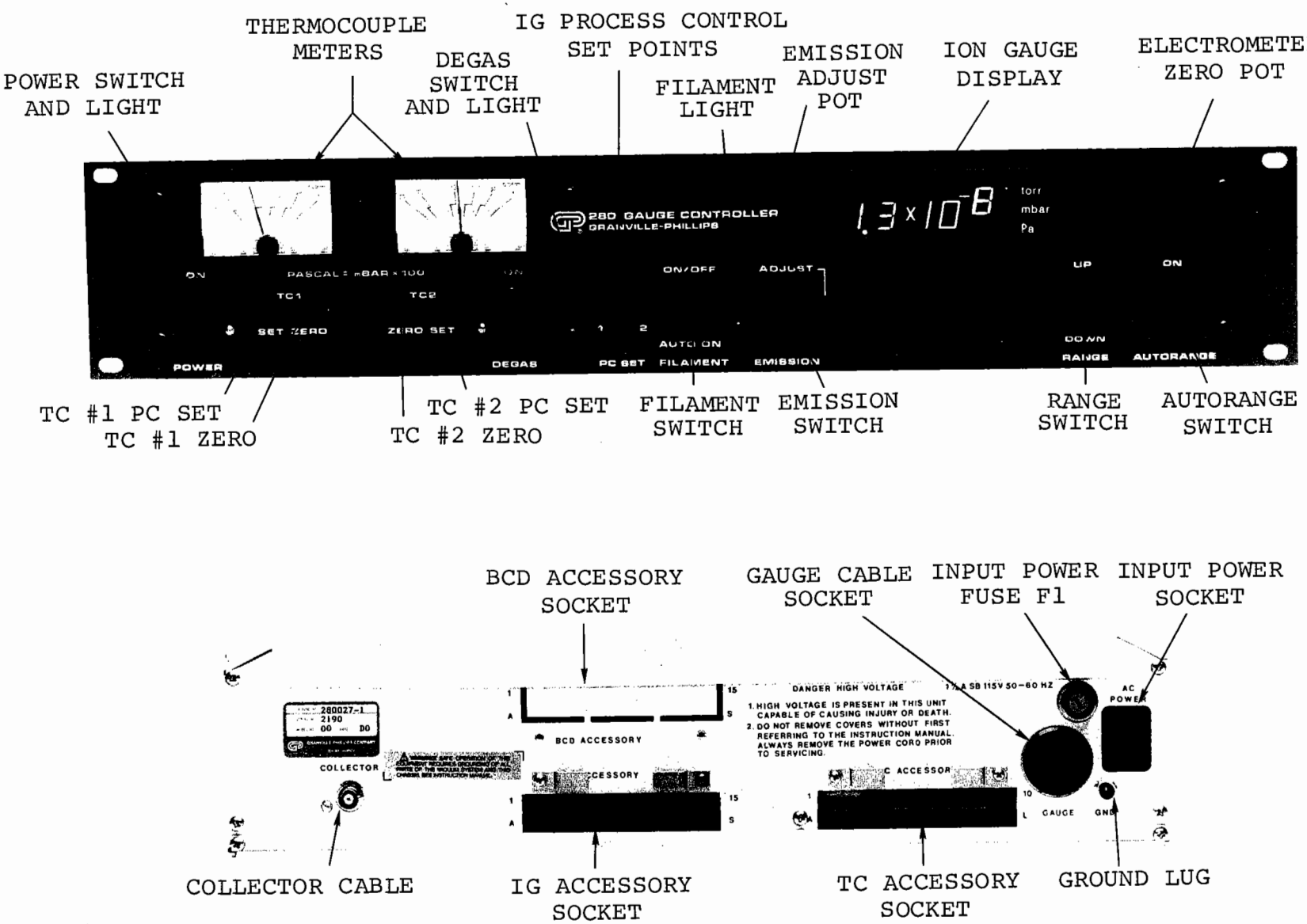


FIG. 4-1 LOCATION OF CONTROLS (FRONT & REAR PANELS)

SECTION 4

OPERATION INSTRUCTIONS

NOTE: It is desirable to read these instructions if full use is to be made of the many features designed into this controller.

4.1 Purpose of Controls (Left to right) (Refer to Fig. 4-1)

Power Switch - Supplies power to the entire unit when switch is placed in the on position.

Power-On Indicator - indicates the status of the power

TC #1 Set - recessed pot for adjusting the set point where the TC #1 process relay energizes.

TC #1 Zero - recessed pot for adjusting the TC #1 zero.

TC #2 Zero - recessed pot for adjusting the TC #2 zero.

TC #2 Set - recessed pot for adjusting the set point where the TC #2 process relay energizes and/or the ion gauge filament on/off circuit is controlled.

Degas Light - indicates the status of the degas power.

Degas Switch - switches the degas power to the gauge tube grid.

PC Set #1 - recessed pot for adjusting the set point corresponding to decade and meter reading where the IG process relay #1 energizes.

PC Set #2 - recessed pot for adjusting the set point corresponding to decade and meter reading where the IG process relay #2 energizes.

Filament Switch (280004, 280017) - three position switch which controls filament status.

1. Auto On (down) - control of the filament is by use of the TC #2 process set point.
2. Center - intermediate position.
3. On/Off (up)- spring loaded position which reverses filament state each time toggled.

Filament Switch (all other models) - spring loaded switch which changes the filament state each time toggled.

Filament Light - indicates the status of the filament.

Emission Switch - spring loaded switch which in the adjust position displays a reading corresponding to the emission current on the ion gauge meter.

Emission Adjust - recessed pot used to adjust the emission current to the recommended value depending upon gauge tube sensitivity.

Unit of Measure Indicators - indicates measurement units; Torr, mbar, Pa.

Range Switch - selects pressure decade during manual operation.

Electrometer Zero - recessed pot used to zero the electrometer.

Electrometer Zero Indicator - circuitry has been provided that causes the decimal point to flash when the electrometer is at a true zero point.

4.2 Thermocouple Zero

1. Make certain the installation described in Section 2 has been completed.

2. With the power switch off, check that the meter reads zero. If it does not, zero the meter using the adjustment in the center of the meter.

3. Turn the power switch on. The power light adjacent to the power switch should turn on.

4. Using the ion gauge as an indicator or some supporting gauge verify that the pressure in the vicinity of the thermocouple gauge tube is based out (less than 1×10^{-4} Torr). Very slowly rotate the corresponding TC zero pot in the direction of desired motion until the meter reads zero.

5. Repeat for the second channel.

4.3 Thermocouple Set Point Adjust

1. Visual Set Point Adjustment (power off)

It is possible to approximate the set point by visually positioning the screwdriver adjust slot of the pot to a degree reading as follows:

Slot fully CCW - 1×10^{-3} Torr (generally not used)

Slot rotated CW to a horizontal position - 1×10^{-2} Torr

Slot rotated CW to a 45° point above horizontal - $.3 \times 10^{-1}$ Torr

Slot rotated CW to a vertical position - $.5 \times 10^{-1}$ Torr

Slot rotated CW to a 45° point past vertical - 1×10^{-1} Torr

Slot rotated CW to a horizontal position - 0.2 Torr

2. Thermocouple #1 Set Point Adjust (power on)

   1. Complete the previous section on thermocouple zero.

   2. Rotate the TC #1 set pot full CCW.

   3. Set the system pressure for the desired trip point.

   4. Slowly rotate the TC #1 set pot CW until the #1 process relay energizes.

3. Thermocouple #2 Set Point Adjust

NOTE: This is the set point which also determines the filament status when in the auto on mode of filament control. For a standard Bayard-Alpert gauge tube with an iridium coated filament we recommend that the set point be adjusted for $.5 \times 10^{-2}$ to 1×10^{-2} Torr.

1. Complete the previous section on thermocouple zero.

2. Rotate the TC #2 set pot full CCW.

3. Place the filament switch in the preset position if auto filament control is to be used.

4. Set the system pressure for the desired trip point.

5. Slowly rotate the TC #2 set pot CW until the filament light turns on and/or the #2 process relay energizes.

4.4 Electrometer Zero (check)

1. Make certain the installation described in section 3 has been completed.

2. Turn the power switch on. The power on indicator should be on.

3. Place the auto range switch to the off position.

4. Depress the range switch to the down position until a reading in the 10^{-8} range is achieved.

5. Observe that the displayed reading should be 0.0×10^{-8} with the decimal point flashing. If it is not then adjust the electrometer zero for flashing decimal point. See Fig. 4-1 for location of this recessed front panel control.

6. Check the remaining ranges to assure a zero in all ranges.

4.5 Ion Gauge Process Control Set Point Adjustment

The IG process control feature provides relay operation that can be used to control external devices as a function of system pressure as measured on the ionization gauge. Two completely independent relay circuits are provided which can be adjusted to operate anywhere over the pressure range.

1. IG Set Point Adjust (power off)

It is possible to approximate the set point by visually positioning the screwdriver adjust slot of the pot to a degree reading as follows:

Slot fully CCW - 0×10^{-8} (not used)

Slot rotated CW to a horizontal position - 7×10^{-8} Torr or mbar

Slot rotated CW to a 45° point above horizontal - 7×10^{-7} Torr or mbar

Slot rotated CW to a vertical position - 5×10^{-6} Torr or mbar

Slot rotated CW to a 45° point past vertical - 5×10^{-5} Torr or mbar

Slot rotated CW to a horizontal position - 5×10^{-4} Torr or mbar

Slot rotated full CW - 1.2×10^{-3} Torr or mbar

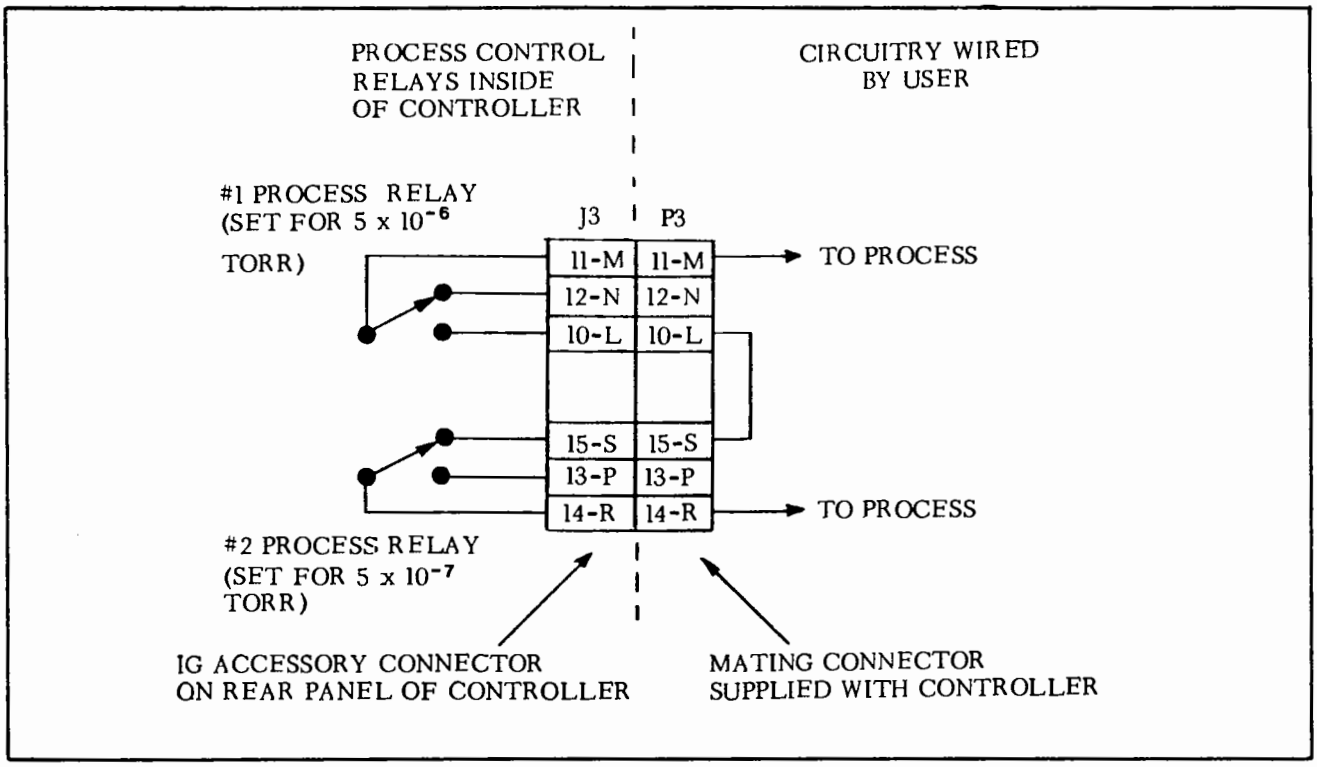


FIG. 4-2 PROCESS CONTROL WITH PRESSURE BAND

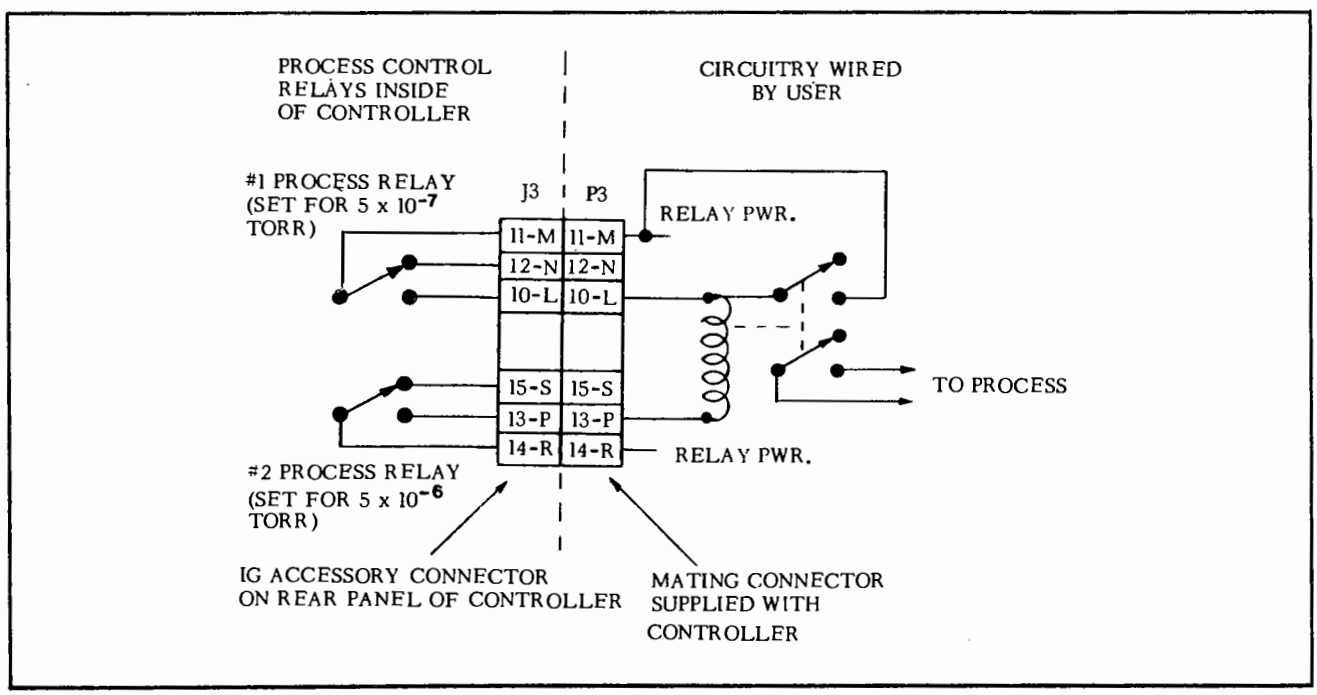


FIG. 4-3 PROCESS CONTROL WITH HYSTERESIS LOOP

2. IG Set Point Adjust (power on)

1. Rotate the set point pot fully CCW.
2. Allow pressure in the system to stabilize at the desired control point.
3. Slowly rotate the pot CW until the process relay energizes.

The process control relays on the ionization gauge are interlocked in the following manner:

1. Operation is only possible when the autorange switch is in the on position.
2. The filament relay must be energized for a period of two seconds to allow for filament turn on and to create an electrometer output.

Pin information for the IG process relay output is given in Section 3. In order to prevent oscillation around the trip point there is a built-in hysteresis effect amounting to approximately 15% of a decade. For example, if a set point is established to pull in a relay at 5×10^{-6} it will not drop out until the pressure rises above 6.5×10^{-6}.

The process control relays may be used separately or together to suit your specific application. Two examples are shown in Fig. 4-2 and Fig. 4-3.

Fig. 4-2 can be used to allow a process to operate over a specific pressure band. In the example shown the process would only be allowed if the system pressure is between 5×10^{-6} Torr and 5×10^{-7} Torr.

Fig. 4-3 can be used to control a process where a large pressure rise is expected once the process is initiated. In the example shown the process would begin when the pressure decreased to 5×10^{-7} Torr and remain on as long as the pressure remained below 5×10^{-6} Torr.

4.6 Filament Control

Starting the Filament (Manual Mode)

CAUTION: Gauges with tungsten filaments may be damaged by attempting to operate the filament in active gas atmospheres at pressures greater than about 1×10^{-3} Torr.

1. When operating the controller for the first time or with a system at an unknown pressure, set the autorange switch either to on or to off in 10^{-4} range.
2. Momentarily toggle the filament switch to the on/off position and observe the following events.
3. The ionization gauge filament should glow. Note that the tungsten filament glows much brighter than a thoria coated iridium filament when operated at the same emission current.
4. The red filament LED should come on and stay on. NOTE: The filament LED will not stay on if the required electron emission current is not attained within approximately 1 second after the filament switch is depressed. Common causes of no emission are:
   - A. Gauge cable not connected
   - B. Pressure in tube is too high
   - C. Open filament in tube
   - D. Grid shorted
5. To turn off the filament again toggle the filament switch to the on/off position.

Starting the Filament (Automatic Mode)

In the automatic filament control mode the status of the gauge tube will be directly controlled by the TC #2 set point status. For this reason it is required that the previous calibration procedure relating to TC #2 zero and TC #2 set point adjust be completed prior to use of this feature.

To utilize this feature place the filament switch to the auto on position. This can be done at any time either prior to or during operation. The primary control of the filament will be the pressure sensed by TC #2. As the TC #2 pressure reading drops below the set point, the filament will turn on and as it rises above the set point the filament will turn off.

Remote Filament Operation

Remote operation of the filament is possible by use of signals to the IG accessory connector. To turn on the filament a momentary short (approximately 1/2 second) should be applied between pins 7 or H and 9 or K. Filament turn off is accomplished by applying a momentary short between pins 8 or J and 9 or K.

Filament Protect

During filament operation there are two conditions, each of which will turn off the gauge filament.

a. If at any time the preset emission current cannot be obtained or maintained the filament relay will de-energize and turn off the filament.

b. If at any time the ion current sensed, which is a function of pressure, exceeds the equivalent of 3×10^{-3} Torr the filament relay will de-energize and turn off the filament. (Note: This means that the filament will not turn off during pressure bursts, auto ranging or manual operation, when the meter is pegged in a low pressure decade until a pressure of 3×10^{-3} Torr is reached.)

Filament Protect (Automatic Mode)

In addition to the above filament protection, when the automatic filament on/off is used, the filament will turn off as the TC #2 pressure increases across its process control set point.

4.7 Emission Current

1. The normal emission current required to make your controller direct reading with a gauge tube sensitivity of 10 per Torr for N_2 is 2mA dc. To improve readability on the meter scale this is equal to a reading of 10.0. To make the controller direct reading for gauge tubes with sensitivities between 8 and 25 per Torr use Eq. (1) to determine the correct meter reading.

$$\text{Meter reading} = \frac{10/\text{Torr}}{\text{Gauge Sensitivity}} \times 10$$

Disregard the exponent.

Note: The minimum emission adjust range of 0.6 mA to 3 mA allows use of gauges with actual sensitivities from 33/Torr to 6.7/Torr, thus assuring adequate calibration adjustment range for tubes specified at 25/Torr to 8/Torr nominal.

For example, if your tube has a sensitivity of 25/Torr, then the meter reading during calibration to make the controller direct reading is:

$$\text{Meter reading} = \frac{10/\text{Torr}}{25/\text{Torr}} \times 10 = 4.0$$

2. To set the emission current, proceed as follows. Establish the necessary meter reading as described in the previous section. Toggle the spring loaded emission switch to the adjust position. Use a small screwdriver to rotate the emission adjust pot until the desired meter reading is obtained. Read the number in the digital ion gauge display, ignoring the range exponent.

4.8 Reading Pressure

The gauge tube pressure is indicated on the front panel display. This display is a direct reading of pressure in units as indicated by the units indicators to the right side of the display.

If the measured pressure exceeds the measuring capability of the instrument, or if the pressure exceeds 19.9 in a manually selected decade range, the two rightmost in-decade digits will blank out, leaving a display of 1×10^{-x}.

At very low pressures with respect to a manually locked range, or at pressures well below 1×10^{-9} Torr, the display will show all zeros in the in-decade digits with the decade digit properly displayed. When the electrometer output is zero, the display reads 0.0×10^{-x}, where x indicates the range (decade), with the decimal point flashing. The display cannot display negative values and the decimal point disappears for reverse polarity electrometer outputs.

4.9 Automatic Ranging

The controller can be operated with the autorange switch either on or off. When it is off, the range switch is used to select the desired decade. When the autorange switch is on, the autorange circuit is preset to select a range which will give a meter reading between 9.5 and 117 percent of full scale. Process control is operational only when the autorange switch is on.

During autorange operation the electrometer will always return to the 10^{-4} decade any time the filament relay de-energizes.

4.10 Degassing the Gauge Tube

Degassing of the tube is accomplished by resistance heating of the grid structure. To utilize this feature, place the degas switch to the on position. If the filaments were on they will turn off after approximately one second. It is not possible to monitor pressure in the system during degas. When degassing is complete turn off the degas switch and start the filament by toggling the filament switch once to the on/off position.

If, while in degas, the autorange switch is turned off and the 10^{-8} pressure decade selected, an electrometer reading will be observed. This is due to ion desorption from the grid.

4.11 Recorder Outputs

1. Thermocouple - The output of both TC's is available at the TC accessory connector (refer to Section 3 for pin information). This is a 0-2V dc signal corresponding to the meter scale with a source impedance of 1860 ohms. This allows a remote thermocouple meter (see parts list) to be directly driven if remote indication is desired. A graphical plot of output voltage versus pressure is shown in Fig. 4-4.

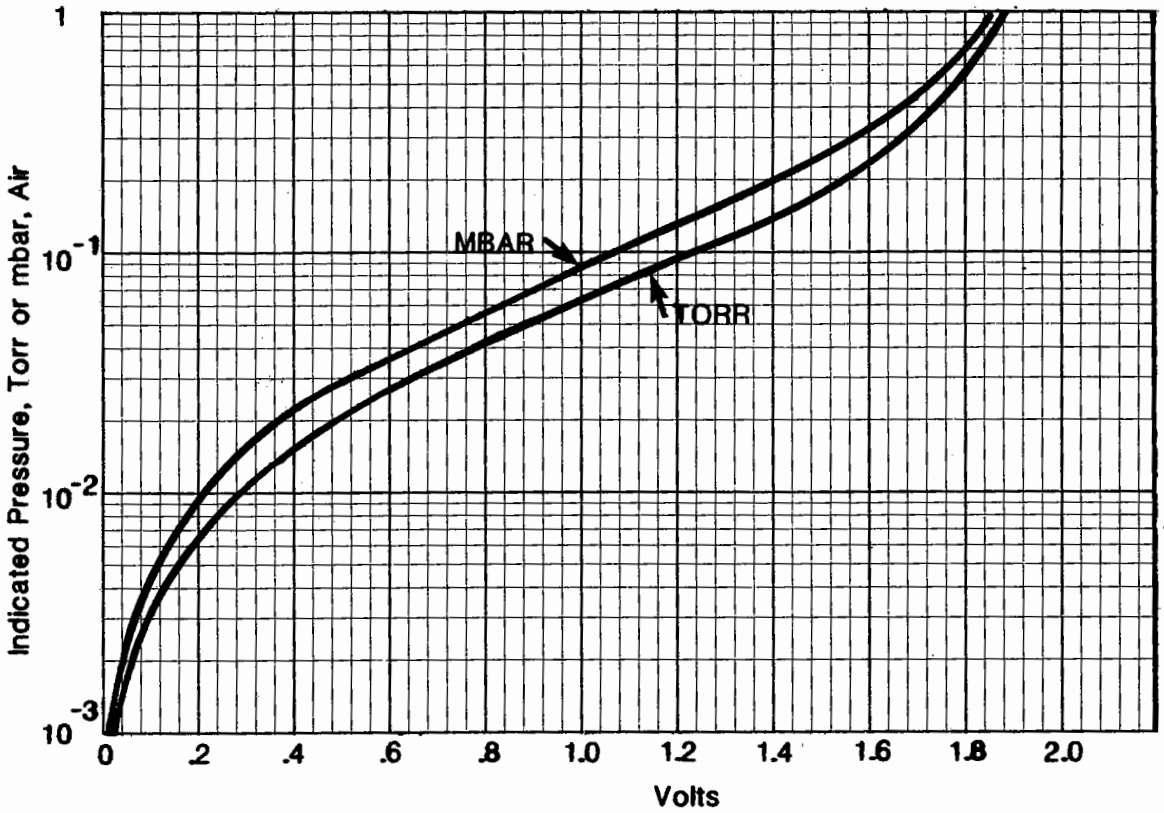


Fig. 4-4. THERMOCOUPLE GAUGE RECORDER OUTPUT

2. Electrometer - The electrometer output is available on the IG accessory connector (refer to Section 3 for pin information). This is a 0 to -4.0V dc signal corresponding to the meter reading of 0 to 19.9 with a source impedance of 2Kohms. Remote meter operation is also possible with an appropriate series resistor.

3. Pressure - The pressure output is available on the IG accessory connector (refer to Section 3 for pin information). This is a 0 to -5V dc signal corresponding to the entire pressure range, (1 volt/decade) with a source impedance of 2Kohms. This output is only operational when the autorange switch is on.

   The output is as follows:

0 to -1V dc	linear corresponding to the 8 range	(Pa 6 range)
-1 to -2V dc	linear corresponding to the 7 range	(Pa 5 range)
-2 to -3V dc	linear corresponding to the 6 range	(Pa 4 range)
-3 to -4V dc	linear corresponding to the 5 range	(Pa 3 range)
-4 to -5V dc	linear corresponding to the 4 range	(Pa 2 range)

   This output is well suited for remote meter operation since both decade and within a decade information is available. Since the output may be erroneous when the filaments are off or when in manual range operation, a -10 to -12V dc signal is applied during this period.

4.12 Long Cable Operation

The controller is capable of supplying rated filament power to a tube with up to a 40 foot gauge cable. A longer cable can be used if the filament and grid wire size is increased to maintain a line resistance of less than .06 ohms per lead. Consult Granville-Phillips for long cables.

Degas power of 80 watts nominal is available using a 10 foot cable. The degas power at the tube will decrease with longer cable lengths. This will result in a longer period of time being required to degas the tube when long cables are used.

4.13 Digital BCD Output Option

This section deals primarily with use and logic of the output lines provided. All signal lines have been buffered before reaching the connector. This buffering provides two important functions; first, it allows for easier interfacing to external equipment and, secondly, it provides some measure of isolation for the BCD circuitry.

The logic provided on all signal lines is positive true logic capable of driving 2 standard TTL loads or CMOS logic at a 5 V level. As indicated in Section 3.5 there are 18 signal lines plus the ground connections with the pin outs in a logical order. The data valid line (pin 1) is used to indicate when the data is latched in the data latches and stable, ready for use. Fig. 4-5 shows the period width and shape of this pulse.

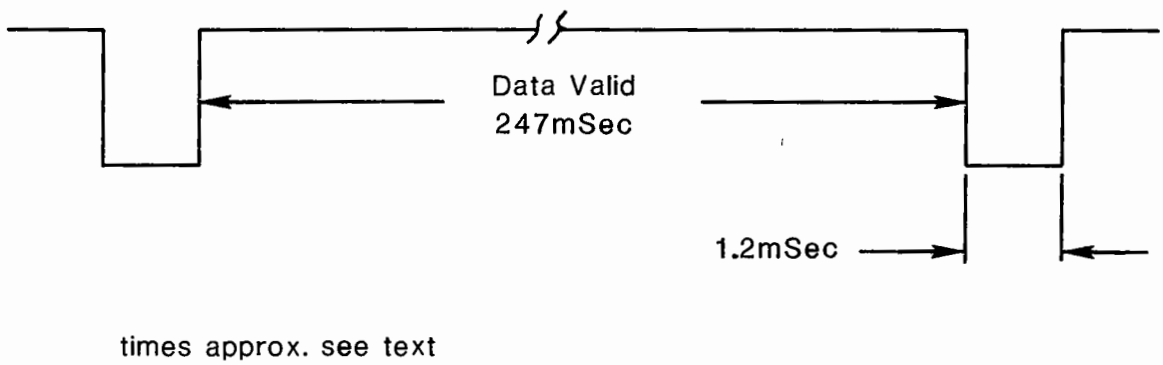


FIG. 4-5 TIMING DIAGRAM OF DATA VALID LINE FOR BCD OPTION

The times shown are nominal values that can vary up to $\pm$ 10% due to component tolerances and temperature. The ideal time to take data would be after the rising edge of the "data valid" period. During this time (approximately 178 msec) the data presented at the BCD outputs, NOT THE PC OR FIL STATUS, is steady and will not change.

The process control and filament status lines are real time lines that reflect the status of the control relays in the 280 controller. The information is valid no matter what state "data valid" is in.

NOTES

SECTION 5

THEORY OF OPERATION

5.1 General Theory of Operation of Ion Gauge Tubes

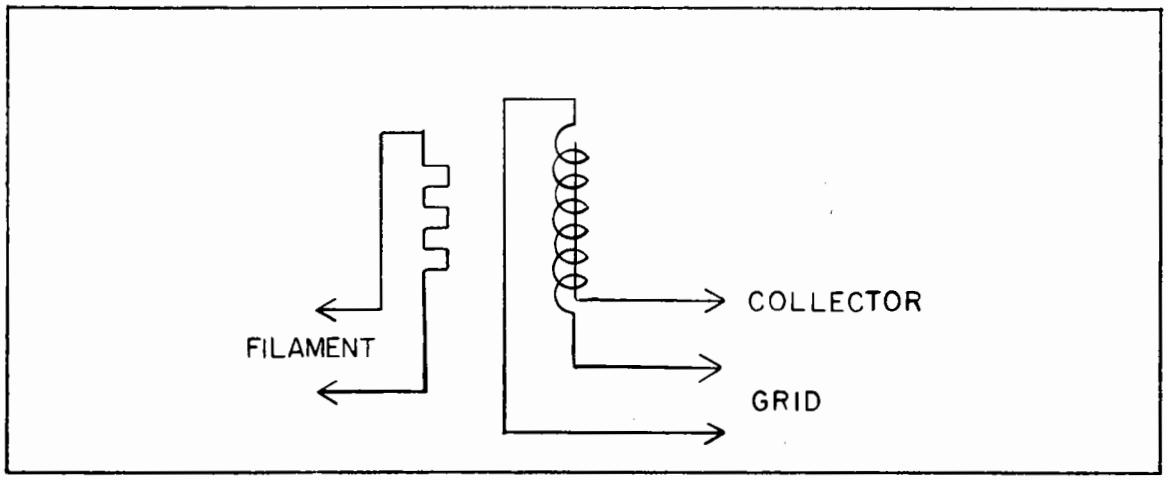


FIG. 5-1 SCHEMATIC OF COMMON IG TUBE

The pressure indication of a Bayard-Alpert gauge is based on the ionization of gas molecules by a constant flow of electrons. The functional parts of the gauge, shown schematically in Fig. 5-1, are the filament, the grid, and the collector. In ionization gauge tubes as well as some electronic vacuum tubes the filament serves as the cathode (hot cathode) or emitter. It's purpose is to emit a stream of electrons. This is accomplished by heating and thereby imparting energy to the molecules thus causing electrons to be boiled off. The rate at which electrons move from the cathode is dependent on the filament temperature and grid potential which must both be highly controlled by the filament power supply and the grid bias supply.

The grid (anode) serves to control the electron beam or more accurately the speed of the electron. In the ion gauge tube the grid is placed at a positive voltage such that most of the electrons emitted at the filament are accelerated through the grid structure and into a drift or interaction region which is the volume surrounding the collector, enclosed by the grid.

Since the ion gauge is open to the vacuum system and since vacuum is the measure of gas particles absence or presence there will be a varying density of gas particles in the electron interaction region depending on the vacuum pressure. The electrons emitted from the cathode will now collide with the gas particles dislodging electrons and producing ions in numbers that are proportional to the gas density. The collector is at a negative potential and thus the positive ions are attracted to it and a current (I^+) is produced also being proportional to gas density. The electrons being negative particles are attracted to the grid structure, this current is noted as I^-. It is these two currents I^+ and I^- which allows the precise measurement of the vacuum. Through electronic detection and control, currents are monitored and vacuum pressure indicated.

Fig. 5-2 illustrates how the controller derives a pressure indication from the gauge. Once emitted, the electrons see an acceleration potential between the filament and the grid. This potential amounts to approximately 150V and provides the electron with its ionization energy. The filament bias supply and the grid bias supply provide the acceleration potential. The accelerated electrons then enter the drift region interacting with the gas molecules present in the vacuum and producing the ionization current I^+ which flows through the electrometer. The electrometer converts the small current into a usable signal which is converted to digital data and displayed.

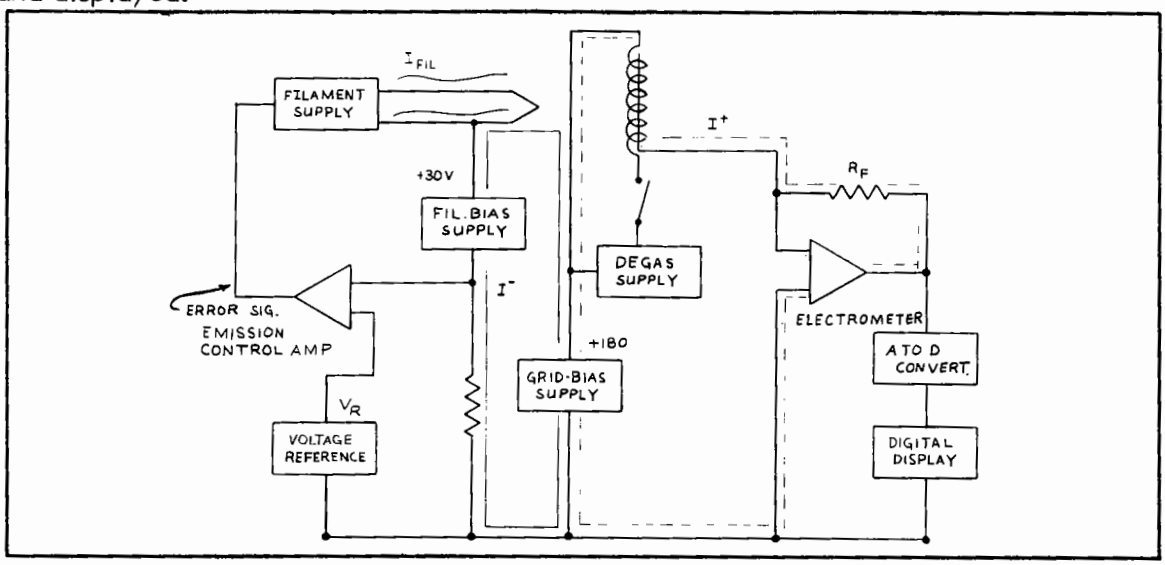


FIG. 5-2 BLOCK DIAGRAM OF IG CONTROLLER

Degas is provided through the degas supply, which causes a large current to flow through the grid structure. This current produces heating and thus causes the elements to outgas and clean themselves. Pressure measurements are not possible during degas operation.

5.2 Power Supplies (Refer to Fig. 5-3)

CR26 is used as two full wave rectifiers supplying $\pm$ 23V to the filters C19 and C20. These two raw voltages are then zener regulated to $\pm$ 12V dc by CR1 and CR2, with current limiting provided by R1 and R2. A +6V dc reference voltage is generated by R3, a current limiting resistor and CR3, a 6 volt zener. These voltages are distributed throughout the 280 controller.

The 180V grid bias is provided by CR27 and C21, a half wave rectifier on the 145VRMS winding. The sync signal, a 120 Hz negative 23 volt signal, is also supplied by CR26 acting as a full wave rectifier.

Power for the analog to digital converter,display and BCD option is supplied by the $10V_{RMS}$ winding which feeds the converter board.

A line voltage selection switch is provided and is located near the power transformer T4. Through the positioning of the two switches, three different line voltage options are provided (i.e., 115V, 230V, 100V nominal). The switches need only to be positioned per the inscription on the switch bracket. NOTE THAT THE POWER CORD SHOULD BE UNPLUGGED when switching these switches.

5.3 Degas Supply (Refer to Fig. 5-3)

The power for the resistance heating type degas is supplied by T4 winding terminals 9 and 10. Note that this winding provides power both for degas and the emission/filament circuitry. Therefore, measurement of pressure is not possible because during degas the filament cannot be powered.

5.4 Filament On-Off (Refer to Fig. 5-4)

Transistor Q14 and filament relay K3 control the power to the filament. During manual operation the base of Q14 is turned on by the +10V signal applied from C7 when the filament switch is momentarily toggled to the on/off position. This energizes K3 establishing a holding path through R26 and R24. The voltage at test point V then drops to -12V dc. Momentarily toggling S1 again to the on/off position applies the negative signal to the base of Q14 turning it off causing relay K3 to de-energize. In the auto on position of switch S1 the output of TC #2 process control voltage comparator IC 13-A whose output is either in negative or positive saturation is used, instead, to control the base of Q14.

Remote operation can be performed at any time by use of the IG accessory connector. A momentary short between J3-7, H and J3-9, K will turn on the filament and between J3-8, J and J3-9, K will turn off the filament.

Once energized there are two automatic sources which will result in a filament shutdown. If the output of the emission control amplifier exceeds -6V dc the base of Q14 will be turned off causing the filament relay to de-energize. In addition when not in the auto on mode of filament operation, should the ion current rise to a level corresponding to 3×10^{-3} Torr, transistor Q9 turns on removing the +12V to relay K3, pin 6, removing the source of base current for Q14.

5.5 Emission Control (Refer to Fig. 5-4)

The emission control circuit consists of: An emission reference supply, an emission sensing resistor RA9-4, a high-gain amplifier IC10-A, a synchronized pulse generator composed of Q11, Q17 and T1, and a triac SCR-1 in series with the filament. The output of IC10-A is shorted to its input through contacts 14 and 15 of K3 until the filament circuit is turned on. When the filament circuit is energized, the positive input from the emission reference supply (0.3 to 1.2 volts depending upon the setting of the emission adjust potentiometer R28) to pin 2 of IC10-A results in a negative going output from IC10-A. This increases the output of the current source Q11, which in turn fires unijunction Q17 at earlier and earlier times in the power line cycle. Pulses from Q17 are coupled to the triac, SCR-1, through transformer T1. These pulses cause SCR-1 to conduct for the remainder of the half cycle, thereby making possible current through the filament. As IC10-A output becomes more negative, the filament is turned on for a larger fraction of the half cycle. The resulting heating of the filament generates the emission current through emission sensing resistor RA9-4. The resulting emission signal voltage serves as a feedback signal to IC10-A, closing the control loop. The signals which synchronize the pulses from Q6 with the power line are obtained from the sync signal generator.

5.6 Emission Sensing Amplifier (Refer to Fig. 5-4)

IC10-B and its associated components form a conventional inverting amplifier with a gain of two and are used to drive the ion gauge meter when the emission switch is held in the adjust position.

5.7 Electrometer Circuit (Refer to Fig. 5-5)

A high gain negative feedback type amplifier consisting of Q20 and IC9-A is used so that the collector electrode is normally maintained within millivolts of ground potential. Due to the high input impedance of Q20, essentially all of the ions from the collector electrode must flow through the feedback resistor, R_f, of Fig. 5-2. Since the amplifier input is maintained at ground potential by the high loop gain, the output voltage is the product of the ion current times the feedback resistance. This output is used to supply information to the recorder output, converter, and autoranging circuit. The collector lead is attached to the gate of one side of the dual JFET Q20 through a protection network consisting of a surge voltage protector, C1, R4, CR4 and CR36. The other gate is grounded. The JFET is used as a source follower and is coupled to operational amplifier IC9-A's differential input. The loop is

then closed around the appropriate feedback network dependent upon the decade which is selected by JFET switches Q18, Q19 and Q10. Amplifier IC9-B is a non-inverting amplifier having a unity gain which prevents loading of the divide-by-ten network consisting of R17 and R18.

Transistors Q6, Q7 and Q8 along with their associated components interface the logic levels of the nand gates to that required by the JFET switches.

5.8 Pressure Amplifier (Refer to Fig. 55)

Amplifiers IC8-A, IC8-B along with the associated resistor array form a pressure amplifier whose output is linear within a decade and logarithmic over the decade range. The output is as follows:

Range	Output
10^{-8} Torr/mbar	0 to -1V
10^{-7} Torr/mbar	-1V to -2V
10^{-6} Torr/mbar	-2V to -3V
10^{-5} Torr/mbar	-3V to -4V
10^{-4} Torr/mbar	-4V to -5V

The pressure amplifier output is valid only when the filament is on and the autoranging is on. If the filament and/or the autoranging is off, the pressure amplifier output will be -10 to -12V dc.

5.9 Autoranging (Refer to Fig. 5-6)

The autoranging circuit consists of a pair of voltage comparators IC7-A and IC7-B, a clock, IC1-A and IC1-B, a binary up/down counter IC5, digital decoding circuitry IC1, IC2, IC3, and IC4, and drivers. The output of the electrometer is continuously compared to reference voltages corresponding to 9.5% and 117% of the ion gauge display full scale (full scale here means a displayed reading of 10.0) whenever the filament and autoranging are turned on. If the electrometer output rises above 117% or drops below 9.5% of the ion gauge display full scale, the outputs of comparators IC7-A or IC7-B will result in the up/down counter IC5 counting in the direction required at a rate determined by the clock. The clock is a digital type of oscillator designed to have a period of approximately .3 to .4 seconds.

The remaining NAND gates form a decoder to convert the outputs of IC5 to control signals for the electrometer switches and converter. The Truth Table for this logic is shown on the schematic (Ref. Fig. 5-6).

IC14 prevents counting down scale past the 10^{-8} range and also prevents counting up scale past the 10^{-4} range. Reset is accomplished each time power is turned on by the application of a positive pulse to IC5 pin 9.

When the autorange is off, range change is accomplished by using range switch S2. When toggled, S2 supplies either a ground or -12V dc to the comparators, depending which range direction is desired.

5.10 IG Process Control (Refer to Fig. 5-7)

The process control circuit consists of two identical independent relay control circuits and a time delay circuit to allow the pressure reading to stabilize before enabling the process relays. Transistors Q16 and Q15 with their associated components make up the time delay circuit. It is necessary for the output of the emission control amplifier IC10-A to exceed -0.6V dc before Q16 can turn on charging C13 and allowing Q15 to turn on. This applies power to the two relay coils.

IC6-A and IC6-B are voltage comparators having as their inputs a voltage corresponding to the desired set point and the output of the pressure amplifier. When the pressure is lower than the set points selected the amplifier switches from positive saturation to negative saturation turning on the relay driver transistor and energizing the relay. Each comparator has regenerative feedback which causes hysteresis of approximately 15% of a decade.

5.11 Thermocouple Circuit (Refer to Fig. 5-8)

The thermocouple circuit consists of a transducer power supply, two identical amplifiers IC11 and IC12, and meter circuits. Only one circuit will be discussed since operation is identical.

Power to heat the filament of the GPC 270006 transducer is regulated by a pair of back to back zeners, CR31 and CR32, whose output signal is an approximate square wave as shown in Fig. 5-8. This signal is coupled to the thermocouple by transformer T2. R49 is used to adjust the output of the thermocouple to 10 mV dc when the pressure at the thermocouple is less than 1×10^{-3} Torr. Amplifier IC11 is a low drift, inverting amplifier with a DC gain of 200. Initial adjustment of the amplifier is made by adjusting R54 for an output of +2.0V dc with the 270006 transducer at atmosphere. At a pressure of 1×10^{-3} Torr or lower the output of the amplifier is reduced to zero due to the +10 mV input from the thermocouple. The amplifier output is used to power the meter.

5.12 Thermocouple Process Control (Refer to Fig. 5-9)

The thermocouple process control circuit consists of two identical voltage comparators IC13-A and IC13-B, and relay drivers Q21 and Q22. Again only one channel will be discussed since they are identical. The output of the thermocouple amplifier is compared with the output of the set pot through resistors RA12-1 and RA12-2. Voltage comparator IC13-A is at negative saturation when the pressure is above the desired set point. When the pressure input decreases to the desired set point the output of the amplifier switches to positive saturation turning on the relay driver and energizing the relay. The comparator has regenerative feedback which provides hysteresis operation.

The output of IC13-A is also used to control the filament relay (refer to Fig. 5-9).

5.13 Digital Display (Refer to Fig. 5-10)

Physically the display section is comprised of U401 thru U404., LED's 401 thru 403, and R401 and R402. U401 thru U404 are .43 inch large, high efficiency 7 segment display units. The LED's are high intensity red light emitting diodes. R402 and one of the LED's, since one is always on, provides a constant load to the +6V reference supply. It is important that this load is not changed as it will affect the regulation in the reference supply. R401 is used to limit the current supplied to a portion of the display.

In decade information is provided by U401 thru U403. U404 provides decade or range information. LED's 401 thru 403 indicate the units of measure the controller displays.

5.14 Converter Section (Refer to Fig. 5-11)

The converter section (board) is comprised of five major circuits; power supply, range encoder, analog to digital converter (ADC), control logic and display driver section. The converter section derives its power and signal inputs from the 280 controller main section. These signals, with the exception of AC power, are routed through the display board via J10 and J20 connectors. 10 volt RMS power is supplied via a shielded 2 conductor cable providing power for CR201, a full wave rectifier bridge. VR201 and its associated filters then regulate the rectified voltage to a +5V dc level which is distributed throughout the converter board,

and to the BCD output option board. In addition to this positive voltage a -5V dc reference is produced by zener (CR204) regulation of the -12V (Fig. 5-5) supply brought up from the 280 main board via J10 and J20. CR201 and its related components are used to provide the +1V reference for the ADC. All of the power supply lines are provided with AC and RF filtering.

The analog to digital converter (ADC) is a dual slope integrating type converter housed in IC201. Along with the A to D function this IC also provides timing, control and multiplexing signals. R205 and R206 provide input signal conditioning and with C205 and C207 provide filtering insuring a noise-free display. The clock for synchronizing the multiplexing output format is provided by the ADC and is used to time the BCD data selection. The BCD data from the ADC and the BCD decade encoder are sent to the multiplex data selector IC202.

The data selector is controlled by IC209 which gates the range digit select with the polarity signal decoded by IC210. Thus IC202 passes to the display and BCD option either the decade data from U203 or the within-decade data from the ADC. IC210 and the remaining three gates of IC209 generate a lengthened End of Conversion (EOC) signal which is used on the BCD option for data timing.

The display circuit is comprised of IC211, a BCD to 7-segment decoder and driver, and IC208, a digit select driver. The BCD to 7-segment decoder and driver receives multiplexed BCD data from the data selector, IC209, and drives all of the display digit segments simultaneously. The digit select driver completes the circuit for segment current one digit at a time, receiving timing pulses from the ADC. Transistor Q1, driven from the ADC's polarity line, drives the decimal point on the display board. Other signals are produced or passed through the display and converter board to service the BCD output option.

5.15 Digital BCD Output Option (Refer to Fig. 5-12)

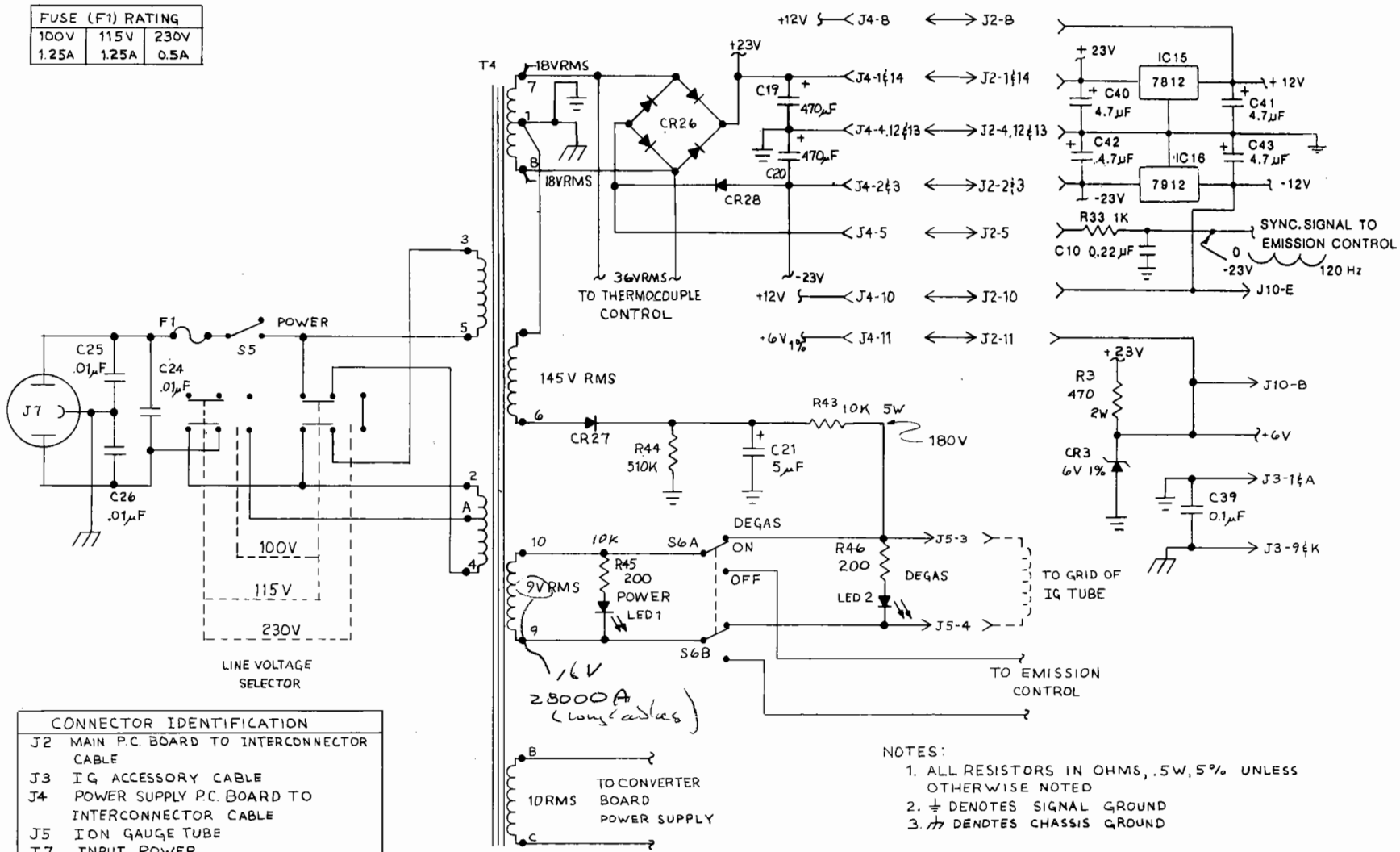
The BCD output option is comprised of 4 data latches U304, U305, U306, and U307, output buffer/drivers U308, U309, and U310, and signal conditioning and control provided by U301, U302, and U303. The signal conditioning circuitry processes the BCD and digit select data so that it is presented to the data latches in the proper form.

IC301A and B are wired as an R-S flip-flop to detect the presence or absence of the ten's select pulse. A "1" at the Q4 output of IC304 is latched when the tens select pulse is present.

Overrange condition is detected by IC301D by sensing the non-coincidence of the range digit enable and the range digit select pulses. A "1" is latched in the Q1 output of IC304 when overrange is detected by sensing a missing range digit enable pulse. This latched "1" is then "ored" with the 4 BCD data lines by IC303 going to the units and tenths latches thereby causing the illegal code of all 1's to be latched during overrange.

The latch for the range digit bits is not affected by overrange since it is connected directly to the BCD data lines. This allows proper range data to be latched at all times.

All of the BCD data present at the data latch outputs, plus the "data valid", process control status, and filament status are buffered by the output drivers IC308, 309, and 310 so that TTL as well as CMOS loads can be driven.



CONNECTOR IDENTIFICATION	
J2	MAIN P.C. BOARD TO INTERCONNECTOR CABLE
J3	IG ACCESSORY CABLE
J4	POWER SUPPLY P.C. BOARD TO INTERCONNECTOR CABLE
J5	ION GAUGE TUBE
J7	INPUT POWER
J10	MAIN BOARD TO DISPLAY BOARD
J20	DISPLAY BOARD TO CONVERTER BOARD

NOTES:
1. ALL RESISTORS IN OHMS, .5W, 5% UNLESS OTHERWISE NOTED
2. ⏚ DENOTES SIGNAL GROUND
3. ⏚ DENOTES CHASSIS GROUND

FIG.5-3 POWER SUPPLY SCHEMATIC

CONNECTOR INDENTIFICATION	
J1	COLLECTOR IN PUT
J2	MAIN P.C. BD. TO INTERCONNECT CABLE
J3	ION GAUGE ACCESSORY CABLE
J4	POWER SUPPLY P.C. BD. TO INTERCONNECT CABLE
J5	ION GAUGE TUBE
J10	MAIN BOARD TO DISPLAY BOARD
J20	DISPLAY BOARD TO CONVERTER BOARD

NOTES:
1. ALL RESISTORS ARE IN OHMS, .5W, 5% UNLESS OTHERWISE NOTED
2. RESISTOR ARRAYS (RA) ARE 1/8W
3. ⏚ DENOTES SIGNAL GROUND
4. ⏚ DENOTES CHASSIS GROUND
5. ◇ DENOTES TEST POINTS

FIG. 5-4
EMISSION CONTROL SCHEMATIC

DECADE	SWITCH Q18	SWITCH Q19	SWITCH Q10	EQUIVLENT RF
10^{-4}	ON	OFF	ON	100K
10^{-5}	OFF	ON	ON	1M
10^{-6}	OFF	ON	OFF	10M
10^{-7}	OFF	OFF	ON	100M
10^{-8}	OFF	OFF	OFF	1000M

NOTES:
1. ALL RESISTORS IN OHMS, .5W, 5% UNLESS OTHERWISE NOTED
2. RESISTOR ARRAYS (RATYPES) 1/8W
3. ⏚ DENOTES SIGNAL GROUNDS
4. ⏚ DENOTES CHASSIS GROUNDS
5. ◇ DENOTES TEST POINTS

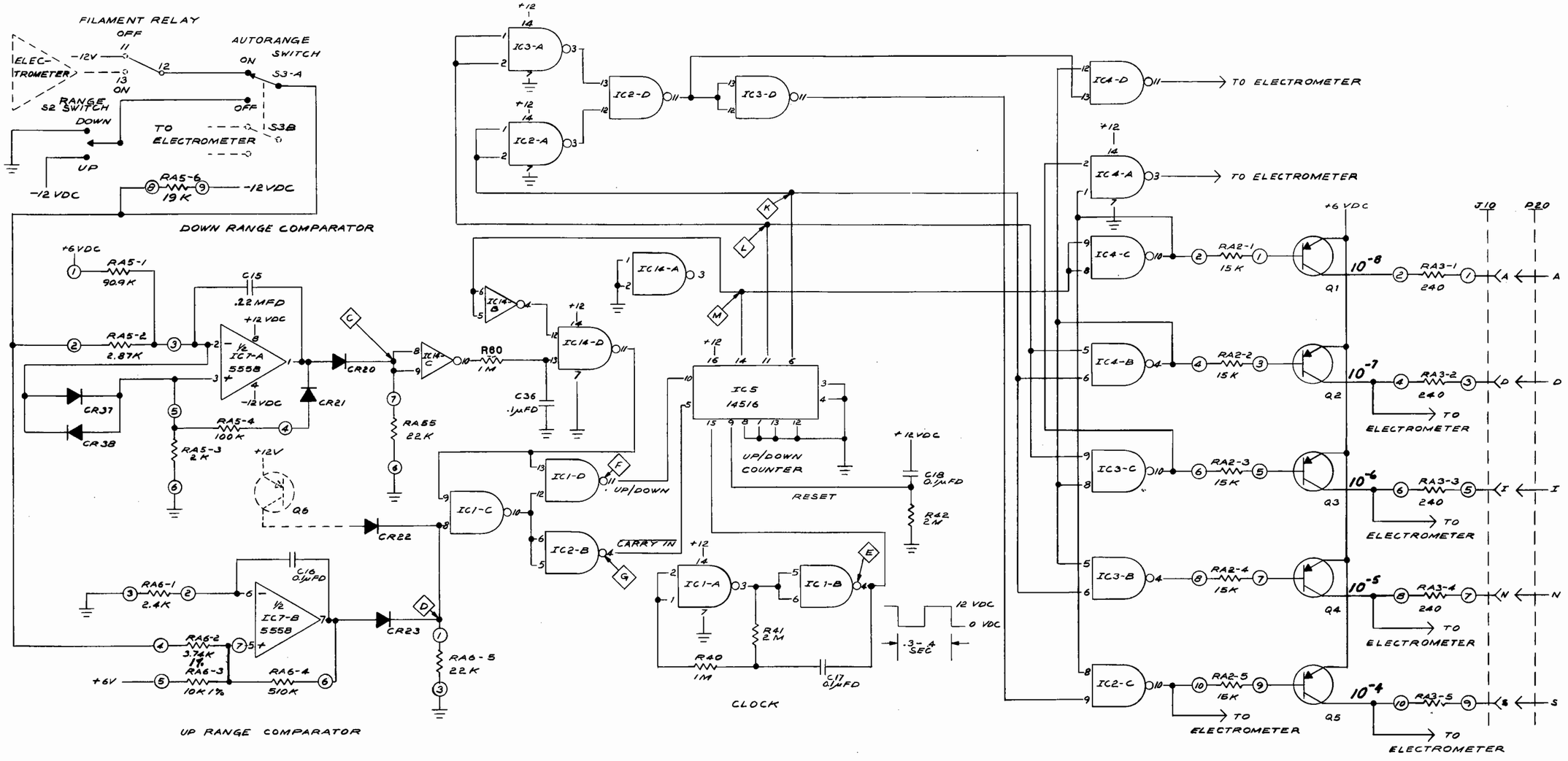
CONNECTOR INDENTIFICATION
J1 COLLECTOR INPUT
J3 IG ACCESSORY
J10 MAIN BOARD TO DISPLAY BOARD
J20 DISPLAY BOARD TO CONVERTER BOARD

Note 1:

PRESSURE AMPLIFIER

007013 101

FIG.5-5
ELECTROMETER SCHEMATIC



DIGITAL DECODER TRUTH TABLE

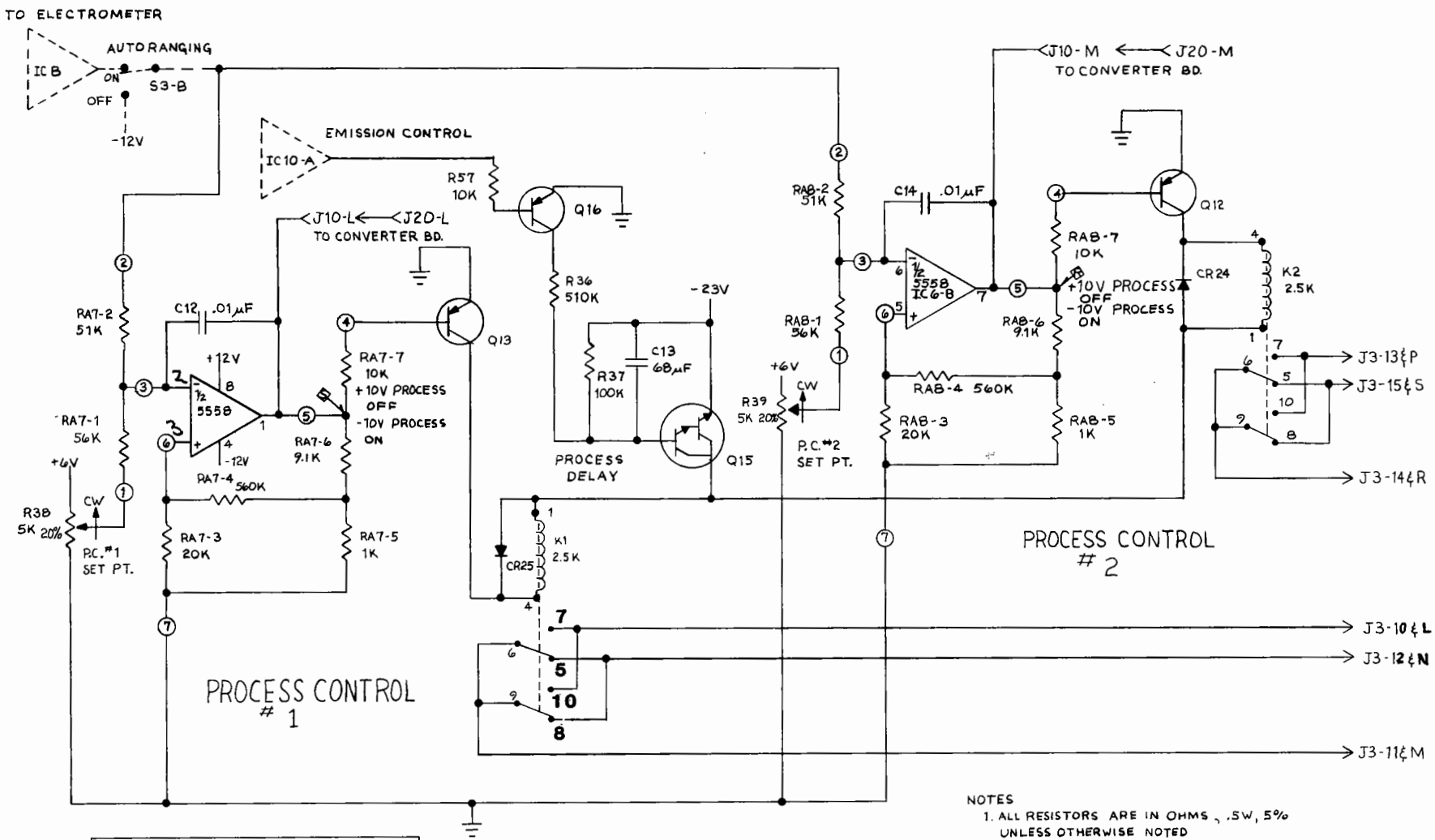
DECADE	IC5			IC2			IC3				IC4			
	N	L	K	PIN 3	PIN 10	PIN 11	PIN 3	PIN 4	PIN 10	PIN 11	PIN 3	PIN 4	PIN 10	PIN 11
10^{-4}	0	0	0	1	0	0	1	1	1	1	0	1	1	1
10^{-5}	0	0	1	0	1	1	1	0	1	0	0	1	1	0
10^{-6}	0	1	0	1	1	1	0	1	0	0	1	1	1	0
10^{-7}	0	1	1	0	1	1	0	1	1	0	0	0	1	1
10^{-8}	1	0	0	1	1	0	1	1	1	1	1	1	0	1

U/D COUNTER TRUTH TABLE

ELECTROMETER OUTPUT	C	D	IC1 PIN 10	F	G	ACTION
GREATER THAN -.19VDC	0	1	1	1	0	COUNT DOWN
LESS THAN -.19VDC AND GREATER THAN -2.34 VDC	1	1	0	1	1	STEADY STATE
LESS THAN -2.34 VDC	1	0	1	0	0	COUNT UP

NOTES:
1. ALL RESISTORS ARE IN OHMS, .5W, ±5% UNLESS OTHERWISE SPECIFIED.
2. RESISTOR ARRAYS (RA TYPES) ARE V8 W.
3. ⏚ DENOTES SIGNAL GROUND.
4. ALL QUAD NAND GATES ARE 14011 TYPE.
5. ◇ DENOTES TEST POINT.

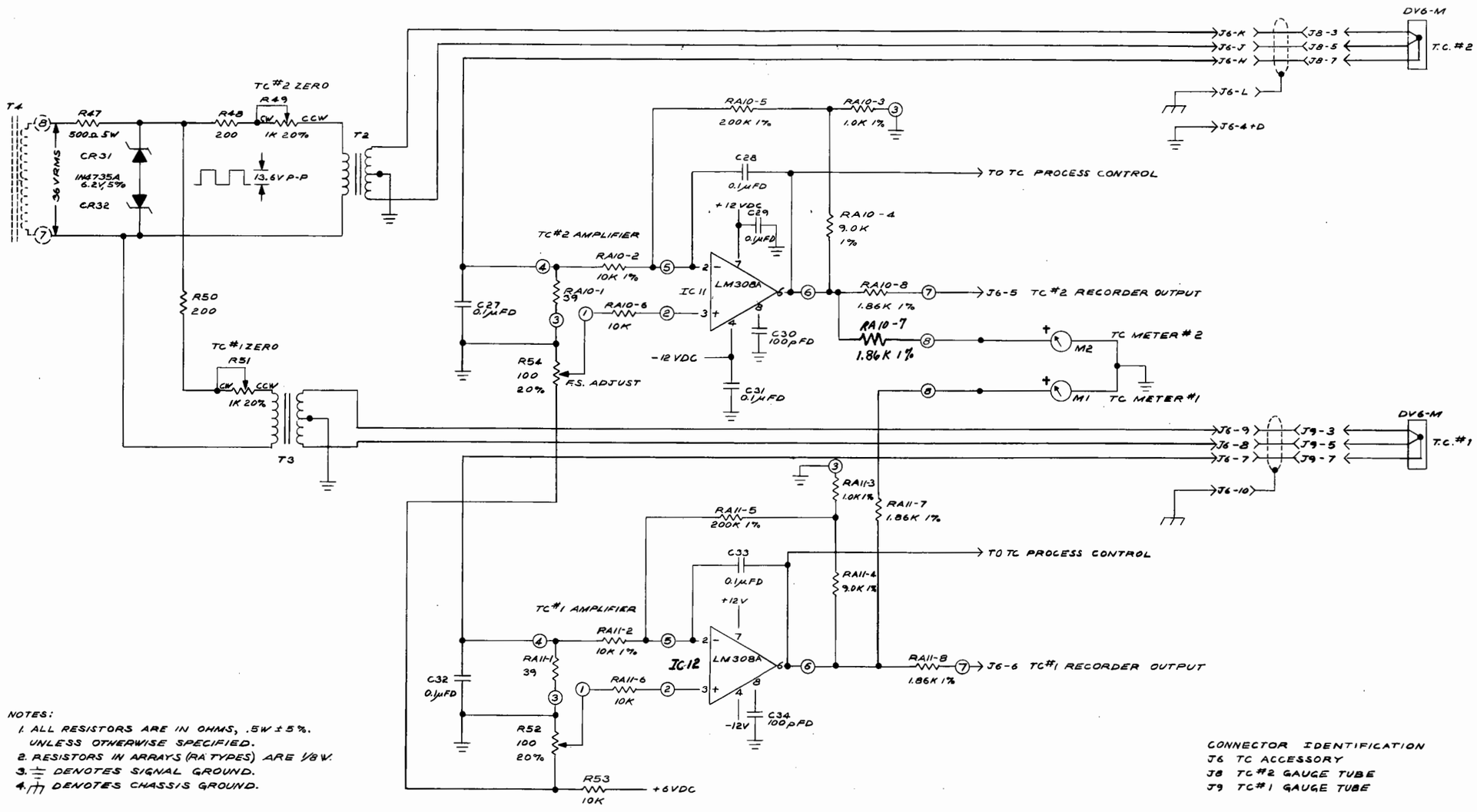
FIG.5-6
AUTORANGING SCHEMATIC



CONNECTOR IDENTIFICATION	
J3	IG ACCESSORY
J10	MAIN BOARD TO DISPLAY BOARD
J20	DISPLAY BOARD TO CONVERTER BOARD

NOTES
1. ALL RESISTORS ARE IN OHMS, .5W, 5% UNLESS OTHERWISE NOTED
2. RESISTOR ARRAYS (RA TYPES) ARE ⅛ W
3. ⏚ DENOTES SIGNAL GROUND
4. ⏚ DENOTES CHASSIS GROUND
5 ◇ DENOTES TEST POINT

FIG. 5-7 ION GAUGE PROCESS CONTROL



NOTES:
1. ALL RESISTORS ARE IN OHMS, .5W ± 5%. UNLESS OTHERWISE SPECIFIED.
2. RESISTORS IN ARRAYS (RA TYPES) ARE 1/8 W.
3. ⏚ DENOTES SIGNAL GROUND.
4. ⏚ DENOTES CHASSIS GROUND.

CONNECTOR IDENTIFICATION
J6 TC ACCESSORY
J8 TC #2 GAUGE TUBE
J9 TC #1 GAUGE TUBE

FIG. 5-8
THERMOCOUPLE SCHEMATIC

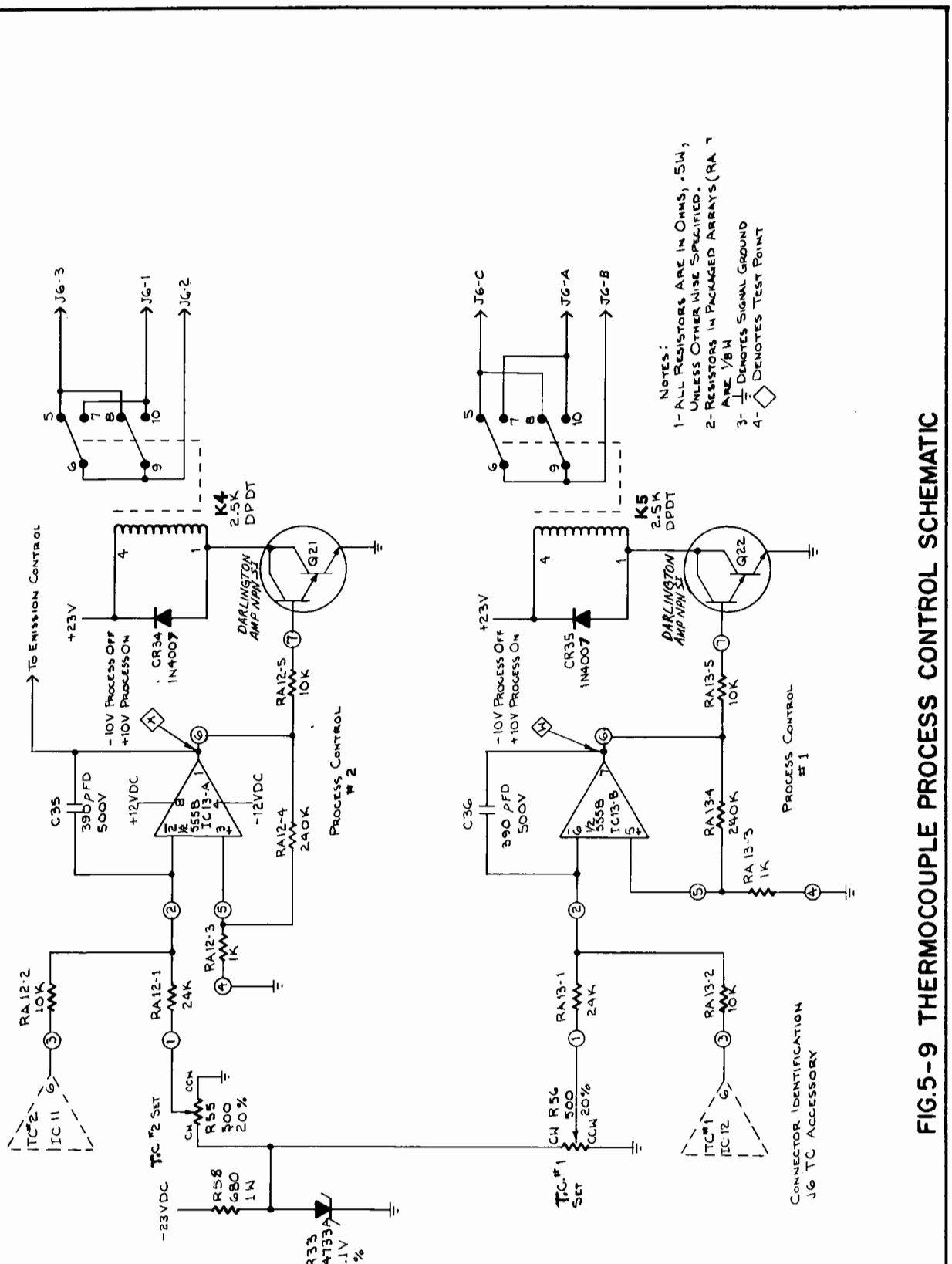


FIG.5-9 THERMOCOUPLE PROCESS CONTROL SCHEMATIC

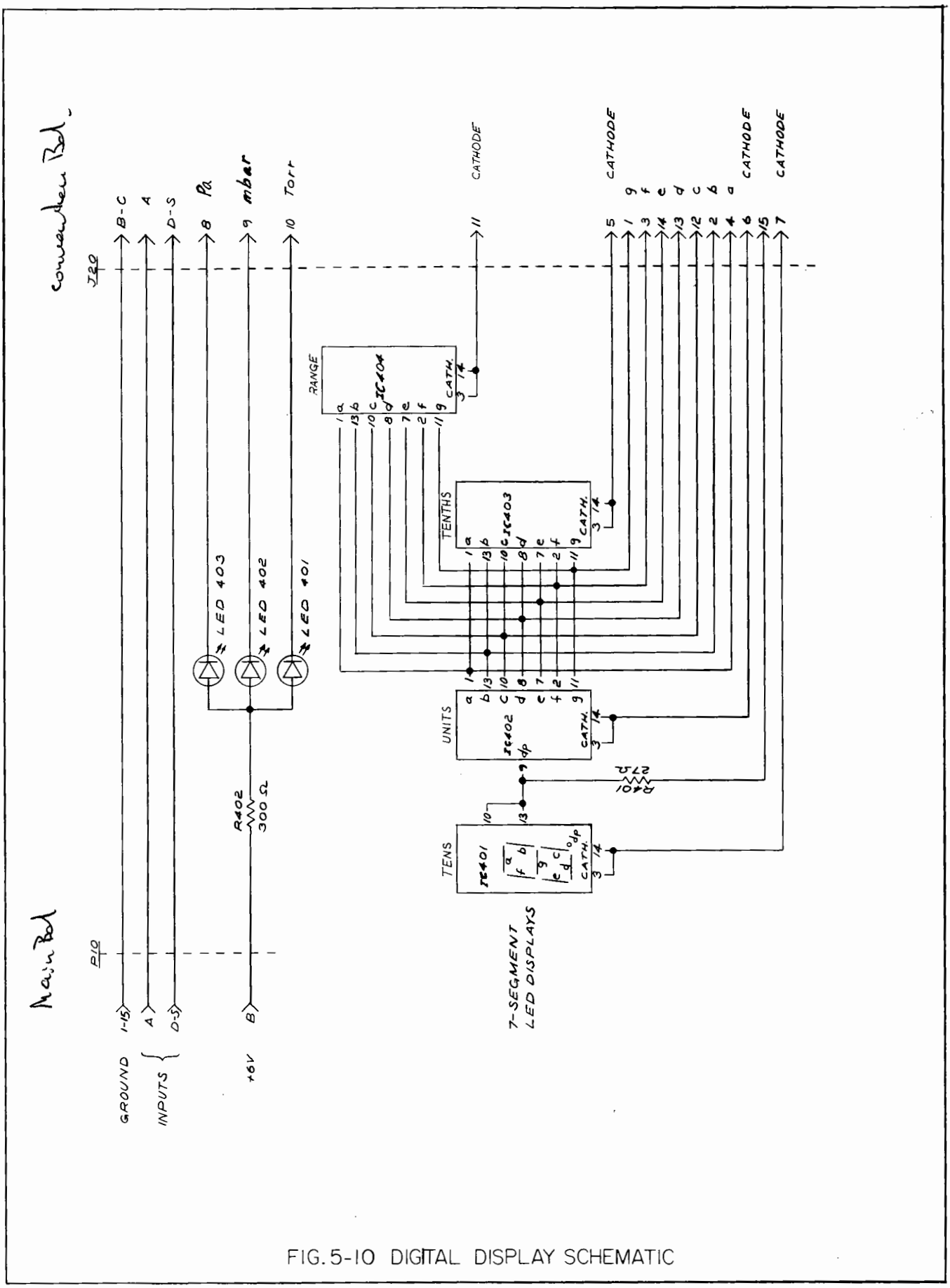


FIG. 5-10 DIGITAL DISPLAY SCHEMATIC

NOTES

1. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
2. ALL RESISTORS ARE 5%, 1/4 WATT IN OHMS UNLESS OTHERWISE NOTED.

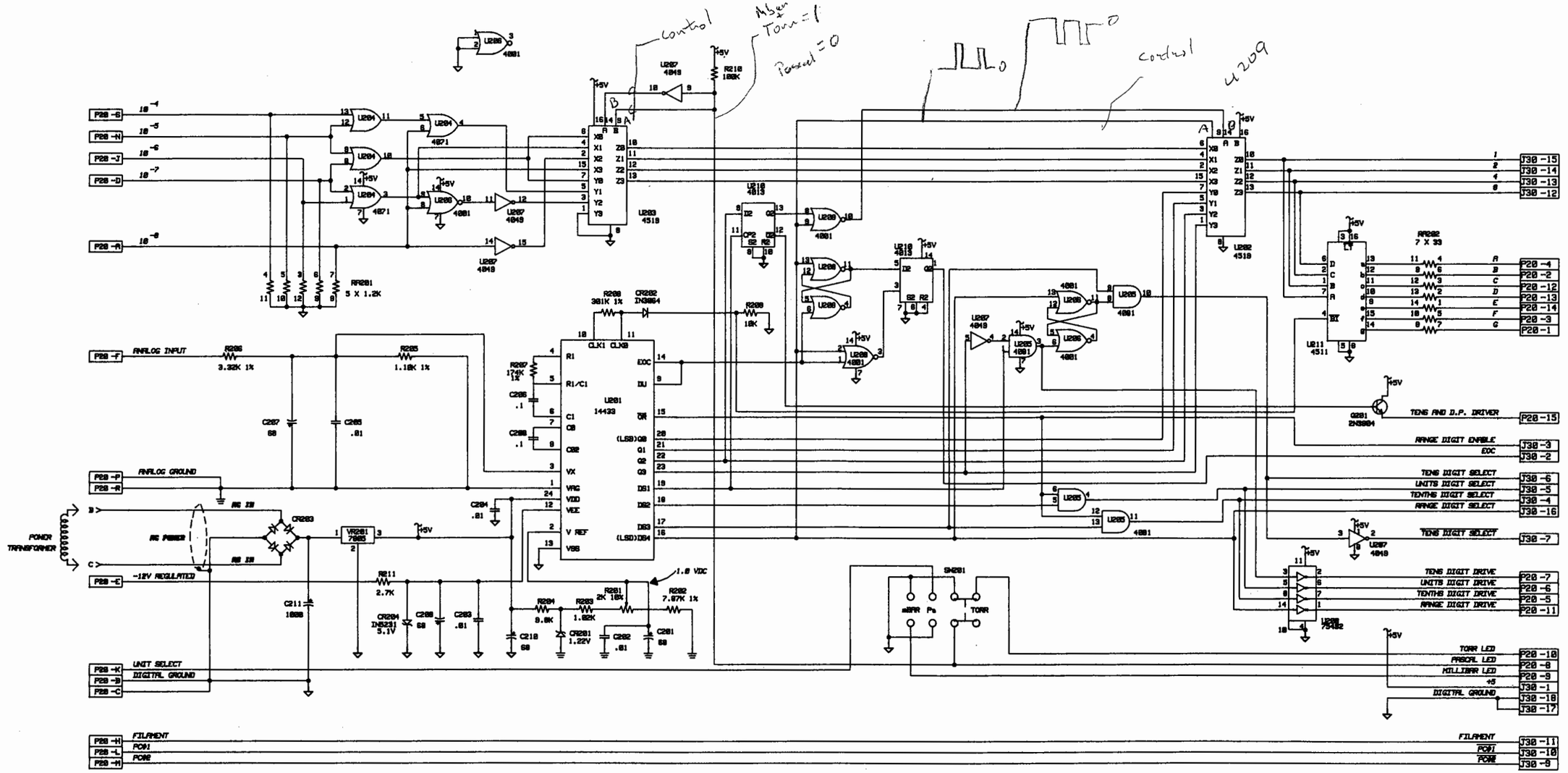


FIG. 5-11 SCHEMATIC OF CONVERTER BOARD

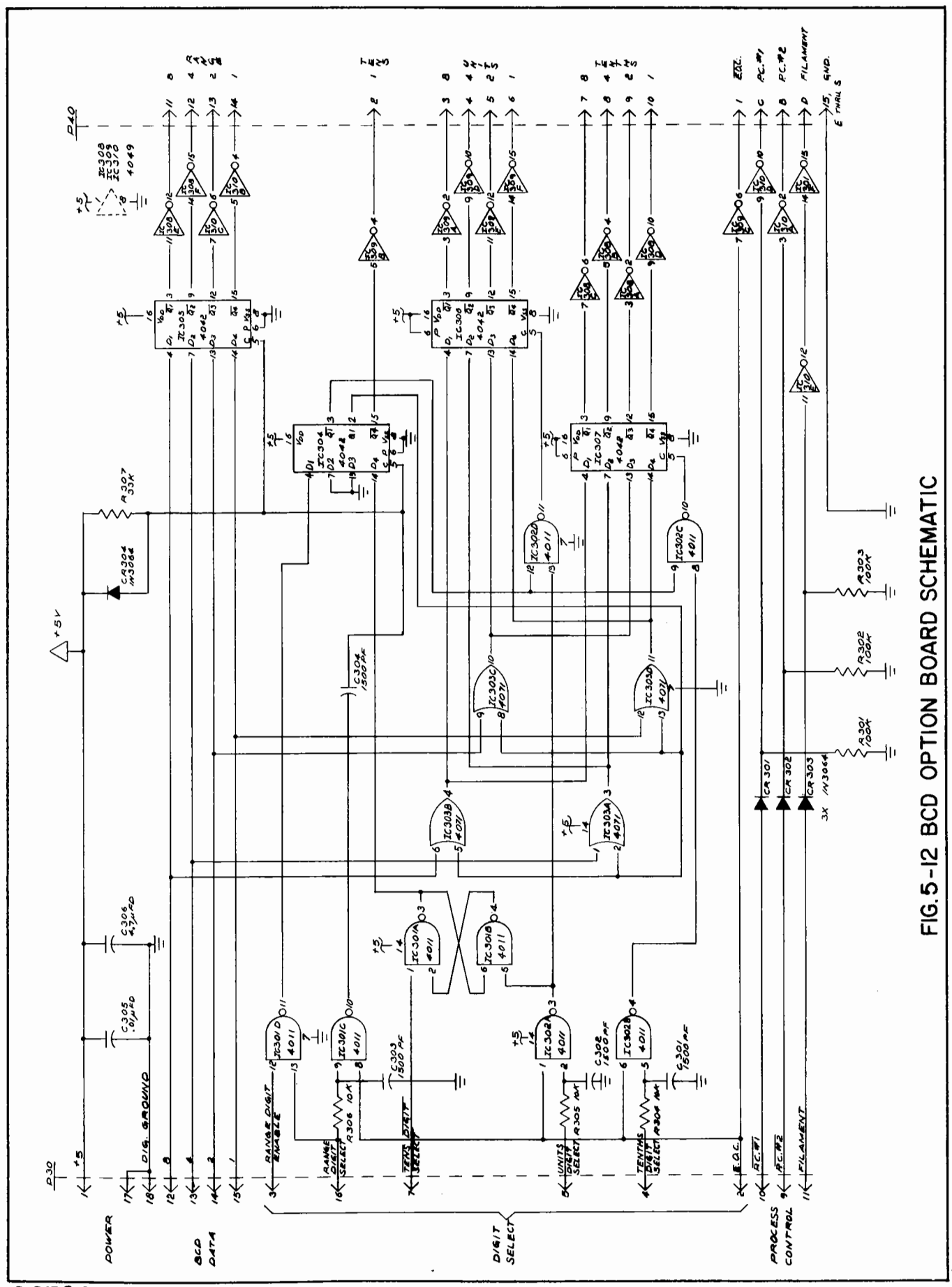


FIG. 5-12 BCD OPTION BOARD SCHEMATIC

007000 100

SECTION 6

MAINTENANCE AND CALIBRATION

6.1 General Information

Although this instrument was designed using as many commonly available components as possible, thus allowing easy service, it is still recommended that only qualified technical personnel attempt repairs.

Should difficulties be encountered in the use of your controller, the following list of symptoms and remedies, along with the circuit descriptions of Section 5, the schematics, and the parts location diagrams can prove useful in quickly getting back into operation.

The warranty on this instrument provides for free service at the factory for the first full year after delivery, and at a reasonable service charge thereafter. However, since the majority of parts are readily available at your local electronics supply stores, it may, in some cases, prove most expedient for you to repair minor troubles should they occur.

If the prescribed remedies do not correct the troubles, or if additional assistance or special parts are required, contact the Technical Service Department, Granville-Phillips Company, 5675 East Arapahoe Avenue, Boulder, Colorado, 80303. Telephone: 303-443-7660. Repairs properly made with equivalent electronic parts and rosin core solder, which do not damage other portions of the unit, do not represent a violation of the warranty. A desoldering tool is required for satisfactory removal of components from the circuit boards.

Check the following list for the observed symptoms. This listing of symptoms and remedies is not complete, but should be sufficient to solve most problems. All possible causes of failure should be thoroughly explored before attempting any component replacement.

DANGER HIGH VOLTAGE

HIGH VOLTAGE IS PRESENT WITHIN THIS UNIT CAPABLE OF CAUSING INJURY OF DEATH. DO NOT TOUCH CABLE CONNECTIONS OR INSIDE OF THE CONTROLLER WHEN POWER IS APPLIED. FOLLOW SAFE PROCEDURES WHEN OPERATING AND WORKING ON THE EQUIPMENT TO AVOID SHOCK HAZARDS.

CAUTION: It is necessary to use extreme caution when troubleshooting to prevent damage to the CMOS logic elements.

6.2 Guidelines for Troubleshooting

The following guidelines are manufacturer recommended when performing troubleshooting involving these components.

1. Avoid placing static charges on any component.
2. Use a conductive grounded work surface.
3. Use a grounded type of soldering iron.
4. Use conductive envelopes to store or ship CMOS devices.

5. Do not remove or install CMOS devices with power turned on.

6. Do not operate the unit with a portion of the CMOS devices removed.

7. Do not handle the CMOS devices any more than absolutely necessary.

8. Avoid using an ohmmeter for troubleshooting. Rely on voltage measurements to analyze problems.

6.3 Input Power Problems

Problem	Possible Cause	Cure
1. Power light will not light (all functions inoperative.) Refer to Fig. 5-3.	1. Power cord not plugged in.	Plug in power cord.
	2. No power to receptacle.	Restore power to receptacle.
	3. Controller fuse F1 blown.	Replace fuse with correct type and value; 1-1/4A slo blo for 100V operation, and 115V operation, 1/2A slo blo for 230V operation.
	4. Defective transformer T4. Check for continuity of primary winding.	Replace T4 if defective.
	5. Switch S5 defective	Replace S5.
2. Controller power fuse F1 blows as soon as the power switch is turned on. Refer to Fig. 5-3.	1. Incorrect power source. Check power source vs. controller requirements.	Connect controller to proper source of power or reset selector switching as shown in Fig. 4-2.
	2. Incorrect fuse rating.	Use correct fuse. A 1-1/4 or 1.25A "slo blo" for 100V operation and 115V operation, 1/2A "slo blo" for 230V operation.
	3. Defective component of power supply P.C. board. Remove gauge cable, interconnect cable to main board and thermocouple gauge cable. If problem remains, trouble is with T4, CR26, C19, C20, C27, C21.	Locate defective component and replace.

6.4 Power Supply Problems (Refer to Fig. 5-3 and Fig. 6-2)

Whenever a problem persists after elimination of possible external causes by removing all cables but the power cable, and thus appears to be in the controller, the power supplies should be checked first. Use a standard DVM to check the labeled points on Fig. 6-1 and 6-2 for the following outputs with respect to ground:

Problem	Possible Cause	Cure

Test Point (V dc)	Reading (V dc)
+23	+20 to +25
+12	+11 to +13
-23	-20 to -25
-12	-11 to -13
+180	+160 to +200 filament on +180 to +220 filament off
+6	+5.9 to +6.1

If measured voltages do not agree with these readings, it will be necessary to correct this problem before proceeding further. In a great majority of the cases, the location of the fault creating the power supply problem will correct the original problem as well.

1.	Bias supply output less than 160V dc.	1.	Excessive current being drawn from supply, causing current limiting. Determine current by measuring voltage drop across R43. — Locate cause of current drain and correct.
		2.	Insufficient voltage across C21. Open secondary pins 6 and 1 on T4. Rectifier CR27 open. Defective capacitor C21. — Replace faulty component.

6.5 Filament Turn on and Emission Problems (Refer to Fig. 5-4 and Fig. 6-1)

1.	Gauge tube filament will not light when filament switch is toggled (filament indicator light turns on and then after approximately one second turns off).	1.	Gauge tube not connected to gauge cable — Connect gauge tube.
		2.	Gauge cable not connected to controller. — Connect gauge cable.
		3.	Open filament in ion gauge tube. — Replace ion gauge tube or switch to second filament if available.
		4.	Open in gauge cable filament lead. — Repair or replace gauge cable.
		5.	External filament remote control applying a ground to J3-8 or J3-J. — Repair filament remote control circuit.
		6.	Degas switch in the on position. — Place degas switch to the off position.

Problem	Possible Cause	Cure
	7. IC10-A or associated component defective. Using an oscilloscope, verify that the waveform present on pin 1 of IC10-A is as shown on Fig. 5-4 when the filament light is on.	Troubleshoot and repair
	8. Verify that the waveform present at the junction of R33 and C10 is as shown on Fig. 5-3 when the filament light is off. If not CR28, R33 or C10 is defective.	Troubleshoot and repair as necessary.
	9. Attempt to turn on the filament and check for pulses riding on the above waveshape during the time the filament light is on. If not present, check Q11, Q17 and associated components.	Troubleshoot and repair as necessary.
	10. Defective triac SCR1 or pulse transformer T1. Using an oscilloscope check for firing pulses on SCR1 gate to anode 1 (across C23) during period when light is on. If pulses are present, the triac is defective. If pulses are not present, check for shorts across SCR1, C23 or T1.	Troubleshoot and repair.
	11. Defective degas switch, S6, or 9 and 10 of transformer, T4.	Troubleshoot and repair.
2. Gauge tube filament will not light when filament switch is toggled (filament indicator light does not light even momentarily).	1. Incorrect input applied from remote input.	Correct source of remote input. Must be momentary type of input.
	2. Power supply voltage problem.	Refer to Power Supply Problems.
	3. Defective relay K3.	Replace relay.
	4. Defective circuit components R21, R22, C7, CR5, K3 or no input from electrometer circuit.	Troubleshoot and repair.

Problem	Possible Cause	Cure
	5. Defective op amp IC10-A or associated component. Check that the output at IC10-A (test point N) pin 1 is zero when the filament light is off.	Troubleshoot and repair.
	6. Defective circuit component C8, R25, R24, Q14, S1 or LED3.	Troubleshoot and repair.
3. Gauge tube filament lights when the filament switch is toggled on and then turns off after approximately 1 sec.	1. Pressure in tube too high to permit emission.	Decrease system pressure.
	2. Normal operation. Pressure in tube greater than 3×10^{-3} Torr resulting in a shutdown from the electrometer circuit.	Decrease system pressure.
	3. Low line voltage.	Connect to power line of proper voltage.
	4. Open in gauge cable to grid.	Repair or replace gauge cable.
	5. Grid bias supply shorted by either tube or cable.	Troubleshoot and repair. Refer also to section on bias supply.
	6. Degraded filament emissive coating not furnishing required emission.	Replace gauge tube.
	7. Glass tube envelope electrostatically charged.	Remove static charge. Apply anti-static coating, or use other static removal procedures.
	8. Defect in emission control amplifier IC10-A or associated circuit. Using an oscilloscope, verify that the waveform present on pin 1 of IC10-A is shown in Fig. 5-4 when the filament light is on.	Troubleshoot and repair.
	9. Loss of feedback signal to pin 3 of IC10-A, Fig. 5-4. RA9-4, CR15, CR18 or RA9-5 defective.	Troubleshoot and repair.

Problem	Possible Causes	Cure
4. Gauge tube filament turns on as soon as ac power is turned on. Filament light is not on. Filament glows very brightly indicating high emission current.	1. Shorted triac SCR1, Fig. 5-4. Apply a short from gate to anode 1 (across C23).	Replace triac.
	2. Defective synchronous pulse generator.	Troubleshoot and repair.
5. Gauge tube filament turns on as soon as power is applied. (Emission normal with filament light on.)	1. Transistor Q14 shorted, Fig. 5-4.	Replace relay.
	2. Relay K3 pins 6 to pin 7 shorted.	Replace relay.
	3. External filament remote control applying a ground to J3-7 or J3-H.	Correct external remote control circuit. It must be a momentary type of input.
6. Gauge tube filament turns on as soon as power is applied. (Emission normal with filament light off.)	1. Defective relay K3. (Pins 14 and 15 open.	Replace relay K3.
7. Erroneous indication of emission current on meter but operation of the filament appears normal.	1. Defective emission current amplifier IC10-B or related circuit component, Fig. 5-4.	Troubleshoot and repair.

6.6 Electrometer Circuit (Refer to Fig. 5-5 and Fig. 6-1)

1. Zero meter indication in any range. (Emission normal.)	1. Collector cable not connected to gauge tube and/or controller.	Connect cable to controller.
	2. Collector cable open. Check continuity of collector cable.	Repair or replace as necessary.
2. With only the power switch on, the electrometer will not zero in any range.	1. Defect in collector cable.	Repair or replace gauge cable.
	2. Power supply problem.	Refer to section on power supplies and repair same.
	3. Defect in electrometer circuit. Check Q20, IC9 or related circuit component.	Replace or repair as necessary.

Problem	Possible Causes	Cure
3. Electrometer readings do not change by factors of 10 as the pressure range is varied in the manual position. Autoranging mode very erratic or oscillating.	1. Switching FETS Q18, Q19, Q10 or gate driver Q6, Q7, Q8 defective. Refer to the logic table on Fig. 5-6 and check for each decade.	Troubleshoot and repair.

6.7 Autoranging Problems (Refer to Fig. 5-6 and Fig. 6-1)

NOTE: Since the autoranging mode is essentially identical to the manual ranging mode most problems can be identified and corrected earlier in the manual mode of operation.

1. Both manual and autoranging inoperative, 10^{-4} decade digit displayed.	1. Down range comparator IC7-A or associated component defective. Check voltage at test point C for 0V dc in the manual mode and when the manual switch is depressed to the down position.	Troubleshoot and repair voltage comparator.
2. When ac power is first applied the unit resets to the 10^{-4} decade and then steps to the 10^{-8} range.	1. Defective down range comparator IC7-A or associated component.	Troubleshoot and repair.
3. Unit does not reset to 10^{-4} range when power is first turned on. Otherwise operation is normal.	1. Defective IC5 UP/DOWN counter.	Replace IC5.
	2. Capacitor C18 open.	Troubleshoot and repair.
4. Incorrect decade digit displayed.	1. Defective IC2, IC3, IC4, or IC5. Check IC's using logic table shown on Fig. 5-6.	Troubleshoot and repair.
	2. Defective Q1, Q2, Q3, Q4 or Q5.	Troubleshoot and repair.
	3. Defective 7-segment display	Troubleshoot and repair.
	4. Defect in range decoding logic on converter board.	Troubleshoot and repair.
5. Range changing continues with erratic sequence of range digits above 10^{-4} range.	1. Lock out signal from Q6 through CR22 missing.	Troubleshoot and repair.

Problem	Possible Causes	Cure
6. Manual or autoranging only operates in down-range direction.	1. Defective up range comparator IC7-B or associated comparator defective. Check voltage at test point D for 0V dc when the manual switch is depressed to the up position.	Troubleshoot and repair.
7. Range changing continues with erratic sequence of digits below 10^{-8} range.	1. Lock out signal from IC5 through CR14 missing.	Troubleshoot and repair.

6.8 Ion Gauge Process Control (Refer to Fig. 5-7 and Fig. 6-1)

1. Both process control circuits inoperative.	1. Normal operation. Autoranging switch is in the manual position.	Place switch in auto position.
	2. Defective delay circuit component Q16, Q15, R36, R37 or C13. Check for -23V dc on Q15 collector after filament is turned on.	Troubleshoot and repair.
	3. Defective pressure amplifier IC8, or associated component (Refer to Fig. 5-5). Measure the output at test point H for the following output:	Troubleshoot and repair.
	10^{-8} range 0V to -1V dc corresponding to the meter reading 10^{-7} range -1V dc to -2V dc corresponding to the meter reading 10^{-6} range -2V dc to -3V dc corresponding to the meter reading 10^{-5} range -3V dc to -4V dc corresponding to the meter reading 10^{-4} range -4V dc to -5V dc corresponding to the meter reading	
2. One process control circuit inoperative.	1. Defective circuit component IC6, RA7, RA8, Q13, Q12, K1 or K2.	Troubleshoot and repair.

6.9 Thermocouple Circuit (Refer to Fig. 5-8 and Fig. 6-2)

1. Both TC's inoperative. TC meter reads atmosphere with vacuum system pumped down.	1. TC cable not connected to controller or tubes.	Install cable.

Problem	Possible Causes	Cure
	2. Defective TC power supply component R47, CR31 or CR32. Check that the waveshape across the two zeners is as shown on Fig. 5-8.	Troubleshoot and repair.
2. Insufficient range of both zero adj. pots when system pressure is known to be below 1×10^{-3} Torr.	1. Defective TC power supply component R47, CR31 or CR32.	Troubelshoot and repair.
3. At atmosphere the meter does not read atmosphere.	1. The internal F.S. adjust is mis-adjusted.	Adjust R54 for TC#2 and R52 for TC#1 until a F.S. reading is obtained. This should be equal to 2V dc at the output of the amplifier.
	2. Power supply problem. Check that the +6V dc supply is between the limits of 5.9V dc and 6.1V dc.	Troubleshoot and repair.
4. Insufficient range of one zero adj. pot.	1. Contaminated T.C. gauge tube.	Rinse out gauge tube with Acetone.
	2. Defective T.C. gauge tube	Replace gauge tube.
	3. F.S. internal adjust pot incorrectly positioned. Check that the meter reads atmosphere with the system at atmosphere or with the cable disconnected from the gauge tube.	Adjust F.S. pot (refer to 3 above).
	4. Defective T.C. gauge power supply component R48, R49, R50, R51, T2 or T3. Measure the voltage across either C27 or C32 using a digital voltmeter with the system pressure known to be below 1×10^{-3} Torr. It should be 10 mV for a zero reading.	Troubleshoot and repair.

Problem	Possible Causes	Cure
	5. Defective op amp or associated circuit component. Check that the amplifier has a DC gain of 200. Ein: 0 mV, 5 mV, 10 mV Eout: 2V dc, 1V dc, 0V dc	Troubleshoot and repair.
5. Meter pegged hard against either stop.	1. Defective amplifier or associated component.	Troubleshoot and repair.

6.10 Thermocouple Process Control (Refer to Fig. 5-9 and Fig. 6-2)

1. One P.C. circuit will not energize its associated relay.	1. Defective amplifier IC13-A or B, or associated component. Check the voltage at test point W or X to determine if the problem is with the amplifier or relay driver.	Troubleshoot and repair.
2. One P.C. circuit will not de-energize its associated relay.	1. Defective amplifier IC13-A or B, or associated component. Check the voltage at test point W or X to determine if the problem is with the amplifier or relay driver.	Troubleshoot and repair.
3. Both P.C. circuits cannot be set.	1. Defective -5.1V dc supply component R54 or CR33.	Troubleshoot and repair.

6.11 Digital Display Board (Refer to Figs. 5-11 and 6-3)

NOTE: Many problems associated with the board may be corrected by checking and cleaning the connectors.

1. No display or display indicators lit.	1. No power to controller.	Refer to Section 6.3.
	2. Converter board is not properly seated in connector.	Check connector and repair as needed.
	3. Defective +5V supply on converter board, Fig. 5-11. CR201 or VR201. Refer to Fig. 6-4.	Troubleshoot and repair as necessary.

Problem	Possible Cause	Cure
2. No measurement unit indicator lit, but digit display is lit.	1. Switch SW201 to a different unit of measure - if LED for new units lights, the LED may be defective.	Replace LED.
	2. If 1 above does not work, check SW201, R402, and the +6Vdc at J10-B. Refer to Fig. 5-3 for +6V power supply.	Troubleshoot and repair as necessary.
3. Units indicator lit. No digit display lit.	1. Check the operation of IC210 and IC211.	Replace, if necessary.
4. One or two digits not displayed.	1. Check the affected display element's anodes for signal. Remember the display is multiplexed. Also check for signal at IC 210, Fig. 5-11, inputs. If there are signals at both points then either IC 210 or the display unit is defective.	Troubleshoot and repair.

6.12 Converter Board (Refer to Figs. 5-11 and 6-4)

1. All zero displays in decade digits.	1. Short in the analog input circuit. Check C204 and C205 for short.	Repair as necessary.
	2. Check the analog input signal for steady, non-zero voltage at pin 3 of IC205. Multiply this voltage by 10 and check the BCD output lines, Pins 11(A), 12(B), 13(C), 14(D) where A (pin 11) is the LSB, for a BCD coded number equal to that calculated above.	Check the reference supply. Repair as necessary. Replace IC205.
	3. If the BCD code No. is correct, check operation of IC209.	Repair as necessary.
2. Display does not correspond to actual pressure.	1. Check electrometer circuit, section 6.6.	Repair as necessary
	2. Check the values of R207 and R208, and the leakage of C204 and C205.	Replace as required.

Problem	Possible Cause	Cure
	3. Check reference voltage to IC205, Pin 6 should be +1.000V dc with respect to analog ground. R215 is used to adjust the 1.000V reference.	Repair as necessary.
	4. Perform Step 1 of section 6.12.	
3. Range or decade indication is wrong.	1. Check autorange circuitry per Section 6.7.	Repair as required.
	2. Check R201 thru R205.	Replace as needed.
	3. The range data is encoded to BCD by IC201, IC202, and IC203. Check the inputs to IC204 for proper BCD code.	Replace IC201, 202, 203 or IC204 as needed.
	4. If IC204 is operating properly check the operation of IC209.	Replace as needed.
4. Always gives overrange indication.	1. Check that controller is in autorange.	Place in autorange.
	2. Check that system pressure is less than 1×10^{-3} Torr or 1 mbar.	Repair system.
	3. Check reference voltage. It should be 1.000Vdc.	Repair as necessary.
	4. Collector input shorted.	Repair.
	5. Electrometer malfunction.	Troubleshoot electrometer.

6.13 Digital BCD Output Option (Refer to Fig. 6-5)

1. No output on <u>any</u> line.	1. No power to BCD board. Check for +5V dc at pin 1 of P30.	Troubleshoot and repair as necessary.
2. No BCD data for units, tenths,	1. Check for BCD data input at pins 12, 13, 14, 15 of P30.	Troubleshoot as necessary. Refer to Section 6.12.

Problem	Possible Cause	Cure
	2. Check IC308, IC307, IC310 for proper operation.	Repair, replace as needed.
3. No status signals for PC	1. Check IC309, IC310 for proper operation.	Troubleshoot and repair as needed.
	2. Check R301, R302, R303 for shorts.	
	3. Check CR301, CR302, CR303 for opens.	
	4. Refer to Section 6.8.	
4. Indicates over range all 1's in tens, units and tenths places.	1. Check IC303 for proper operation	Troubleshoot and repair as required.
	2. Check IC304 for proper operation.	
	3. Check IC301 for proper operation.	

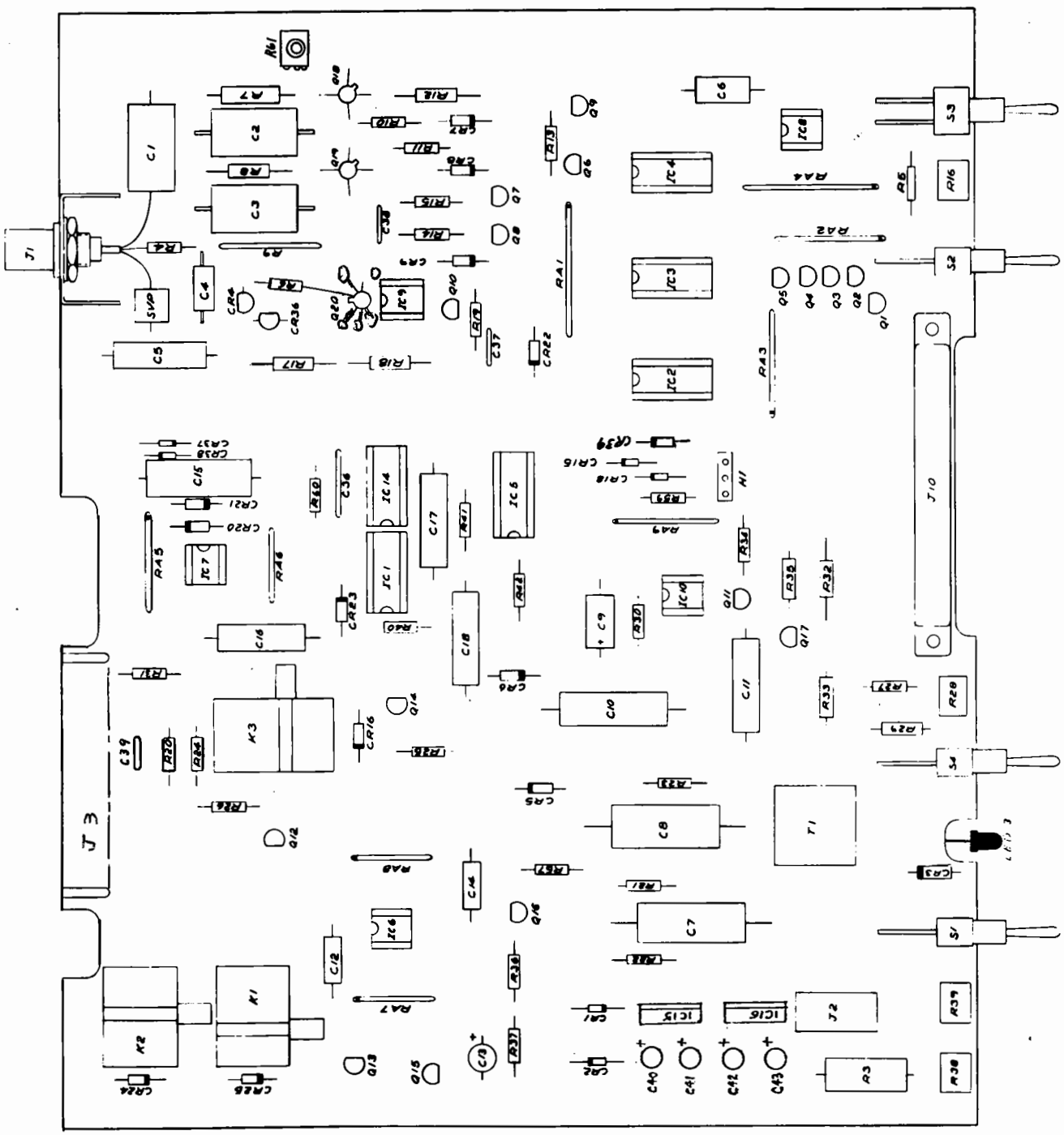


FIG.6-1 COMPONENT LOCATION MAIN BOARD

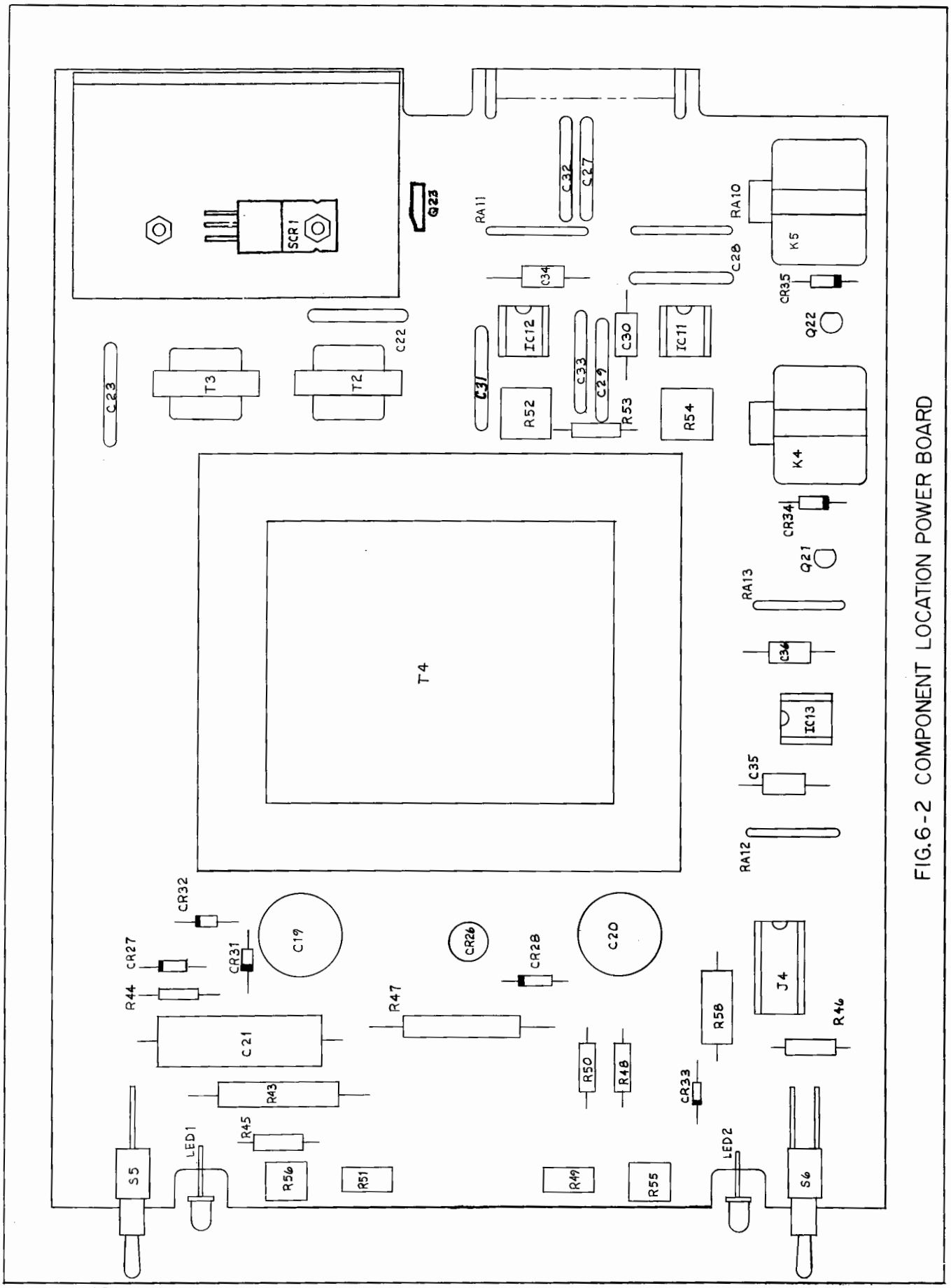


FIG.6-2 COMPONENT LOCATION POWER BOARD

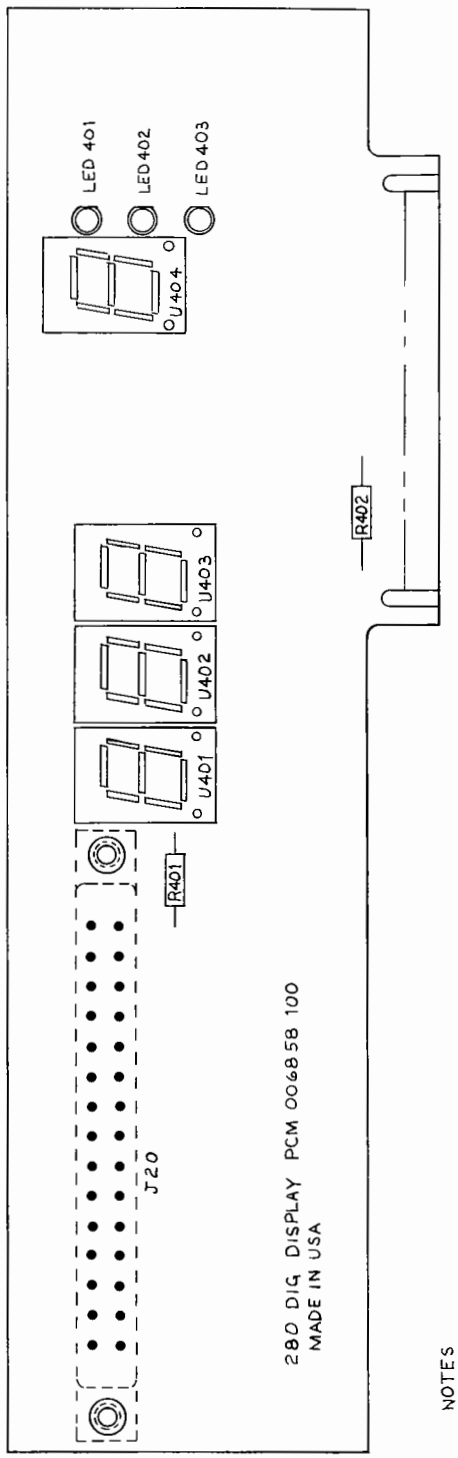


FIG. 6-3 COMPONENT LOCATION DISPLAY BOARD

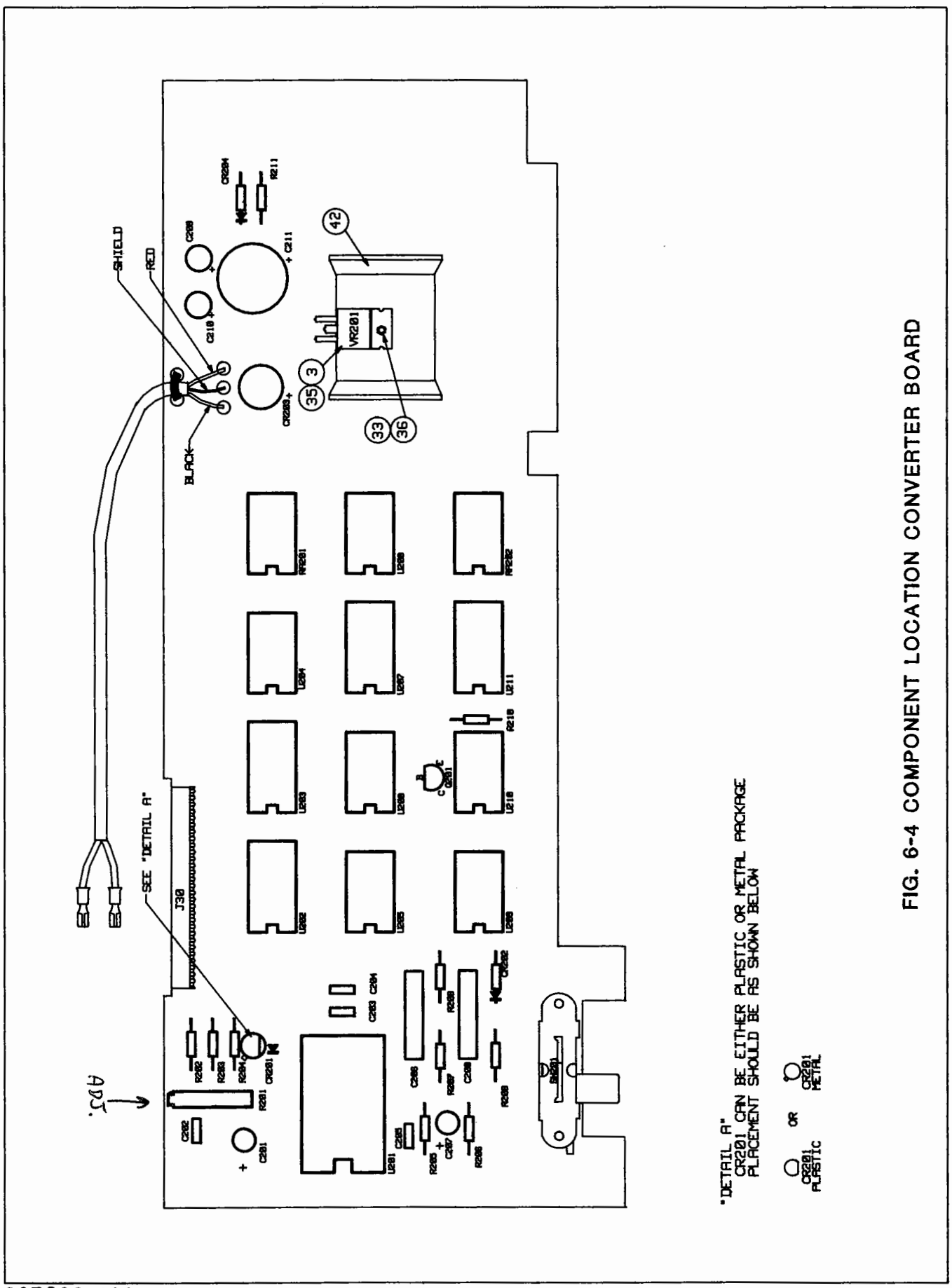


FIG. 6-4 COMPONENT LOCATION CONVERTER BOARD

007603 100

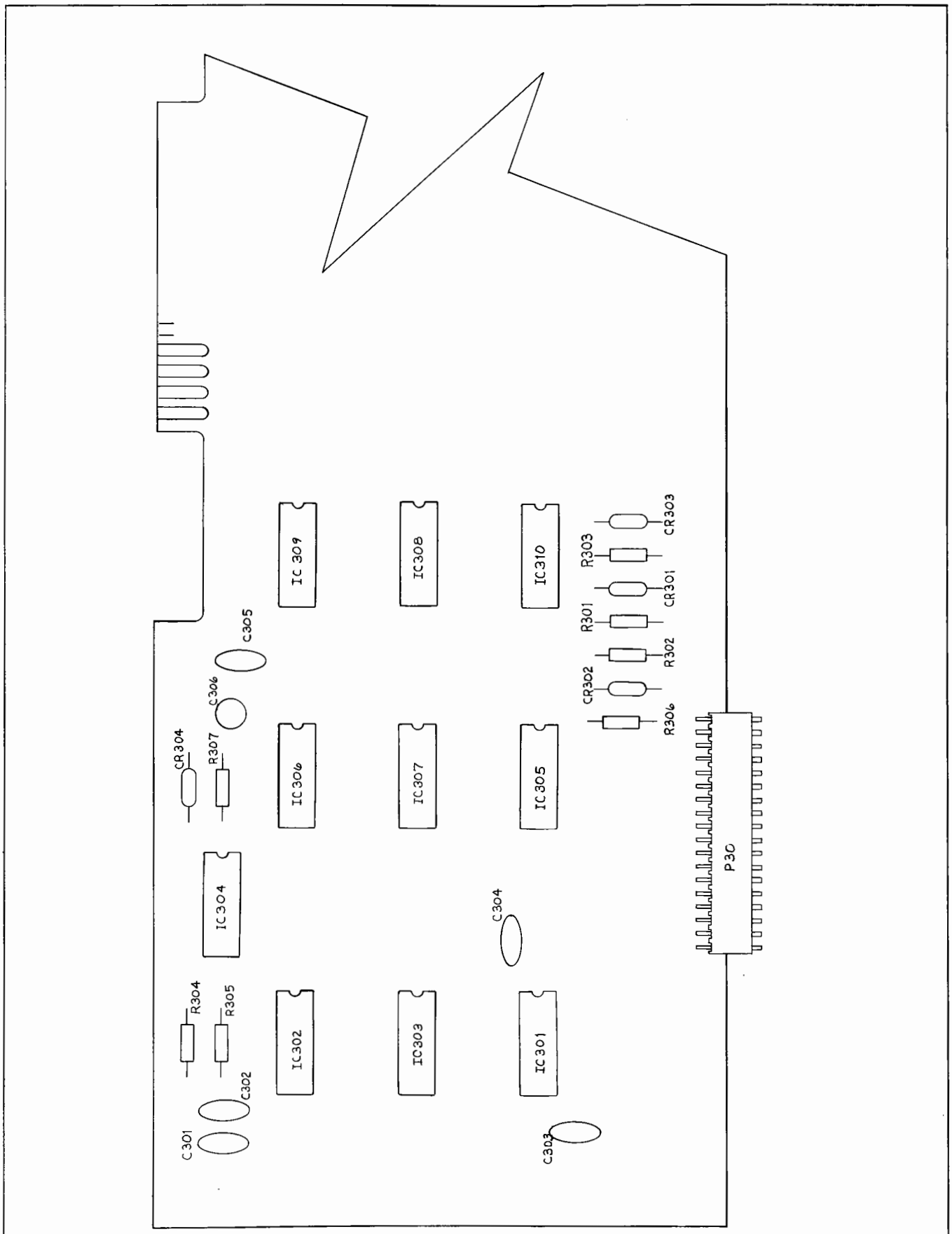


FIG. 6-5 COMPONENT LOCATION BCD OPTION BOARD

SECTION 7

REPLACEMENT PARTS AND REPAIRS

7.1 Replacement and Repair Order Instructions (Refer to Figs. 6-1, 6-2, 6-3 and 6-4)

To minimize customer inconvenience caused by down time, the controller has been designed with as many standard parts as possible. In most cases, the parts required to repair your controller can be most easily obtained from your local electronics parts distributor. In addition it is possible to easily replace the printed circuit board assemblies. To replace the P.C. boards proceed as follows:

1. Remove the top and bottom covers by removing the four screws at the rear corners of the unit. Slide the covers off.

2. Remove the four screws and two nuts from the ground lug on the rear panel. Remove the rear panel.

3. Disconnect the interconnect cables from the P.C. board and transformer.

4. Disconnect the two meter leads (if required) from each meter.

5. Slide the P.C. board out slowly until clear of the chassis.

6. To replace a P.C. board reverse steps 1 thru 5. When inserting the new board it is necessary to use extreme caution during the time the switches and LED's engage the front panel to assure satisfactory alignment.

Pre-tested P.C. boards are available from Granville-Phillips Company. If a replacement board assembly is desired, it is important that you give the Customer Service Department the complete catalog and model number for your controller. This will insure that you receive the correct replacement P.C. board assembly for your model controller.

Address all replacement/repair orders and correspondence to Granville-Phillips Company, Service Department, 5675 East Arapahoe Avenue, Boulder, Colorado 80303. Telephone: (303) 443-7660. Telex No.: 45-791. Please include with your request the telephone number and address where you can be reached. UNDER NO CIRCUMSTANCES WILL GRANVILLE-PHILLIPS BE LIABLE FOR SHIPPING DAMAGES due to rough handling, improper packing, or other circumstances beyond our control.

ALL RETURN SHIPMENTS MUST BE FREIGHT PREPAID.

7.2 Main Circuit Board Parts List (Refer to Fig. 6-1)

Circuit Designation	Description	G-P Part Number
	Integrated Circuits	
IC1 thru IC4	Quad 2-input NAND 4011UB	004697 101
IC5	Binary up/dn counter 4516B	004696 100
IC6 thru IC8	Dual Operational amp MC1458, Motorola	007509 002
IC9	Dual Operational amp RC4558DN	005406 100
IC10	Dual Operational amp MC1458, Motorola	007509 002
IC14	Quad 2-input NAND 4011UB	004697 101
IC15	IC, Volt. Reg. +12V, 7812	005287 100
IC16	IC, Volt. Reg. -12V, 7912	005283 101
	Transistors	
Q1 thru Q8	Transistor 2N3906 PNP Si	001881 100
Q9	Transistor Darlington NPN Si General Electric GES5308	003880 101
Q10	Field Effect Transistor, Siliconix J112	004794 100
Q11 thru Q13	Transistor 2N3906 PNP Si	001881 100
Q14, Q15	Transistor Darlington NPN Si General Electric GES5308	003880 100
Q16	Transistor 2N3906 PNP Si	001881 100
Q17	Unijunction 2N4871, Motorola	004403 001
Q18, Q19	Field Effect Transistor, Selected 2N4118A Motorola SFE-1359	006004 100*
Q20	Field Effect Transistor, Selected U235	007644 100*
	Diodes	
CR3	Zener diode, 6.0V, 1.0W, 1% Schauer SZ6.0-1%-10mA	004240 100
CR4	Zener, modified D38W14	004836 101*
CR5 thru CR9	Signal diode 1N4007 Si	001896 100
CR15	Zener diode, 30.0V, 1.0W, 1N4751	005787 001
CR16	Signal diode 1N4007 Si	001896 100
CR18	Zener diode, 5.1V, 1.0W, 1N4733A	005228 002
CR20 thru CR25	Signal diode 1N4007 Si	001896 100
CR36	Zener, modified D38W14	004836 101*
CR37,CR38	Signal diode 1N3064 Si	004563 002
SVP	Protector, surge voltage Siemens B1-C90/3	003574 102
LED3	Diode, light emitting, red Dialight 521-9200	003378 100
	Capacitors	
C1,C2,C3	Capacitor, 4700 pf, 500V, polystyrene Centralab CPR-4700J	001459 101
C4	Capacitor, 100p, 500V, polystyrene Centralab CPR-100J	1462 101
C5	Capacitor, 0.01uf, 100V, mylar Cornell Dubilier WMF 1S1	004570 001
C6	Capacitor, 10.0 uf, 16V, electrolytic Sprague 500D106G016BA7	005785 001

Circuit Designation	Description	G-P Part Number
C7	Capacitor 5.0 uf, 300V, electrolytic Sprague 500D505F300DF7	005753 001
C8	Capacitor, 0.47 uf, 100V, mylar Cornell Dubilier WMF 1P47	002348 100
C9	Capacitor, 10.0 uf, 16V, electrolytic Sprague 500D106G016BA7	005785 001
C10	Capacitor, 0.22 uf, 100V, mylar Cornell Dubilier 1P22	004572 001
C11	Capacitor, 0.1 uf, 100V, mylar Cornell Dubilier WMF 1P1	004571 001
C12	Capacitor, 0.01 uf, 100V, mylar Cornell Dubilier WMF 1S1	004570 001
C13	Capacitor, 68.0 uf, 10V, tantalum Sprague 196D686X0010FB	005850 003
C14	Capacitor, 0.01 uf, 100V, mylar Cornell Dubilier WMF 1S1	004570 001
C15	Capacitor, 0.22 uf, 100V, mylar Cornell Dubilier 1P22	004572 001
C16,C17,C18	Capacitor, 0.1 uf, 100V, mylar Cornell Dubilier WMF 1P1	004571 001
C36,C39	Capacitor, 0.1 uf, 100V, ceramic	002606 102
C37,C38	Capacitor, 0.01 uf, 500V, ceramic	002806 103
C40 thru C43	Capacitor, 4.7 uf, 35V, TS	005936 100
	Transformers	
T1	Transformer pulse	005792 002*
	Relays	
K1,K2	Relay, 5.8 mA,2500 ohm,2PDT,3A con.,115V American Zettler AZ420-C56-4HUS	006513 100
K3	Relay, 24V,700ohm,4PDT,5A con.,115V Allied TE154-4C-24V	002024 102
	Resistors/Arrays & Potentiometers	
R3	Resistor, 470 ohm,5.0%,2W,carbon	004782 100
R4	Resistor, 10.0 Kohm,5.0%,0.5W,carbon	000464 100
R5	Resistor, 27.0 Kohm,5.0%,0.5W,carbon	001025 100
R6	Resistor, 1.0 Mohm,5.0%,0.5W,carbon	000296 100
R7	Resistor, 68.1 Kohm,1.0%,0.5W,metal film	006005 100
R8	Resistor, 1.0 Mohm,1.0%,0.5W,metal film	001447 100
R9	Resistor, 100.0 Mohm,2.0%,1.0W,dep carbon	004778 102
R10,R11	Resistor, 1.0 Mohm,5.0%,0.5W,carbon	000296 100
R12	Resistor, 24.9 Kohm,1.0%,0.5W,metal film	004023 100
R13,R14,R15	Resistor, 7.5 Kohm,5.0%,0.5W,carbon	001210 100
R16	Pot, 5.0 Kohm,20.0%,0.5W	006479 100
R17	Resistor, 90.9 Kohm,1.0%,0.5W,metal film	001686 100
R18	Resistor, 10.0 Kohm,1.0%,0.5W,metal film	001017 100
R19	Resistor, 1.0 Mohm,5.0%,0.5W,carbon	000296 100
R20	Resistor, 2.0 Kohm,5.0%,0.5W,carbon	001108 100
R21	Resistor, 20.0 Kohm,5.0%,0.5W,carbon	001022 100
R22	Resistor, 220.0 Kohm,5.0%,0.5W,carbon	001031 100

Circuit Designation	Description	G-P Part Number
R23	Resistor 510.0 Kohm 5.0% 0.5W carbon	005691 001
R24	Resistor 100.0 Kohm 5.0% 0.5W carbon	000292 100
R25	Resistor 20.0 Kohm 5.0% 0.5W carbon	001022 100
R26	Resistor 100.0 Kohm 5.0% 0.5W carbon	000292 100
R27	Resistor 1.3 Kohm 5.0% 0.5W carbon	007024 100
R28	Pot 500.0 ohm 20.0% 0.5W	006480 100
R29	Resistor 75 ohm 5.0% 0.5W	007023 100
R30	Resistor 2.0 Mohm 5.0% 0.5W carbon	004774 100
R31	Resistor 2.0 Kohm 5.0% 0.5W carbon	001108 100
R32	Resistor 2.26 Kohm 1.0% 0.5W metal film	006085 001
R33	Resistor 1.0 Kohm 5.0% 0.5W carbon	000462 100
R34	Resistor 2.0 Kohm 5.0% 0.5W carbon	001108 100
R35	Resistor 100.0 ohm 5.0% 0.5W	000379 100
R36	Resistor 510.0 Kohm 5.0% 0.5W carbon	005691 001
R37	Resistor 100.0 Kohm 5.0% 0.5W carbon	000292 100
R38, R39	Pot 5.0 Kohm 20.0% 0.5W	006479 100
R40	Resistor 1.0 Mohm 5.0% 0.5W carbon	000296 100
R41, R42	Resistor 2.0 Mohm 5.0% 0.5W carbon	004774 100
R57	Resistor 10.0 Kohm 5.0% 0.5W carbon	000464 100
R59	Resistor 1.50 Kohm 1.0% 0.1W metal film	005791 100
R60	Resistor 1.0 Mohm 5.0% 0.5W carbon	000296 100
RA1	Resistor Array	004685 101*
RA2	Resistor Array	004683 101*
RA3	Resistor Array	007635 100*
RA4	Resistor Array	004665 102*
RA5	Resistor Array	004667 102*
RA6	Resistor Array	004666 102*
RA7, RA8	Resistor Array	004671 102*
RA9	Resistor Array	004668 102*
R61	Pot 10.0 Kohm 20% 1.0W	003277 101
	Switches	
S1 (man)	Switch, fil. control, man., SPDT, on-x-mom C & K 7108 J1V5BE	007936 100
S1 (auto)	Switch, fil. control, auto., DPDT on-off-mom C & K 7207J1V5BE	007937 100
S2	Switch, up/down, SPDT mom-off-mom C & K 7105J1V5BE	007938 100
S3	Switch, autoranging, DPDT on-x-on C & K 7201J1V5BE	007934 100
S4	Switch, emission, SPDT on-x-mom C & K 7108J1V5BE	007936 100
	Connectors and Sockets	
J1	Connector BNC female Amphenol UG1094-U	000608 100
J10	Connector edge card 15 position 30 contact Dale EB7D-K15GFX	005405 001
XK1, XK2	Socket Relay 10 contact PCB mtg.	001165 103
XK3	Socket Relay 16 contact PCB mtg.	001166 103

7.3 Power Board Parts List

Circuit Designation	Description	G-P Part Number
	IC's	
IC11, IC12	Operational amplifier, LM308A National LM308AN	004694 100
IC13	Dual Operational amplifier 1458 Motorola MC1458	007509 002
	Transistors, Triac	
Q21, Q22	Transistor, Darlington, NPN, silicon General Electric GES5308	003880 101
SCR 1	Triac, 15A, 200V TO-220	008512 100
Q23	Protector, Surge Voltage, RCA SGT03U13	009095 100
	Diodes: Rectifiers, Zeners, and Signals	
CR26	Rectifier assembly, 100V, 1A Varo VE-18	005226 004
CR27, CR28	Diode, Signal, Silicon 1N4007	001896 100
CR31, CR32	Diode, Zener, 6.2V, 1W, 1N4735A	005995 001
CR33	Diode, Zener, 5.1V, 1W, 1N4733A	005228 002
CR34, CR35	Diode, Signal, Silicon 1N4007	001896 100
	Capacitors	
C19, C20	Capacitor 470 uf 25V electrolytic Sprague 503D477F035QE	003863 100
C21	Capacitor 5.0 uf 300V electrolytic Sprague 500D505F300DF7	005753 001
C22, C23, C27,C28, C29	Capacitor 0.1 uf 100V ceramic Sprague 33C41BE	002606 102
C30	Capacitor 100 pf 500V polystyrene Mallory SX310 or MIAL 100J	001462 101
C31, C32, C33	Capacitor 0.1 uf 100V ceramic Sprague 33C41B6	002606 102
C34	Capacitor 100 pf 500V polystyrene Mallory SX310 or MIAL 100J	001462 101
C35, C36	Capacitor 390 pf 600V polystyrene Mallory SX339 or MIAL 390J	001461 102
	Transformers	
T2, T3	Transformer, Thermocouple Magnetek 1074B	004695 101*
T4	Transformer, power, IGC	005248 101*
	Resistor Arrays	
RA10, RA11	Array, resistor	004664 103*
RA12, RA13	Array, resistor	004663 102*

Circuit Designation	Description	G-P Part Number
	Resistors and Potentiometers	
R43	Resistor 10 Kohm 5.0% 5.0W	004780 100
R44	Resistor 510 Kohm 5.0% 0.5W	005691 001
R45, R46	Resistor 200 ohm 5.0% 0.5W	004773 100
R47	Resistor 500 ohm 5.0% 5.0W	004781 100
R48	Resistor 200 ohm 5.0% 0.5W	004773 100
R49	Pot 1 Kohm 20.0% 0.5W	006481 100
R50	Resistor 200 ohm 5.0% 0.5W	004773 100
R51	Pot 1 Kohm 20.0% 0.5W	006481 100
R52	Pot 100 ohm 20.0% 1.0W	007247 100
R53	Resistor 10 Kohm 5.0% 0.5W	000464 100
R54	Pot 100 ohm 20.0% 1.0W	007247 100
R55, R56	Pot 500 ohm 20.0% 0.5W	006480 100
R58	Resistor 680 ohm 5.0% 1.0W	000463 100
	Light Emitting Diodes	
LED1, LED2	Diode, light emitting, red Dialight 521-9200	003378 100
	Relays	
K4, K5	Relay 5.8 mA 2500 ohm 2PDT 3A con. American Zettler AZ420-C56-4HUS	006513 100
	Switches	
S5A, S5B	Assembly, Switch, Line Selector	006890 100*
S5	Switch, power, SPDT, on-x-on C & K 7101J1V5QE	007933 100
S6	Switch, degas, DPDT, on-x-on C & K 7201J1VSQE	007935 100
	Fuses	
F1 (100,115V)	Fuse, 1.25 Amp, 250V, slow blow (English) Littelfuse 3AG 313 1.25	004966 100
F1 (230V)	Fuse, 0.5 Amp, 250V, slow blow (Metric) Littelfuse 213.500	006967 100
	Fuse Holder	006910 100
	Metric Insert Cap	006965 100
	English Insert Cap	006966 100
	Connectors and Sockets	
	Socket, Relay, 10 contacts, PCB Mt Potter Brumfield ALL-10	001165 103
	Insert cap, metric fuse Schurter FEV 031.1653	006910 100
	Insert cap, English fuse Schurter FEK 031.1666	006966 100
	Connector, female, 6 pin Amphenol 78-56-071	001318 100
	Connector, power, 3 blade recessed Switchcraft EAC-301	006443 100
	Miscellaneous	
	Shield, Transformer	007536 001*

7.4 Display Board Parts List (Refer to Fig. 6-3)

Circuit Designation	Description	G-P Part Number
	Resistors	
R401	Resistor 27 ohm 5% 0.25W	006912 100
R402	Resistor 300 ohm 5% 0.25W	006913 100
	Display	
Q401, Q402, Q403, Q404	IC display, LED, red, 7-seg, 0.43H Hewlett-Packard No. 5082-7653	005549 100
LED401,LED402,	Diode, Light emitting, red Texas Instrument TIL-209	005333 100
	Hardware	
	Standoff, Nylon, .188D x ,.375L Amatom No. 8079-NO440	006911 100
	Miscellaneous	
J20	Connector, female, PCB edge Dale EB7D-K15GFX	005405 002

7.5 Converter Board Parts List (Refer to Fig. 6-4)

Circuit Designation	Description	G-P Part Number
	IC's	
IC201	3½ digit A/D converter Motorola MC14433P	007599 100
IC205	Quad 2-input and gate 4081B RCA CD4081BE	007029 100
IC206, IC209	Quad nor gate 4001B Motorola MC14001B	007600 100
IC207	Hex inverter 4049UB Motorola MC14049U	006868 100
IC210	Dual "D" flip flop 4013B Motorola MC14013	008157 100
IC211	BCD 7 seg latch/decoder/driver Motorola MC14511	005289 001
IC204	Quad 2-input or gate 4071B Motorola MC14071BCP	006943 100
IC202, IC203	4-bit data selector 4519B Motorola MC14519BCP	006944 100
IC208	Hex digit driver National DS75492	006946 100
	Voltage Regulator	
VR201	Voltage regulator, 5 volt positive Motorola MC7805CT	006948 100
	Transistor	
Q201	Transistor, NPN, silicon, 2N3904	005822 004
	Diodes: Rectifier, Voltage Reference, Zener	
CR203	Rectifier assembly, 100V, 1A Varo VE-18	005226 004
CR204	Zener, 5.1V, 0.5W, 1N5231B	004567 001
CR201	Voltage reference, 1.22V, 100 ppm Teledyne 9491	006949 100
CR202	Signal diode 1N3064S1	004563 002
	Capacitors	
C211	Capacitor 1000 uf 25V electrolytic Sprague 503D108G025EU	007128 100
C201, C207, C209, C210	Capacitor 68 uf 10V tantalum Sprague 196D686X0015PE3	005850 003
C202, C203, C204, C205	Capacitor 0.01 uf 100V ceramic Sprague Products Number TG-S10	005277 100
C206, C208	Capacitor 0.1 uf 100V mylar CDE WMF 1P1	004571 001

Circuit Designation	Description	G-P Part Number
	Resistors and Potentiometers	
R203	Resistor 1.02 Kohm 1% 0.10W	005159 100
R207	Resistor 174 Kohm 1.0% 0.12W	007596 100
R206	Resistor 3.32 ohm 1.0% 0.10W	009258 100
R205	Resistor 1.10 Kohm 1.0% 0.10W	009157 100
R208	Resistor 301 Kohm 1.0% 0.12W	007597 100
R209	Resistor 10 Kohm 5.0% 0.25W	006996 100
R202	Resistor 7.87 Kohm 1.0% 0.10W	006814 100
R210	Resistor 100 Kohm 5% 0.25W	006969 100
R211	Resistor 2.7 Kohm 5% 0.25W	006968 100
R204	Resistor 6.8 Kohm 5% 0.25W	006951 100
R201	Pot 2.0 Kohm 20% 1.0W	006815 100
RA201	Resistor Array 7 X 1.2 Kohm 5%	007598 100
RA202	Resistor Array 7 x 33 ohm 5%	007112 100
	Miscellaneous	
	Heatsink, black, anodized Staver Company Inc. V2-1	005419 001
SW201	Switch, slide, 2P3T UID SW323SD30PBL00	006954 100
J30	Connector,female, PCB, edge Molex Series 4455-A, 901-22-15-2181	005286 100
	Cable, power, assembly	006953 100*

7.6 BCD Output Option Parts List (Refer to Fig. 6-5)

Circuit Designation	Description	G-P Part Number
IC301, IC302	IC, Quad, 2-input NAND gate 4011UB	004697 101
IC303	IC, Dig., Quad or 4071B	006943 100
IC304, IC305, IC306, IC307	IC, Quad, clocked latches 4042B	006870 100
IC308, IC309, IC310	IC, Hex inverter 4049UB	006868 100
CR301, CR302, CR303, CR305	Diode, Silicon, Signal 1N3064	004563 002
C301, C302, C304	Capacitor, 1500 pf, 100V, ceramic Erie 851-000-X5F0-152K	005311 102
C305	Capacitor, .01 uf, 100V, ceramic Sprague TG-S10	005377 100
C306	Capacitor, 4.7 uf, 35V, solid tantalum Sprague 196D475X0035JA1	005936 100
R301, R302, R303	Resistor, 100K ohm, 5%, .25W, carbon	006969 100
R304, R305, R306, R307	Resistor, 10K ohm, 5%, .25W, carbon Resistor, 33K ohm, 5%, .25W, carbon	006996 100 006998 100

7.7 Chassis Components

Meter, Thermocouple Modutec	006835 100*
Cable, Interconnect Spectra Strip	002370 100
Cover, Top & Bottom	004562 100

7.8 Cable and Hardware Components

10 ft Ion Gauge Cable for Glass Tube	270007 001
10 ft Ion Gauge Cable for Nude Tube	270009 002
10 ft Thermocouple Gauge Cable	270011 001
Power Cable, 3 blade recessed, U.S.A. Electro-Cords E1015 (8.0) Gray	006444 100
I.G. Accessory Connector Kit	005491 100*
BCD Accessory Connector Kit	005944 101*
Power Cable, 3 blade recessed, W. Europe Electro-Cords 2123-02MGY	006971 100

*Parts which must be purchased from Granville-Phillips Company.

NOTE: The manufacturers part numbers given are for reference only to assist in obtaining parts locally. Parts ordered from G-P may or may not have the listed manufacturer and part number but meet the required G-P part number specification.

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