

# INSTRUCTION MANUAL FOR 170M-60A CHARGE-RATE™ ION GAUGE PRESSURE/MEASUREMENT SYSTEM



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## SECTION 1 INTRODUCTION

### 1.1 General

MKS Instruments, the leader in high accuracy vacuum gauging since 1961, introduces the TYPE 170M-60A Ionization Gauge Control, to extend the useful range of MKS vacuum gauging capability to  $1 \times 10^{-9}$  Torr.

The MKS TYPE 170M-60A Charge-Rate™ B/A Ion Gauge Control is a compact, general purpose hot filament, digital ion gauge control for use in vacuum systems, at pressures below  $10^{-3}$  Torr.

Named for the unique patented technique\* employed for measurement of ion current, the instrument has one continuous range of  $10^{-9}$  to  $10^{-3}$  Torr and presents pressure on a clear LED display and in BCD for remote readout.

Superior instrument performance is now made possible in two critical areas: instrument zero drift, range settling time and range tracking error are eliminated.

The simplified circuitry provides exceptional performance in high energy environments, such as particle accelerators, lasers, Van DeGraaff generators, sputtering, etc.

\*U.S. Patent No. 4, 035, 720 issued July 12, 1977

The 170M-60A Charge-Rate\* Ion Gauge† is a completely automatic pressure indicating system which is small, simple, rugged, reliable, and accurate. It has no periodic adjustments or maintenance procedures. Its operation is controlled by one three-position switch on the front panel (OFF-ON-DEGAS) or, if the user wishes, remote (on/off) through a connector on the back panel which is standard on all units.

The instrument is protected against common forms of abuse such as over-pressure and short circuits and is specifically designed for permanent installations in laboratory and industrial environments.

\*A trademark of MKS INSTRUMENTS, INC.

†U.S. Patent #4,035,720

Inside, it has two types of novel circuits† using the Charge-Rate\* technique; one that converts the ion current into charge pulses, and a floating-point pulse counter with a digital display. Thus the instrument has only one continuous range from  $10^{-9}$  to over  $10^{-3}$  Torr. The emission current is automatically reduced at high pressures to maintain accuracy. These circuits are quite simple and compact.

The instrument is shown disassembled in Figure 1-1. It consists of a chassis assembly including transformers and power connector, a digital processor with display, an analog processor, a bottom cover with rubber feet, a top cover, a red acrylic front panel, and an escutcheon (gauge cable and power cable not shown). A typical display is shown in Figure 1-2. The front panel controls are shown in Figure 1-3.

### 1.2 Specifications

**RANGE**  
 $10^{-9}$  to  $10^{-3}$  Torr.

**REPEATABILITY**  
 $+3\% \pm 1$  L.S.D.

**DISPLAY FORMAT**  
 $X.X \cdot 10^{-X}$ .

**MINIMUM READING**  
 $0.1 \cdot 10^{-8}$  Torr.

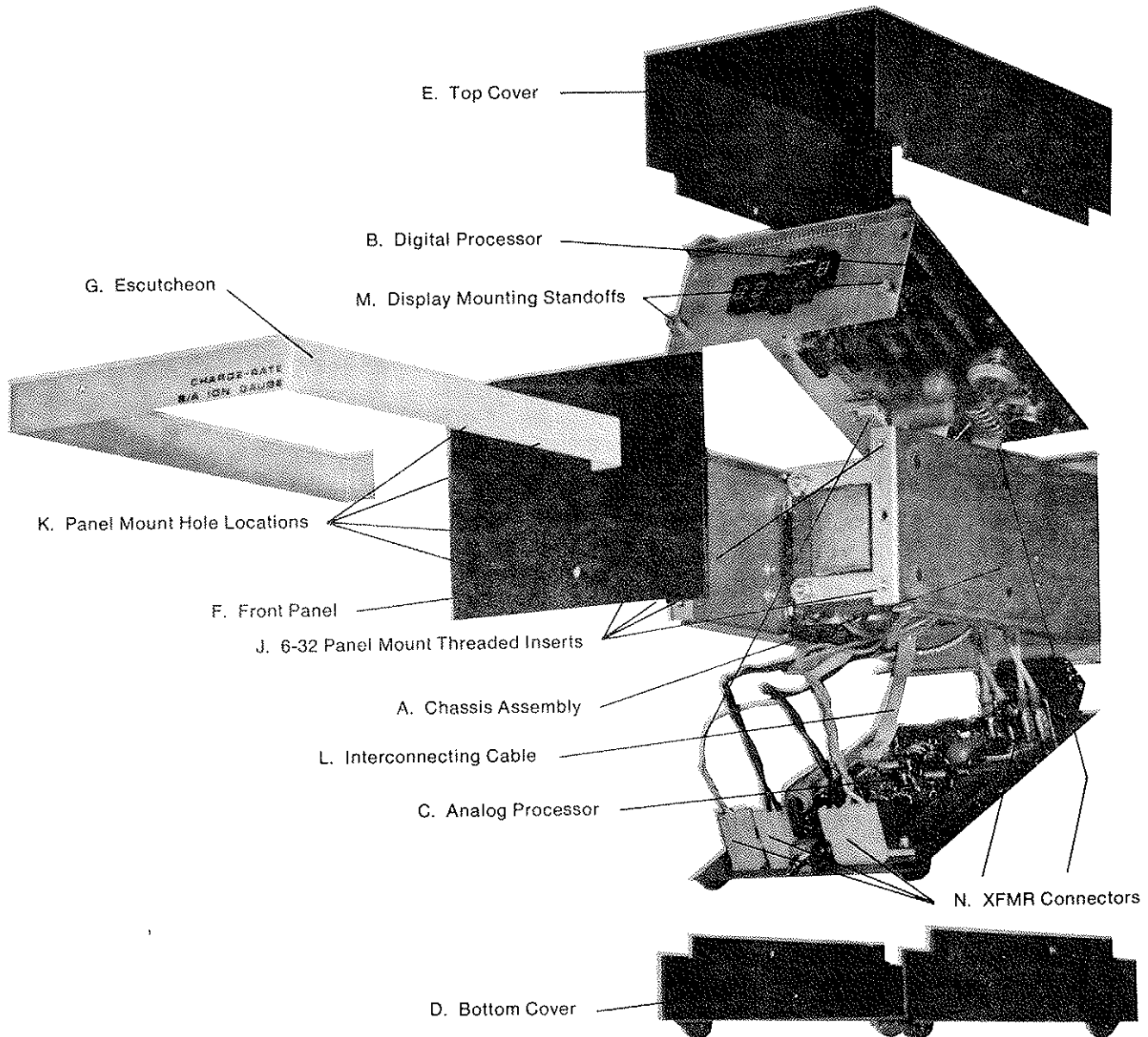
**DISPLAY UPDATE TIME**  
0.8 sec, except 2.8 sec in  $10^{-8}$  range.

**LOW PRESSURE VISUAL INDICATOR RATE**  
5 per second per  $10^{-8}$  Torr (500 MHz per Torr).

**GAUGE SENSITIVITY**  
 $10 \text{ Torr}^{-1}$  (for RG 75 or NRC 563, gauge tube).

**OPTION**  
Adjustable sensitivity for gauges with other sensitivities. Range of adjustability: 5.0-50.0





Not Shown:

- H. Gauge Cable
- I. Power Cable

Figure 1-1 Exploded View, 170M-60A Ion Gauge

**EMISSION CURRENT**

9 ma below  $10^{-6}$  Torr, decreasing to less than 0.5 ma at  $10^{-3}$  Torr.

**PROTECTION**

Overpressure: above  $10^{-3}$  Torr, air release, Filament: Short, Anode: Short.

**DEGAS**

60 watts nominal, resistance type. (EB degas optional)

**LINE VOLTAGE**

100-130 VAC 50/60 Hz, or 210-250 vac 50/60 Hz.

**POWER CONSUMPTION**

50 watts normal, 110 watts with resistance degas ON.

**FUSE**

3AG 1.5 Ampere Slo-Blo (MDL 1.5), on 115 vac models, 3/4A on 230 volt models.

**SHIPPING WEIGHT**

12 lbs. (5.5 kg).

**DIMENSIONS**

5¼"W x 4¼"H x 8½"D (133.35mm x 107.95mm x 215.9mm).

**PANEL MOUNTING**

170M-66 Panel Mount.

**GAUGE CABLE**

10 ft. (3m), 8-pin Jones plug (P308CCT)

**POWER CORD**

8' (2.4m).

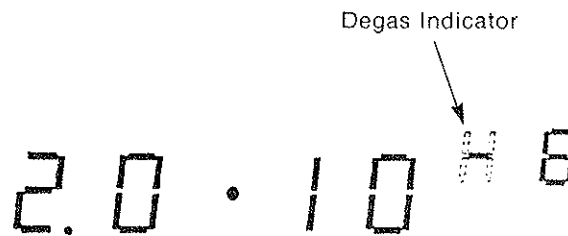


Figure 1-2 Typical Display

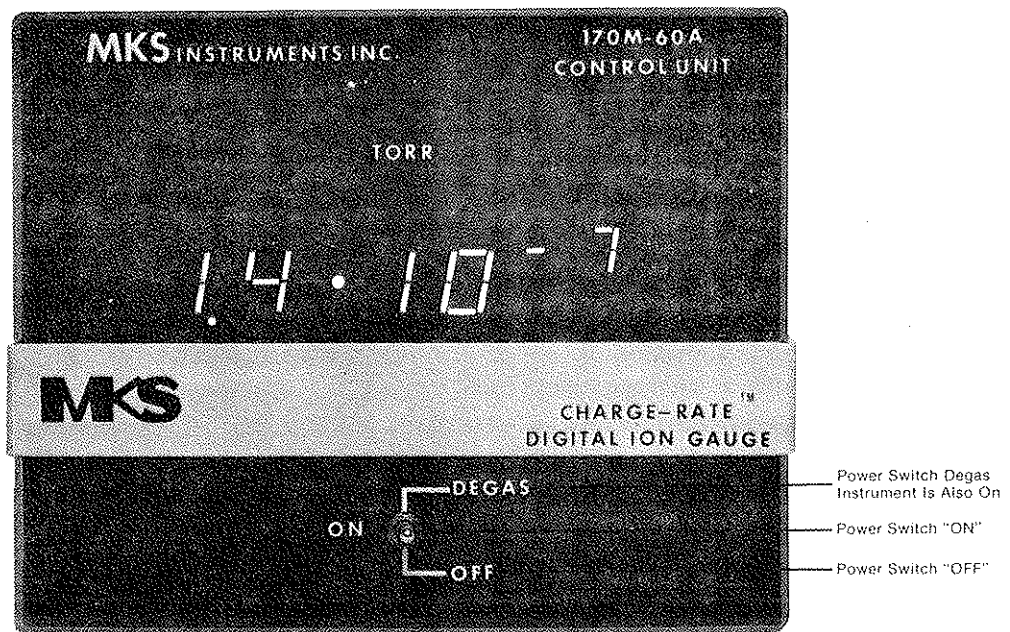
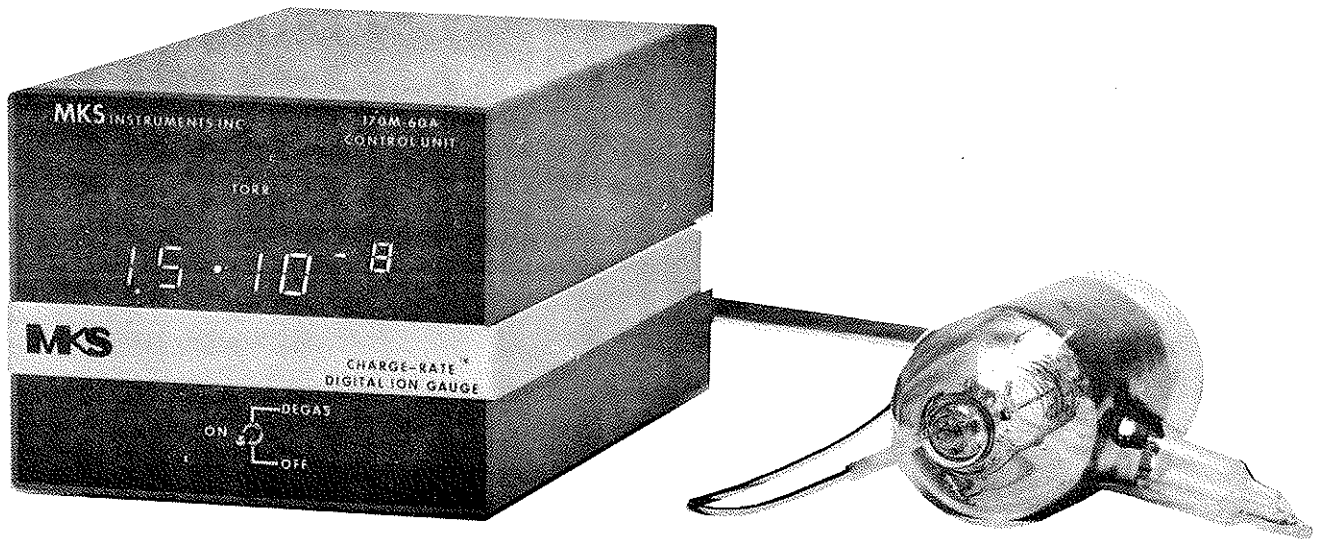


Figure 1-3 Front Panel Controls

170M-66 RACK MOUNT  
PANEL



CABINET STYLE

Figure 1-4 Cabinet, Rack Mount Styles

## SECTION 2 INSTALLATION AND OPERATION

### 2.1 General

Installation of the gauge controller consists of obtaining a suitable Bayard Albert type gauge tube and mounting it, placing the instrument in some suitable location and/or panel mounting it, connecting the gauge to the instrument (standard cable provided is 10 ft.), and connecting the instrument to the 117-volt Ac line (8 ft. long cable). A diagram of the gauge tube connections appears on a label at the rear of the instrument (see Figure 2-1. User-provided cables should use a P-308-CCT 8-pin Jones Plug as indicated).

We ask that the user plan and execute this installation carefully and slowly. Cables should be kept away from hot spots, sharp edges and moving parts. Care in installing the instrument will result in longer troublefree operation.

### 2.2 Gauge Cable

To assure a reliable connection to the gauge tube, a custom designed connector is used (see Figure 2-2).

The wiring at the four-pin gauge connector is somewhat flexible to prevent stressing of the soft nickel or kovar gauge pins commonly used. The connector should always be handled by its body—never by pulling the wires.

Since the instrument is intended for permanent installations, security of the collector connection is emphasized over ease of removal. Therefore, it is recommended that the collector terminal be removed first when the cable is disconnected from the gauge tube. Otherwise when the main connector comes off, the sudden release may take up the collector wire slack and bend the collector pin.

The gauge cable is insulated with PVC and Mylar, so that it will be damaged if allowed to drape over diffusion pump heaters or roughing-pump belts. Careful installation promotes longer service life.

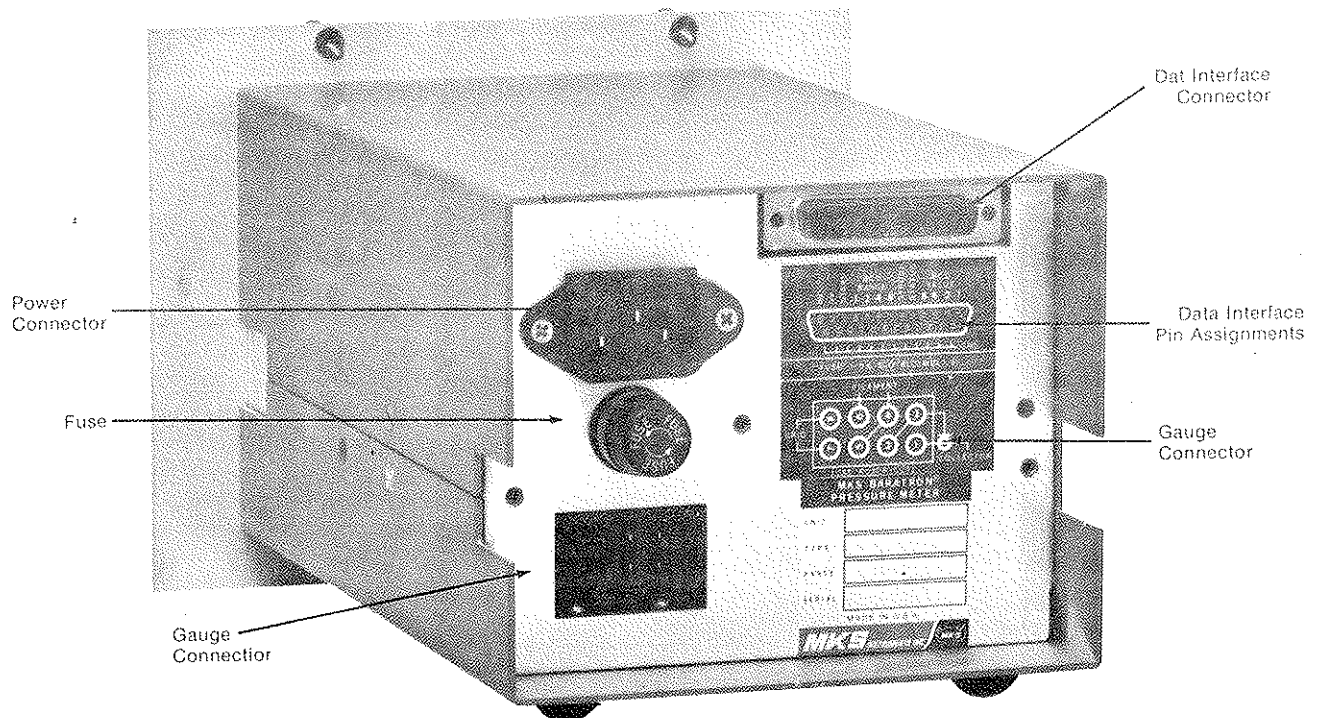


Figure 2-1 Rear Panel Connections



## 2.3 Panel Mounting

The instrument is easily mounted in a rack panel (Fig. 2-3) when ordered with a Type 170M-66 Panel Mount Kit. This kit converts a 170M-60A to a 2A 170 Series Module which can then be mounted into a 170-53 19" rack frame. A selection of blank panels to fill the gap in the 19" rack is available unless the spaces are already occupied by other MKS Baratron® Capacitance Manometers equipment or perhaps another 170M-60A Ion Gauge. Cabinets of various widths are available to accommodate the 170M-60A. See the 170 brochure for outline drawings.

## 2.4 Manual Operation

There is a single three-position switch on the front panel (see Figure 2-4). When the pressure at the gauge tube is below  $10^{-3}$  Torr,

turn the switch from OFF, which is the DOWN position, to ON, which is the MIDDLE position (see Figure 2-4). The gauge filament should light up and, after a short pause, a number should appear on the instrument front panel which corresponds to the gauge pressure (see Figure 2-4). To turn the gauge OFF, simply push the switch DOWN (see Figure 2-4). To DEGAS the gauge tube, push the switch to its UP or DEGAS position (see Figure 2-5). Two vertical lines on either side of the "-" sign will Flash, reminding the user that the DEGAS power is on (see Figure 2-5). DEGAS is normally applied with the gauge tube ON. That is, moving the switch to DEGAS turns on the gauge tube, so that it will monitor pressure during DEGAS unless some fault condition such as over-pressure has automatically turned the filament off.

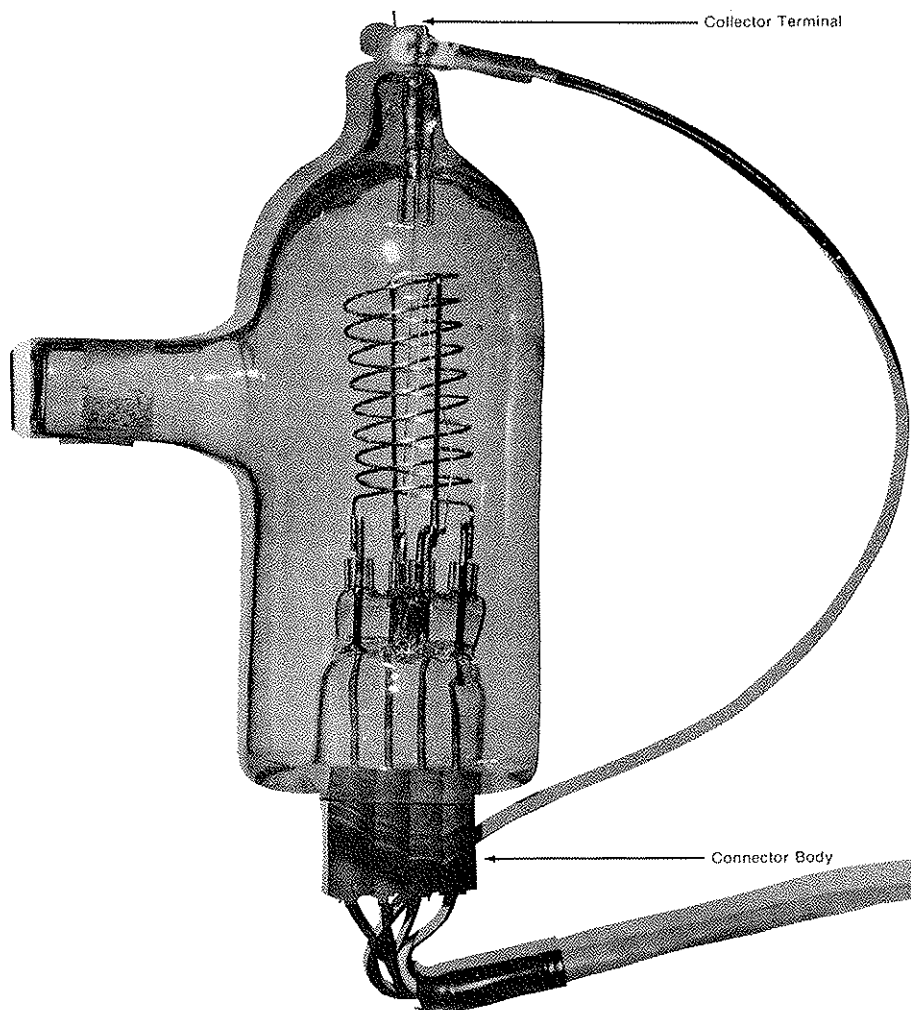


Figure 2-2 Gauge Tube Connections

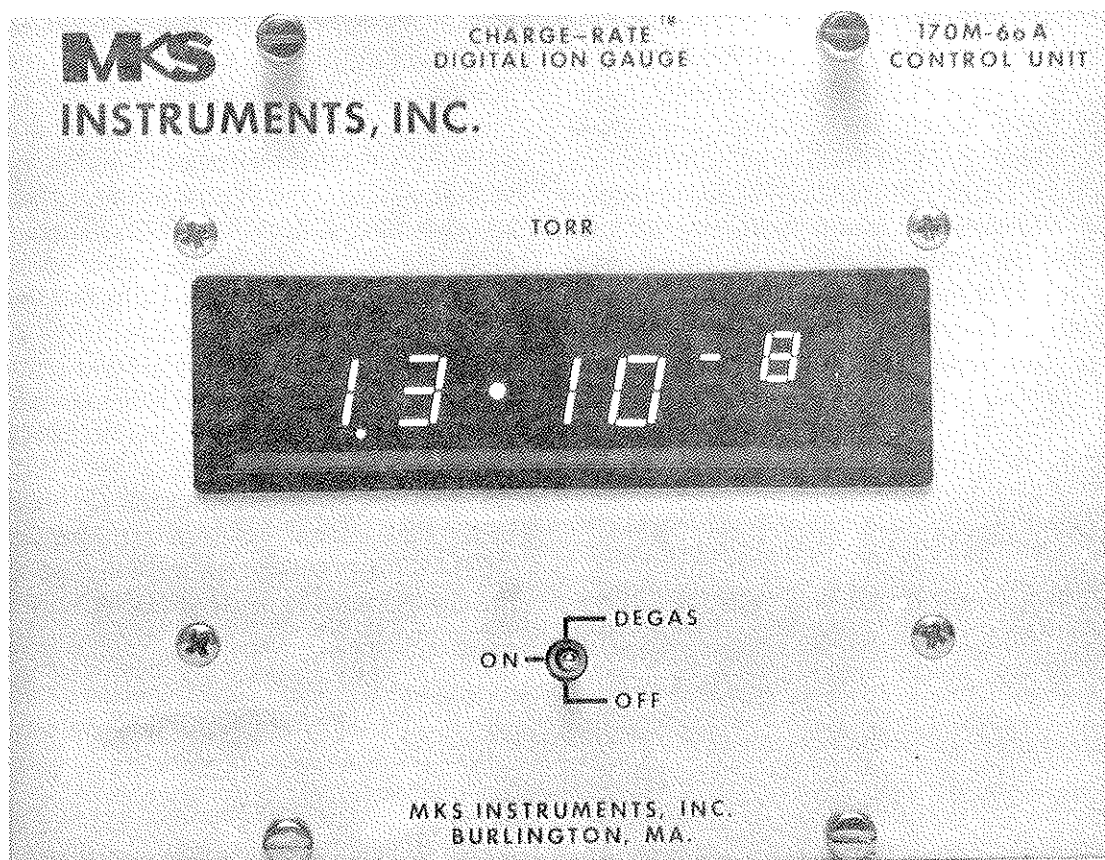


Figure 2-3 170M-60A Mounted on a 170M-66 Panel Mount Kit

## 2.5 Fault Conditions

If there are any characters lit on the front panel, the instrument is ON and has power. If the display shows "•" (no pressure) reading, the gauge tube filament has been turned off due to some fault condition (see Figure 2-6). If the fault is evident, correct it and restart the gauge by turning power OFF for a few seconds and trying it again. If the fault persists, examine the installation to determine what it is before trying again. There may be a discharge in the gauge tube, a shorted or open wire in the cable or a pressure higher than  $10^{-3}$  Torr.

Serious faults may blow the fuse. After clearing the fault, replace the fuse only with the recommended type. Anything else will give either too much or too little protection.

If nothing lights up on the front panel with power applied and a good fuse, there is something wrong inside, and MKS should be notified. (Contact Customer Service Coordinator).

## 2.6 Remote Operation

At the rear of the unit is a 25-pin female Miniature "D" Data Interface Connector (see Figure 2-1). This connector carries parallel BCD data lines for the integer part and the exponent part of the display (the fractional digit is dropped). There is also a line carrying a short "data valid" STROBE pulse any part of which may be used for strobing data into another device. A STATUS line indicates whether the instrument is operating or not, but also carries short pulses whose frequency is proportional to the pressure which may be used to operate analog accessories. The START line is used to turn on or off remotely.

The logic outputs are all low true open collectors, so that when the instrument is switched off at the front panel power switch it will read all zeros and indicate that it's off. For flexibility of application, the 7406-type outputs all have sinking capabilities of 30 ma. low and voltage ratings of 30V high. The remote START/OFF requires 1.8 ma. low and

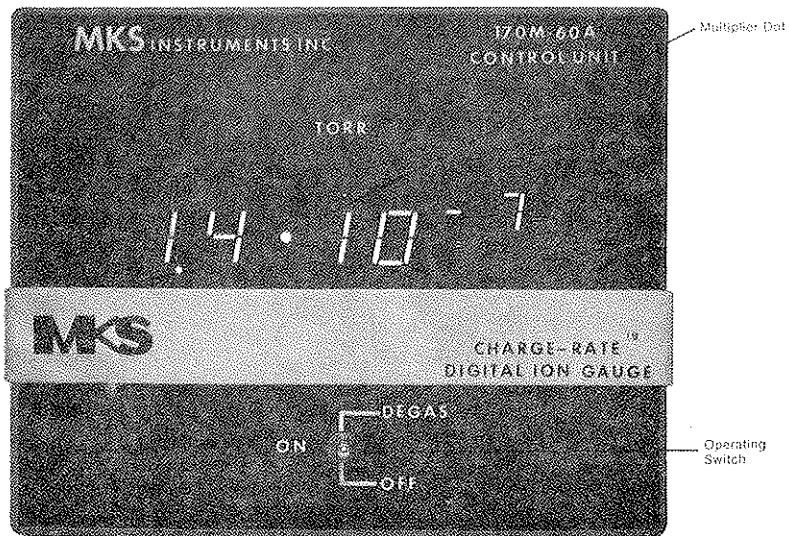


Figure 2-4 Typical Operating Display ( $1.4 \cdot 10^{-7}$ )

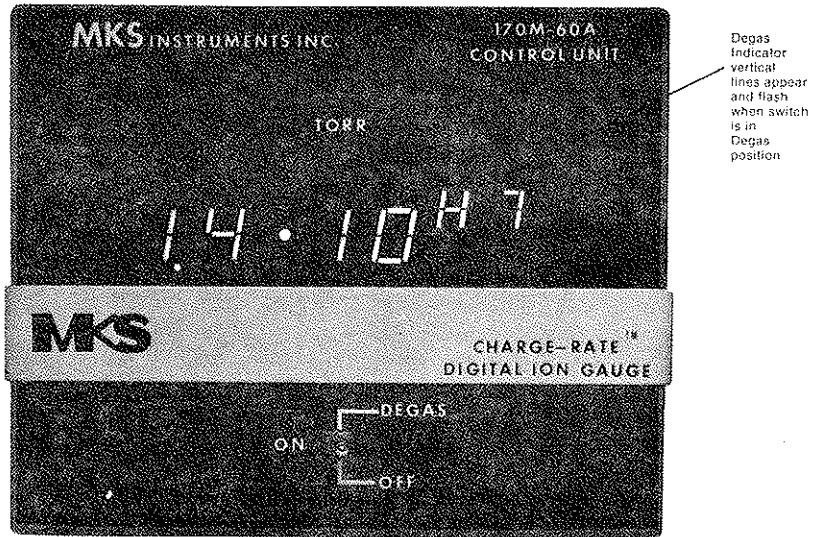


Figure 2-5 Typical Operating Display with Degas "ON"

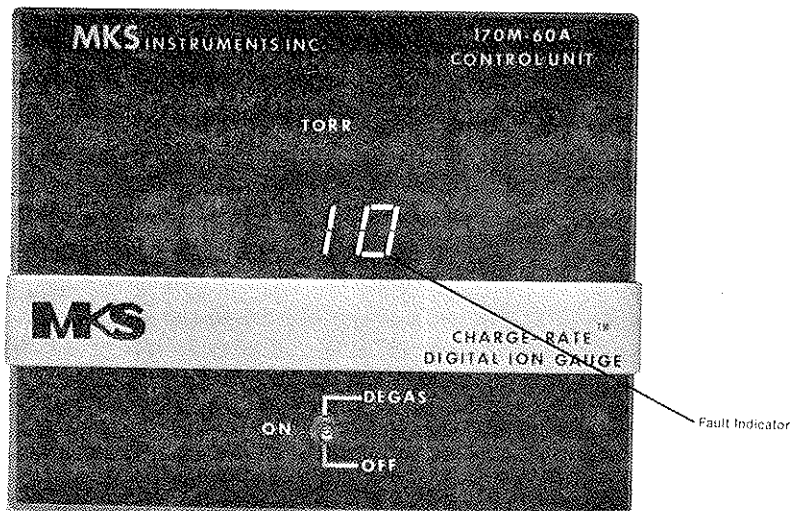


Figure 2-6 Fault Condition Display

2 to 30 volts high. High is START and low is OFF. Thus when the instrument remote START/OFF is operated by an uncommitted-collector driver or by normally open relay contacts in an auxiliary device, it will automatically revert to manual control if that device is turned off. All data inputs and outputs are compatible with CMOS, TTL, HTL, RTL and relay logic.

In addition to the above, +5 volts regulated and +8 volts unfiltered are available for operating other accessories. Each of the data lines is located opposite a ground bus pin for convenience. The pin assignments for the Data Interface Connector are given in the Specifications section and on the rear panel label.

## 2.7 Interfacing Information

Rear Panel Data Interface Connector: 25-pin female D-miniature (D25S).

Pin			
1: Most Significant Digit- pressure	BCD	LSB	<u>D1</u>
2: pressure			<u>D2</u>
3: pressure			<u>D4</u>
4: pressure	MSB	D8	

- 5: Status indicates whether instrument or gauge tube is operating or not —  
ON
- 6: Data Strobe, strobes data into other devices STROBE
- 7: Exponent Range I.D. BCD MSB X8
- 8: Exponent X4
- 9: Exponent X2
- 10: Exponent LSB X1
- 11: Remote Control used to turn on or off remotely START
- 12: +5V Regulated. Available for operating accessories
- 13: +8V Unregulated. Available for operating accessories
- 14-25: GND (case)

Data outputs 30V, 30ma uncommitted collectors, low true.

Remote START/STOP 4V, 1.8ma low, 2-30V high, internal pull-up.

<i>LEGEND</i>	
<i>BCD</i>	<i>Binary Coded Decimal</i>
<i>LSB</i>	<i>Least Significant Bit</i>
<i>MSB</i>	<i>Most Significant Bit</i>
<i>X</i>	<i>Exponent</i>
<i>D</i>	<i>Data Line</i>
<i>D</i>	<i>Complement</i>

## SECTION 3 THEORY OF OPERATION

### 3.1 General

The Charge-Rate\* Ion Gauge uses a patented† technique of measuring pressure which consists of two parts—converting the ion current-to-emission current ratio into frequency, and digitally counting that frequency in a compact and simple way in a floating-point counter.

### 3.2 Charge-Rate\* Analog Processor

The ion current charge flow is permitted to charge a capacitor over a voltage excursion which is proportional to the emission current. The capacitor is then discharged, and allowed to charge again. The frequency of the discharge cycle is then strictly proportional to the ion current charge rate and inversely proportional to emission current. This ratio is the basis of pressure measurement in the Bayard-Alpert gauge tube, so we need only measure the frequency to obtain pressure, even if the emission current varies.

In addition to converting the charge rate to a pulse rate, the analog processor contains an emission regulator which senses the frequency (and therefor the pressure) and reduces the emission current at higher pressures in accordance with good vacuum practice. It also contains protection circuits to shut down the gauge tube if the filament or anode is shorted or if the pressure is too high. There are provisions for protecting the instrument from several other types of abuse, and a circuit for activating the DEGAS indicator.

A schematic of the analog processor is shown in the Appendix.

### 3.3 Digital Processor

The digital processor counts the frequency of the pulses coming from the analog processor in floating-point numbers and displays the result on an LED display. It also converts

the DEGAS indication from the analog processor to a flashing display, presents numerical data to the data interface, and assures that a proper reading is ready before strobing data after turn-on.

The floating-point frequency count is made by permitting the pulses to be counted in a two-decade counter designated 0.0 to 9.9 in 100 steps of 0.1. At the start of a measurement cycle, the counter is monitored for a short time to see if a count of ten pulses (1.0) has been reached. If not, the exponent register is incremented and the monitoring time is increased to ten times as long as before. This continues until the measurement count reaches or exceeds 1.0. Then at the end of the next monitoring period the exponent is incremented but the count is stopped and the number in the counter and the exponent are displayed. Thus the count will be equal to the number of pulses per unit time, where the unit of time is an integral power of ten times a basic interval, and this power of ten is displayed as the exponent in the floating-point display. If the exponent  $-7$  is reached without enough pulses to reach 1.0, the counter contents are simply displayed as-is after the period with a  $-8$  exponent.

At very low pressures, the time between pulses can be quite long because of the very small ion current. To afford the user some ability to discern rapid changes in small pressures, the multiplier dot in the display (see Figure 2-4) is made to flash each time a pulse occurs. At pressures above  $10^{-8}$  the flashes merge, so that most of the time they will not be in evidence. However, at about  $10^{-8}$  and below, they can be seen and the rate of flashing corresponds to the pressure. Timing these with a stopwatch allows measurements down into the  $10^{-10}$  range.

A schematic of the digital processor is shown in the appendix.

\*A trademark of MSKS INSTRUMENTS, INC.

†U.S. Patent #4,035,720



## SECTION 4 MAINTENANCE

### 4.1 General

This instrument can be kept clean and attractive by wiping it with a damp cloth occasionally. The gauge tube should also be kept clean to avoid surface leakage, especially near the collector terminal. The instrument is much better off when left alone, and other maintenance is not usually beneficial. The connectors function best when not disturbed.

### 4.2 Calibration

There is no provision for calibration, although a check on operation can be made with an MKS Gauge Tube Simulator Type 170M-81. This device plugs into the gauge cable connector on the back of the instrument

and simulates electronically a gauge tube operating at a selectable pressure values ( $8.5 \times 10^{-X}$  X=2 to 8).

### 4.3 Repairs

Should any difficulties be encountered in the use of your instrument, it is recommended that you contact any authorized MKS sales office or home office for repair instructions.

If it is necessary to return the instrument to MKS for repair, it is desirable to have an ERA NO. \_\_\_\_\_ (Equipment Return Authorization Number) issued by MKS for identification purposes. Please call the MKS home office Customer Service Department to get an ERA NO. before you return the instrument.

# SECTION 5 APPENDIX

## Digital Proc. Parts List—PL106502-C

LINE ITEM NO.	DWG. CODE	IDENTIFICATION NUMBER	QTY	ITEM NAME & DESCRIPTION	MFR. CODE IDENT.	NOTE NO.
201	D	AC106522	1	DIGITAL PC BD		
202	C	EA106503	1	DISPLAY ASSY		
203	C	106524	REP.	DIGITAL PC SCHEMATIC		
204		005-4488	2	CAP. 100PF C1, C2		
205		005-4459	2	CAP. 100PF, 20V C3, C11		
206		005-4458	2	CAP. 1.1UF, 50V C4, C5		
207		007-4486	3	CAP. 15UF, 20V C6, C8, C9		
208		007-4487	1	CAP. 2000UF, 20V C10		
209						
210		011-4494	1	CERAMIC RESONATOR, 500KHZ XI		
211						
212		015-4462	7	DIODE, 1N4005, CR1-CR6, CR8		
213		015-4463	1	DIODE, 1N4263, CR7		
214		017-4466	1	DIODE, 1N4734A, CR9		
215						
216						
217		037-4470	3	I.C., 5N7413, U1, U2, U3		
218		037-4471	3	I.C., 74C74, U4, U5, U16		
219		037-9026	1	I.C., CD4551, U6		
220		037-9027	4	I.C., CD4518, U7-U10		

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LINE ITEM NO.	DWG. CODE	IDENTIFICATION NUMBER	QTY	ITEM NAME & DESCRIPTION	MFR. CODE IDENT.	NOTE NO.
301		036-9006	1	I.C., CD4049, U1		
302		033-4474	1	I.C., LM309K, U12		
303		036-4472	2	I.C., 5N7406, U13, U14		
304		037-4473	1	I.C., 74C123, U5		
305						
306						
307		044-2050	1	RES. 10R, 1/4W, 5% R1		
308		044-3099	2	RES. 10R, 1/4W, 5% R3, R8		
309		044-2396	5	RES. 2200R, 1/4W, 5% R9, R11, R24, R22		
310		064-2446	10	RES. 33K, 1/4W, 5% R13, R28		
311		064-4051	1	RES. 470K, 1/4W, 5% R19		
312						
313						
314		083-2624	1	TRANS. 2N3655 Q1		
315		082-2952	2	TRANS. MPS6531 Q2, Q3		
316						
317						
318		110-6054	1	CONNECTOR, MOLEX J1		
319		110-6049	1	CONNECTOR, AMP J2		
320		156-6018	1	CONNECTOR, BELL J3		

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LINE ITEM NO.	DWG. CODE	IDENTIFICATION NUMBER	QTY	ITEM NAME & DESCRIPTION	MFR. CODE IDENT.	NOTE NO.
401		100-6021	6	RESISTOR LIST		
402		155-6046	4	PH. RIVET, 8 DA, 4 SW, 1000		
403		163-6035	2	UNFINISHED #2 & 1/4 SW, 1000		
404		146-3102	2	#4-40 W/T		
405		185-2140	2	#4 W/T SW, 1000		

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# Analog Proc. Parts List—PL106500-A

LINE ITEM NO.	DWG. CODE	IDENTIFICATION NUMBER	QTY	ITEM NAME & DESCRIPTION	MFR. CODE IDENT.	NOTE NO.
201	D	PC106520	1	ANALOG M.C. CD		
202	A	FS-106501	2	HEAT SINK		
203	B	CM 106519	1	CINCH CONNECTOR ASSY		
204	C	106521	REF	ANALOG RE. SCHEMATIC		
205		110-6160	1	PATCH CABLE		
206		005-4458	5	CAP. 1.0M, 50V 01C3,09,012		
207		005-4459	5	CAP. 1.0M, 50V 01C3,09,012		
208		005-4460	1	CAP. 33PF CS		
209		005-4461	4	CAP. 22PF 06,07,07,09		
210		007-4457	3	CAP. 22M, 20V 01C02,021		
211		007-4426	1	CAP. 10M, 250V CA		
212		005-2230	2	CAP. 1.0M, 50V 01S,016		
213						
214						
215		015-4462	11	DIODE, 1N4005 01,06, 01S,019		
216		019-4465	1	DIODE, 1N2703 017		
217		017-4464	2	DIODE, 1N4714 019, 010		
218		017-4466	1	DIODE, 1N4734 011		
219		015-4463	3	DIODE, 1N6263 012,014		
220						

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**PL** 106500

LINE ITEM NO.	DWG. CODE	IDENTIFICATION NUMBER	QTY	ITEM NAME & DESCRIPTION	MFR. CODE IDENT.	NOTE NO.
301		032-4467	3	I.C. TL117 01-03		
302		036-4468	1	I.C. 74LS132 0A		
303		031-4469	1	I.C. LM339J 0S		
304						
305						
306		067-4482	2	RES. 12, 3W 01, 02 03, 05, 010, 014 020, 022, 024 025, 027, 030, 033 036, 040, 045, 050, 055, 060, 068		
307		064-3099	10	RES. 10K, 1/4W, 5% 01, 02, 03, 04, 05, 06, 07, 08, 09, 10		
308		064-23916	11	RES. 2200R, 1/4W, 5% 01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11		
309		064-2446	8	RES. 33C, 1/4W, 5% 01, 02, 03, 04, 05, 06, 07, 08		
310		064-2050	1	RES. 10K, 1/4W, 5% 01		
311		064-2469	7	RES. 10K, 1/4W, 5% 01, 02, 03, 04, 05, 06, 07		
312		064-4483	1	RES. 75K, 1/4W, 5% 01		
313		064-4051	4	RES. 42K, 1/4W, 5% 01, 02, 03, 04		
314						
315		064-2589	1	RES. 910K, 1/4W, 5% 01		
316		SELECT 6 OHM	1	RES. 7/8W, 5% 01		
317						
318						
319		087-4475	1	TRANS. E305 01		
320		084-4477	1	TRANS. 2N4258 02		

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LINE ITEM NO.	DWG. CODE	IDENTIFICATION NUMBER	QTY	ITEM NAME & DESCRIPTION	MFR. CODE IDENT.	NOTE NO.
401		082-4476	1	TRANS. 2N4996 03		
402		082-4478	1	TRANS. 2N4275 04		
403		086-4479	2	TRANS. 1N100M 05, 06		
404		082-4480	1	TRANS. MPS-A92 07		
405		082-4481	5	TRANS. 2N4299 08-012		
406						
407						
408						
409		110-6160	1	PATCH CABLE 02		
410		110-6040	1	CONNECTOR, MOLEX 03		
411		110-6041	1	CONNECTOR, MOLEX 04		
412		110-6042	1	CONNECTOR, MOLEX 05		
413		174-3446	2	CONNECTOR, AMP 06, 07		
414		174-6043	2	CONNECTOR, AMP 08, 09		
415						
416		072-4484	1	SWITCH, CRK 01		
417						
418		024-2602	1	FUSE, 2A SLO-BLO F1		
419						
420		025-4493	2	FUSE, 0.5A		

REV. A  
SH  
3-75

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**PL** 106500

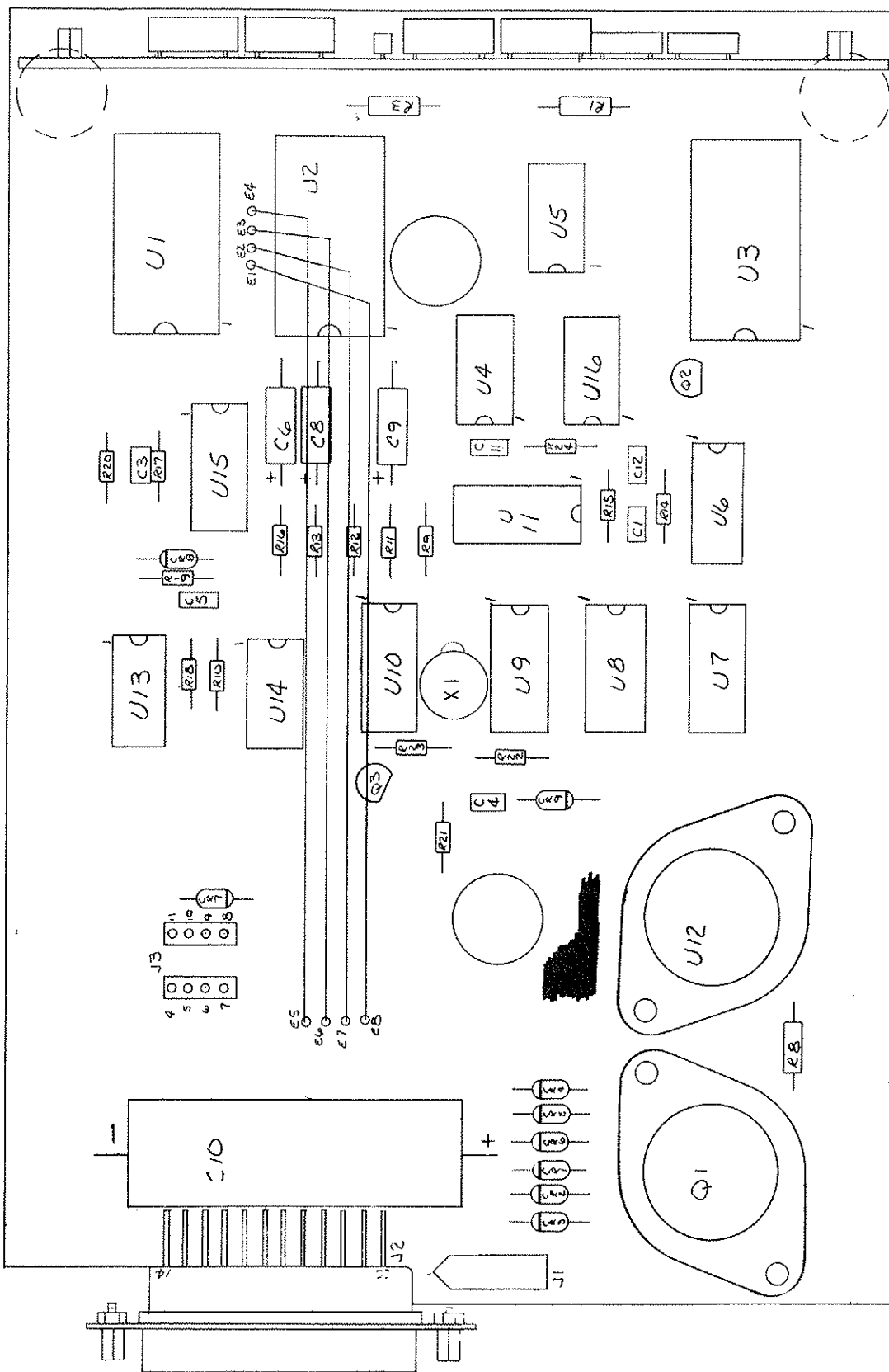
LINE ITEM NO.	DWG. CODE	IDENTIFICATION NUMBER	QTY	ITEM NAME & DESCRIPTION	MFR. CODE IDENT.	NOTE NO.
501		155-6075	2	RP RIVET 1/8 DIA x 3/8 GRW CRANE		
502		155-6046	2	RP RIVET 1/8 DIA x 1/2 GRW CRANE		
503		120-6047	6	RUBBER FEET		
504						
505						
506						

REV. A  
SH  
3-75

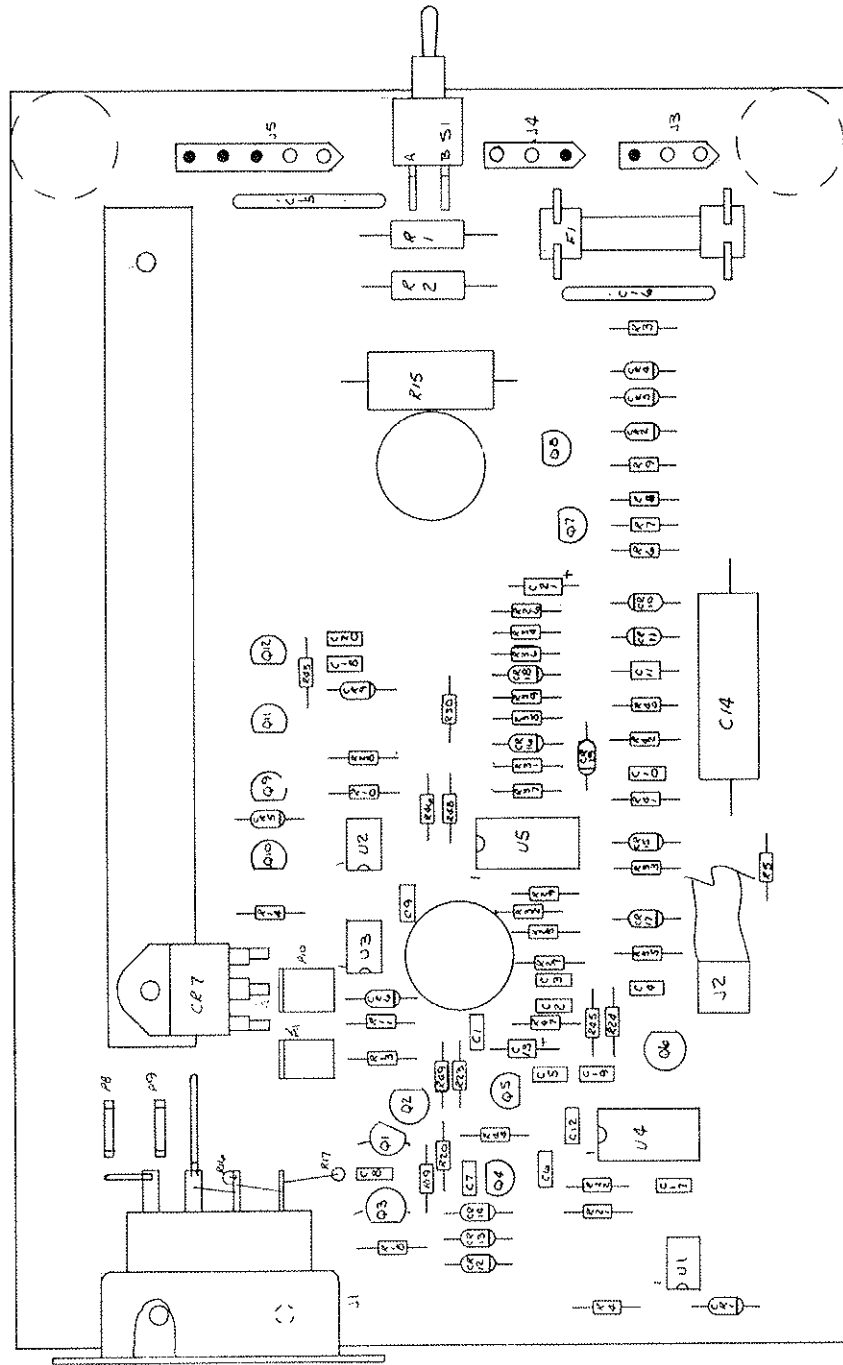
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**PL** 106500

Digital P.C. Layout—D106502-A



# Analog P.C. Layout—D106500-A





# Digital Proc. Schematic—D106524—C

