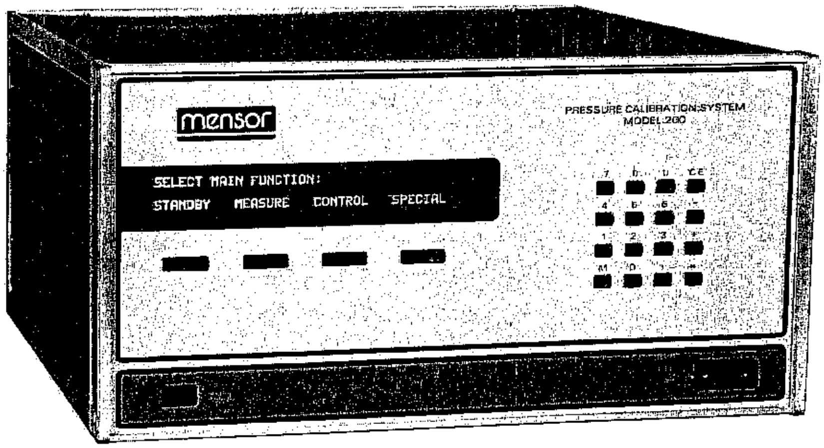
mensor

PRESSURE CALIBRATION SYSTEM

MODEL 200



OPERATION MANUAL

- PACKAGING INSTRUCTIONS -

THIS INSTRUMENT CONTAINS A HIGHLY SENSITIVE PRESSURE SENSING ELEMENT.

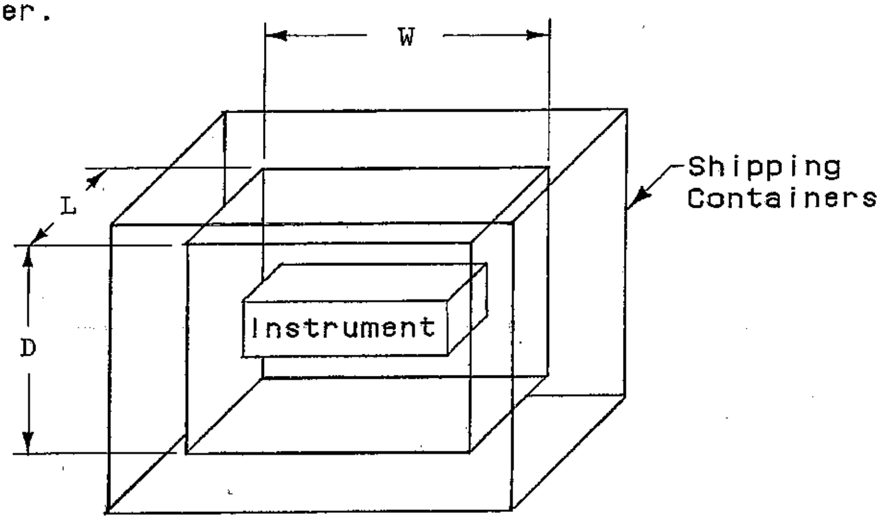
If this instrument is to be shipped by common carrier it should be packaged properly to minimize the risk of damage.

The important consideration in packaging is the density and resiliency of the packaging material. If the packaging material is too dense, it will transmit shock loads to the instrument. If the material isn't resilient, it will not return to its original form or shape after being subjected to a shock load and consequently will be useless when a second loading occurs. If the material is too resilient [urethane foam], damaging resonances can be transmitted to the delicate sensor.

DOMESTIC

The recommended method of packaging is to place the instrument in a container, surrounded on all sides with shock attenuation material such as PELASPAN [peanuts].

The minimum inside shipping container size for the PCS is 27" long, 24" wide, and 16" deep. Insert the container into a second container.



Instrument surrounded by 3-1/2" cushion of packaging material in the inside container, and 2" of packaging material in the outside container.

MENSOR® PRESSURE CALIBRATION SYSTEM

MODEL 200

OPERATING INSTRUCTIONS
12400-001F

The Mensor Pressure Calibration System accurately controls, measures, and displays pressure. With proper care, this instrument will give you years of trouble-free performance.

Before attempting to operate this instrument, please read these instructions carefully.

Additional copies of these instructions are available from Mensor Corporation.

This equipment complies with the requirements in part 15 of FCC rules for a Class A computing device. Operation of this equipment in a residential area may cause unacceptable interference to radio and TV reception requiring the operator to take whatever steps are necessary to correct the interference.

Trademarks

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About the Manual

This manual describes the function and operation of all versions of the Pressure Calibration System Model 200, unless otherwise noted.

Organization of the Manual

Section 1:
Is a general description of the PCS.

Section 2:
Describes the installation of the PCS

Section 3:
Explains the software mode choices and their results.

Section 4:
Provides techniques of operation. Explains the use of the modes from Section 3 as applied to actual use.

Section 5:
Gives instructions on calibration of the PCS.

Section 6:
Describes the various sub-assemblies of the PCS.

Section 7:
Lists the operating specifications of the PCS.

Section 8:
Explains the communications interfaces and lists the optional accessories.

Appendix A: is a reference table of features and sub-assemblies. Also contains programming examples.

Appendix B:
Contains figures referenced in the manual.

Appendix C:
Contains the instrument wiring diagram.

Appendix D:
A trouble-shooting guide.

TABLE OF CONTENTS

1.0 DESCRIPTION

The Mensor Pressure Calibration System [PCS] combines time-proven quartz bourdon tube technology with advanced microprocessor-based electronics to produce and extremely accurate, highly versatile pressure measuring and controlling instrument. Pressure is displayed in direct reading engineering units on an easy-to-read vacuum fluorescent screen.

The microprocessor permits the user to easily change between any of the seven standard engineering units without affecting the accuracy of the instrument. The PCS also allows the use of four easily programmed automated pressure control sequences stored in non-volatile memory. The standard computer interfaces [GPIB and Serial] supplied with the PCS make it equally useful in both automatic data acquisition systems and manual applications.

2.0 UNPACKING AND SETUP

2.1 UNPACKING

The PCS is shipped from the factory ready for immediate use. Keep the shipping and packing material until the PCS has been put into operation successfully. If there is any apparent damage to the PCS due to shipping, inspect the shipping cartons. Notify the carrier immediately if the cartons are damaged. In this case, Mensor will aid in the description and repair of the PCS, but the carrier should assume the cost of repair.

2.1.1 REPACKAGING

If the PCS must be shipped to a different location or returned to Mensor for any reason, see the inside of the cover sheet of this manual for packaging instructions.

2.2 INITIAL CHECKOUT

A preliminary run should be made to familiarize the operator with its operation and to be sure no damage has occurred during shipment. See Figure 2.2 for the front and rear panel connections. Their functions are described in Table 2.2.

The line power source is normally 115 volts, 60 Hz. If the PCS has been equipped for other than this, e.g. 220 volts, 50 Hz, this will be shown on a label near the power connector on the PCS rear panel.

Connect the instrument in to the proper line power. Remove the plastic thread protectors from the pressure ports on the rear panel. Do not make any pressure connections at this time as the following operation will be done at either zero differential pressure for units measuring differential pressure or at atmospheric pressure for units measuring absolute pressure (ranges of 14.7 psia or greater only). For ranges less than 14.7 psia, consult the factory for information on how to do this.

The PCS, after being turned on, goes thru a brief (less than three minutes) internal initialization sequence. During this time the display will show the following:

MENSOR PCS-200 VER #.## (PRESS. RANGE)
INITIALIZING

Then:

MENSOR PCS-200 VER #.## (PRESS. RANGE)
RAM TEST

During this internal initialization, the PCS is performing several system checks. If the system fails one of these checks a warning will be issued on the front panel display. Note the warning, turn the unit off, and consult Appendix D. If this fails to solve the problem, consult the factory.

Note: If the PCS was ordered with the GPIB option, do not connect the BUS line to the PCS at this point. The initial display above, will include information showing the IEEE 488 device address or requesting that a IEEE 488 device address be assigned. If the latter occurs the display will designate a range of addresses to choose from and tell how to enter this. Pick an address within the range and enter it. This will complete the initialization process. For more information on the GPIB see Section 8.

Upon completion of the initialization sequence the display will change immediately to show the following:

SELECT MAIN FUNCTION:
STANDBY MEASURE CONTROL SPECIAL

This is the main menu of the various modes of operation of the instrument. These modes will be discussed in detail in Section 3.0. For now though, the MEASURE mode is all that will be used. Proceed by pressing the MEASURE key. This will put the instrument in the MEASURE mode and the display will show the following:

MEASURE MODE
MEASURED PRESSURE #.##### IN.HG.

The pressure units shown will be those in use when the instrument was last turned off. Conversion to other pressure units will be discussed in Section 3.0. Several comments on the measured reading shown are in order. First, the reading will be near zero pressure for a PCS measuring differential pressure or be near atmospheric pressure for a PCS measuring absolute pressure. Second, as the unit warms up, the reading will change gradually to its final value. Now return to the main menu by pressing the 'M' key in the lower left corner of the main key board.

This completes the initial check.

Note: It is recommended to leave the system powered up to avoid the time required for the system to warm up.

2.3 INSTALLATION

2.3.1 BENCH MOUNTED

The mounting surface should be level and free of vibration. The zeroing procedure, described in Section 3, should be done only after the PCS is in place on such a surface. Units having an absolute Quartz Pressure Sensor (QPS) must be situated on a vibration free surface. During the zeroing of the absolute QPS the air in the space around the bourdon element must be evacuated to a degree (below 100 mTorr) which removes nearly all the damping action. With no damping, table vibration will sustain oscillation of the bourdon element, thus preventing a true null.

Do not stack other equipment on top of the PCS or place other equipment, especially heat-generating equipment, closely around its sides. Accurate temperature control of the QPS within the PCS depends on adequate heat dissipation from the PCS.

2.3.2 RACK MOUNTED

The PCS is easily rack mounted. The rack used should satisfy the dimensional requirements given in Figure 2.3.2. It should be free of vibration, as noted in Section 2.3.1, and excessive heat, as noted below.

Install the chassis slide per Figure 2.3.2, being sure to allow the proper spacing above and below the PCS. A PCS with the rack mount option, Ref. Figure 7.5, is then installed from the front of the rack. Now, before installing the PCS, remove the four feet from the bottom of the instrument. Slide the PCS all the way in position and secure the instrument to the rack before connecting power and pneumatic lines to the rear panel.

After all equipment is installed in the rack, check to see that the temperature inside the rack does not exceed 38°C. If it does, additional rack spacing and/or ventilation must be considered.

CAUTION: If forced ventilation is used, the ventilating device used should be mounted such that vibrations are not induced into the rack.

2.3.3 PRESSURE PORTS

There are four ports on the rear panel of the PCS. SOURCE PRESSURE, EXHAUST, MEASURE/CONTROL PRESSURE, and REF. PRESSURE. Note: The port pattern is different on the absolute and the differential instruments [see Table 2.2]. All fittings are female 1/8 inch NPT.

SOURCE PRESSURE: Connect a regulated source of dry instrument air or water-pumped nitrogen, at a pressure which is 5 to 10 psi above the maximum controlled pressure to this instrument. For the PCS with a QPS range of 100 psi or lower, the maximum pressure is 150 psi. For those with a higher range QPS, the maximum pressure is 50 psi above the regulator range.

EXHAUST: For controlled pressures of 0.1 psig or greater, this port may be vented to atmosphere. For lower controlled pressures, connect this port to a vacuum pump [see Section 7.4.0 for pump specifications]. Never block this port while the PCS is in the CONTROL mode.

MEASURE/CONTROL PRESSURE: This is the input-output port for measurement and control.

REF. PRESSURE: This port is not present on absolute pressure instruments. With differential pressure this port is connected to the regulator reference pressure chamber and to the QPS reference pressure chamber. The PCS will measure and control the differential pressure between the REF. PRESSURE port and the MEASURE/CONTROL PRESSURE port.

The REF. PRESSURE port is dead-ended within the instrument and can be evacuated to a pressure of about 60 microns after pumping for a period of about 4 to 8 hours. This may be used to measure absolute pressures with a differential PCS.

2.3.4 PLUMBING TECHNIQUES

The pressure ports on the manifold/fitting block are threaded 1/8 NPT to accommodate male 1/8 NPT fittings. Fittings to convert from tapered pipe threads to other thread forms should be added at this point. Note: It is recommended that an o-ring fitting such as the SWAGELOK SS-400-1-2-OR fitting be used. This will minimize the chance of thread damage to the ports in the manifold/fitting block.

If conventional NPT fittings are used, some form of thread sealant must be used. Use either TEFLON thread sealing tape or LOCTITE Hydraulic sealant.

TEFLON tape should be wrapped around the threads with 1 to 2 threads exposed on the end. This technique will prevent slivers of tape from being sliced off as the fitting is tightened, to be drawn subsequently into the pneumatic system and possibly into the QPS, regulator, or valves. Whenever such a fitting is removed, use tweezers to carefully remove every scrap of tape from the thread before replacing the fitting.

Other types of thread sealants may be used. Mensor has found LOCTITE hydraulic sealant to be suitable for applications from the highest pressures for which a QPS is designed down to the 1 mTorr vacuum region.

Keep the fittings clean and replace worn fittings. They are a major source of leaks. This is especially true of the 37 degree Flare, 'AN' type of fitting. Leaks cause pressure gradients which can be a source of error in measurement.

3.0 MODES OF OPERATION

This section will explain the various modes of operation of the PCS. Input of these is through the front panel keyboards, the serial port, the GPIB (optional), and the remote keyboard With these modes of operation the operator will be able to control the various pressure measuring and controlling functions of the instrument as well as how the instrument outputs the data obtained.

The modes of operation are structured under four main headings, see Figure 3.0. These are STANDBY, MEASURE, CONTROL, and SPECIAL. These four make up what will be referred to as the 'main menu' from this point on. The main menu can be reached at any time, from any mode that the instrument is operating in, by pressing the 'M' key (except when under GPIB control). This will not change the mode currently in use until a different mode selection is made from the menu. There are two exceptions to this. The CHG UNITS mode and the SET LIMITS mode may be entered and utilized without interrupting the previous pressure measuring or controlling function of the instrument. Upon completion of either of these modes, the instrument will return to the previous mode. More detail on this will be given in the respective mode sections below.

The remaining portions of this section assume that the instrument has been through the initial checkout and installation per Section 2.2 and Section 2.3. It also assumes that the unit is turned on, has initialized, and is currently displaying the main menu.

Note: This section is intended to explain the various modes of operation only and does not attempt to cover all the various techniques of pressure measurement and control. Therefore, for safe and proper usage, use this section in conjunction with Section 4.0 and Section 5.0.

3.1 STANDBY MODE

Press the STANDBY key. This puts the instrument into the STANDBY mode and the following is displayed:

```
MENSOR   PCS-200   VER #.## (PRESS. RANGE)
STANDBY MODE ....   PUSH 'M' TO CONTINUE
```

In this mode, all drive systems are disabled. Power is left on the null assembly heater, the temperature control circuit, and the null assembly lamp. Press 'M' to return to the main menu.

3.2 MEASURE MODE

Press the MEASURE key. This puts the instrument into the MEASURE mode and the following is displayed:

```
MEASURE MODE
MEASURED PRESSURE:            ##.#### PSI
```

The reading will be displayed in the last used pressure units. Conversions to display the reading in other pressure units are possible and will be discussed in Section 3.4.3. This mode is used when an unknown pressure is to be determined.

The instrument will display the measured reading for any pressure within the calibrated range of the instrument. For pressures below the lowest calibration point the display will show the following:

```
MEASURE MODE
MEASURED PRESSURE:            ------- PSI
```

For pressures above the highest calibration point, the display will show the following:

```
MEASURE MODE
MEASURED PRESSURE:            +++++++ PSI
```

CAUTION: THIS IS NOT AN OVER-PRESSURE PROTECTION FEATURE. IT WILL NOT PREVENT DAMAGE TO THE PRESSURE SENSING PARTS OF THE INSTRUMENT. Its only purpose is to inform the user that the instrument is outside the calibrated range. Any protection from over-pressure must be provided through the use of relief valves (see Section 6.1.7).

3.3 CONTROL FUNCTIONS GROUP

From the main menu, press the CONTROL key. This will bring up the following display:

```
SELECT CONTROL MODE
MANUAL   CAL. PTS.   SEQ. 1    OTHER
```

This is the first menu of control modes within the CONTROL functions group. Press the OTHER key to obtain the next menu. The display will be as follows:

```
SELECT CONTROL MODE
SEQ. 2    SEQ. 3     SEQ. 4    OTHER
```

This is the second and last menu of control modes within the CONTROL functions group. As can be seen, there are three ways to control pressure within the CONTROL functions group. They are 1] Manual, 2] Cal points, and 3] Sequences. For the third method, the sequences, there are four versions allowed. Use of each of these will be discussed below.

To return to the first control menu, press OTHER again. To return to the main menu, press 'M'.

Note: Selection of any of the function keys to this point does not change the previous pressure measuring or controlling function of the instrument. Selection of any of the six control functions from the two menus above will change the previous pressure measuring or controlling function.

3.3.1 MANUAL

This mode allows the user to manually enter, by way of the main keyboard, any pressure control point within the set upper and lower limits [see Section 3.4.3.3].

From the first menu of the CONTROL functions group, press the MANUAL key. The display will then show the following:

```
CONTROL POINT:                        MBAR
MEASURED PRESSURE:            XXX.XXX MBAR
```

Now, until the control point is set in as explained below, the PCS will be functioning as if it were in the MEASURE mode. It will be measuring the internal regulator pressure, not controlling pressure.

Enter the numeric value of the control point desired. This will display as follows:

```
CONTROL POINT:                YYYY.YY MBAR
MEASURED PRESSURE:            XXX.XXX MBAR
```

At this point the user has several options. They are as follows:

1. Press '=' to enter the new control point. The instrument will then drive to the new control point showing SLEWING rather than MEASURED PRESSURE until the control point is reached.
2. Press '+' to add the new value [YYYY.YY] to the previous control point. The instrument will drive to this sum [XXX.XXX + YYYY.YY]. Press '+' again to increment the control point by the new value [YYYY.YY]. This may be done repetitively within the SET LIMITS.

3. Press '-' to subtract the new value from the previous control point. The instrument will then drive to this difference [XXX.XXX - YYYY.YY]. Press '-' again to decrement the control point by the new value [YYYY.YY]. This may be done repetitively within the SET LIMITS.
4. Press 'CE' to correct the new control point. Each stroke of the clear entry [CE] key will clear the right most digit of the new control point until the entire number has been cleared. At this point, another stroke of the 'CE' key will bring the previous control point back.
5. Press 'M' to return to the main menu. This may be used to abandon this mode or to route to the SPECIAL functions mode to change pressure units or to set new limits [see Section 3.4.0].

Note: If, when entering the new control point, the new value is outside the SET LIMITS, a warning signal will be given. This signal will indicate that the new control point is either above the upper limit or below the lower limit. Press the 'CE' key to return to the previous display. At this point, either enter a new control point or go to the SET LIMITS mode [Section 3.4.3] to reset the limits.

3.3.2 CAL. PTS. [CALIBRATION POINTS]

This mode allows the user to control pressure at the calibration points of the PCS. To do this, go to the first menu of the CONTROL mode. Press the CAL. PTS. key. This will display the following:

```
CAL. POINT:    1 OF 20        AMBIENT MBAR
MEASURED PRESSURE:             ###.## MBAR
```

At this point the instrument is measuring pressure, with atmospheric pressure applied through the vent solenoid, while waiting for a command on how to proceed. The options the user has at this point are as follows:

1. Press '+' to increment the control pressure up by one calibration point for each keystroke.
2. Press '-' to decrement the control pressure by one calibration point for each keystroke.
3. Enter a calibration point number and press '=' to control pressure at a specific calibration point.

Note: Incrementing above the top calibration point or below the lowest calibration point will generate a warning signal. Press 'CE' to recover.

Note: The SET LIMITS mode [Section 3.4.3] does not function within the CAL. PTS. mode. The limits in the CAL. PTS. mode are set by the lower and upper calibration points.

3.3.3 SEQ. 1 [SEQUENCE]

The SEQUENCE modes allows the user to automatically run a sequence of user specified control pressure points with user specified time intervals between points. Sequences are programmed by the user through the LEARN SEQUENCE mode [Section 3.4.6]. Four different sequences may be programmed with up to 228 programmable control points allowed between the four sequence modes. More details on this will be given in Section 3.4.6.

To use any of the sequence modes, assuming they have been programmed and that the PCS is properly set up, the user selects the CONTROL mode and then, depending on which sequence is wanted, selects SEQ. 1, SEQ. 2, SEQ. 3, OR SEQ. 4. The PCS begins the sequence immediately with a typical first display as follows:

```
SEQ. 1 POINT # 1        5.0000 PSI
SLEWING...              4.5000 PSI
```

Here, the PCS is going to the first set control point which is the pressure unit on the first line. SLEWING... on the second line, indicates that the control pressure is not stable yet. As soon as the control pressure stabilizes, the pressure reading on the second line will be the actual measured pressure and the display will change to something like the following:

```
SEQ. 1 POINT # 1    DELAY   50  SEC.
MEASURED PRESSURE:        5.0000 PSI
```

At this point the time delay before changing control points begins. The DELAY time shown will count down, displaying time remaining. Upon completing the time delay, the PCS will begin driving to the next control point. This will continue until the sequence has been completed.

Note: Delay timing is done by an internal counting system and is not intended to be an accurate timing device. Timing accuracy can be in error as much as +20%.

Upon completion of the sequence, the display will be as follows:

```
PUSH '1' TO REPEAT, OR 'M' FOR MENU..
MEASURED PRESSURE:       50.000 PSI
```

The measured reading shown should be that of the last control point in the sequence. As stated in the first line, by pressing '1' the sequence will be repeated or by pressing 'M' the PCS will return to the main menu.

3.3.4 SEQ. 2

Same as Section 3.3.3 except this executes SEQUENCE 2.

3.3.5 SEQ. 3

Same as Section 3.3.3 except this executes SEQUENCE 3.

3.3.6 SEQ. 4

Same as Section 3.3.3 except this executes SEQUENCE 4.

3.4 SPECIAL FUNCTIONS

The modes within this group gives the user a wide latitude over how the instrument is used, how the instrument is controlled, and how the data is presented. Each of these will be explained individually below, but first, become familiar with the modes available by stepping through all the menus of the SPECIAL functions group. Follow along on Figure 3.0 while doing this to get a mental picture of the organization of this group of functions. Begin by selecting the SPECIAL functions group from the main menu. The display will show the following:

```
SELECT SPECIAL FUNCTION:
STATUS       VENT       SETUP       OTHER
```

Press STATUS to display the following:

```
SELECT STATUS MODE:
CAL DATA   CAL CHART   INTERNAL   EXTERNAL
```

This is the selection of the functions within the STATUS group. Now, return to the top level of the SPECIAL functions group by going to the main menu [press 'M'] and then select SPECIAL.

The next choice under SPECIAL functions is VENT. This is an end use function, therefore do not select it at this time. It's use will be discussed later in this section.

Now press SETUP. This will bring up the first menu of the SETUP modes, which will be displayed as follows:

SELECT SETUP MODE:
CHG UNITS TIMER SET LIMITS OTHER

Press OTHER to bring up the second menu of SETUP modes as follows:

SELECT SETUP MODE:
IEEE ADR PRINTER RS232 OTHER

Now return to the top level of the SPECIAL functions group as before. Press 'M' and SPECIAL.

Now press OTHER to display the three remaining top level SPECIAL functions group. The display will show as follows:

SELECT SPECIAL FUNCTION:
CAL TESTS LEARN SEQ. OTHER

Press CAL to obtain the calibration modes, displayed as follows:

SELECT CALIBRATION MODE:
ZERO RECAL 1 PT.CAL -

Now press 'M', press SPECIAL, press OTHER and then press TESTS to obtain the testing modes, displayed as follows:

SELECT TEST MODE:
RAM TEST CLOCK CAL CHK DISPLAY

The last special function is the LEARN SEQUENCE mode. This is an end use function so do not select it at this time. This is all the functions within the SPECIAL functions group. Each of these will be explained individually below. Press 'M' to return to the main menu.

3.4.1 STATUS

The selections within this group makes available to the user various aspects of the status of the instrument. It is presented to the user when requested by selecting STATUS from the SPECIAL functions group [main menu item] and then selecting the type of status desired. These types of status will be discussed below.

3.4.1.1 CAL DATA [CALIBRATION]
[Version 3.0 and higher, only]

This selection will display the date of last calibration, the number of counts offset due to rezeroing the instrument, the QPS temperature at calibration, and the instrument and QPS serial numbers. The PCS returns to the current mode of operation when 'M' is pressed.

3.4.1.2 CAL CHART

(Version 3.0 and higher, only)

This selection will display the internal calibration chart (true pressure vs. encoder counts). It allows scrolling up or down through the chart by using the '+' or '-' keys. The PCS returns to the current mode of operation when 'M' is pressed.

3.4.1.3 INTERNAL

This selection displays the temperature of the Quartz Pressure Sensor in degrees centigrade, vacuum gauge reading in current pressure units (differential pressure measuring instruments will read zero here), null meter reading in encoder counts, and time with date (time feature not available yet). This information will be displayed as follows:

```
QPS TEMP: ##.##C    TIME: MM/DD/YY HH:MM
NULL :     ##.#CTS  VAC: #.#### PSI
```

The PCS returns to the current mode of operation when 'M' is pressed.

3.4.1.4 EXTERNAL - NOT AVAILABLE

This feature is not implemented at this time and is reserved for future requirements.

3.4.2 VENT

This mode vents the system, including any devices connected to the MEASURE/CONTROL port. To utilize this, enter the SPECIAL function group from the main menu. Press VENT key. The display will be as follows:

```
SYSTEM VENTED...
MEASURED PRESSURE:        ##.#### PSI
```

Press 'M' to return to the main menu.

3.4.3 SETUP

The modes within this group give the user the ability to setup various parameters for particular applications of the instrument. These include such things as pressure units, time, control limits, and others. Each of these will be discussed below.

3.4.3.1 CHG UNITS

This selection allows the user to select any of seven pressure units. This can be done whenever the instrument is on. After selecting the new pressure units, the PCS automatically returns to the last used mode of operation.

To change units, go from the main menu to the SPECIAL functions group. From this point select the SETUP mode and then the CHG UNITS mode. The display will be as follows:

```
     SELECT NEW UNITS:
     IN.HG.     MBAR       PSI       OTHER
```

Press OTHER to obtain the following:

```
     SELECT NEW UNITS:
     INH20     MMHG.      KPA       OTHER
```

Press OTHER to obtain the following:

```
     SELECT NEW UNITS:
     MTORR      COUNTS     -         OTHER
```

Press OTHER one more time to return to the first CHG UNITS menu. The user may select the new pressure units by depressing the appropriate key. The PCS will then change the units and return to the previous mode of operation. If no change is desired, then press either the same units as are in use or press 'M' to return to the main menu.

For standard reference temperatures of the pressure units, see Section 7.1.

3.4.3.2 TIMER

This selection will allow the user to set or change the month, day, hour, minute, and seconds of the internal clock. The PCS returns to the main menu upon exit.

3.4.3.3 SET LIMITS

This selection allows the user to set the allowable upper and lower pressure control points to limit the range of control to any value within the calibrated pressure range. These limits apply only when controlling in the MANUAL control mode. The user can use this to limit the pressure going to any device(s) under test. Utilization of this mode does not interrupt the previous mode of operation. After setting in new limits the instrument will return to the previous mode.

To set new limits, begin by entering the SPECIAL functions mode from the main menu. Then press the SETUP modes key, followed by the SET LIMITS key. The display will be as follows:

```
CONTROL LIMITS:  0.000 :  XXX.XXX MBAR
ENTER NEW LOWER LIMIT:
```

Enter the new lower limit on the main keyboard, then press the '=' key. Assume YY.YYY is the new lower limit, then the display will be as follows:

```
CONTROL LIMITS:  YY.YYY :  XXX.XXX MBAR
ENTER NEW UPPER LIMIT:
```

Now enter the new upper limit and press '='. This will set the new limits. The display will then request a confirmation. Press 'M' if the limits as they appear on the display are correct. If not, press 'CE' to reset the limits.

Notes:

1. Attempting to enter a value greater than the upper calibration point will result in a set point equal to the upper calibration point.
2. Attempting to enter a value less than the lower calibration point will result in a set point equal to the lower calibration point.
3. Entering a new lower limit that is greater than the present upper limit will result in the new value being entered for both the upper and lower limits.
4. Entering a new upper limit that is less than the lower limit will result in the new upper limit being set equal to the present lower limit.

3.4.3.4 IEEE ADR

This selection allows the user to specify the device address of the PCS for use over the GPIB (option). See Section 8.1.2.1. The PCS returns to the main menu upon exit.

3.4.3.5 PRINTER- NOT AVAILABLE

This feature is not implemented at this time and is reserved for future requirements.

3.4.3.6 RS-232-C

This selection allows the user to set the serial configurations including baud rates, word length, stop bits, and parity. See Section 8.1.3.1. The PCS returns to the current mode of operation upon exit.

3.4.4 CAL

This group contains the calibration modes for the PCS. There are three modes within this group for setting or correcting the calibration of the instrument.

3.4.4.1 ZERO

The ZERO mode is used to set the zero on a differential PCS. Setting zero on a differential unit is typically a very simple process and, except for unusual situations, can be done based on the following explanation.

To set the zero on a differential PCS, select SPECIAL from the main menu, then OTHER, then CAL, and then ZERO. The display will be as follows:

```
     ZERO MODE:                CALCULATING......
                                 35842
```

Initially the number on the second line of the display will be changing. When this number stabilizes, the instrument will delay about 10 seconds, then go to the MEASURE mode.

During the zeroing process the PCS isolates the pressure port of the QPS from the rear panel pressure port. The QPS pressure port is then opened to the reference port, which is open to the rear panel. The instrument will be zeroed at whatever pressure is present at the reference port.

The ZERO mode is not recommended for setting the zero offset of a differential PCS used in an absolute configuration. See Section 3.4.4.3.

3.4.4.2 RECAL

The RECAL. mode is used to enter new calibration information in the memory of the PCS. Basically, for each calibration point, a precisely controlled pressure is applied to the instrument through the MEASURE/CONTROL port and the numeric magnitude for this pressure is applied through the main keypad. This is repeated for as many calibration points as the user desires up to 62 [#1 to #62] points. Note: The typical number is 40 and the recommended minimum number is 20.

NOTE: DO NOT ATTEMPT TO RECALIBRATE THE PCS ON THE BASIS OF THIS SECTION ALONE. The main concern of this section is to explain the software aspects of recalibration. For this reason the pressure related aspects of recalibration are mentioned here without sufficient detail to recalibrate the PCS. See Section 5.0 for complete details on this process.

Begin by selecting the RECAL. mode from the CAL modes group of the SPECIAL functions group. The display at this point will show as follows:

RECALIBRATION MODE ...
ENTER RECALIBRATION PASSWORD

The user must now enter the proper password to further access this mode of operation. As this number is entered, the display will show a filled character position for each character of the password entered. The password itself will not be displayed. Two attempts to enter the proper password are allowed, then the PCS 'locks up' preventing any further operation of any kind. To clear this the instrument must be turned off for a brief period of time, then turned on again to allow it to reinitialize. At this point another attempt to enter the RECAL. mode may be made or another mode of operation may be selected.

Assuming the proper password was entered, access to the recalibration sequence will be given and the display will show as follows:

-WARNING- PRESSING '=' TO CONTINUE WILL
DESTROY THE PRESENT CAL. CHART ['M' TO EXIT]

At this point the user must either commit to recalibrating the PCS or abandon this mode of operation. If the user commits, the present calibration chart will be destroyed. Therefore, DO NOT press '=' unless the user has read and understands the remainder of this section and all of Section 5.0. To abandon, press 'M' to return to the main menu.

Note: The remainder of this section will be presented as if the user has read Section 5.0 and is proceeding with the recalibration sequence. Therefore, if the user is reading this section simply to gain the understanding of the process, DO NOT perform the commanded operations on the PCS.

Begin by pressing '='. As stated above this will destroy the present calibration chart, clearing the memory for the new calibration chart. The instrument will set its mechanical zero (less than three minutes). The display will then show the first prompt, shown as follows:

```
ENTER TRUE CAL. PRESSURE OR 'M' TO QUIT
#1              COUNTS            PSI
```

At this point, there are a few things to consider. These are as follows:

1. Pressing 'M' to quit will allow the user to exit the RECAL. mode, but it must be noted that at this point the calibration chart has already been destroyed and without this the PCS is not functional.
2. Check the pressure units on the right side of the second display line. Those shown will be the pressure units used in the previous mode of operation. If other pressure units are desired, then the units should be changed at this time. Press 'M' to exit the RECAL. mode, change the units per Section 3.4.3.1, and then re-enter the RECAL. mode as was done above.
   Note: 'Counts' cannot be used for pressure units in this mode.
3. On the left side of the second line of the display is the calibration point number. The number shown above is the #1 calibration point. This is the first of up to 62 points (#1 to #62) that will be utilized to define the calibration points of the PCS. These, as well as the applied pressures, must be dealt with in sequential order, from lowest to highest.
4. In the center of the second line of the display, the number of counts will be shown. See Section 6.2. for an explanation of counts. This number will be calculated by the PCS microprocessor according to the numerical pressure value put in for each calibration point.

Continue the RECAL. sequence by doing the following:

1. Apply the appropriate pressure to the PCS. See Section 5.0 for information on this.
2. Input the corresponding numerical pressure value through the main keypad. This must be done in the pressure units shown on the display. Any entry longer than seven

characters including the decimal will be truncated to seven characters. Mistakes may be corrected at this point with 'CE' key. CAUTION: Be careful to correct any mistakes now, because once entered in Step 3, the only means of correction is to abandon and restart the RECAL. sequence.

3. Press '='. This will tell the microprocessor to accept the numerical pressure value and to calculate and display the number of counts. The display will be as follows:

```
PRESS '=' WHEN SYSTEMS STABILIZE
#1          YYYY COUNTS    XXXX PSI
```

4. Allow the PCS to stabilize, then press '=' again. This tells the microprocessor to equate the applied pressure from Step 1 to the input numerical pressure value from Step 2 and then store this as a certain calibration point. The display will then show:

```
ENTER TRUE CAL. PRESSURE OR 'M' TO QUIT
#2                   COUNTS         PSI
```

   Note that the calibration point number has now incremented by one to the next calibration point.

5. Repeat Step 1 through Step 4 for each calibration point. Again, the minimum recommended number of calibration points is 20, typical is 40, and the maximum is 62.
6. To complete the RECAL. sequence, press 'M'. This tells the microprocessor that this is all of the calibration points, to perform the necessary calculations, and to return to the main menu.

3.4.4.3 1 PT.CAL

This mode is for a PCS that measures absolute pressure, although, if desired, it may be used with differential pressure units. The purpose of this mode is to allow the user to correct the zero offset of the PCS. Basically, this is done by entering a known pressure within the range of the PCS to the MEASURE port on the rear of the instrument. The pressure must have an accuracy greater than or equal to a PCS. The numerical value for this known pressure is then entered into the instrument. The PCS now takes this value and compares it to its own measured value of the input pressure. It then sets the offset accordingly. The PCS returns to the main menu upon exit.

Functionally, this is all done by first going to the SPECIAL functions group from the main menu. Then by pressing OTHER, then CAL, and then 1 PT.CAL, the display will appear as follows:

```
SINGLE POINT CAL ...
ENTER TRUE PRESSURE          ? PSI
```

Now apply a known pressure to the MEASURE port. There are available methods for applying the known pressure:

1. Typically, for convenience barometric pressure may be used. In this case, the MEASURE port is left open to atmospheric pressure and a barometric pressure reading of accuracy greater than or at least equal to that of the PCS is used.
2. Use the setup described in Section 5.2.2 to apply a known pressure within the range of the instrument. The known pressure may come from a reference standard in which case vacuum may not be required, or from a vacuum gauge in which case a reference standard may not be required. When using a vacuum gauge, measure the pressure as close to the PCS as possible. If the QPS has a vacuum gauge installed and wired internally, use it.

   Note: When the vacuum is measured at the rear of the PCS, the pressure is generally 40% higher [300 microns and below] than that measured at the QPS. This is due to outgassing and continues for up to 72 hours or more.

Next enter the numerical value for this known pressure. Note that this value must be in the same pressure units as shown on the display. If it is not, then the user must either convert the applied pressure to the diplayed pressure units or, by use of the CHG UNITS mode [Section 3.4.3.1], convert the displayed units to those of the applied pressure. After entering this pressure value, press '='. Errors in the value may be corrected with the CE key prior to pressing '='. To correct errors after pressing '=', the user must return to the main menu and then re-enter the 1 PT.CAL mode. With the pressure value entered and after pressing '=', the display will show as follows:

```
SINGLE POINT CAL...
PUSH '1' TO SET CAL AT:  ## PSI
```

Assuming that the input pressure is stable, allow approximately one minute to insure that the instrument has stabilized and then press '1' to set the calibration.

3.4.5 TESTS

The selections within this group allow the user to make certain checks on the operation of the pressure system of the PCS. Details on each test are given below.

3.4.5.1 RAM TEST

This is an internal system check to verify the operation of the random access memory [RAM]. Begin by selecting SPECIAL, then OTHER, then TESTS, and finally RAM TEST. At this point the display will be as follows:

    RAM TEST

The first item covered is the battery back-up. If either of the two batteries in each of the two RAM chips was found to be low or bad during the last power up of the PCS, a beeper will sound and the display will be as follows:

    **** WARNING ********* WARNING ****
    ....PENDING RAM BATTERY FAILURE 1

This will remind the user of a battery failure for RAM 1 [as shown], RAM 2, or RAM 1&2. See Appendix D for information on this failure. Pressing 'CE' will allow the RAM test to continue.

The second item checked is the random access memory cells. A failure here will sound a beeper and a warning will display as follows:

    **** WARNING ********* WARNING ****
       .....RAM 1 ERROR

As before, this will indicate an error for RAM 1 [as shown], RAM 2, or RAM 1&2. See Appendix D for further information.

If no errors are found the display will be as follows:

    PRESS '1' TO REPEAT, OR 'M' FOR MENU
    RAM TEST

This completes the RAM test. The PCS will return to the main menu upon exit.

3.4.5.2 CLOCK
(Version 2.57 and higher)

This puts the internal clock into a test mode. This test requires additional hardware to verify and is for factory adjustment only. The PCS must be powered down to exit this test mode.

3.4.5.3 CAL CHK
(Version 2.57 and higher)

This checks the calibration chart for obvious omissions of data. When completed it returns to the current mode of operation.

3.4.5.4 DISPLAY
(version 3.0 and higher)

This puts the display into a test mode to verify proper operation of the display cells. The test may be exited by pressing 'M' at any time. The PCS will return to the current mode of operation.

3.4.6 LEARN SEQ

This selection allows the user to program automatic sequences of control pressures and time delays. Up to four different sequences may be stored (ref. Section 3.3) with up to 228 control points being allowed between the four sequences.

Begin the programming sequence by selecting SPECIAL from the main menu, then OTHER, then LEARN SEQ.. This will bring up the following display:

LEARN SEQUENCE MODE
ENTER SEQ. NUMBER..(1, 2, 3, OR 4)

At this point enter the number of the sequence to be programmed. The display will then show:

ENTER UNITS...
0 = INHG
1 = MBAR
2 = PSI
3 = MMH20
4 = MMHG
5 = KPA
6 = MTORR
7 = CTS

Press the number corresponding to the units desired. The next display will be as follows:

```
ENTER CONTROL POINT OR 'M' TO END SEQ.
SEQ. 1 POINT #  1 [227]           PSI
```

At this point there are several points to consider.

1. Pressing 'M' at this point erases any previously stored sequence in this sequence mode [SEQ. 1 here] and returns the user to the main menu.
2. On the second line, SEQ. 1 identifies which sequence is being programmed. POINT # 1 identifies which point in the sequence is being programmed. [227] indicates how many possible programmable points are left, not including the point being programmed. Note that the 228 points are total for all four sequences.

Now enter the first pressure point in the pressure units shown on the display [here PSI]. Press '=' to record. Now the display will request a time delay as follows:

```
ENTER TIME DELAY.... [0 TO 65535 SEC.]
SEQ. 1 POINT # 1                SEC.
```

Enter the time delay desired in seconds. Press '=' to record.

Note: Delay timing is done by an internal counting system and is not intended to be an accurate timing device. Timing accuracy can be in error as much as ±20%.

This completes the programming of the first point. Repeat this for as many control points and time delays as are desired. Note that pressures can be run up and down scale within the range of the instrument as desired with different time delays between points as desired. Complete the sequence by pressing 'M' to store the sequence and to return the PCS to the main menu.

4.0 TECHNIQUES OF OPERATION

The purpose of this section is to provide the user with the basic techniques required to obtain the results desired from the PCS. This will consist mostly of information on how to properly use the PCS, but it will also include some information on the more basic technique of pressure measurement and control. These techniques, along with some discussion of typical errors, should give the user the ability to obtain results of the highest quality for the PCS.

4.1 INITIALIZATION AND WARMUP

Initialization of the PCS is an operation the user should generally not have to be concerned about since the operation is completely automatic. The user simply turns the unit on via the power switch on the front panel. Once this is done the PCS automatically undergoes a brief (about 45 seconds) internal initialization. Assuming all internal checks are successful, the unit, after initialization, will display the following:

SELECT MAIN FUNCTION:
STANDBY MEASURE CONTROL SPECIAL

Should the PCS not pass one of the internal checks, the display should show one of the following warning or error messages.

1. PENDING RAM BATTERY FAILURE
2. RAM FAILURE

An explanation of these messages as well as other possible problems can be found in Appendix D. Should the unit still fail to initialize, please consult the factory.

Note: If the PCS includes the GPIB option, the initializing displays will include information showing the IEEE 488 device address or requesting that a IEEE 488 device address be assigned. If the latter occurs the display will designate the range of addresses to choose from and tell how to enter this. For further information, see Section 8.1.

Now, once the unit has initialized, it must be allowed a warm up time of about 1½ hours to allow temperature stabilization of internal parts. This is very important if the highest quality data is desired.

Note: The temperature displayed by the PCS in the INTERNAL status mode is the Quartz Pressure Sensor (QPS) temperature. This temperature stabilizes about 30 minutes after the unit is powered up, but it takes about one hour before the complete unit stabilizes.

4.2 SETTING THE ZERO OFFSET

This section describes the methods used to set the zero offset on both differential and absolute units. To do this, the two modes of operation available are the ZERO mode and the 1 PT.CAL. mode. Either of these can be used for differential units, but only 1 PT.CAL. may be used on absolute units. This will be discussed below.

4.2.1 SETTING THE ZERO OFFSET ON A DIFFERENTIAL PCS

Setting the zero offset on a differential pressure PCS is the simplest of the procedures for setting zero offset. What is required here is that the PCS be initialized and warmed up as discussed above. The reference pressure port on the rear panel is typically opened to atmospheric pressure. Then simply follow the procedure for using the ZERO mode given in Section 3.4.4.1. The PCS will automatically connect the pressure side of the QPS to the reference side through the zero solenoid valve (ref. Figure 6.1), thus placing a zero differential pressure on the QPS. The microprocessor will then automatically adjust the zero offset internally and return the PCS to the main menu or to the previous mode of operation.

CAUTION: When using a differential pressure PCS to measure absolute pressures (i.e., placing a vacuum on the reference pressure port), it is still recommended to set the zero offset at atmospheric pressure rather than attempting to pump the system down to some vacuum level. The problem with the vacuum approach is that the outgassing rates of the pressure side and the reference side of the QPS are different. This results in a higher pressure on the reference side for <u>several</u> days of continuous pumping.

As mentioned above, there are two means of setting zero offset. The second one uses the 1 PT.CAL. mode (see Section 3.4.4.3). Typically this is not used for differential pressure units for several reasons, the first being that it is more involved. It requires a known pressure of accuracy greater than or equal to the PCS to be input to the PCS. The other reason, which deals with accuracy, is that the ZERO mode, which connects the pressure and reference ports of the QPS together, gives a true zero differential pressure whereas the 1 PT.CAL. mode, which uses another pressure standard, introduces some uncertainty from the standard. Admittedly, the uncertainty introduced should be well within acceptable limits, but it will essentially always be greater than that introduced through the ZERO mode.

4.2.2 SETTING THE ZERO OFFSET ON AN ABSOLUTE PCS

Setting the zero offset on an absolute PCS will require a calibration setup as discussed in Section 5.2.2 for best results, although others can be used. The mode of operation will be the 1 PT.CAL. mode [see Section 3.4.4.3] and the PCS should be initialized and warmed up per Section 4.1. Once this is completed the PCS will be ready for the zero offset adjustment.

To do this, follow the procedure in Section 3.4.4.3. Select a pressure within the range of the PCS. For greatest accuracy this pressure should be the same as or close to one of the calibration points of the PCS and, for convenience, it may be above atmospheric pressure. This eliminates the need for a vacuum pump and the associated pump-down time. Apply this pressure and enter its numerical value per Section 3.4.4.3 to complete the process.

4.3 PRESSURE MEASUREMENT

Pressure measurement with a PCS is a very simple process with very few considerations necessary from the user to obtain high accuracy measurements and, since every PCS is direct-reading in any of seven different pressure units [see Section 3.4.3.1], the user may receive the measurements directly in the pressure units desired. This section, although not intended to be a comprehensive discussion of pressure measurement, will discuss pressure measurement with both differential and absolute pressure PCS as well as several items relevant to pressure measuring in general.

One of the first things to consider is trapped air. This can cause a thermometer effect on the readings with variations in ambient temperatures. This can cause significant variations in the pressure being measured, depending on the pressure range and volume being worked with.

Note: Verify that the protective plastic caps have been removed from the rear pressure ports. Frequently, when using a differential unit for gauge pressure applications, the protective closure is not removed from the reference pressure port since there is no connection to this port. This causes the reference pressure to vary with temperature.

Another consideration is head pressure. If the source of the pressure being measured is at a different level from the PCS, then a correction for the head pressure difference between the two devices may be required for readings of maximum accuracy. See Figure 4.3A and 4.3B for this correction.

4.3.1 DIFFERENTIAL PRESSURE MEASUREMENT

A differential pressure PCS can be used to measure gauge pressure (differential pressure referenced to atmospheric pressure), absolute pressure (differential pressure referenced to zero absolute pressure), as well as other differential pressures in general. Basically, all that is required is that the PCS be initialized and warmed up per Section 4.1. Connect the pressure to be measured to the MEASURE/CONTROL port and the reference pressure to the REFerence pressure port (ref. Section 2.3 on plumbing). Then select the MEASURE mode from the main menu. The PCS will then measure the applied pressure differential and display it on the front panel in the pre-selected pressure units.

Note: A low range PCS will respond to small atmospheric pressure transients such as air conditioner cycling or doors opening or closing. This will make the instrument appear to be unstable if the instrument under test (ex. manometer or dead weight tester) has more 'inertia' to pressure changes.

Note: Occasionally it may be necessary to adjust the gain and damping of the measure circuitry of the PCS. For information on when and how to do this, see Section 6.4.1.3.

GAUGE PRESSURE

For gauge pressure measurement, leave the reference pressure port open to atmospheric pressure. The PCS will then be referencing the applied pressure to atmospheric pressure, thereby providing gauge pressure measurements.

ABSOLUTE PRESSURE

For absolute pressure measurements with a differential pressure PCS connect a vacuum pump to the REF pressure port. This pump should meet the requirements given in Section 7.4. A thermocouple vacuum gauge should be connected in the reference pressure line next to the reference pressure port to provide a measurement of the reference pressure. Once pumping, the reference side should be pumped four to six hours before the first measurements are made and for best results should be continuously pumped thereafter. This reduces the pressure variations due to outgassing in the reference chamber and in the lines.

Once the reference side has pumped down to a vacuum that is low relative to the resolution of the instrument, and stable [i.e., not changing up or down], the PCS is essentially ready for absolute pressure measurements, but the readings at this point will need a correction applied to compensate for the small residual pressure on the reference port. To obtain the corrected absolute pressure use the following equation.

Absolute pressure = Pressure reading from PCS +
Reference Pressure

This correction can be applied in two ways depending on the usage of the PCS. If only a few absolute readings are to be taken with the unit, then converted to be used for other differential measurements, then this correction should be applied manually. If, however, the PCS will be in long term usage for absolute measurements, an offset of the calibration should be indirectly applied through the 1 PT.CAL. mode. This will allow the PCS to read the corrected absolute pressure directly. The procedure to do this is as follows:

1. Pull a vacuum on the reference port, as described above, until a stable vacuum is achieved. This reading should be recorded and monitored periodically. If it varies significantly, this procedure will have to be continued until the pressure reading is stable.
2. Now perform a single point calibration [1 PT.CAL.] using the procedure given in Section 3.4.4.3 and the setup described in Section 5.2.2. The applied pressure must be within the range of the PCS.

Now, with the PCS in the MEASURE mode and with a stable vacuum on the reference pressure port, any pressure applied to the MEASURE/CONTROL port will be measured directly in absolute units.

Note: If, after doing the single point calibration, the PCS is to be used with any other reference pressure, it will have to be re-zeroed at atmospheric pressure using the ZERO mode. See Sections 3.4.4.1 and 4.2.1 for this.

DIFFERENTIAL PRESSURE

True differential pressure measurements with references other than atmospheric pressure or zero absolute pressure can be made by simply applying the desired reference pressure to the REF pressure port. This will allow differential pressure measurements for applied pressures equal to or greater than the reference pressure. Typical reference pressures are up to 100 PSIG.

Note: The PCS is designed to measure positive pressure differentials. It can, however, measure negative pressure differentials if the lines on the MEASURE/CONTROL and the REF ports are reversed [i.e., the reference pressure to the MEASURE/CONTROL port and the measured pressure to the REF port].

Note: Every differential pressure PCS, unless specified otherwise, is equipped with a relief valve on the pressure side of the QPS set at the gauge pressure equivalent of the range of the instrument [i.e., a 0-600 PSID unit would have a relief valve set at slightly above 600 PSIG]. If reference pressures above atmospheric pressure are to be used, this will need to be changed. Please consult the factory.

CAUTION: When using reference pressures above atmospheric, be sure to stay below the maximum case pressure of the QPS. This is 100 PSIG for the standard QPS and 600 PSIG for the Highline QPS.

Additionally: If the REF port is equipped with a vacuum gauge, the maximum reference pressure is 50 PSIG.

4.3.2 ABSOLUTE PRESSURE MEASUREMENT

An absolute pressure PCS is designed to measure absolute pressures without the associated pump down complications that are needed when making absolute pressure measurements with a differential pressure PCS. This is done at the factory by pumping a hard vacuum in the quartz helix of the QPS and then permanently sealing it. This provides the near zero absolute pressure reference required for absolute pressure measurements.

With an absolute pressure PCS, all that is required to make absolute pressure measurements is to connect the pressure to be measured to the MEASURE/CONTROL port and then select the MEASURE mode from the main menu. The unit is now ready to measure absolute pressures.

CAUTION: Do not use helium or helium contaminated gases with an absolute QPS. Quartz is porous to helium and although the diffusion rate is very slow, the vacuum sealed within the quartz helix in the QPS will be degraded if helium or helium contaminated gases are used. Absolute pressure measurement of helium or helium contaminated gases should be done with a differential QPS using a vacuum reference.

4.4 PRESSURE CONTROL

The PCS gives the user the ability to control pressure precisely. There are three modes of pressure control programmed into the PCS. These are the MANUAL control mode, the CAL.PTS. [calibration points] control mode, and SEQ [sequence] control mode. Functional details of each of these modes are given in Section 3.3. This section will discuss the use of these modes in controlling pressure.

Before beginning though, a comment with regard to the control capability of the PCS is in order. The PCS is designed to precisely control pressure to dead ended systems. It is not designed to control pressure to systems with pressure gradients in the system [i.e., open ended systems]. In general, however, it will control very small pressure gradients [i.e., small leaks]. Large leaks and open ended systems will prevent the PCS from producing a stable controlled pressure. An indication of this will be that the second line of the display will not change from 'SLEWING' to 'MEASURED READING'.

Now, to control pressure, the PCS should be initialized and warmed up per Section 4.1. Pneumatic connections should be made per Section 2.3.3. Then by selecting the CONTROL mode from the main menu, the user will be ready to select the mode of control desired. The selections will be: MANUAL, CAL. PTS., SEQ.1, SEQ.2, SEQ.3, or SEQ.4.

Notes:

1. Occasionally it may be necesary to adjust the gain and damping for the control circuitry. See Section 6.4.1.5 for information on when and how to make these adjustments.
2. On differential units, if pressure is to be controlled at elevated reference pressures, the PCS should be functioning in the CONTROL mode before elevating the reference pressure. This allows the PCS to keep the control pressure at some point above the reference pressure thereby preventing the QPS from being driven excessively in the negative direction.
3. It is good practice, if possible, to set the last control pressure to some low pressure [i.e., near Zero PSID for differential units and atmospheric pressure for absolute units]. This brings the servo regulator of the PCS to a low pressure set point prior to de-energizing.

4.4.1 PRESSURE CONTROL - MANUAL

Reference Section 3.3.1 MANUAL.

The MANUAL control mode is used any time random discrete control points are to be used. Within the MANUAL control mode there are two ways of commanding new control pressures. These are:

1. Direct Input: The user keys in the numerical value of the control pressure desired, then presses '='. The PCS-200 will then drive to this control pressure.
2. Incrementing or Decrementing Inputs: The user may repetitively increment or decrement the control pressure by keying in a value and then pressing either '+' or '-'. This will increment or decrement the control pressure by the magnitude of the value. This allows the user to command step changes to the control pressure.

Also available in the MANUAL control mode is a safety feature that allows the user to set the upper and lower limit of control pressures to prevent damage to units under test. For example, a manufacturer using a 100 PSID PCS to calibrate 50 PSID transducers that have a 10 PSID maximum allowable overpressure, would be able to set the upper control limit of the PCS to 55 PSID, thus preventing an accidental overpressure of the units under test.

For information on how to set these limits, see Section 3.4.3.3.

Note: The control limits set by the SET LIMITS mode function only in the MANUAL control mode.

4.4.2 PRESSURE CONTROL - CALIBRATION POINTS

Reference Section 3.3.2 CALIBRATION POINTS.

The CAL. PTS. control mode allows control of pressure at the points the PCS was calibrated at. This can be as many as 62 points depending on how many points are in the calibration. The benefit of this mode is that it allows the user to control pressure at the points of maximum accuracy of the PCS.

Note: For the CAL. PTS. control mode only, the PCS will not control at the #1 calibration point. For this point only, the PCS will be vented to atmosphere and will be measuring rather than controlling. The pressure being measured will be Zero PSID for differential units and atmospheric pressure for absolute units.

4.4.3 PRESSURE CONTROL - SEQUENCES [1 through 4]

Reference Sections 3.3.3 to 3.3.6 SEQ.1.thru SEQ.4.

Reference also Section 3.4.6 LEARN SEQUENCE.

These control modes allow the user to run automated sequences of user specified control pressures with a user specified time delay at each control point. These are programmed by the user through the SPECIAL/LEARN SEQUENCE mode [See Section 3.4.5] and are used by entering one of the sequence modes, SEQ.1, SEQ.2, SEQ.3, or SEQ.4 [See Sections 3.3.3 to 3.3.6].

In programming the sequences, the user may enter any sequence of control pressures within the control limits of the PCS. The control pressures can be evenly or randomly spaced within the pressure range. They can be of increasing magnitude, decreasing magnitude, or randomly mixed, upscale and downscale. Any number of points can be entered up to a total of 228 points between the four sequences.

5.0 CALIBRATION

Good practice requires a program of calibration of any standard to maintain a proper confidence level in the standard. The time between calibrations depends on the application and the history of the confidence levels of the particular standard. The more stringent the application, the shorter the interval between calibrations. The closer the match between data of successive calibrations, the longer the interval that can be allowed.

In the beginning, a three month interval would be good. Perhaps later this could be lengthened to as much as six months.

The purpose of this section is to provide typical pneumatic considerations necessary to calibrate the PCS.

5.1 PRE-CALIBRATION CHECKS

Prior to calibrating the PCS, a check of the general condition of the instrument should be made. General cleanliness should be checked, especially in the area of the null assembly. If the instrument has accumulated dust, lint, dirt, etc. inside, the performance of the instrument will be degraded. Depending on the severity of the contamination, anything from a general cleanup to a factory overhaul should be considered. If in doubt, consult the factory.

Other items to check are the internal baffles. These are the gray sheet material parts surrounding the null assembly. Make sure they are secured and not interfering with the null assembly. Also all wiring should be neatly routed and, as with the baffles, clear of the null assembly.

In addition to the general checks above, a check of the +5 volt supply to the motherboard should be made. See Figure 6.4C. With the PCS turned on and in the MEASURE mode, this should measure 5.05, ±0.05 volts. If it does not, contact the factory.

5.2 SETUPS

Calibrations are usually made by comparison with a mercury manometer, barometer, by an air piston gauge, or with another quartz gauge. The choice of standard is usually determined by the pressure range and availability of the standard.

Pressure Range - Absolute pressures: Approx. 1 PSIA to 30 PSIA
Differential pressures: 0 PSID to 30 PSID

Reference Standard:

1. Capacitance Mercury Manometer
2. Micrometer Mercury Manometer
3. Air Piston Gauge

Pressure Range - Absolute pressures: Approx. 1 PSIA to 1000 PSIA
Differential pressures: 0 PSID to 1000 PSID

Reference Standard:

1. Air Piston Gauge

Typical equipment required to calibrate a PCS:

1. The reference standard as discussed above.
2. Dry nitrogen or air source. Usually water pumped bottled gases are used but instrument air may be used if well filtered.
3. Method of controlling pressure. Valves, variable volumes, and automatic pressure controllers.

Two setups are typically used, of which there are variations of each depending on the equipment available and the desired application of the PCS.

5.2.1 SETUP - DIFFERENTIAL PRESSURE

Figure 5.2.1 shows a typical setup for calibration of a differential PCS. Here the reference pressure is atmospheric pressure and the pressure standard is directly compared to the PCS. No vacuum sources are used in this case. The PCS reference should be connected directly to the reference of the pressure standard and then both vented at one point to atmosphere. The true pressure reading to the PCS will be the reading of the reference standard.

5.2.2 SETUP - ABSOLUTE PRESSURE WITH AN ABSOLUTE QPS

Figure 5.2.2 shows a typical setup for calibration of a PCS with an absolute QPS. In this setup the pressure side of the reference standard is connected directly to the MEASURE/CONTROL port of the PCS. Vacuum gauge readout #1 should be placed near the rear of the PCS to provide a better measurement of the vacuum on the PCS, especially for the #1 calibration point. The vacuum sources should meet the requirements given in Section 7.4. The true pressure here will be the reading of the reference standard plus the reading of Vacuum Readout #2.

5.3 CALIBRATION PROCEDURE

Note: The PCS chassis must be at least ½ inch above the surface it is resting upon for proper temperature control. Rack mount units being calibrated on a bench must be elevated for adequate air circulation.

5.3.1 PREPARATION FOR CALIBRATION

Verify the following items:

QPS temperature is correct for the QPS type
- STD: 52.0 ±0.2°C
- HIGHLINE: 53.0 ±0.2°C

Clock is set to the correct date and time
Internal thermometer operating properly

5.3.2 SET-UP FOR CALIBRATION

Connect the PCS to the calibration panel with the appropriate tubing.

ABSOLUTE CALIBRATION

Pump down the PCS overnight to achieve a good vacuum (≤100 mTorr at the QPS). Excercise the instrument over the full range of pressure a minimum of two times. Pump down the PCS to a good vacuum again, then continue.

DIFFERENTIAL CALIBRATION

Allow the unit to sit undisturbed for a minimum of one hour. Exercise the instrument over the full range of pressure a minimum of two times.

Place the PCS in the pressure units required for the calibration (i.e., psi, in. Hg, etc.). In the MEASURE mode, notice the number of digits following the decimal point. With the exception of the 'zero' pressure point the entered true pressures may not contain more digits after the decimal point than that noted in the MEASURE mode. If required, roundoff the true pressures before entry into the PCS.

5.3.3 ENTERING CALIBRATION MODE

WARNING!! Proceeding beyond this point will destroy the previous calibration stored in the PCS.

Proceed through the menus to the RECAL mode. Enter the calibration password followed by '='. The instrument will go through a calibration initialization procedure.

5.3.4 DETERMINING ABSOLUTE CAL 'ZERO' PRESSURE

Convert the mTorr reading of the vacuum to the pressure units of the calibration. If the vacuum was read at the rear panel of the instrument multiply the pressure by 1.4. This will compensate for the difference in the vacuum at the QPS and at the rear panel.

The 'zero' pressure may contain more digits after the decimal point than any other pressure points entered later in the calibration. The 'zero' pressure may not however, exceed seven digits in length including the decimal point.

5.3.5 ENTERING CALIBRATION DATA

For each calibration point entered into the PCS follow the procedure listed below:

Enter the true pressure for the point followed by an '='. You may use the 'CE' key to backup and redo an entry.

It is not neccesary to put 0's after an entry to fill out decimal places.

Apply the appropriate pressure to the PCS and allow it to stabilize. Verify that the true pressure entry is correct. If not, press the 'CE' key to reenter the true pressure. When stable, press the '=' key. This will record the calibration point into the PCS.

The PCS checks each calibration point entry internally against the previously entered points. If the new entry has a considerable non-linearity error the PCS will display:

CAL ENTRY WARNING - PUSH 'CE' TO RE-TRY
PRESS 'CE' TO RE-ENTER THE CALIBRATION POINT.

It should not be assumed that a calibration point is accurate because the PCS did not display the message above.

5.3.6 ENDING THE CALIBRATION

When there are no more calibration points to enter press 'M' to quit. The PCS will go into an initializing mode similar to that when turned ON.

CAUTION: DO NOT attempt to enter calibration points beyond #62. To do this would cause an overlap of data storage, thus invalidating the calibration.

5.4 GENERAL DISCUSSION

During recalibration of the PCS, the user can tailor the calibration to be more beneficial for the designated end use by considering the number of calibration points and the distribution of these calibration points.

As was mentioned above, the maximum number of calibration points allowed is 62, these being the #1 to #62 calibration points. It is not required that all 62 be used, but it is recommended that no fewer than 20 be used. Typical number is 40. The factor most influential in determining the number of calibration points is the desired confidence level. Increasing the number of calibration points increases the confidence level of the calibration. A user doing a critical job will want as many calibration points as possible to maximize the confidence level.

Next, after considering the number of calibration points, the distribution of the calibration points within the range should be considered. Typically, for general purpose use, the calibration points are essentially equally spaced throughout the range of the instrument, but this is not required. If the confidence level of a portion of the range of the instrument is more critical than the rest of the range, then a larger number of calibration points can be entered in the critical portion. For example, if the majority of the work for a PCS is in the first one third of the range with only limited use in the remainder of the range, then 40 of the 62 calibration points might be placed in the first one third of the range to increase the confidence level of the calibration in that region.

6.0 MODULES

See Table 6.0 and Figure 6.0 for a general description and the location of each subassembly.

6.1 PNEUMATICS

The pneumatics assembly consists of the servo regulator, the servo motor, tachometer generator, the gearing that links the foregoing three, mechanical limit switches, supply and exhaust controllers, five solenoids, and a relief valve to atmosphere. Pneumatic schematics are given in Figures 6.1A through 6.1D.

6.1.1 SERVO REGULATOR

The servo regulator has three sections: the top, the exhaust spacer section and the bottom section. The bottom section is mounted directly to the regulator assembly mounting plate. This section should neither be de-mounted (its position on the plate shifted) nor should its contents or external gearing be disassembled. Reassembly and adjustment involves a proprietary technique.

The only reason the top section should be removed is in the application where continuous use with oily or otherwise contaminated supply gas may have caused an accumulation on the internal valve seats. If this must be done, do it carefully, because the diaphragms usually cause the sections to stick together and some damage can be done during the process of separating the regulator sections.

Remove the regulator top section as follows. Temporarily plug in the regulator. In the CONTROL mode, set in a pressure which will cause the regulator to run to the bottom limit. Go to the STANDBY mode, then switch off the instrument and unplug the regulator. Remove the necessary plumbing running to the regulator top. Remove the four screws in the top. Carefully separate the top section from the exhaust section. It is best to leave the rest of the regulator intact. The two valve seats, one in the middle of the diaphragm section and one in the top section may be unscrewed and cleaned. Use any ordinary cleaning solution, except on the plastic seat. This is Delrin (acetal resin), so do not use a solvent which will attack it.

In replacing the regulator section(s), be careful to get them and the diaphragm back in the original orientation position as removed, or an internal passage will be blocked.

6.1.2 SERVO MOTOR AND TACHOMETER GENERATOR

The motor does not ordinarily malfunction. In rare instances a motor will develop gear noise. This can be detected by removing the drive chain and allowing the motor to run free.

It is also rare to have trouble with the tach generator. Typically problems attributed to the tach generator are due to slack in the drive chain. However, if problems are suspected with the tach generator itself, contact the factory for recommendations before removing it.

6.1.3 DRIVE TRAIN

There are two parts to the drive train: the plastic chain and the precision gear set. Do not attempt to adjust the gear mesh. The only thing which may be done here is to clean and lubricate the gears. This is only rarely needed, but if it must be done, clean the gear teeth with a solvent such as chlorethene and a brush. A paper towel beneath the gear helps to soak up the residue. Re-lubricate with Lubriplate 630-AA, followed by 1-2 drops of light oil such as vacuum pump oil. Also clean and lubricate the limit switch actuator discs, where the arms rub, with the same grease.

If a motor or tachometer must be removed and replaced, then the plastic chain will have to be tended to. Both the motor and the tachometer mounting positions should be shifted to provide just enough chain tension to remove slack but not enough to cause sprocket cogging and/or binding. Both sprockets of a set must be set on their shafts so as to run in the same plane.

After long use the drive chain will dry out and become creaky. To remedy this put light weight oil [such as vacuum pump oil] on its entire length and then blot off the excess.

6.1.4 LIMIT SWITCHES

It is possible that a limit switch may fail, and if it does it must be replaced. To run a regulator with a defective limit switch is to ask for permanent damage to the servo regulator.

If it is suspected that a limit switch is defective or out of adjustment, consult the factory.

Note: On a high pressure regulator, the limit switches are set to operate when the big gear turns about 120 to 180 degrees either side of the null position, unlike the low pressure regulator which has a multiturn operation.

6.1.5 SUPPLY AND EXHAUST CONTROLLERS

The technique used in adjusting the controllers for optimum performance is beyond the scope of this discussion. Therefore, do not open the controllers.

6.1.6 SOLENOIDS

The PCS has four or five solenoid valves, depending on whether absolute or differential. These are to control the input, regulator output, instrument main pressure input/output, zero (differential only), and vent functions. All these valves employ a low wattage, rectified current coil.

To remove a valve, first remove the pneumatics assembly from the chassis. Remove the two cap screws holding the solenoid in question. Be careful not to lose the two o-rings under the solenoid.

If a solenoid does not operate, a diode in its coil may have opened. Either the valve or the coil may be replaced.

A leaky valve may be disassembled and cleaned. Remove the valve and then the nut which holds the coil cover on. Slide the coil off and note the order in which the parts are assembled. Unscrew the stem from the valve base and clean the seats. When the valve is reassembled, be careful that the o-ring seals go into place properly, particularly the one which seals the top fitting on the outside of the valve. This seal can be easily pinched and clipped in two upon reassembly.

6.1.7 RELIEF VALVES

The PCS is equipped with a relief valve to atmosphere from the main pressure output. This valve, unless otherwise specified, is set to approximately 10% above the instrument span. If, on a differential PCS, the reference pressure is to be above atmosphere, this valve may be adjusted to include this added differential from atmosphere. Obviously, this defeats the purpose of the relief valve, in which case a differential relief valve is recommended (See section 8.6, OPTIONAL RELIEF VALVES). The maximum reference pressure is 100 PSI on a standard QPS, and 600 PSI on a Highline QPS.

All valves reseat at a pressure slightly below, but very close to the cracking pressure. A valve set to crack at 55 PSI, for example will reseat at about 53 to 54 PSI, repeatedly. A seated valve, clean and in good condition, will be vacuum tight (in the 10 mTorr region). If a valve does not perform this well, it is probably dirty.

All valves may be removed for cleaning or resetting the cracking pressure. When a valve is put back into place, be careful that the pipe threads are cleaned. The original installation uses an anaerobic hydraulic sealant which crumbles when the valve is removed. All such debris must be removed before re-installation of the valve. The same is true if teflon tape is used. If any sealant particles get into the valve seat, the valve will not completely reseal once it is cracked.

6.1.7.1 LOW PRESSURE VALVES (LESS THAN 155 PSI)

On low pressure valves the spring-adjusting screw is reached through the male pipe end, or higher pressure end. It will be noted that the spring is held by a 3-lobed nut which is, in turn, locked by a very small hex nut. The ideal way to manipulate these two nuts is with Circle Seal tools #10086 and #10087. These tools not being available, a needle-nose pliers for the hex nut and a thin probe for the 3-lobed nut will suffice. Unlock the hex nut and adjust the 3-lobed nut until the cracking pressure is correct, then hold the latter and lock the former. Ordinarily this valve can be cleaned without disassembly. Manually depress the poppet and hold it open while flushing the valve with solvent, then use clean instrument air to blow it out. The seal is Buna-N so do not use a solvent which will attack it.

6.1.7.2 HIGH PRESSURE VALVES (OVER 155 PSI)

The seat of the high pressure valve is in the input end of the valve. To disassemble the valve, remove it from the manifold, then remove the large allen plug in the input end. Being careful to note the order of assembly, remove the plug, plunger, and spring. Clean the valve parts with a suitable solvent, blow dry with clean instrument air, and reassemble. To adjust the cracking pressure of the valve, turn the allen socket at the top or output end of the valve.

6.2 NULL ASSEMBLY

The null assembly is the heart of the instrument. It is a precision electro-mechanical device requiring great care in its use and adjustment. Most repairs to the null assembly are beyond the scope of this text and should not be attempted by the user. There are, however, several maintenance items that the user may perform. These will be discussed in this section, but first the user should be aware of certain items that will affect the calibration of the instrument.

6.2.1 THINGS AFFECTING CALIBRATION

The following is a list of items with regard to the null assembly, which if done, will affect the calibration of the PCS. Care should be exercised if doing any maintenance on or around the null assembly with regard to these items.

Changing the lamp, or moving the lamp.
Moving the lamp mounting block.
Loosening or moving the solar cell assembly.
Changing a solar cell.
Shifting the top plate.
Shifting the QPS mounting piece.
Shifting or bumping the optical encoder.
QPS cleanliness.

6.2.2 QPS

6.2.2.1 INSTALLATION

Clean the glass with a soft lint-free material. Ease the QPS over the studs, mirror towards the lamp, and lower it so that it slides freely down to seat on the flange.

Put the instrument into MEASURE and allow it to null.

Hold the QPS down with a finger on the middle of its top and try to rock the QPS lightly back and forth with the fingers of the other hand. Watch the reading change. About 0.02% f.s. is normal. Try this for various axes of the QPS. If the reading change is excessive, it is caused by a particle under the flange of the QPS. Try to locate the most sensitive pivot point. Remove the QPS and locate the particle. After removal, replace the QPS and try again (as many times as necessary).

While tightening the nuts, push the QPS flange away from the lamp.

Install the tubing(s), temperature probe, and vacuum connector as required.

6.2.2.2 REMOVAL

Loosen and remove the nuts, then gently pull the QPS up off the QPS mount.

6.2.3 THE LAMP

The lamp used is a Mensor part [0010051001]. Adjustment of this item is critical to the proper operation of the instrument and any movement of the lamp will invalidate the calibration. If the lamp is replaced, adjust the lamp spot such that the filament is vertical and the spot is just smaller than the QPS mirror.

6.2.4 SERVO MOTOR AND TACHOMETER GENERATOR

The drive assembly consists of the motor, the tach generator and the delrin drive train.

The motor does not ordinarily malfunction. In rare instances a motor will develop gear noise. This can be detected by removing the drive chain and allowing the motor to run free. The motor can be replaced without requiring removal of anything except the instrument cover.

It is also rare to have trouble with the tach generator. If problems are suspected with this item, contact the factory for recommendations before removing it from the null asssembly.

6.2.5 DRIVE ASSEMBLY

As long as the worm and the worm gear [the large brass gear segment] runs freely and smoothly there is almost nothing else of concern under the heading 'the gearing'. The worm gear is designed to have free play and is spring loaded to remove backlash. Make sure the flat spring on the solar cell assembly is looped around the idler spool on the drive side of the null assembly.

Proper tensioning of the drive chain is set as follows. Remove the idler sprocket, loosen the drive assembly upward until all of the free slack is out of the chain. Tighten the screws. Replace the idler sprocket and set its spring so that it lightly tightens the chain.

After long use the drive chain will dry out and become creaky. To remedy this put light weight oil [such as vacuum pump oil] on its entire length and then blot off the excess.

6.3 POWER SUPPLY MODULE

The power supply module consists of a DC power supply and a power control printed circuit board. These items are mounted on a common bracket. An optional 'Nonstandard Voltage' transformer, for input voltages other than 115 VAC may also be mounted on this bracket.

The functions of the power supply module are shown in the block diagram, Figure 6.3A. From the control board, power is distributed to all other modules and boards in the PCS.

6.3.1 DESCRIPTION OF OPERATION

AC power is applied to the control board through the rear panel fuses and the Radio Frequency Interference [RFI] filter. A push button power switch, operated from the front panel, is mounted on the board, and turns on the voltage to the Low Voltage Detection circuit.

The Low Voltage Detection circuit senses when the mains voltage drops to below 85 volts, and it sends a 'loss of power' signal [zero volts] to the microprocessor. The detection circuit also turns off all the AC power used by the rest of the circuits in the instrument. This causes the servo motors to stop, and all solenoid valves to de-energize. The normal DC power supply is also turned off, and the front panel display will go off.

When the AC power is switched on and/or comes up above 95-volts, then the detection circuit switches on the AC, by a triac, to the rest of the instrument, and signals the microprocessor that the power is on. This is a 5-volt signal on J3 Pin-2 [see Figure 6.3.1B].

There are seven triac control circuits that supply 115-VAC power to the servo motors and solenoid valves. These are controlled individually by 5-volt signals from the microprocessor. The signals are on J2 and the outputs are on J6 for the solenoids, J4 for the null assembly motor, and J5 for the regulator motor [see Figure 6.3.1B].

The front panel vacuum flourescent display gets its power from a DC to DC Converter. This module [M1] gets its power from the +15 volt supply from the main power supply. This module outputs -45 volts for the display grids, 9-VAC at -35 VDC bias for the filaments, and ground for the anode. The -35 VDC bias is adjustable [pot R21 on Figure 6.3B] to set the display brightness.

The control board has a dual output 10-Volt AC Transformer rated at 1.2 amps each for power to each of the two servo motors in the instrument. This transformer is switched on by the triac controlled by the low voltage detection circuit.

The main DC Power Supply provides +5 volts at 6-amps, and ±15 volts at 1-amp each. AC power to this supply is controlled by the triac that is in turn controlled by the low voltage detection circuit.

6.3.2 POWER SUPPLY MODULE-MAINTENANCE

Remove the instrument cover and left side panel to access the power supply module. On the control board, the location of adjustments, test points and lights are shown in Figure 6.3.1B.

CAUTION: This PC assembly contains devices sensitive to static electricity. This board should therefore be handled only in static safe situations. If the board is to be removed from the instrument case for storage or shipping, it should have shorting bars placed on the connectors and should be placed in a static safe container.

6.3.2.1 POWER ON-OFF VOLTAGE

The Power On Power Off voltage may be adjusted with pot A3R1 while slowly lowering the voltage from 115 VAC to below 84-VAC. Adjust the pot so that LED CR1 goes out when the voltage drops to 84-volts. When the voltage is slowly raised, the LED should come on at about 95-volts ±3 volts.

6.3.2.2 REMOTE SENSING CHECK

The +5 volt supply and the 5-volt regulator uses 'remote' sensing on the motherboard and therefore it is best to check the voltage on or near the motherboard. One of the best places to check these is on capacitor A9C64 on the amplifier board [see Figure 6.4C]. The voltage at this point should be 5.00 to 5.05. Adjust per Figure 6.3.1B as required.

6.3.2.3 BIAS ADJUSTMENT

The bias adjustment for the front panel display [A3R21] may be adjusted for the desired brightness of the display. If the brightness is set too high, some of the digits may appear to be slightly on when they should be off. The display is adjusted to minimum brightness at the factory for maximum life of the display.

6.4 SERVO AMPLIFIER BOARD

The servo amp board provides the necessary signal conditioning to drive the null assembly servo motor and to drive the pressure regulator servo motor. This board is located just behind the instrument front panel and is plugged into the front slot of the motherboard.

The functions of servo amplifier are shown in the block diagram, Figure 6.4B. The adjustments and test points are shown in Figure 6.4C. Other component designators (such as R20 and Q2) referenced in the discussion below may be found on the PCB silkscreen.

6.4.1 THEORY OF OPERATION

6.4.1.1 GENERAL

See Figure 6.4A for the overall SERVO SYSTEM BLOCK DIAGRAM (an absolute unit is used as the example). The basic purpose of the servo amplifier is to amplify the small error signal produced by the QPS to a level that will cause the servo motor to turn, thus reducing the error to zero. In the MEASURE mode the standard QPS, when subjected to a full scale pressure, will cause a reflected beam of light to swing through an arc of about 100 degrees. This light falls on a set of solar cells that produce an error voltage. This voltage is amplified by the servo amplifier and causes the servo motor on the null assembly to drive the solar cells around until the error voltage goes to zero (when the beam is evenly divided between the two "main" cells). A digital encoder is also connected to the solar cells and produces about 1,024,000 pulses for the full scale pressure range. The gain of the servo amplifier can be adjusted to resolve the pressure to about one part (count) per million. This represents a signal of only 7.5 microvolts. About 0.2 volts AC will cause the motor to move.

In the CONTROL mode the null assembly solar cells are driven around to an angle that corresponds to a desired pressure set point, selected by the user. The servo amp provides gain to drive the null assembly motor in response to the difference between the digital encoder counts and the desired counts from the user input. This digital difference is converted to an analog signal by a digital to analog converter on the encoder board. When this difference is zero, the motor stops turning, and the desired pressure set point is displayed on the front panel.

At the same time the null assembly motor is being driven to the desired set point, the error signal from the solar cells is amplified and causes the servo regulator motor to start driving the output pressure to the desired set point. This pressure is also applied to the QPS which causes the light beam to deflect, thus reducing the error signal from the solar cells.

When the null assembly stabilizes on the desired set point and the regulator drives to the same pressure and stabilizes, the error signal from the solar cells goes to zero and the regulator servo motor stops changing the output pressure.

6.4.1.2 MEASURE/CONTROL SWITCHING

In the MEASURE or STANDBY modes, the microprocessor provides a signal to the servo amplifier board that sets the relays and switches as shown in Figure 6.4B. At the same time, the reference voltage to the null assembly servo motor is enabled, so that it can run, and the reference to the regulator motor is disabled.

In the CONTROL mode, the uP signal switches transistor Q1, Z3 and Z9 so that the digital encoder signal (DES) is applied to the null assembly servo motor circuits, and the solar cell signal is applied to the regulator servo motor circuits.

6.4.1.3 MEASURE MODE CIRCUITS - GAIN AND DAMP

In the MEASURE or STANDBY modes the solar cell signal level is controlled by the MEASURE GAIN pot R27. See Figure 6.4C for the location of controls. This pot is adjusted to set the servo loop gain so that the measured pressure reading is repeatable within ±2 PPM. If the gain is too high, the null assembly will over control and be too 'nervous'.

From the gain pot, the signal goes through a notch filter that is tuned to the natural frequency of the QPS (about 31 Hz).

The signal from the null assembly tachometer is controlled by the MEASURE DAMP pot (R24). This pot is adjusted to set the stability of the null assembly servo. The tach provides an opposite polarity signal from that of the solar cell signal, when the motor is running. This slows the motor to a stop as the solar cell signal approaches zero. If the DAMP pot is set too high, the null assembly motor will go into oscillation and 'buzz'. If the pot is set too low, the motor will 'overshoot' too much when it comes into null and may cause an oscillation that will prevent the servo from stopping on a number.

From the DAMP pot the tach signal goes to a phase correction damping network and then is summed with the solar cell signal from the filter.

The combined signal is then converted to a 50 or 60 Hz signal by the chopper [Z4]. This electronic switch alternately connects the input of the op-amp [Z7] to the signal or to ground. The chopper frequency is derived from, and is in phase with the power main frequency. This provides the proper frequency and phase for the AC servo motors used.

The principal reason for the chopper, besides the AC servo motor, is to prevent errors due to the DC offset drift in the required high gain amplifiers.

From the chopper, the signal goes through the AC amplifier section [Z7 & Q4] to the motor amplifier. The peak to peak level is now 882 times the DC level of the signal at the input of the chopper. This signal is multiplied by 78 in the motor driver circuit to a P-P level of 68,796 times the DC input level.

The motor drive circuit provides phase and level shifting for a 'push-pull' power output [Q14 & Q15]. The motor control winding is center tapped for 'push-pull' operation. Capacitor C34, 75 uf, is across the motor winding to tune it for a more efficient sine wave operation.

6.4.1.4 DIGITAL CIRCUITS - GAIN AND DAMP

The digital circuits come into play only in the CONTROL mode. They provide the signal to the null assembly motor. This positions the solar cells to the desired pressure set point.

The voltage level of the signal from the D/A converter is much higher than that of the solar cells and requires much less gain. The first op-amp has a gain of one, and provides a low impedance drive for the DIG. GAIN pot [R33]. The setting of this pot is more critical than the setting of the MEASURE GAIN pot because its signal is derived from a digital error signal where a slow change of ½ digit [1 PPM] error causes a step change of 78 millivolts on the pot. A change of ½ digit from the solar cells produces a proportional change of 0.75 microvolts.

If the DIG. GAIN pot is set too high, the null assembly will hunt ±1 digit or more and will 'buzz'. If the gain is set too low, it can stay off of the desired number by one or more digits.

The signal from the null assembly tachomoter is controlled by the DIG. DAMP. pot [R28] and is applied to the damping phase correction network. The adjustment of the DIG. DAMP pot should be set just high enough for the null assembly motor to over shoot the set point once or twice before stabilizing on the set pressure point. If the pot is set too high, the motor will 'buzz'.

The signal from the damping pot goes to a phase correction network. The signal from the gain pot and from the phase network are summed together at the input to the chopper, and then amplified as an AC signal by amplifier Z7 and Q4.

The signal then goes through finally to the motor drive circuit and to the null assembly servo motor as did the measure signal.

6.4.1.5 CONTROL CIRCUITS - GAIN AND DAMP

In the CONTROL mode the solar cell signal goes to the control circuits instead of the measure circuits. From relay Z3, the signal goes to the CONT. GAIN pot.

The CONT. GAIN pot R39 is adjusted so that the controlled pressure is within about ±5 digits and is repeatable. Too much gain will cause the controlled pressure to be noisy or to overshoot and oscillate around the set point.

From the gain pot, the signal goes to a notch filter that is tuned to the same frequency as the measure filter, about 31 Hz.

The regulator tachometer signal goes to the CONT. DAMP. pot R34. This pot is adjusted to set the stability of the pressure control servo. If it is set too high, the regulator motor will 'buzz' and not control properly. If it is set too low, the output pressure will overshoot the set point too much and/or the regulator will oscillate about the control point and never stabilize.

The signal from the damping pot goes to a phase correcting network.

The signal from the filter and from the phase correcting network are summed together at the input to the chopper [Z4]. From there it is amplified by the AC amplifier Z8 and Q5. The signal then goes through switch Z9 to the control servo motor drive circuit and on to the regulator servo motor through Q16 and Q17.

6.4.2 AMPLIFIER BOARD - MAINTENANCE

With the exception of user adjustable pots, servicing of this PC assembly is beyond the scope of this manual. For this reason if problems arise, the user should first check the troubleshooting chart in Appendix D to assist in solving the problem. If in doing this the problem is traced back to this PC assembly, then consult the factory on how to proceed.

CAUTION: This PC assembly contains devices sensitive to static electricity. This board should therefore be handled only in static safe situations. If the board is to be removed from the instrument case for storage or shipping, it should have shorting bars placed on the connectors and should be placed in a static safe container.

6.5 ENCODER BOARD

The encoder board processes the signals from the optical encoder to provide the microprocessor with the current null assembly position, and also includes a comparator with analog output for driving the null assembly to a particular set point. See Figure 6.5A for a block diagram of the encoder board, and Figure 6.5B for adjustment locations.

6.5.1 DESCRIPTION OF OPERATION

The pulses from the optical encoder are conditioned and sent to a phase decoder to determine direction of rotation and then to either increment or decrement a 24 bit counter (present encoder position). A means is provided of loading this counter with a desired starting count. The index phase of the encoder, one pulse/rev, is used to make sure that 1024 pulses occur for each revolution to account for any loss or gain of counts due to noise. Another 24-bit counter contains the count of the last set point (desired control point). A 24 bit subtraction circuit is provided to determine the difference between the desired set-point and the present encoder position. This difference is then processed by a digital to analog converter to furnish the amplifier board with an appropriate signal to drive the null assembly motor. The offset of this analog signal is adjusted by two pots on the board, R5 and R6. These pots are factory set and should not be adjusted by the user.

Also included on the encoder board are address decoders. These allow the microprocessor to manage the various control lines in the PCS.

Binary encoder boards, in addition to the features discussed above, contain a battery supported real time clock circuit.

6.5.2 ENCODER BOARD - MAINTENANCE

Servicing of this PC assembly is beyond the scope of this manual. For this reason if problems arise, the user should first check the troubleshooting chart in Appendix D to assist in solving the problem. If in doing this the problem is traced back to this PC assembly, then consult the factory on how to proceed.

CAUTION: This PC assembly contains devices sensitive to static electricity. This board should therefore be handled only in static safe situations. If the board is to be removed from the instrument case for storage or shipping, it should have shorting bars placed on the connectors and should be placed in a static safe container.

6.6 DISPLAY/KEYBOARD

For ease of operation, the PCS comes equipped with an easy to read 80 character vacuum flourescent display and 20 data input keys. The PCB controlling these functions is mounted on the rear side of the front panel.

6.6.1 DESCRIPTION OF OPERATION

The display is controlled by a set of display drivers which perform all the necessary voltage shifting, ASCII to dot matrix conversion and multiplexing synchronization.

The display has been designed so that each anode (dot) in a 5X7 matrix is connected in parallel to the corresponding anode in the 39 other characters in that row. Thus there are 35 (i.e., 5X7) anode connections to each row of the display. The top and bottom row of anode matrices are each controlled by an anode driver, thus two anode drivers (see Figure 6.6.1). Each character column of the display has a grid positioned above the anodes of that column. Since there are 40 columns of characters there are 40 grids. The left 20 grids are controlled by one grid driver while the right 20 are controlled by another grid driver.

Over the grids are six filaments which are connected to a 9-VAC source. This 9-VAC source is offset approximately -35 VDC. These anodes, grids, and filaments are enclosed in an evacuated glass case.

Note: Should it become necessary to remove the front panel, handle it carefully to avoid damage to the display.

Before displaying characters the display drivers go through a brief initialization. This sets up items such as the multiplexer frequency, duty factor, starting character position and display type [inverse, blank].

Each grid driver contains ram and ram management circuitry sufficient to store character generation information for 20 characters. Since there are 80 characters, two more grid drivers are used for their ram functions only. Thus each of the four grid driver rams contain information pertinent to a particular quadrant of the display.

When a message is to be displayed the desired characters are shifted into the appropriate grid driver ram[s]. Four control lines from the encoder board are used to shift data in from the data bus.

The display is multiplexed with each grid being energized sequentially from left to right repeatedly.

When a grid is energized the appropriate ram information is sent in a serial fashion. It is sent from the two grid driver rams that correspond with that column to the anode drivers. The level shifters in the display driver, when set normally, holds all grids and anodes at -45 VDC. When a grid or anode is energized the voltage is brought to -15 VDC for that grid or anode. This allows free electrons from the filaments to collide with the phosphor on the selected anode beneath the selected grid. When a grid is energized, all selected anodes behind that grid will light up.

By increasing the potential between energized grids and anodes, and the filaments, electrons hit the phosphor with a greater energy and the anode becomes brighter. A pot on the power module assembly [see Figure 6.3.1B] is used to adjust the DC bias of the filament [-35 VDC nom] which varies the brightness of the display. The display is adjusted to minimum brightness at the factory for maximum life of the display.

The 20 keys on the front of the PCS are arranged in a matrix of rows and columns. A keyboard decoder determines which key has been pressed by it's row and column address. The keyboard is polled at the end of each conversion cycle by the CPU to determine if a key is pressed. For convenience a 'M' [menu] key is provided to allow the user to return to the main menu easily.

A piezo-electric beeper gives an audio indication when a key has been pressed. The beeper is also used to signal errors, warnings, and power down.

6.6.2 DISPLAY/KEYBOARD - MAINTENANCE

With the exception of user adjustable pots, servicing of this PC assembly is beyond the scope of this manual. For this reason if problems arise, the user should first check the troubleshooting guide in Appendix D to assist in solving the problem. If in doing this the problem is traced back to this PC assembly, then consult the factory on how to proceed.

CAUTION: This PC assembly contains devices sensitive to static electricity. This board should therefore be handled only in static safe situations. If the board is to be removed from the instrument case for storage or shipping, it should have shorting bars placed on the connectors and should be placed in a static safe container.

6.6.2.1 KEYPAD PROBLEMS

If the keypad becomes faulty they may be replaced.

6.7 CENTRAL PROCESSING UNIT

6.7.1 DESCRIPTION OF OPERATION

The PCS uses a Z80 microprocessor based Central Processing Unit [CPU].

The CPU assembly uses a custom decoder PROM [Programmable Read Only Memory] chip for memory addressing. It also has two battery supported RAM [Random Access Memory] chips for data storage and one to four EPROM [Erasable Programmable Read Only Memory] chips for non-volatile system program storage. In addition, the board has been strapped for use in the PCS. Refer to Figure 6.7B for the strapping configuration for the CPU-2A.

Placement of PROMs, RAMs, and EPROM is as follows:
(Reference Figure 6.7A for locations)

Decoder PROM	U4
EPROM #1	U9
RAM	U15
RAM	U16

Additional information on the board may be obtained from the factory or by contacting Winsystems Inc. for information on their MCM-CPU2A.

6.7.2 MAINTENANCE

Servicing of this PC assembly is beyond the scope of this manual. For this reason if problems arise, the user should first check the troubleshooting chart in Appendix D to assist in solving the problem. If in doing this the problem is traced back to the PC assembly, then consult the factory on how to proceed.

CAUTION: This board contains devices sensitive to static electricity. Take proper precautions when handling this board to avoid damage to these static sensitive components.

6.8 INPUT/OUTPUT BOARD

The I/O board provides the necessary buffers, interfaces and address decoders for the central processing unit to communicate, via the Standard Bus, with such things as the serial port, the output port, and the analog temperature, vacuum and servo null meter circuits. This board is located in the third slot from the front of the instrument in the motherboard.

The functions of this board are shown in the block diagrams, Figures 6.8A and 6.8B. The adjustments and testpoints are shown in Figure 6.8C. Other component designators (i.e., R5, Z4, etc.) mentioned in the discussion below may be found on the PCB silkscreen.

The I/O board functions can be divided into digital functions, and analog functions. The theory of operation of these functions will be discussed below.

6.8.1 DESCRIPTION OF OPERATION

6.8.1.1 DIGITAL FUNCTIONS

The digital portion of the I/O board provides the PCS user with a serial port for remote operation from a terminal or modem and an output port (reserved for future use).

CAUTION: Be careful to plug output port equipment into upper connector and serial equipment into lower connector, otherwise damage to peripheral equipment and/or the PCS may result.

OUTPUT PORT (Reserved for future use)

SERIAL PORT

The serial port has been designed to allow the user remote operation of the PCS from a terminal or over a modem. The serial port uses standard RS-232-C logic. All signals are RS-232-C compatible. The port is a non-standard pinout configuration.

The circuit employs a programmable baud rate generator allowing rates from 150 to 19,200 to match the desired RS-232-C device to be connected to the PCS. Word length, parity, and stop bits are also programmable.

For further information, see Section 8.0.

6.8.1.2 ANALOG FUNCTIONS

NULL METER

The purpose of the null meter circuit is twofold. First, in the MEASURE mode, it provides an indication of the amount of error between the actual pressure on the QPS and the position of the solar cells, as indicated by the encoder counts on the null assembly. In the CONTROL mode however, this error indication is the difference between the 'measured' pressure and the 'control point' pressure. The microprocessor subtracts the null meter error reading from the encoder position reading and displays this as a MEASURED PRESSURE reading when the error is within 0.002% of span. It displays SLEWING pressure when the error is greater than 0.002% (0.004% for high pressure units) of span.

The null meter circuit is divided into a fine resolution (high gain) circuit and a lower resolution (low gain) circuit. The high gain circuit is used over the range of ±0.010% of span with a resolution of 0.0001%. The low gain circuit is used from ±0.010% to ±0.100% of span with a resolution of 0.001%. The low gain is used when the pressure is SLEWING and there is less need for accuracy.

The solar cell error signal goes through a notch filter and is amplified by OP-AMP Z33. The null meter zero adjust pot, R111 (see Figure 6.8C), on this amp is used to set the basic null meter circuit to 'zero' when the measured pressure is stable and the servo system has minimum servo error.

From Z33 the signal splits and goes to the high and low gain amplifiers. The low gain amplifier, Z32, has a gain of 5 and a pot, R6, that adjusts the output to mid range (0.2V). This is used by the digital circuits as zero. The high gain amplifier, Z31, has a gain of 50 and a pot, R7, that adjusts its output to mid-range (0.2V).

The signals from the high and low gain amplifiers go to a multiplex chip and then to a times 10 amplifier that raises the the voltage to 2, ±2 volts. This goes to the A/D converter and buffer. Then it goes to the microprocessor.

THERMOMETER

The thermometer is provided in the PCS to monitor the temperature of the QPS. Maximum instrument accuracy is assured if the QPS is within ±0.20°C of the temperature at which it was calibrated. This temperature is about 52°C (53 for Highline QPS units) and is noted on the record of calibration provided with the instrument.

The temperature probe is a linear dual thermistor type and is connected to J5 on the top of the I/O board.

A 2V reference is applied through precision resistors to the probe and to OP-AMP Z28 and Z29. A pot, R2, is provided to adjust the low temperature end of the range (45°C). A TEMP. SPAN pot, R1, sets the proper span of the circuit (45 to 57°C). Once the span pot is set, adjusting the TEMP. ZERO pot, R2, to an exact calibrated temperature has little effect on accuracy.

From OP-AMP Z28, the signal (zero to +0.4 volts) goes to the multiplex circuit.

VACUUM GAUGE

A thermocouple type vacuum gauge is provided on the absolute pressure PCS of 50 PSIA and below. The vacuum can be read by switching to the INTERNAL STATUS mode while it is pumping down.

The excitation voltage for the gauge tube is adjusted with the VAC. SPAN pot, R4. The voltage from this pot goes through the impedance amplifier Z1 and Q1, and sets the DC voltage on the primary center tap of transformer (T1).

Q2 and Q3 alternately switch the ends of the primary winding to ground. These transistors are driven with a 3.5 KHz signal from Z3 and Z2.

The signal from the vacuum gauge tube is developed across R20 and is amplified by Z4. A VAC. ZERO pot on this OP-AMP sets the ambient pressure end of the range. The signal (zero to 0.4 volts) then goes to the multiplex chip.

MULTIPLEX AND A/D

The multiplex and analog to digital circuits convert the two null meter ranges, the vacuum reading, and the temperature measurement to a digital signal that ranges from zero to 256 counts. This signal is available on the Standard Bus for the microprocessor.

Any of four inputs on the multiplex chip (Z7) is addressed by the microprocessor through latch Z10. The signal out of the multiplex is amplified by Z8, which has a gain of ten, to a level of zero to 4-volts. It then is converted to an 8-bit digital signal by Z9 and is stored in the output latch Z11 until it is read by the microprocessor.

6.8.2 I/O BOARD - MAINTENANCE

With the exception of adjusting the null meter zero, servicing of this PC assembly is beyond the scope of this manual. For this reason if problems arise, the user should first check the troubleshooting chart in Appendix D to assist in solving the problem. If in doing this the problem is traced back to this PC assembly, then consult the factory on how to proceed.

CAUTION: This PC assembly contains devices sensitive to static electricity. This board should therefore be handled only in static-safe situations. If the board is to be removed from the instrument case for storage or shipping, it should have shorting bars placed on the connectors and should be placed in a static-safe container.

6.8.2.1 NULL METER ZERO

Adjust the null meter 'ZERO' while the PCS is in the MEASURE mode with Pot A10R111.

6.9 NULL ASSEMBLY BOARD

The null assembly board contains a proportional temperature control circuit, a lamp voltage regulation circuit, and solar cell balancing circuitry.

6.9.1 DESCRIPTION OF OPERATION

The proportional temperature controller is used to regulate the QPS temperature. The circuit is capable of controlling the temperature within 0.05°C. On the PCS the QPS temperature can be monitored in the INTERNAL status mode.

CAUTION: This circuit is floating at line voltage. Do not connect grounded test instruments to it.

A thermistor mounted near the QPS provides feedback for the proportional temperature control. This thermistor along with pot R2 comprise a voltage divider that biases the base of Q1. The supply for the temperature controller is full wave rectified AC, thus power is available to the circuit 120 [100 for 50Hz line] times per second. As the QPS temperature drops, the thermistor's resistance increases and the voltage on the base of Q1 decreases. When the voltage of Q1 drops to about 17.4 volts Q1 starts to turn on and C1 begins to charge up. When C1 charges up, unijunction transistor Q2 is turned on allowing C1 to discharge through the emitter-base junction of Q2, and triggers SCR Q3. This applies power to the heater until the full wave supply returns to zero volts at which time SCR Q3 is latched off. If the temperature is too high, Q1 never turns on, so the SCR is not triggered. In the event of component failure, a thermostat [S1] is in series with the heater to keep the QPS temperature below 60°C.

The power supply for the lamp is also on this board. The system 5-volts is reduced to 2.13 volts by voltage regulator Z1. A soft start circuit [Q4, CR3, R26, C6] turns the lamp power on slowly to prolong the life of this lamp. R19 is selected for 2.13 volts at the lamp. Ordinarily this will not need to be adjusted.

6.9.2 NULL ASSEMBLY BOARD - MAINTENANCE

QPS TEMPERATURE

R2 is used to adjust the QPS temperature. Adjustment is 0.6°C per turn, clockwise to increase.

Note: Changing the QPS temperature will affect calibration. Check the temperature against the temperature when the instrument was last calibrated. The QPS temperature should be within ±0.20°C of the calibration temperature.

The nominal QPS temperatures are 52 ±0.5°C for the standard QPS and 53 ±0.5°C for the Highline QPS. The adjustment pot is in the center of the board [see Figure 6.9.1].

Note: Do not adjust the pot [R24] on the top of the null assembly board. This is a factory adjustment used to balance the solar cell output.

7.0 SPECIFICATIONS

7.1 MEASUREMENT SPECIFICATIONS

Pressure Ranges:
0 to 1 PSI up to 0 to 725 PSI full scale [F.S.].
Absolute, gauge, or true differential pressure measurements may be selected.

Pressure Units:
The following pressure units are standard:

in. Hg. [at 0°C]
mBar
psi
in. H20 [at 4°C]
mm. Hg. [at 0°C]
kPa
mTorr [at 0°C]
counts

Special pressure units or conversion temperatures are available. Consult the factory.

Accuracy:
The achievable accuracy at calibrated points with a confidence level of 95% is:

Differential Pressure Measurement:
- For ranges ≤300 psi
  - ±0.01% of reading, ±0.003% of F.S.
- For ranges >300 psi
  - ±0.01% of reading, ±0.006% of F.S.

Absolute Pressure Measurement:
- For ranges ≤300 psi
  - ±0.01% of reading, ±0.003% of F.S., ±5 microns
- For ranges >300 psi
  - ±0.01% of reading, ±0.006% of F.S., ±5 microns

Note: The accuracy statement assumes that the instrument has been properly zeroed, servo adjustments made and the system checked for leaks per operating instructions.

The ±0.01% of reading refers to Mensor's reference standards, traceable to the NBS. For calibrations not performed by Mensor, this value may be different.

Linearity between zero and F.S. in counts:
±0.25% F.S. endpoint.

Linearity between cal points in pressure units
±0.010% of F.S.

Pneumatic Repeatability and Hysteresis:
For ranges ≤300 PSI: ±0.002% F.S. maximum.
For ranges >300 PSI: ±0.004% F.S. maximum.

Dynamic Response:
Slew rate 60 seconds F.S. in response to a F.S. pressure step function for a PCS operating at 60 Hz, 72 seconds when operating at 50 Hz. Servo resonant frequency is 5 CPS.

Resolution:
±0.001% F.S. minimum.

Case Pressure Effect:
±0.00015% F.S. per 1 PSI change in case pressure; apparent pressure change caused by applying pressure to the chamber surrounding the Bourdon helix. May be removed by zeroing.

QPS Temperature Coefficient
-0.014% of reading per °C of QPS temperature change.

7.2 CONTROL SPECIFICATIONS

Pressure Stabilization Time:
Equal to slew rate plus 15 seconds. 30 seconds below 2 In. Hg.

Stability of Controlled Pressure:
±0.002% F.S.

Minimum Controlled Pressure:
0.1% F.S. above exhaust pressure.

7.3 INPUTS/OUTPUTS

Front Panel Inputs
16 Key numeric keyboard
4 Key function selection keyboard
Power switch

Front Panel Outputs
Vacuum fluorescent display: two rows of 40 characters
5X7 matrix for each character

Rear Panel Inputs/Outputs
Electrical: AC power

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I/O: IEEE-STD-488-1978 bus (optional)
Output port
Serial port (RS-232-C signal levels)

Pneumatic: Reference pressure
Exhaust pressure
Measure/Control pressure
Source pressure

7.4 PRESSURE REQUIREMENTS

Supply Pressure:
Regulated dry instrument quality air or water-pumped nitrogen at a pressure 5 to 10 PSI above the range of the PCS. When stable in the CONTROL mode the gas consumption is between 3 and 12 SCFH, dependent upon control point.

Exhaust Pressure:
For a differential PCS using a subatmospheric reference pressure and for absolute PCS, a vacuum must be applied to the exhaust port (see the note below). Otherwise, atmospheric pressure is used.

Note: Vacuum pump requirements vary with the pressure range of the PCS and the pressures being controlled by the user. This makes it difficult to list requirements for every application, but a vacuum pump that would meet essentially all requirements would have a performance curve (displacement versus pressure) that includes or betters the following two points:

25 liters/minute at atmospheric pressure
10 liters/minute at 0.1 mTorr

Reference Pressure: Differential PCS only.
Vacuum to 100 PSIG on units with standard QPSs.
Vacuum to 725 PSIG on units with Highline QPSs.

Measure/Control Pressure:
Any clean, dry, non-corrosive, non-flammable gas (except helium on absolute units) is acceptable with maximum pressure as listed below by PCS pressure range.

PCS Pressure Range	Maximum Overpressure
To 3.6 PSI	200% of full scale press.
3.7 to 200 PSI	100% of full scale press.
201 to 725 PSI	50% of full scale press.

7.5 MATERIALS IN CONTACT WITH PRESSURE MEDIA

The following materials are in contact with the pressure media inside the PCS:

Metallics
Aluminum
Brass
Invar [36]
Platinum
Silver Solder
Stainless steel [316]
Stainless steel [430F]

Non-metallics
Buna-N rubber
Viton
Loctite sealant
Nylon
PVC
Quartz
Silicone grease
Teflon

Pressure media: clean, dry, non-corrosive gases.

7.6 PHYSICAL PROPERTIES [SEE FIG. 7.5]

Width	17.05 inches	standard
	19.00 inches	rack version
Height	8.72 inches	
Length	20.00 inches	
Weight	47 lbs.	low pressure
	52 lbs.	high pressure
	74 lbs.	shipping - low pressure
	79 lbs.	shipping - high pressure
	4 lbs.	rack option [add to above]

Internal Pneumatics Volume

In milliliters...	Measure/Control	Reference
Measure mode:		
Low pressure, diff.	30	125
High pressure, diff.	30	88
Low pressure, abs.	114	N/A
High pressure, abs.	52	N/A
Control mode:		
Low pressure, diff.	110	125
High pressure, diff.	95	88
Low pressure, abs.	194	N/A
High pressure, abs.	117	N/A

Ports:
All external pressure ports 1/8 NPT

Temperature Ranges

	Deg. F	Deg. C
Operating	41 to 100	5 to 38
Storage	-22 to 176	-30 to 80

7.7 POWER

Mains: 115 ±15V or 230 ±30V, 50 or 60 Hz, Single Phase,
125 VA max.
Fuses: For 115 VAC: 1½ Amp, Type 3AG-250 V, slow blow
For 230 VAC: 1 Amp, Type 3AG-250 V, slow blow

DC Power Supply
±5V ±0.05V, 6 amps
±15V, ±0.15V, 1 amp each

7.8 AUXILIARY CONNECTIONS

IEEE-STD-488-1978 BUS:
GPIB [General Purpose Interface Bus] Conn.
2 X 12 Pins on 0.1" X 0.1" centers
Typical connectors include MICRORIBBON [Amphenol or Cinch Series 57] or CHAMP [AMP] with metric screwlock fasteners.

Serial Port: 25 Pin D-Subminiature Connector, female

Output Port: 25 Pin D-Subminiature Connector, female

7.9 MOUNTING

Standard: Table model
Optional: Rack mountable

8.0 COMMUNICATIONS AND ACCESSORIES

8.1 COMMUNICATION INTERFACES

8.1.1 GENERAL INFORMATION

The PCS supports the communication interfaces common in today's technical and industrial workplace. They are the IEEE-STD-488-1978 Interface bus, commonly known as the GPIB, and the serial port. Both interfaces require microprocessor time to process commands and data requests. This time can cut into the normal processing of internal data and can be detrimental to instrument performance. Specifically, the pressure stable indication requires 175 consecutive conversion cycles of the null meter to be within the 'window' before stable is indicated. If the microprocessor is handling large amounts of I/O, the delay can stretch out from about 3 seconds to well over a minute. Therefore it recommended that this be kept in mind when designing the interface program.

When making repeated readings over the communications port, it is only necessary to put the PCS into a specific output format once for most commands. If commands are issued repeatedly as opposed to only requesting a reading the PCS must interpret the command, act on it, and in some cases restart a calculation cycle.

Monitoring the serial port poses an additional tax on the system. It is therefore recommended it be turned 'off' when not in use.

The PCS can communicate over both interfaces simultaneously with one restriction, the PCS will execute a GPIB request over a serial request.

The PCS also has an OUTPUT port, formerly referred to as the PRINTER port.

8.1.2 GPIB

The GPIB is also known as the HP-IB as a reference to the inventor of the bus, Hewlett Packard, and the IEEE-488 bus or the 488 bus as a reference to the 1978 IEEE standard defining the interface bus.

8.1.2.1 ADDRESSING

From the main menu, select the IEEE ADR setup mode by pushing the SPECIAL key, SETUP key, OTHER key, then the IEEE ADR key.

The display should now show the following:

```
ENTER NEW IEEE-488 DEVICE ADDRESS      ##
... [0 TO 31]  THEN PUSH '=' TO CONTINUE
```

In the upper right corner the current device address is displayed. Enter a new address as prompted or push 'M' to keep the current address. The PCS will then perform a RAM test then return to the main menu.

8.1.2.2 CAPABILITY IDENTIFICATION

The following capabilities will be implemented by the GPIB interface adapter.

- SH1 - Source Handshake, complete capability
- AH1 - Acceptor Handshake, complete capability
- T2 - Talker, Basic with Serial Poll
- L2 - Listener, Basic
- SR1 - Service Request, complete capability
- RL1 - Remote Local, complete capability
- PP0 - Parallel Poll, no capability
- DC0 - Device Clear, no capability
- DT0 - Device Trigger, no capability
- C0 - Controller, no capability

8.1.3 SERIAL PORT

The PCS serial interface port transmits and receives digital data asynchronously at baud rates of 150, 300, 600, 1200, 2400, 4800, 9600, or 19200. A character can be seven or eight bits in length with one start bit, one or two stop bits, and even, odd, or no parity.

The PCS serial port has a 1-character buffer only. Input must be accomplished either by use of the handshaking lines, or by verifying an echo of each character of the command string and resending characters not echoed. Unless this is done commands may be unrecognizable to the PCS. The PCS does not support any handshaking method other than the DTR and RTS lines. Protocol converters are available from several sources to convert from DTR/RTS to X-ON/X-OFF and other handshaking methods. They may be of help in difficult interfacing situations.

An additional consideration in communicating over the serial port is the time required by the PCS to assemble each line of output. The example programs in sections 8.5.3 and 8.5.4 include a delay to handle this. Unless taken into consideration it can lead to device timeout errors in the user program.

8.1.3.1 SETUP PROCEDURE

From the main menu, select the RS-232-C setup mode by pushing the SPECIAL key, SETUP key, OTHER key, then the RS-232-C key.

The display should now show the following:

```
SELECT SERIAL DATA:     OFF     7/1/E     9600
ON/OFF     BIT FORMAT     BAUD RATE     QUIT
```

The display identifies this screen as the serial data selection mode. It also displays the configuration status of the port. This status represents the actual port configuration on entry to this screen and then displays the current changes to data format as they are made. The status first indicates if the PCS is online, followed by the data word length/number of stop bits/parity, and finally the baud rate. The second line lists the operating parameters available for selection. A brief description of the parameters is provided below:

ON/OFF - sets the PCS serial port online or offline. Pushing the key below 'ON/OFF' toggles this function to the opposite states. This function takes effect immediately.

Note: Leaving the PCS in the online mode is an acceptable procedure even if no serial device is connected providing the system update rate is not a major concern. For maximum conversion speed the port should be placed in the offline mode when not being used.

BIT FORMAT - sets the word length, number of stop bits, and parity. Selections available include seven bit word with one stop bit, seven bit word with two stop bits, eight bit word with one stop bit, and eight bit word with two stop bits. The parity selection may be odd, even, or none. Selections made will immediately be displayed in the upper right half of the display, but will not take effect until the QUIT key is pressed.

BAUD RATE - sets both the transmit and receive data rates. Valid rates are 150, 300, 600, 1200, 2400, 4800, 9600, and 19200 baud. Selection is made by pushing the appropriate number [0-7] on the numeric keypad on the right front panel. This selection does not become effective until the QUIT key is pressed.

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QUIT - terminates the setup mode, reconfigures the serial format to the currently displayed settings, and then returns to the previous mode of operation.

Once the setup is complete, the operating parameters are stored in non-volatile memory. This stored configuration is automatically set during the initializing process at power-up.

8.1.3.2 SPECIFICATIONS

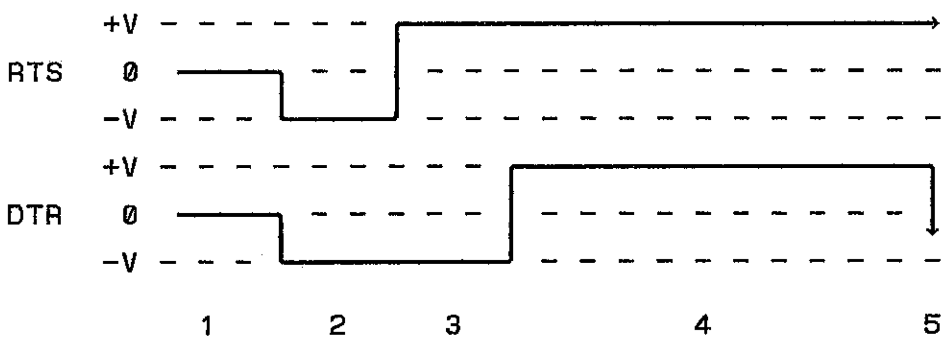
Data format - Serial, binary asynchronous, 7 or 8 data bits, 1 or 2 stop bits, odd, even, or no parity.

Baud rates - 150, 300, 600, 1200, 2400, 4800, 9600, or 19200 baud.

Buffer size - one character.

Connector - 25 pin female (DB-25). See figure 8.1.3.2 for pinouts.

Handshaking - provided by the RTS and DTR lines. The timing of the lines is shown in the following diagram:



Where at position:

1 - the PCS is powered 'off'.
2 - the PCS is 'on' but the serial port is 'off'
3 - the serial port is 'on' but not ready for data.
4 - the serial port is 'on' and ready for data.
5 - the serial port is no longer ready for data.

Recommended cables - the four suggested cable configurations shown in figures 8.1.3B and 8.1.3C are generic in nature. The user should consult the technical information available on the specific terminal, modem, or computer being connected to the PCS for its special requirements.

8.1.4 OUTPUT PORT

The output port is reserved for future use.

8.2 COMMUNICATIONS PROTOCOL

The GPIB and the serial port use an essentially identical command structure. The differences lie in the error handling and string transfers. The commands listed in the command reference are available on all versions of PCS Model 200's unless otherwise specified.

8.2.1 GPIB I/O

Examples of command usage are given for some commands using a style associated with National Instruments GPIB-PC software. They are program fragments only and are not intended to be used without the supporting program structures. The example programs in section 8.5 were written using GPIB-PC in COMPAQ BASICA (essentially identical to Microsoft BASICA) and Microsoft QuickBASIC on a COMPAQ Deskpro.

LISTENER (INPUT)

All commands should end with EOI asserted. The PCS will not accept commands greater than 11 bytes. An 11 byte string will be interpreted with or without the EOI asserted. Invalid commands are ignored.

TALKER (OUTPUT)

All output strings will be terminated with a linefeed (ASCII 0A Hex) and EOI asserted.

8.2.2 SERIAL PORT I/O

The example programs of serial port communication in section 8.5 were written in COMPAQ BASICA (essentially identical to Microsoft BASICA) and Microsoft QuickBASIC on a COMPAQ Deskpro.

INPUT

The PCS will not accept commands greater than 11 bytes in length. All commands are terminated with an 'X'. Invalid commands are ignored. The characters of the command are echoed back followed by a carriage return (ASCII 0D Hex). Software versions less than 3.0 also return a linefeed (ASCII 0A Hex).

OUTPUT

Output strings are specified as either fixed or variable length. Variable length output must be dealt with be searching for an ending string. Each line of output is terminated with a carriage return [ASCII 0D Hex]. For software version 3.0 and higher, output is terminated with a linefeed [ASCII 0A Hex]. Lower versions however, have a linefeed after each line of output. Output must be completed before a new command is entered.

8.3 COMMAND REFERENCE

The following symbols will be used throughout section 8.3:

* = Mode of operation as specified below:

M = MEASURE
C = CONTROL
Q = CONTROL SEQUENCES
V = VENT
S = STANDBY
F = SPECIAL FUNCTION

$ = Pressure units as specified below:

0 = in.Hg
1 = mBars
2 = psi
3 = in.H_2O
4 = mm.Hg
5 = kPa
6 = mTorr
7 = counts

= 1 byte of variable data

<LF> = Linefeed [ASCII 0A Hex]

<CR> = Carriage return [ASCII 0D Hex]

• = Space [ASCII 20 Hex]

. = '.' [ASCII 2E Hex]

/ = '/' [ASCII 2F Hex]

: = ':' [ASCII 3A Hex]

; = ';' [ASCII 3B Hex]

X = 'X' [ASCII 58 Hex]

8.3.1 CHANGING THE MODE OF OPERATION

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MEASURE

Long format (11 bytes):

```
   1   2   3   4   5   6   7   8   9   10  11
 | M | $ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X |
```

Bytes 3-10 are ignored.

Short format (3 bytes):

```
   1   2   3
 | M | $ | X |                (version 2.51 and higher)
```

The long and short formats place the PCS in the MEASURE mode in the specified pressure units.

Mini format (2 bytes):

```
   1   2
 | M | X |                    (version 2.51 and higher)
```

The mini format places the PCS in the MEASURE mode in the current pressure units.

CONTROL

Long format (11 bytes):

```
  1   2   3   4   5   6   7   8   9   10  11
| C | $ | # | # | # | # | # | # | # | 0 | X |
```

Byte 10 is ignored.

This command places the PCS in the CONTROL mode in the pressure units specified at the pressure specified. Example: To command 5.2 In.Hg on a 40 In.Hg unit, all of the following pressure strings (bytes 3-9) would be acceptable:

```
5.20000
005.200
00005.2
+0005.2
000+5.2
••5.2••
```

Note that the decimal point requires 1 bytes out of the seven. Also note that spaces (ASCII 20 Hex) are allowed.

Short format (4 to 10 bytes):

```
  1   2   3   4   5   6   7   8   9   10
| C | $ | # | # | # | # | # | # | # | X |
```

(version 2.54 and higher)

With this format only the significant digits of the pressure string are required. To command 5.2 In.Hg as above only '5.2' is required, making the total command string 6 bytes long.

Mini format (2 bytes):

```
  1   2
| C | X |                    (version 2.51 and higher)
```

This command places the PCS into the CONTROL mode in the current pressure units at the equivalent pressure in the current units to the last commanded control pressure.

CONTROL AT CAL. PTS.

Short format [3 or 4 bytes]:

```
  1   2   3                    1   2   3   4
| D | # | X |       or       | D | # | # | X |

                               [version 2.53 and higher]
```

This command puts the PCS into CAL. PTS. CONTROL mode in the current pressure units. It allows an input that corresponds to one of the 64 calibration points [0-63]. The PCS cannot control at the calibrated 'zero' therefore when cal point 0 is commanded, the PCS vents to atmosphere.

Mini format [2 bytes]:

```
  1   2
| D | X |                      [version 2.53 and higher]
```

This command puts the PCS into CAL. PTS. CONTROL at the current [last used] cal point.

EXECUTE SEQUENCE

Long format (11 bytes):

1	2	3	4	5	6	7	8	9	10	11
Q	0	0	0	0	0	0	0	0	#	X

(version 2.57 and higher)

Bytes 2-9 are ignored.

Entering a 1 through 4 in byte 10 selects one of the four stored sequences in the PCS in the pressure units the sequence specifies. A sequence may not be programmed remotely.

Short format (2 bytes):

1	2
Q	X

(version 2.57 and higher)

This command places the PCS in the current (last used) sequence.

VENT

Long format [11 bytes]:

```
  1   2   3   4   5   6   7   8   9   10  11
| V | $ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X |
```

Bytes 3-10 are ignored.

Short format [3 bytes]:

```
  1   2   3
| V | $ | X |                 [version 2.51 and higher]
```

The long and short formats vent the PCS both internally and externally in the specified pressure units.

Mini format [2 bytes]:

```
  1   2
| V | X |                     [version 2.51 and higher]
```

This command vents the PCS both internally and externally in the current pressure units.

STANDBY

Long format [11 bytes]:

1	2	3	4	5	6	7	8	9	10	11
S	$	0	0	0	0	0	0	0	0	X

Bytes 3-10 are ignored.

Short format [3 bytes]:

1	2	3
S	$	X

[version 2.51 and higher]

Mini format [2 bytes]:

1	2
S	X

[version 2.51 and higher]

These commands place the PCS into the STANDBY mode. The long and short formats will change the pressure units when exiting another mode such as MEASURE, CONTROL, or VENT. Once the PCS is in STANDBY, subsequent standby commands will not change the pressure units.

CHANGE UNITS

Short format (3 bytes):

```
  1   2   3
| U | $ | X |              (version 2.53 and higher)
```

This command changes the pressure units to those specified in byte 2 of the command.

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DIFFERENTIAL RE-ZERO

Mini format [2 bytes]:

```
  1   1
| Z | X |
```

This command mechanically and pneumatically re-zeros differential PCS's. The instrument should be properly adjusted and at a stable operating temperature [See section 4.1 and 4.2]. During the re-zero the PCS will not communicate over the GPIB or serial port with one exception. The PCS will assert a service request on the GPIB and on a resulting serial poll will respond with a 4D Hex indicating the RE-ZERO mode is active. When a user program issues this command this shutdown of communications must be anticipated. Otherwise, device timeout errors are likely to occur. This mode always returns to the MEASURE mode when complete. Failure to return to the MEASURE mode within three minutes indicates a misadjustment of the servo system, mechanical vibration or hardware failure.

Determining when the RE-ZERO mode is completed can be a troublesome task. Over the GPIB, one method would be to change the timeout on the GPIB to over three minutes before attempting to read the PCS. The read will wait to complete for three minutes in which the PCS should finish. After the read completes, reset the timeout to the previous value. Note: This method assumes that it is acceptable for the controller to be idle while waiting on the PCS.

Another method that is applicable to the serial port as well as the GPIB is one of 'polling' the PCS. This method would allow processing to continue between successive 'polls' of the PCS. The way it would work is to have the program be aware that a command that shuts the communications down for a time has occurred. It would then expect subsequent reads to possibly fail because of this. By having a special case for handling timeout errors caused by this condition, a program could repeatedly read the PCS until a read was successful indicating the PCS is back on-line.

RE-INITIALIZE

Long format [11 bytes]:

1	2	3	4	5	6	7	8	9	10	11
F	0	0	0	0	0	0	0	0	1	X

Bytes 2-9 are ignored.

This command will place the PCS in the initializing status similar to that when first powered up. The PCS will not communicate over the GPIB or the serial port during the initialization, which may be as long as three minutets. When a user program sends the RE-INITIALIZE command, this shutdown of communications should be anticipated. Otherwise, device timeouts in the user program are likely to occur. This command also causes all the buffers to be cleared and the PCS to go to the LOCAL mode on the GPIB. The ouput format will be the standard format and all bytes will be set to 'I' except byte 18 until another mode is commanded.

See the RE-ZERO command for additional information.

8.3.2 CHANGING OUTPUT FORMAT

Unless otherwise specified the output format remains in effect until changed.

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RETURN CURRENT READING (serial port only):

Mini format (2 bytes):

```
  1   2
| R | X |                    (version 2.51 and higher)
```

This command causes the PCS to transmit data per the current output format.

RETURN STANDARD READING

Long format [11 bytes]:

```
  1   2   3   4   5   6   7   8   9   10  11
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X |
```

Bytes 2-9 are ignored.

Short format [3 bytes]:

```
  1   2   3
| R | 0 | X |                 [version 2.51 and higher]
```

These commands change the PCS output format to the standard [default] format. When used on the serial port it also causes the data to be output.

Returns a 20 byte string:

```
*$################<CR><LF>
```

Where:

Byte 1 is mode of operation.
This byte also determines which portions of the remaining string are valid. For example, in the STANDBY and SPECIAL FUNCTION modes, and immediately after initialization, the only valid byte is 18. All other values are set by previous conditions. In the MEASURE and VENT modes all bytes except 11-17 are valid. Bytes 11-17 will represent the last control pressure. In any of the CONTROL modes, the entire string is valid.

Byte 2 is the current pressure units.

Bytes 3-9 is the measured pressure.
This string represents the true measured pressure if byte 10 indicates a stable pressure. The seven characters may include a decimal point with the same fractional digits as displayed on the front panel of the PCS. Leading blanks will be filled with spaces [ASCII 20 Hex].

Byte 10 is the instrument status where:
'S' indicates a stable pressure.
This means the servo system has been within the window [see below] of null for 175 consecutive conversion cycles [approx. three seconds]. In the MEASURE and VENT modes this would indicate the servo

system is tracking the pressure within the window. In the CONTROL modes, this indicates the measured pressure is within the window of the commanded control pressure.

Where the window is:

80 PPM [40 counts] for ranges $\leq$1.45 PSI
40 PPM [20 counts] for all other ranges

'U' indicates an unstable pressure.
This means the servo system is driving to null out all errors or is oscillating more than the window [specified above] around null. In the MEASURE and VENT modes this would indicate the system is seeking a new pressure reading. The system should become stable within 75 seconds. Failure to do so indicates the servo system may be oscillating and need adjustment, or there may be a leak in the system. In the CONTROL modes the 'U' indicates the measured reading does not match the commanded control pressure or the servo system may be oscillating and in need of adjustment. A measured pressure reading that is consistently 0.1%FS above or below the commanded control pressure may indicate a problem with the source or exhaust pressure. A leak will also cause a constant offset of varying size depending upon the size of the leak.

'E' indicates that an error condition exists.

'L' indicates that the measured reading has been compensated for servo errors and the reading may be used where reduced accuracy of up to 0.1%FS is acceptable. This feature is not available on all units.

Bytes 11-17 is the control pressure. This is the current [last used] control pressure. The string may include a decimal point and leading spaces [ASCII 20 Hex].

Byte 18 is the communication status. This byte will be an 'S' if the reading was obtained over the serial port. If the reading was obtained over the GPIB, then this character will be an 'R' to indicate the PCS is in the REMOTE mode or an 'L' to indicate the PCS is in the LOCAL mode.

The following example indicates the PCS is measuring pressure in In.H_2O. The current pressure reading is 102.357 but is an unstable reading. The last control pressure entered was 200.000 and the reading was taken over the serial port.

M3102.357U200.000S

When the numeric output format is 'on' this command sets the output format to return a 9 byte string:

#######<CR><LF>

Where:

Bytes 1-7 are the measured pressure.

Example:

102.357

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RETURN CALIBRATION DATA

Long format [11 bytes]:

```
   1   2   3   4   5   6   7   8   9   10  11
 | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | X |
```

[version 2.52 and higher]

Bytes 2-9 are ignored.

Short format [3 bytes]:

```
   1   2   3
 | R | 2 | X |
```

[version 2.52 and higher]

These commands set the output format to transfer the calibration data of the PCS in the current pressure units. When the short form is used on the serial port it also causes the data to be output. The format is valid for one output, then returns to the standard output format.

Returns a variable length string:

```
*$;<CR>                                       [4 bytes]
CALIBRATION•CHART•-•MENSOR•PCS-200•••<CR>     [41 bytes]
•••••SERIAL•NUMBER:•••#####<CR>               [28 bytes]
•••••DATE•OF•CAL:••mm/dd/yy<CR>               [    "    ]
•••••QPS•TEMP:•••••••##.##C<CR>               [    "    ]
•••••ZERO•OFFSET:••••######<CR>               [    "    ]
<CR>                                          [1 byte]
•••PRESSURE•POSITION<CR>                      [21 bytes]
••••#######••#######<CR>                      [    "    ]
--•-•-------••-------<CR>                     [    "    ]
•1••#######••#######<CR>                      [    "    ]
•2••#######••#######<CR>                      [    "    ]
              -
              -
              -
40••#######••#######<CR>                      [    "    ]
41••#######••#######<CR>                      [    "    ]
--•-•-------••-------<CR>                     [    "    ]
<CR>                                          [1 byte]
<CR><LF>                                      [2 bytes]
```

Where:

Line 1, byte 1 is the mode of operation.
Line 1, byte 2 is the current pressure units.
Line 2, bytes 34-40 is the model number.
Line 3, bytes 23-27 is the PCS serial number.

Line 4, bytes 20-27 is the calibration date.
dd = day [01-31]
mm = month [01-12]
yy = year [00-99]
Line 5, bytes 22-26 is the QPS temp at calibration.
Line 6, bytes 22-27 is the zero offset since calibration.
Line 9, bytes 5-11 is the pressure units of the chart.
Line 11 through end of calibration points:
bytes 1-2 is the cal point number.
bytes 5-11 is the cal point true pressure.
bytes 14-20 is the cal point gauge position.

The true pressure will be specified in the current pressure units and the gauge position will be in unmodified counts.

The following example shows PCS serial number 18 is in the INITIALIZE mode, reading in In.Hg. The calibration date was 06/06/86, and the QPS temperature was 52.30C. The PCS has a zero offset of -19 counts incurred either through re-zeroing or single point calibration.

```
 I0;
 CALIBRATION CHART - MENSOR PCS-200
      SERIAL NUMBER:   00018
      DATE OF CAL:  06/06/86
      QPS TEMP:        52.30C
      ZERO OFFSET:        -19

    PRESSURE POSITION
      INHG    COUNTS
 --  -------  -------
  1  0.00000    33724
  2  0.10164    57061
  3  0.20330    80271
  4  0.30494   103543
  5  0.40654   126665
           -
           -
           -
 19  1.82937   452520
 20  1.93097   475866
 21  2.03262   499248
 22  2.13425   522612
 23  2.23590   546019
 --  -------  -------
```

The numeric output format command has no effect on the calibration data format.

RETURN CALIBRATION DATA

Short format (4 bytes):

```
  1   2   3   4
| R | 2 | 0 | X |          (version 3.0 and higher)
```

This command changes the output format to transfer the calibration data of the PCS in the current pressure units. This data includes the QPS serial number. When the short form is used on the serial port it also causes the data to be output. The format is valid for one output, then returns to the standard output format.

Returns a variable length string:

```
*$;<CR>                                           (4 bytes)
CALIBRATION•CHART•-•MENSOR•PCS-200•••<CR>         (41 bytes)
•••••S.N.:••••######/######<CR>                   (28 bytes)
•••••DATE•OF•CAL:••mm/dd/yy<CR>                   (   "   )
•••••QPS•TEMP:•••••••##.##C<CR>                   (   "   )
•••••ZERO•OFFSET:••••######<CR>                   (   "   )
<CR>                                              (1 byte)
•••PRESSURE•POSITION<CR>                          (21 bytes)
••••#######••#######<CR>                          (   "   )
--•--------•-------<CR>                           (   "   )
•1••#######••#######<CR>                          (   "   )
•2••#######••#######<CR>                          (   "   )
           -
           -
           -
40••#######••#######<CR>                          (   "   )
41••#######••#######<CR>                          (   "   )
--•--------•-------<CR>                           (   "   )
<CR>                                              (1 byte)
<CR><LF>                                          (2 bytes)
```

Where:

Line 1, byte 1 is the mode of operation.
Line 1, byte 2 is the current pressure units.
Line 2, bytes 34-40 is the model number.
Line 3, bytes 15-20 is the PCS serial number.
Line 3, bytes 22-27 is the QPS serial number.
Line 4, bytes 20-27 is the calibration date.
  dd = day (01-31)
  mm = month (01-12)
  yy = year (00-99)
Line 5, bytes 22-26 is the QPS temp at calibration.
Line 6, bytes 22-27 is the zero offset since calibration.
Line 9, bytes 5-11 is the pressure units of the chart.

Line 11 through end of calibration points:
- bytes 1-2 is the cal point number.
- bytes 5-11 is the cal point true pressure.
- bytes 14-20 is the cal point gauge position.

The true pressure will be specified in the current pressure units and the gauge position will be in unmodified counts.

The following example shows PCS serial number 100434 is in the INITIALIZE mode, reading in In.Hg. The QPS serial number is 013784. The calibration date was 07/02/87, and the QPS temperature was 52.25C. The PCS has a zero offset of -4 counts incurred either through re-zeroing or single point calibration.

```
10;
CALIBRATION CHART - MENSOR PCS-200
     S.N.:      100434/013784
     DATE OF CAL:  07/02/87
     QPS TEMP:        52.25C
     ZERO OFFSET:         -4

   PRESSURE POSITION
     INHG    COUNTS
--  -------  -------
 1  0.00000    33724
 2  0.10164    57061
 3  0.20330    80271
 4  0.30494   103543
 5  0.40654   126665
          -
          -
          -
19  1.82937   452520
20  1.93097   475866
21  2.03262   499248
22  2.13425   522612
23  2.23590   546019
--  -------  -------
```

The numeric output format command has no effect on the calibration data format.

RETURN UNIT ID

Long format (11 bytes):

```
  1   2   3   4   5   6   7   8   9   10  11
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | X |
```

(version 2.52 and higher)

Bytes 2-9 are ignored.

Short format (3 bytes):

```
  1   2   3
| R | 3 | X |
```

(version 2.52 and higher)

These commands change the output format to transfer the unit ID data. When the short form is used on the serial port it also causes the data to be output. On the GPIB the output format is valid for one output only. On the serial port the output format remains until changed.

Returns a 53 byte string:

```
*$;•MENSOR•••PCS-200•••V#.##••####•#######••SN#####<CR><LF>
```

Where:

Byte 1 is the mode of operation.
Byte 2 is the current pressure units.
Bytes 14-20 is the PCS model number.
Bytes 25-28 is the version number.
Bytes 31-34 is the pressure range.
Bytes 36-42 is the pressure units.
Leading and trailing blanks will be filled with spaces (ASCII 20 Hex).
For some special pressure ranges the actual location of the data may be different, but will always be within bytes 31-42.
Bytes 47-51 is the PCS serial number.

Example:

```
M2; MENSOR   PCS-200  V2.54C    50 PSI-D    SN00200
```

The numeric output format command has no effect on the unit ID format.

RETURN UNIT ID

Short format [4 bytes]:

```
  1   2   3   4
| R | 3 | 0 | X |          [version 3.0 and higher]
```

This command changes the output format to transfer the unit ID data. The data also includes the QPS serial number. When the short form is used on the serial port it also causes the data to be output. The output format is valid for one output only on both the GPIB and the serial port.

Returns a 60 byte string:

```
*$;•MENSOR•••PCS-200•••V#.##•######•######•SN######/######<CR><LF>
```

Where:

Byte 1 is the mode of operation.
Byte 2 is the current pressure units.
Bytes 14-20 is the PCS model number.
Bytes 25-28 is the version number.
Bytes 30-35 is the pressure range.
Bytes 37-42 is the pressure units.
Leading and trailing blanks will be filled with spaces [ASCII 20 Hex].
For some special pressure ranges the actual location of the data may be different, but will always be within bytes 30-42.
Bytes 46-51 is the PCS serial number.
Bytes 53-58 is the QPS serial number.

Example:

```
M2; MENSOR   PCS-200   V1.00     50 PSI-D    SN110200/013892
```

The numeric output format command has no effect on the unit ID format.

RETURN QPS TEMPERATURE

Long format (11 bytes):

```
  1   2   3   4   5   6   7   8   9   10  11
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | X |
```

(version 2.52 and higher)

Bytes 2-9 are ignored.

Short format (3 bytes):

```
  1   2   3
| R | 5 | X |
```

(version 2.52 and higher)

These commands change the output format to transfer the current QPS temperature. When used on the serial port, data is output.

Returns a 12 byte string:

*$;###.##C<CR><LF>

Where:

Byte 1 is the mode of operation.
Byte 2 is the current pressure units.
Byte 4 is the validity flag.
'<' (ASCII 3C Hex) = Below temperature scale
'space' (ASCII 20 Hex) = Valid reading
'>' (ASCII 3E Hex) = Above temperature scale
Bytes 5-10 is the QPS temperature.

Example:

V1;<44.60C
S2; 52.00C
C5;>57.35C

The temperature readout has a resolution of 0.05°C.

When the numeric output format is 'on' this command sets the output format to return a 7 byte string:

##.##<CR><LF>

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Because there is no validity flag, a reading of 44.60 or 57.35 should be suspected to be invalid.

Examples:

52.05
53.55
49.95

RETURN NULL METER READING

Long format (11 bytes):

1	2	3	4	5	6	7	8	9	10	11
F	0	0	0	0	0	0	0	0	6	X

(version 2.52 and higher)

Bytes 2-9 are ignored.

Short format (3 bytes):

1	2	3
R	6	X

These commands change the output format to transfer the null meter reading as shown below. When used on the serial port, data is output.

Returns a 15 byte string:

*$;#####.#CTS<CR><LF>

Where:

Byte 1 is the mode of operation.
Byte 2 is the current pressure units.
Bytes 4-10 is the null meter reading.
Leading characters will be filled with spaces (ASCII 20 Hex).

Examples:

```
M2; -635.5CTS
C2;    1.0CTS
```

When the numeric format command is in effect this command sets the output format to return a 9 byte string:

#####.#<CR><LF>

Examples:

```
-635.5
   1.0
```

RETURN VACUUM GAUGE READING

Long format [11 bytes]:

```
  1   2   3   4   5   6   7   8   9   10  11
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | X |
```

[version 2.52 and higher]

Bytes 2-9 are ignored.

Short format [3 bytes]:

```
  1   2   3
| R | 7 | X |
```

[version 2.52 and higher]

These commands change the output format to transfer the vacuum gauge reading in the current pressure units. When used on the serial port data is output.

Returns a 15 byte string:

*$;#######VAC<CR><LF>

Where:

Byte 1 is the mode of operation.
Byte 2 is the pressure units.
Bytes 4-10 is the vacuum reading. It is given in absolute pressure units. Leading blanks are filled with spaces [ASCII 20 Hex]. A PCS with no vacuum gauge will typically read all spaces.

Examples:

```
M2;13.3617VAC = 13.3617 psia
S2; 0.0132VAC = 0.0132 psia
M6;     684VAC = 684 mTorr
S0;     ATMVAC = atmospheric pressure
```

When the numerical output format is 'on' this command sets the output to return a 9 byte string:

#######<CR><LF>

Examples:

```
13.3617
 0.0132
    684
    ATM
```

RETURN CLOCK READOUT

Long format [11 bytes]:

1	2	3	4	5	6	7	8	9	10	11
F	0	0	0	0	0	0	0	0	8	X

[version 2.53 and higher]

Bytes 2-9 are ignored.

Short format [3 bytes]:

1	2	3
R	8	X

These commands changes the output format for the internal clock. On the serial port data is output.

Returns a 24 byte string:

*$;mm/dd/yy•hh:mm:ss.s<CR><LF>

Where:
- Byte 1 is the mode of operation.
- Byte 2 is the current pressure units.
- Bytes 4-11
  - mm = month [01-12]
  - dd = day [01-31]
  - yy = year [00-99]
- Bytes 13-22
  - hh = hour [01-24, 24 hour format]
  - mm = minute [00-59]
  - ss.s = seconds to 1/10 second [00.0-59.9]

Example:

C2;04/23/86 10:23:32.3

The numeric output format command has no effect on the clock readout format.

RETURN CONTROL LIMITS

Long format [11 bytes]:

```
  1   2   3   4   5   6   7   8   9   10  11
| F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | X |
```

[version 2.52 and higher]

Bytes 2-9 are ignored.

Short format [3 bytes]:

```
  1   2   3
| R | 9 | X |
```

These commands change the output format to transfer the current control limits in the current pressure units. On the serial port data is ouput. Format is valid for one output, then returns to the standard output format.

Control limits may not be set over the GPIB or the serial port.

Returns a 24 byte string:

```
*$;#######<X<#######<CR><LF>
```

Where:

Byte 1 is the mode of operation.
Byte 2 is the current pressure units.
Byte 4-10 is the low control limit.
Byte 14-20 is the high control limit.

Example:

```
C2; 1.0000<X<85.0000
```

The numeric output format command has no effect on the control limits output format.

RETURN CAL. PTS. CONTROL INFO

Short format [3 bytes]:

```
  1   2   3
| D | ? | X |              [version 2.52 and higher]
```

This command changes the output format to transfer information about the CAL. PTS. CONTROL mode. It can be used to learn the total number of calibration points in the PCS. The format is valid for one output then returns to the standard output format. On the serial port data is output.

Returns a 25 byte string:

*$;•CAL•POINT:•##•OF•##<CR><LF>

Where:

Byte 1 is the mode of operation.
Byte 2 is the current pressure units.
Bytes 16-17 is the current [last controlled] cal point.
Bytes 22-23 is the last cal point.

Example:

M3; CAL POINT: 23 OF 42

The numeric output format command has no effect on the CAL PTS INFO format.

CHANGE TO NUMERIC OUTPUT FORMAT

Short format (3 bytes):

```
  1   2   3
| N | 1 | X |                  (version 3.0 and higher)
```

This command causes the PCS to output readings without the mode, pressure units, and other flags. Examples are given with each applicable command. This command applies to all output formats not otherwise noted.

Short format (3 bytes):

```
  1   2   3
| N | 0 | X |                  (version 3.0 and higher)
```

This causes the PCS to return to the default format that includes the various status flags.

RETURN INSTRUMENT STATUS

Short format [3 bytes]:

```
  1   2   3
| N | 2 | X |                (version 3.0 and higher]
```

This command sets the PCS to transfer the instrument status. See the RETURN STANDARD READING command, [byte 10 of the output] for more information.

Returns a 3 byte string:

#<CR><LF>

Where:

Byte 1 is the instrument status.
- 0 = error condition
- 1 = unstable pressure
- 2 = stable pressure
- 3 = reading is valid but not stable

The numeric output format command has no effect on this output format.

8.4 STATUS AND ERROR MESSAGES

The PCS can return status and error condition messages over the communications interfaces.

They are as follows:

HEX	DECI	MESSAGE	'E'
00H	E000	No request	✓
41H	E065	New reading available	
42H	E066	New reading is stable	
43H	E067	Message format error	✓
44H	E068	Control pressure over range	✓
45H	E069	Control pressure under range	✓
46H	E070	Measure pressure out of range	✓
47H	E071	Out of calibration warning	✓
48H	E072	Numeric overflow/division by 0	✓
49H	E073	Self test error	✓
4BH	E075	Unit placed in local mode	
4CH	E076	Sequence empty	
4DH	E077	Re-zero mode active	

The 'E' column indicates the conditions that will set an 'E' in byte 10 of the standard output format, or a '0' in the instrument status output.

8.4.1 GPIB

The PCS will assert SRQ and request service from the GPIB controller whenever an error or change of device status occurs. The above status byte will be sent during serial poll.

The SRQ will be reset after the service has been carried out.

8.4.2 SERIAL PORT

An error is indicated by an 'E' in byte 10 of the standard output format or a '0' in the instrument status output format.

The commands available for error handling on the PCS over the serial port are:

RETURN AND CLEAR ERROR

Short format [3 bytes]:

```
  1   2   3
| E | ? | X |
```

This command sets the output to transmit the error code and description, transmits the data, then clears the error. The format is valid for 1 output only then returns to the standard output format.

Returns a variable length string:

Byte 1 is 'E'.
Bytes 2-4 is the decimal value of the error.
Bytes 7 to end of string is a message similar to those in the table in section 8.4, followed by the hex value of the error in parentheses, a carriage return and a linefeed.

CLEAR ERROR

Mini format [3 bytes]:

```
  1   2
| E | X |
```

Clears any errors.

Returns nothing.

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8.5 PROGRAMMING EXAMPLES

Included in Appendix A are several demonstration program listings.

8.6 IEEE-488 INTERFACE (GPIB) OPTION

An optional GPIB interface is available for the PCS-200. For more information on the specifications and characteristics, see sections 8.1 through 8.5. See Figure 8.6 for PCB configuration switch settings.

8.7 REMOTE CONTROL KEYPAD

An optional REMOTE CONTROL KEYPAD is available that allows the user to control the PCS from up to six feet away. All functional controls are available from the REMOTE CONTROL KEYPAD, except for instrument power. This is done utilizing a 4 x 5 matrix keypad that incorporates the functions of the function select keypad and the main keypad from the PCS front panel.

The REMOTE CONTROL KEYPAD comes with a six foot cord that connects to the PCS front panel. Connection is made with a snap latching nine-pin D-Subminiature connector.

For further details consult the factory.

8.8 RACK MOUNTING KIT

The PCS may be obtained from the factory ready for rack mounting or a bench mounted model may be adapted to rack mounting in the field with the optional rack mounting kit. This kit consist of two rack slides, two replacement side panels, two rack retaining bars, and the associated fasteners.

Details of the rack and mounting are shown in Figure 2.3.2. The vertical mounting rails in the rack should have the universal RETMA hole pattern. The rack depth should be 24" (slide adjustment range is from 22" to 25"). On the rack it will be necessary to countersink the four slide mounting holes on the two front vertical mounting bars. This is to allow the PCS rack retaining bars to sit flat against the vertical mounting bars.

More information on rack mounting may be obtained from Section 2.3.2 of this manual or from the factory.

8.9 RELIEF VALVES

The standard relief valve on the PCS is a pop-off to atmosphere. It is normally set to 10% above the instrument span. In some cases this is not appropriate, such as when the reference pressure is higher than atmosphere. In this case, the valve must be adjusted to include the added differential from atmospheric pressure. As this will defeat the ability of the valve to protect the QPS from a pressure differential greater than the range of that QPS, a differential relief valve is recommended. Two types are available, depending upon the application.

ONE-WAY DIFFERENTIAL RELIEF VALVE

The one-way valve is appropriate for applications where the reference pressure is to be greater than atmospheric pressure, but not greater than the instrument span. If the differential pressure between the pressure and reference ports is greater than that of the instrument span, the relief will open, allowing the pressure port to bleed over to the reference port, thereby protecting the QPS.

TWO-WAY DIFFERENTIAL RELIEF VALVE

The two-way valve is appropriate for applications where the reference pressure is greater than both atmospheric pressure and the instrument span. An example would be to have a 5 PSI instrument referenced at a pressure of 100 PSI. The instrument span would then be 100-105 PSI. If the pressure port were to fall below 95 PSI, an over-pressure condition can exist, though it is opposite that which is normally considered over-pressure. To protect the QPS, a bi-directional relief valve will relieve any pressure differential that is greater than the instrument span, whether it is from the pressure to the reference port, or vice-versa.

Both the one-way and two-way relief valves are available with a pressure differential of 110 PSI MAXIMUM. Higher pressures are available on special request.

8.10 NON-STANDARD VOLTAGES

This option allows the instrument to operate on a mains voltage of 200 to 260 volts, [the 'standard' range is 100 to 130 volts], 50 or 60 Hz. When operating on 50 Hz, the null assembly servo motor and the pressure regulator servo motor will run about 17% slower than when on 60 Hz.

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TABLE 2.2
FRONT AND REAR PANEL FEATURES

* REF	ITEM	DESCRIPTION	FUNCTION
1	Power Switch	Push-Push Power Switch	This switch controls power to the PCS for all operations
2	Display	Vacuum-Fluorescent Dual 40 Character Lines	Alphanumeric display of current operating mode, readouts, and variable menu selections
3	Function Keys	Four Momentary Switches	Used to select items from the variable menu displayed on the lower line of item 2
4	Main Keyboard	4 X 4 array of Momentary Switches	Contains 10 Numeric keys for entering digits 0-9, as well as a clear entry key [CE] a menu key [M] and four function keys [.,+,-,=]
5	Remote Control Connector [Option]	9-Pin D Subminiature Conn.	Used to connect a remote 20 key control unit to the PCS
6	Supply Pressure	Female 1/8 inch NPT pressure port.	Connection for a source of clean instrument air at a pressure about 5 to 10 PSI higher than the full scale pressure control range.
7	Exhaust	Female 1/8 inch NPT pressure port.	Connection for a vacuum pump, used to provide a low pressure exhaust for the servo regulator when controlling pressures at or below atmospheric pressure.

8	Pressure input/ output	Female 1/8 inch NPT pressure port.	Connection for positive input and/or controlled output pressure. (Differential or absolute pressure).
9	Reference Input (Differential units only)	Female 1/8 inch NPT pressure port	Connection for the reference of a differential pressure or atmospheric pressure for a gauge pressure instrument.
10	Power & Fuses	Power Receptacle & Fuse Holder	A three prong receptacle used to connect the power cord to the PCS. Also houses two fuse holders which holds two fuses. For fuse specifications see Section 7.7
11	IEEE Stnd. 488 Port	GPIB Conn. 2 X 12 on 0.1" X 0.1" centers Ref. Sec. 7.8	Conn. for use with GPIB interface option. Ref. Sec. 8
12	Output Port	25 Pin female D-sub conn.	Reserved for future use.
13	Serial Port	25 Pin female D-sub conn.	Serial port for remote operation from a terminal or modem. See Sec. 6.8.1.1

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TABLE 6.0
SUBASSEMBLIES

* REF	ITEM	DESCRIPTION	FUNCTION
14	Measure Damp	3/4 Turn Potentiometer	Used to adjust damping in the MEASURE mode. See Sec. 6.4.1.3
15	Measure Gain	3/4 Turn Potentiometer	Used to adjust gain in the MEASURE mode. See Sec. 6.4.1.3
16	Digital Damp	3/4 Turn Potentiometer	Used to adjust digital damping in the CONTROL mode. See Sec. 6.4.1.4
17	Digital Gain	3/4 Turn Potentiometer	Used to adjust digital gain in the CONTROL mode. See Sec. 6.4.1.4
18	Ref. Damp	3/4 Turn Potentiometer	Not Available
19	Ref. Gain	3/4 Turn Potentiometer	Not Available
20	Control Damp	3/4 Turn Potentiometer	Used to adjust damping in the CONTROL mode. See Sec. 6.4.1.5
21	Control Gain	3/4 Turn Potentiometer	Used to adjust gain in the CONTROL mode. See Sec. 6.4.1.5
22	Thermometer Port	3/8 Dia. Hole	Access hole to place the ASTM #19C thermometer into the temperature hole of the QPS
23	Motherboard PC assembly	Mensor # 12312001	Connector circuit board connecting the Std. bus, Mensor bus, and other connectors.

24	Amplifier PC assembly	Mensor # 12316001	Servo amplifier board. Ref. Section 6.4
25	Encoder PC assembly	Mensor # 12456001	Binary encoder board. Ref. Section 6.5
26	CPU PC assy.		Central processing unit. Ref. Sec. 6.7
27	Option slot		Option slot typically for the GPIB option. Ref. Section 8
28	Power module		Switching power supply with control board to provide required power. Reference Section 6.3
29	Pneumatic assembly		Precision pneumatic regulator with manifolded pneumatic valving.
31	AC Filter	Corcom 3UR3	A.C. line filter
32	I/O PC assy.	Mensor # 12338002	Input/Output PC assy. Ref. 6.8
33	Pneumatic Filter	Hoke 6314F2B	Inline pneumatic filter

8.5 PROGRAMMING EXAMPLES

Below is a list of terms used in the programming examples that may not be familiar to those not using Microsoft BASIC languages. It also includes terms from National Instruments' GPIB-PC.

BLOAD	- Loads binary machine language routines.
CLEAR	- Clears memory and reserves space for machine language routines.
COM1	- Serial port #1 on a PC.
IBCNT	- GPIB-PC variable. A count of bytes transferred.
IBEOS	- Sets or disables End-Of-String terminator in GPIB-PC.
IBERR	- GPIB-PC error variable.
IBFIND	- GPIB-PC subroutine to assign device pointer.
IBLOC	- Used to put GPIB-PC device in the local mode.
IBRD	- Reads from GPIB-PC device.
IBSTA	- GPIB-PC status variable.
IBWRT	- Writes to GPIB-PC device.
LOC[1]	- Returns number of characters in file buffer #1.
ON ERROR	- Error trapping setup command.
TIMER	- Returns number of elapsed seconds from midnight.
$	- Indicates string variable.
%	- Indicates integer variable.
!	- Indicates single precision variable [default].

```
' ***************************************************************************
' PROGRAM NAME  --------> NAT-10.EXE
' PROGRAM NUMBER  ------>
' FUNCTIONAL NAME  -----> GPIB SAMPLE PROGRAM FOR GPIB-PC
' SOURCE FILE(S)  ------> NAT-10.BAS
' REQ'D LINK FILES  ----> QBIB?.OBJ (GPIB-PC ROUTINES)
' (ie. QBIB2, GWCOM)
' LANGUAGE  ------------> QuickBASIC
' WRITTEN BY  ----------> GMThornton
' RELEASE LEVEL  -------> MENSOR
' RELEASE DATE  --------> 4/3/87
' ***************************************************************************
' REVISION HISTORY
' NEW PROGRAM, 4/3/87

' ***************************************************************************
' GENERAL PROGRAM DESCRIPTION
        ' This program is intended for use with the GPIB-PC software
        ' for QuickBASIC, provided by National Instruments.
        ' either the GPIB-PC file 'QBIB?.OBJ' must be installed
        ' into the libraries and loaded with the /L switch on the
        ' QuickBASIC command line, or the program must be linked with
        ' the 'QBIB?.OBJ' file after compiling. In addition, the system
        ' file 'GPIB.COM' should be installed as a device during boot
        ' in the 'CONFIG.SYS' file.

' ***************************************************************************
' GLOBAL VARIABLE DECLARATIONS

DEFINT A-Z

COMMON SHARED IBSTA%, IBERR%, IBCNT%
CONST TRUE = -1, FALSE = 0
LINEFEED$ = CHR$(10)
EOS% = &H0D
READEOS% = EOS% + &H0400

' ***************************************************************************
' MAIN PROGRAM AREA (WITH LABELS IN ALPHANUMERIC ORDER)

LOCATE 5,10
PRINT "WHEN RUNNING,HIT ANY KEY TO PAUSE FOR NEW COMMAND..."
LOCATE 10,10
PRINT "HIT ANY KEY TO BEGIN..."
HOLD:   IF INKEY$ = "" THEN GOTO HOLD
CLS

BDNAME$ = "GPIB0"
CALL IBFIND(BDNAME$,COMPAQ%) : GOSUB ERRORCHECK
BDNAME$ = "DEV1"
CALL IBFIND(BDNAME$,PCS%) : GOSUB ERRORCHECK
CALL IBEOS(PCS%,READEOS%) : GOSUB ERRORCHECK
GOTO RECEIVE
```
(continued on next page)

```
ERRORCHECK:
        IF IBSTA% < 0 THEN
                PRINT ""
                IF IBERR% = 6 THEN
                        PRINT "GPIB TIME LIMIT EXCEEDED..."
                        PRINT "ENTER 'Q' TO QUIT, ";
                        INPUT "OR <RETURN> TO TRY AGAIN... ",QUIT$
                        IF QUIT$ = "Q" THEN STOP ELSE RETURN
                END IF
                PRINT "GPIB ERROR, IBERR% = " ; IBERR%
                STOP
        ELSE
                IF IBSTA% AND &H4000 THEN
                        PRINT ""
                        PRINT "GPIB INTERRUPT FAILURE..."
                        PRINT "FATAL ERROR..."
                        STOP
                END IF
        END IF
        RETURN

RECEIVE:
        INDATA$ = SPACE$(70)
        CALL IBRD(PCS%,INDATA$) : GOSUB ERRORCHECK
        IF LEFT$(INDATA$,1) = LINEFEED$ THEN
                IF INKEY$ <> "" THEN GOTO TRANSMIT
        ELSE
                PRINT LEFT$(INDATA$,IBCNT%) ;
        END IF
        GOTO RECEIVE

TRANSMIT:
        IF INKEY$ <> "" THEN GOTO TRANSMIT
        PRINT ""
        LOCATE ,20
        INPUT "ENTER COMMAND STRING, OR 'Q' TO STOP... ",CMD$
        IF CMD$ = "Q" THEN
                CALL IBEOS(PCS%,EOS%)
                CALL IBLOC(PCS%)
                CALL IBLOC(COMPAQ%)
                STOP
        END IF
        CALL IBWRT(PCS%,CMD$) : GOSUB ERRORCHECK
        GOTO RECEIVE
```

```
' ***************************************************************************
' PROGRAM NAME  --------> SER232-Q.EXE
' PROGRAM NUMBER  ------>
' FUNCTIONAL NAME  -----> SERIAL PORT SAMPLE PROGRAM
' SOURCE FILE(S)  ------> SER232-Q.BAS
' REQ'D LINK FILES  ----> GWCOM.OBJ
' (ie. QBIB2, GWCOM)
' LANGUAGE  ------------> QuickBASIC
' WRITTEN BY  ----------> GMThornton
' RELEASE LEVEL  -------> MENSOR
' RELEASE DATE  --------> 4/3/87
' ***************************************************************************
' REVISION HISTORY
' NEW PROGRAM, 4/3/87

' ***************************************************************************
' GENERAL PROGRAM DESCRIPTION
        ' This program operates over serial port 'COM1:'.  It requires
        ' the serial port receive buffer size be set to 3000 bytes.  This
        ' may be done by using the /C:3000 switch on the QuickBASIC command
        ' line.  If the program is to be compiled for standalone operation,
        ' the switch should be supplied during compiling and the object
        ' code must be linked with the file 'GWCOM.OBJ'.  The ON ERROR
        ' switch (/E) must be supplied also.

' ***************************************************************************
' GLOBAL VARIABLE DECLARATIONS

DEFINT A-Z

CONST TRUE = -1, FALSE = 0
LINEFEED$ = CHR$(10)
CARRIAGE$ = CHR$(13)

' ***************************************************************************
' MAIN PROGRAM AREA (WITH LABELS IN ALPHANUMERIC ORDER)

LOCATE 5,10
PRINT "WHEN RUNNING, PRESS ANY KEY TO PAUSE FOR NEW COMMAND..."
LOCATE 10,10
INPUT "ENTER BUAD RATE... ",BAUD$
DELAYTIME! = (1/VAL(BAUD$)) * 20
OPEN "COM1:" + BAUD$ + ",N,8,1" AS #1
ON ERROR GOTO ERRORFIX
GOTO TRANSMIT

DELAY:
        LIMIT! = TIMER + DELAYTIME!
        DO
        LOOP UNTIL TIMER > LIMIT!
        RETURN
```
(continued on next page)

```
ENTRY:
        IF INKEY$ <> "" THEN GOTO ENTRY
        LOCATE ,20
        INPUT "ENTER COMMAND STRING, OR 'Q' TO QUIT... ",CMD$
        RETURN

ERRORFIX:
        PRINT ""
        PRINT "SERIAL DEVICE TIMEOUT..."
        INPUT "ENTER 'Q' TO QUIT, OR <RETURN> TO TRY AGAIN... ",QUIT$
        IF QUIT$ = "Q" THEN STOP
        RESUME TRANSMIT

RECEIVE:
        IF LOC(1) < 1 THEN GOTO RECEIVE
        INCHAR$ = INPUT$(1,#1)
        IF INCHAR$ = LINEFEED$ THEN
                GOSUB DELAY
                IF LOC(1) < 1 THEN GOTO TRANSMIT
                GOTO RECEIVE
        ELSE
                IF INCHAR$ <> CARRIAGE$ THEN
                        INDATA$ = INDATA$ + INCHAR$
                        GOTO RECEIVE
                ELSE
                        PRINT INDATA$
                        INDATA$ = ""
                        GOSUB DELAY
                        IF LOC(1) < 1 THEN GOTO TRANSMIT
                        GOTO RECEIVE
                END IF
        END IF

TRANSMIT:
        IF INKEY$ <> "" THEN GOSUB ENTRY ELSE CMD$ = "RX"
        IF CMD$ = "Q" THEN STOP
        PRINT #1,CMD$ ;
        GOTO RECEIVE
```

```
100 ' ********************************************************************
110 ' PROGRAM NAME  --------> NAT-1I.BAS
120 ' PROGRAM NUMBER  ------>
130 ' FUNCTIONAL NAME  -----> GPIB SAMPLE PROGRAM FOR GPIB-PC
140 ' SOURCE FILE(S)  ------> N/A
150 ' REQ'D LINK FILES  ----> N/A
160 ' (ie. QBIB2, GWCOM)
170 ' LANGUAGE  ------------> BASICA
180 ' WRITTEN BY  ----------> GMThornton
190 ' RELEASE LEVEL  -------> MENSDR
200 ' RELEASE DATE  --------> 4/3/87
210 ' ********************************************************************
220 ' REVISION HISTORY
230 ' NEW PROGRAM, 4/3/87
240 '
250 ' ********************************************************************
260 ' GENERAL PROGRAM DESCRIPTION
270 ' This program is intended for use with the GPIB-PC software for
280 ' BASICA, provided by National Instruments.  To run, the GPIB-PC
290 ' file 'BIB.M' must be in the current subdirectory, or the appropriate
300 ' path specified in the BLOAD statement.  In addition, the system
310 ' file 'GPIB.COM' should be installed as a device during boot in
320 ' the 'CONFIG.SYS' file.
330 '
340 ' ********************************************************************
350 CLS
360 KEY OFF
370 LOCATE 5,10
380 PRINT "WHEN RUNNING, PRESS ANY KEY TO PAUSE FOR NEW COMMAND... "
390 LOCATE 10,10
400 PRINT "PRESS ANY KEY TO CONTINUE... "
410 IF INKEY$ = "" THEN GOTO 410
420 CLS
430 '
440 CLEAR   ,50000!
450 IBINIT1 = 50000!
460 IBINIT2 = IBINIT1 + 3
470 BLOAD "BIB.M",IBINIT1 ' add path name to file if required.
480 CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,IBRSC,
    IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF)
490 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,
    IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,IBSTA%,
    IBERR%,IBCNT%)
500 '
510 '
520 BDNAME$="GPIB0" : CALL IBFIND(BDNAME$,COMPAQ%) : GOSUB 740
530 BDNAME$="DEV1" : CALL IBFIND(BDNAME$,PCS%) : GOSUB 740
540 EOS% = &H0D : READEOS% = EOS% + &H400
550 CALL IBEOS(PCS%,READEOS%) : GOSUB 740
560 LINEFEED$ = CHR$(10)
570 GOTO 680
580 '
590 '
```
(continued on next page)

```
600 IF INKEY$ <> "" THEN GOTO 600
610 PRINT ""
620 LOCATE ,20
630 INPUT "ENTER COMMAND STRING, OR 'Q' TO STOP... ",CMD$
640 IF CMD$ = "Q" THEN CALL IBEOS(PCS%,EOS%) : CALL IBLOC(PCS%) : STOP
650 CALL IBWRT(PCS%,CMD$) : GOSUB 740
660 '
670 '
680 INDATA$ = SPACE$(70)
690 CALL IBRD(PCS%,INDATA$) : GOSUB 740
700 IF LEFT$(INDATA$,1) = LINEFEED$ THEN IF INKEY$ <> "" THEN GOTO 600 ELSE
    ELSE PRINT LEFT$(INDATA$,IBCNT%) ;
710 GOTO 680
720 '
730 '
740 IF IBSTA% < 0 THEN IF IBERR% = 6 THEN GOSUB 800 : RETURN
750 IF IBSTA% < 0 THEN PRINT "" : PRINT "GPIB ERROR, IBERR% = ";IBERR% : STOP
760 IF IBSTA% AND &H4000 THEN GOTO 860
770 RETURN
780 '
790 '
800 PRINT ""
810 PRINT "GPIB TIME LIMIT EXCEEDED..."
820 INPUT "ENTER 'Q' TO QUIT, OR <RETURN> TO TRY AGAIN... ",QUIT$
830 IF QUIT$ = "Q" THEN STOP ELSE RETURN
840 '
850 '
860 PRINT ""
870 PRINT "GPIB INTERRUPT FAILURE..."
880 PRINT "FATAL ERROR..."
890 STOP
```

```
100 ' ***********************************************************************
110 ' PROGRAM NAME  --------> SER232-I.BAS
120 ' PROGRAM NUMBER  ------>
130 ' FUNCTIONAL NAME  -----> SERIAL PORT SAMPLE PROGRAM
140 ' SOURCE FILE(S)  ------> N/A
150 ' REQ'D LINK FILES  ----> N/A
160 ' (ie. QBIB2, GWCOM)
170 ' LANGUAGE  ------------> BASICA
180 ' WRITTEN BY  ----------> GMThornton
190 ' RELEASE LEVEL  -------> MENSOR
200 ' RELEASE DATE  --------> 4/3/87
210 ' ***********************************************************************
220 ' REVISION HISTORY
230 ' NEW PROGRAM, 4/3/87
240 '
250 ' ***********************************************************************
260 ' GENERAL PROGRAM DESCRIPTION
270 ' This program operates over serial port 'COM1:'.  It requires the
280 ' serial port receive buffer size be set to 3000 bytes.  This may
290 ' be done by using the /C:3000 switch on the BASICA command line.
300 '
310 ' ***********************************************************************
320 CLS
330 KEY OFF
340 LOCATE 5,10
350 PRINT "WHEN RUNNING, PRESS ANY KEY TO PAUSE FOR NEW COMMAND..."
360 LOCATE 10,10
370 INPUT "ENTER BAUD RATE... ",BAUD$
380 DELAYTIME = (1/VAL(BAUD$))*1
390 OPEN "COM1:" + BAUD$ + ",N,8,1" AS #1
400 LINEFEED$ = CHR$(10)
410 CARRIAGE$ = CHR$(13)
420 ON ERROR GOTO 720
430 '
440 '
450 '
460 IF INKEY$ <> "" THEN GOSUB 650 ELSE CMD$ = "RX"
470 IF CMD$ = "Q" THEN STOP
480 PRINT #1,CMD$;
490 '
500 '
510 IF LOC(1) < 1 THEN GOTO 510
520 INCHAR$ = INPUT$(1,#1)
530 IF INCHAR$ = LINEFEED$ THEN GOSUB 580 : IF LOC(1) < 1 THEN
    GOTO 460 ELSE GOTO 510
540 IF INCHAR$ <> CARRIAGE$ THEN INDATA$ = INDATA$ + INCHAR$ ELSE
    PRINT INDATA$ : INDATA$ = "" : GOSUB 580
550 GOTO 510
560 '
570 '
580 LIMIT = TIMER + DELAYTIME : TIMING = 1
590 WHILE TIMING
600     IF TIMER => LIMIT THEN TIMING = 0
610 WEND
620 RETURN
```

(continued on next page)

```
630 '
640 '
650 IF INKEY$ <> "" THEN GOTO 650
660 PRINT ""
670 LOCATE ,20
680 INPUT "ENTER COMMAND STRING, OR 'Q' TO STOP... ",CMD$
690 RETURN
700 '
710 '
720 PRINT ""
730 PRINT "SERIAL DEVICE TIMEOUT..."
740 INPUT "ENTER 'Q' TO QUIT, OR <RETURN> TO TRY AGAIN... ",QUIT$
750 IF QUIT$ = "Q" THEN STOP ELSE GOTO 460
```

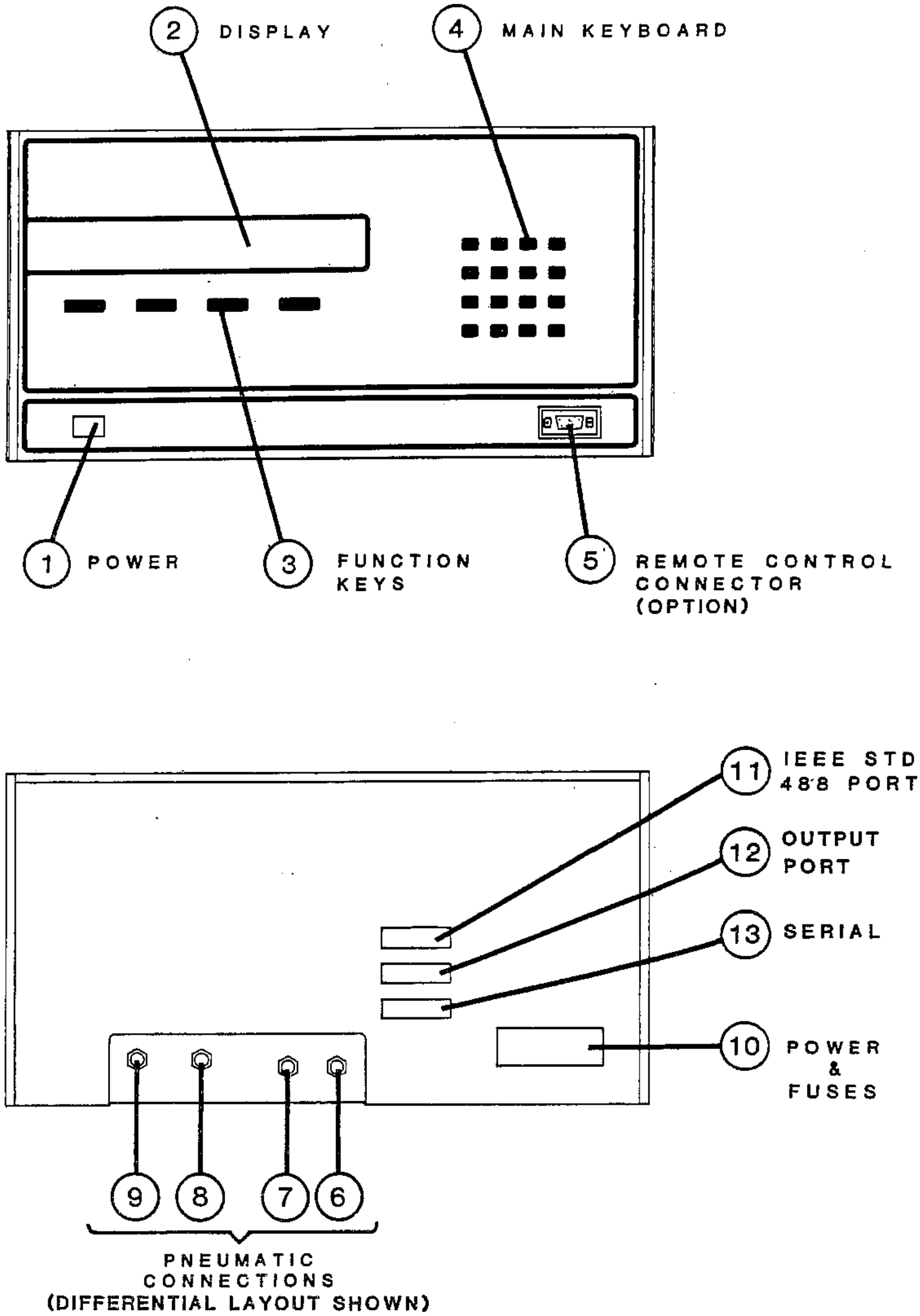
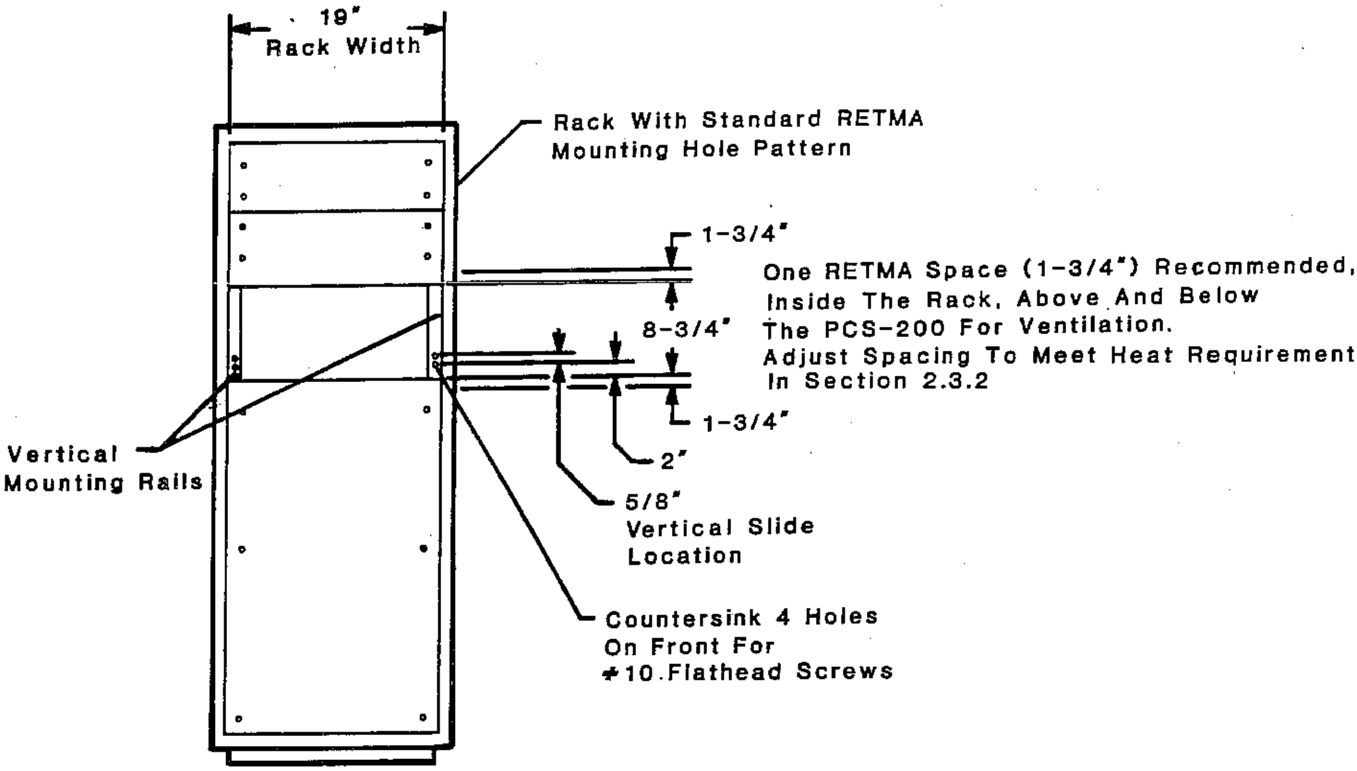


FIG. 2.2

FRONT AND REAR PANEL FEATURES



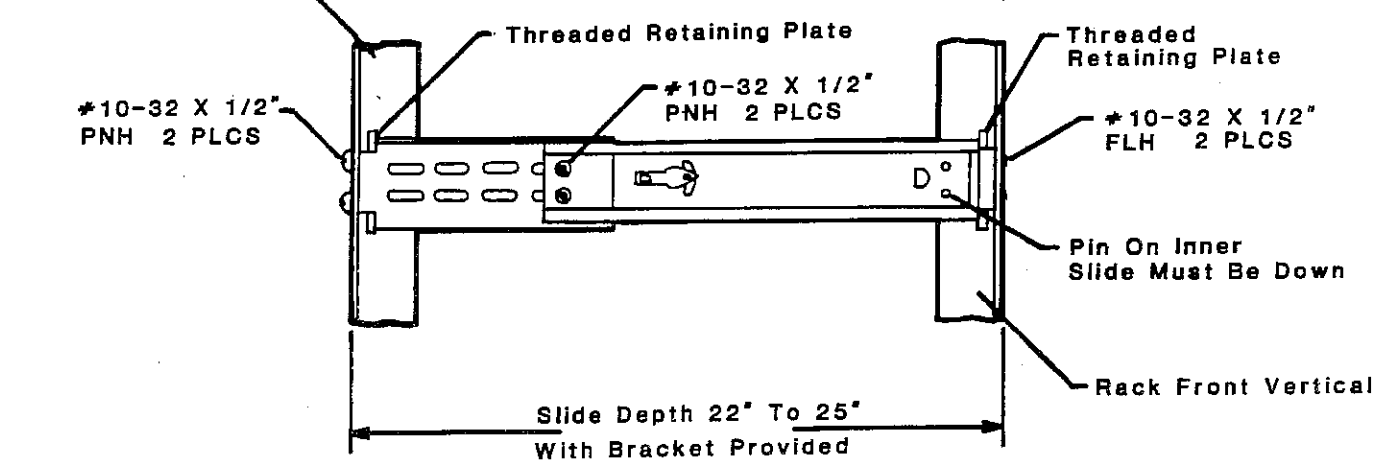


FIG. 2.3.2

RACK MOUNT DETAIL

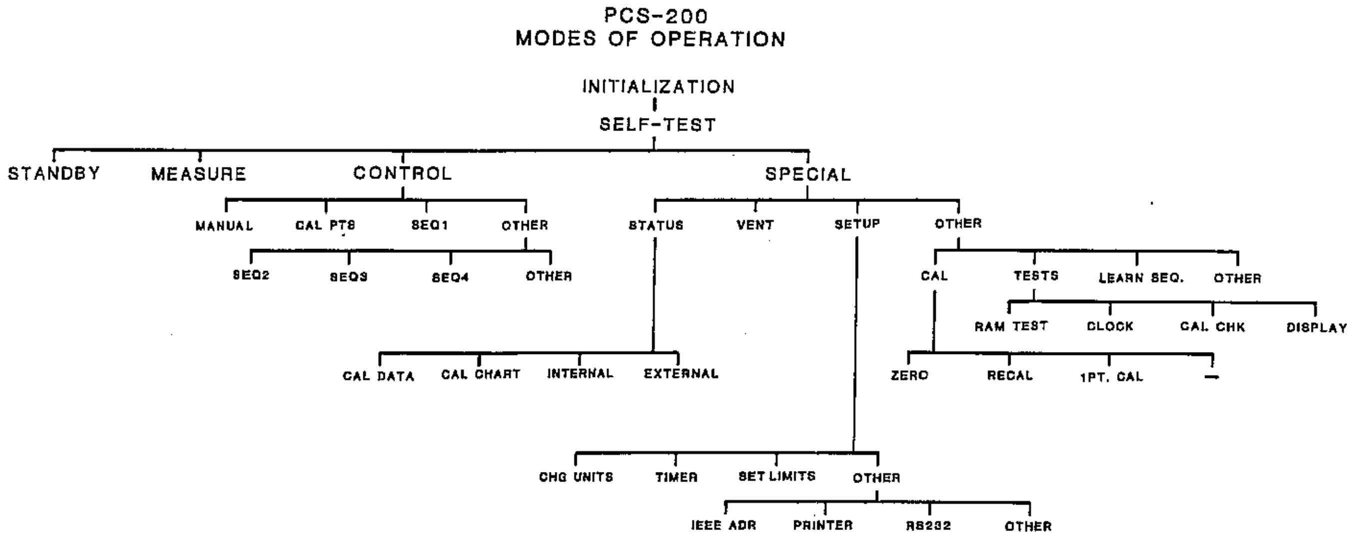
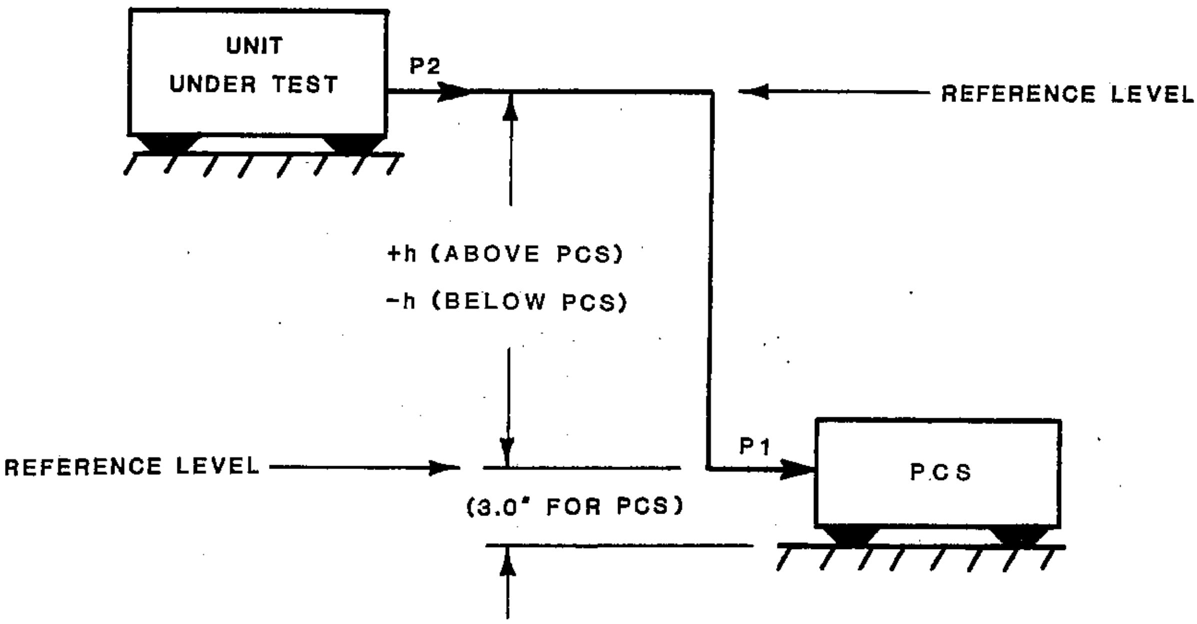


FIG. 3.0

MODES OF OPERATION

Correcting for Head Pressure

The pressure measured by the PCS is referred to a level 3 inches above the surface it is setting on. If the pressure is to be referred to another level a correction should be applied for maximum accuracy.



$$P_2 = P_1 - \alpha\,(\pm h)(P_1)$$

where:

P_1 is the measured pressure by the PCS

P_2 is P_1 corrected for head pressure

P_1 and P_2 are absolute pressure units

α is the gas density ratio @ 23°C (see FIG. 4.3B)

h is the elevation difference in inches

FIG. 4.3A

HEAD PRESSURE CORRECTION

GAS		α (PRESS. RATIO PER INCH)
Air	(Dry)	2.9315×10^{-6}
Argon	(A)	4.0443×10^{-6}
Carbon Dioxide	(CO_2)	4.4824×10^{-6}
Helium	(He)	4.0466×10^{-7}
Hydrogen	(H_2)	2.0379×10^{-7}
Nitrogen	(N_2)	2.8355×10^{-6}
Oxygen	(O_2)	3.2402×10^{-6}

NOTE: The change in density ratio due to temperature changes is insignificant and may be ignored. If desired, for large (over 15°C) changes in ambient temperature a new α may be calculated by using the following equation.

$$\alpha 2 = \alpha[1 + .003661\ (23° - T2°)]$$

where: $\alpha 2$ = New α at T2

α = gas density at 23°C

T2 = actual temperature of gas (°C)

FIG. 4.3B

GAS DENSITY AT 23 DEG. C

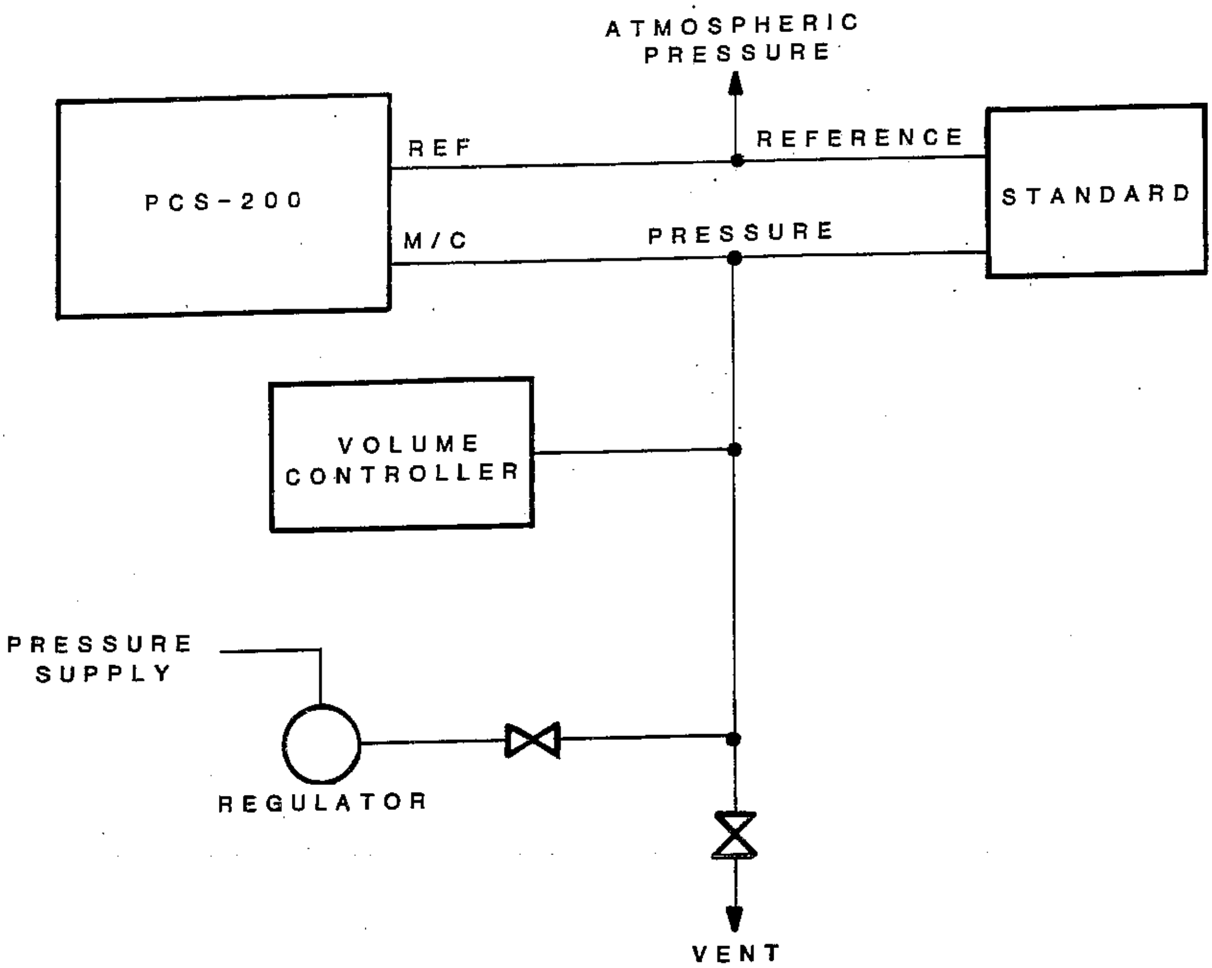
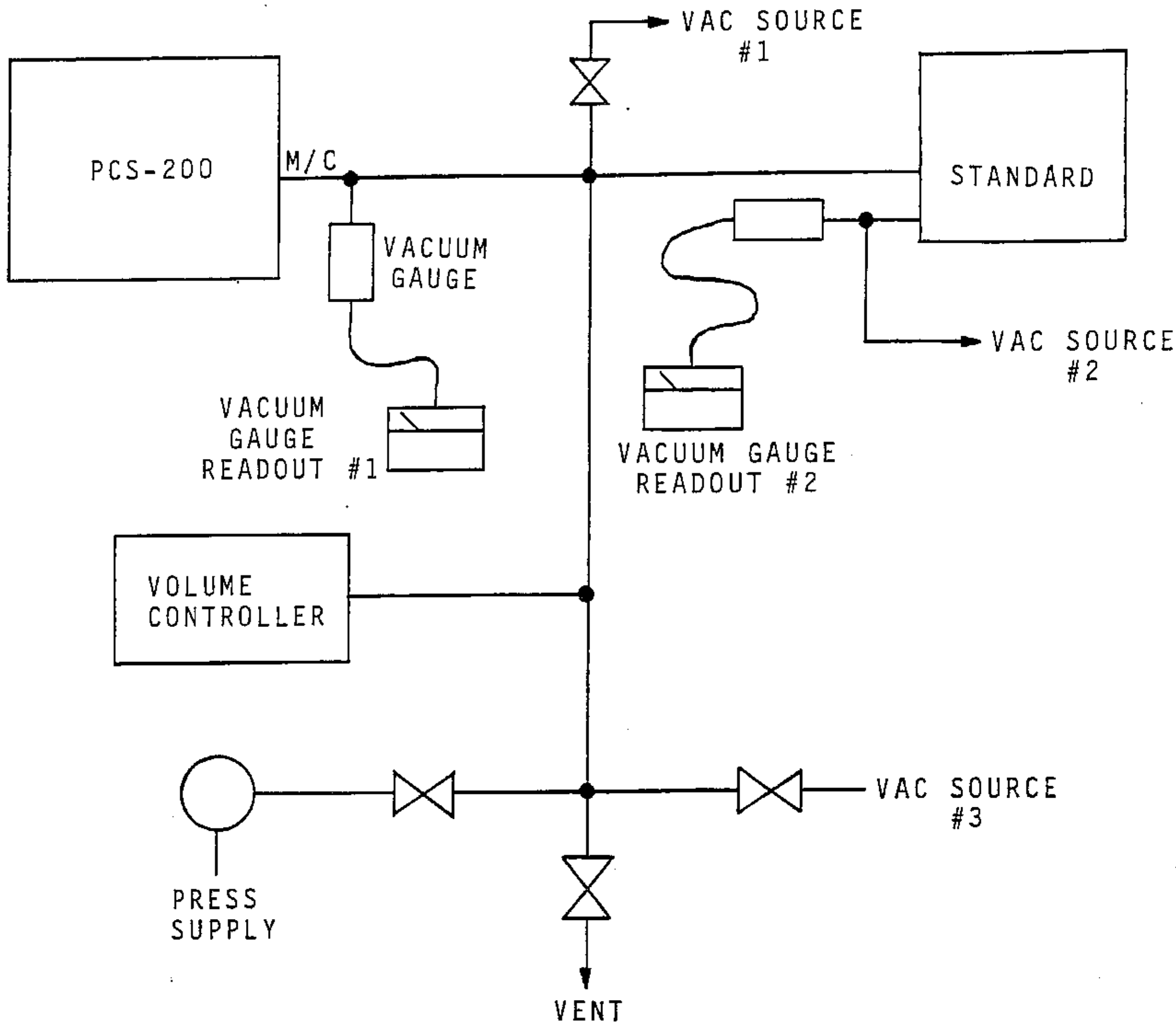


FIG. 5.2.1

CALIBRATION SET-UP
STRAIGHT DIFFERENTIAL PRESSURE



CAUTION: Most thermocouple type vacuum gauges have a pressure limitation of 50 to 100 PSIG. If calibration pressures are to exceed this limitation, provisions must be made to isolate the vacuum gauge from the higher pressures.

FIG. 5.2.2

CALIBRATION SET-UP

ABSOLUTE PRESSURE USING AN ABSOLUTE QPS

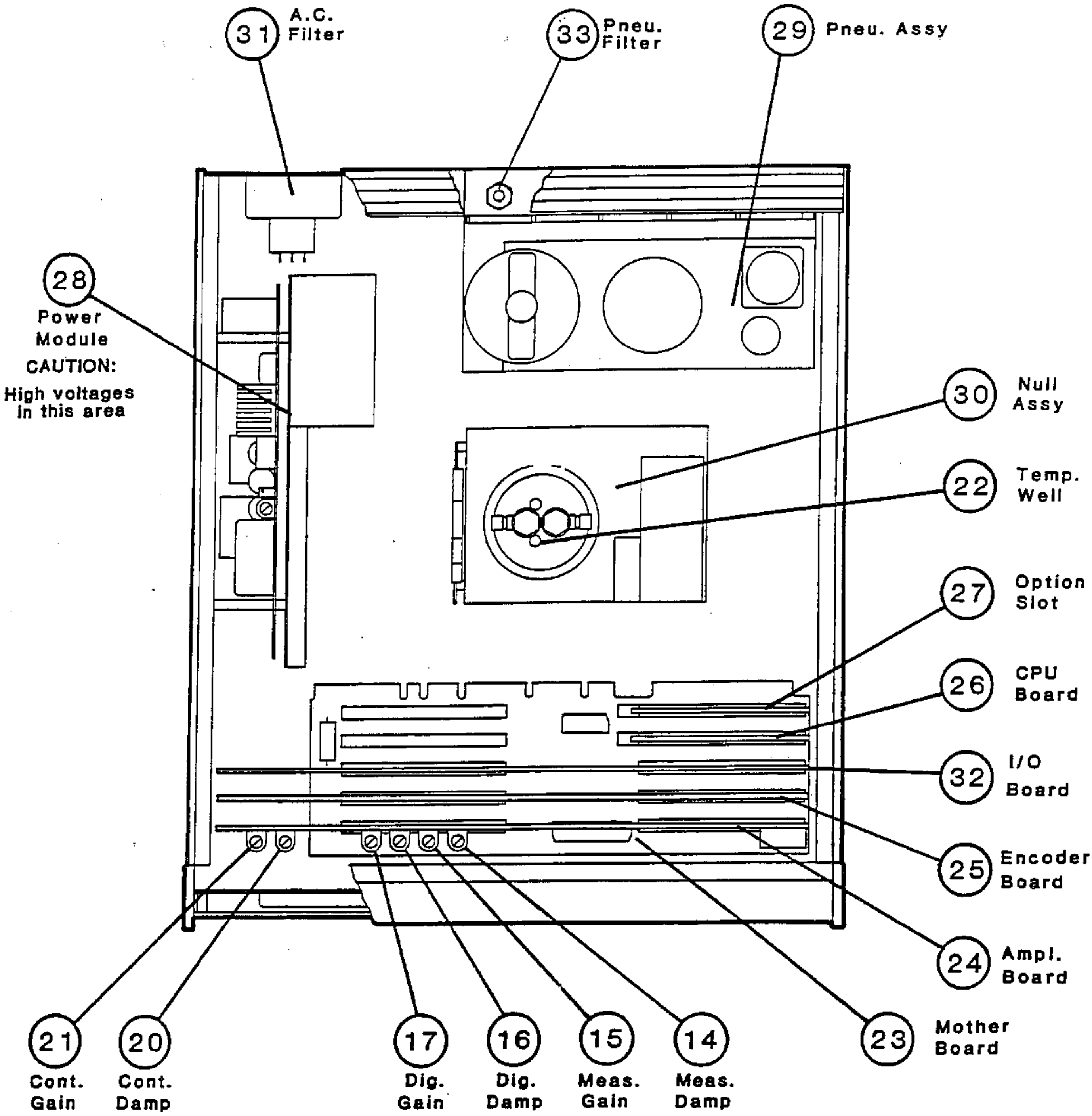


FIG. 6.0

SUB-ASSEMBLY LAYOUT - TOP VIEW

(SEE TABLE 6.0)

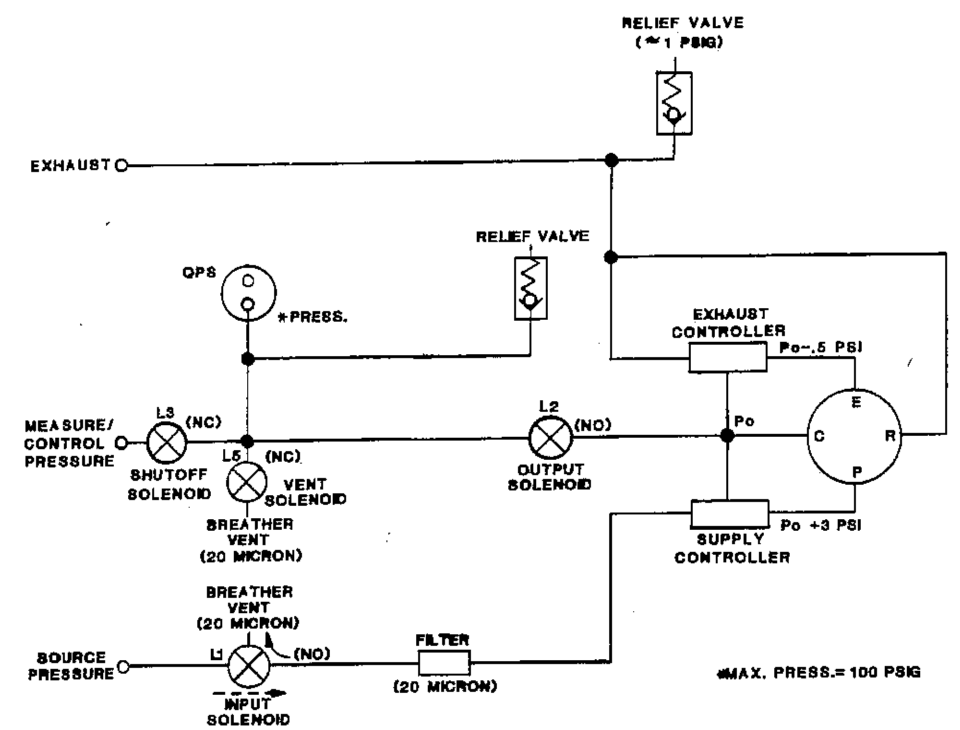


FIG. 6.1A

PNEUMATIC SCHEMATIC
PCS-200 (ABSOLUTE)
LOW PRESSURE

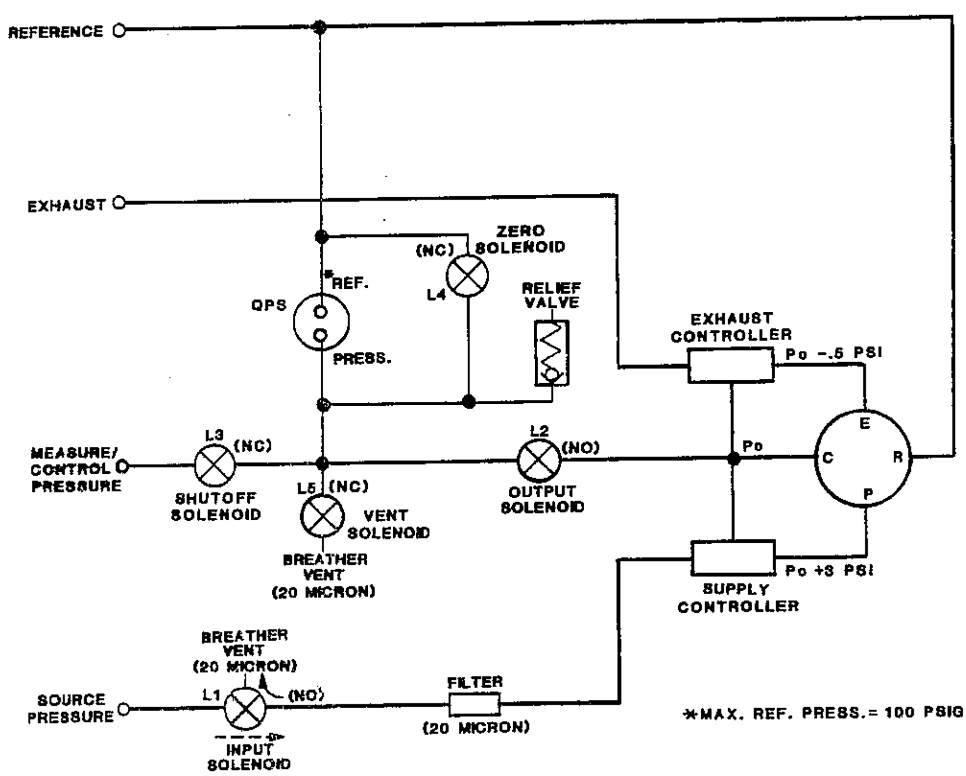


FIG. 6.1B

PNEUMATIC SCHEMATIC
PCS-200 (DIFFERENTIAL)
LOW PRESSURE

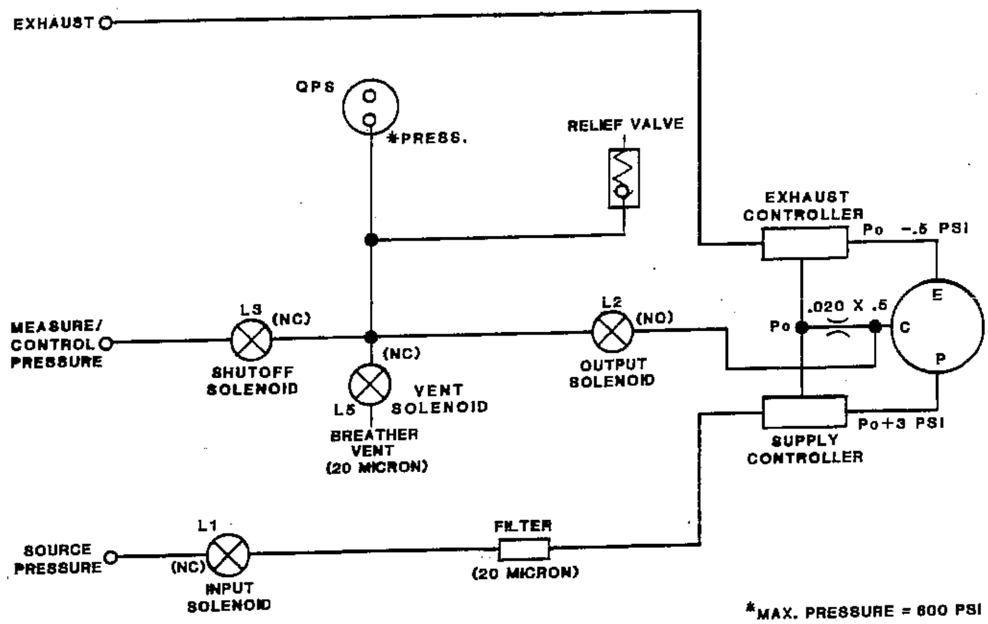


FIG. 6.1C

PNEUMATIC SCHEMATIC
PCS-200 (ABSOLUTE)
HIGH PRESSURE

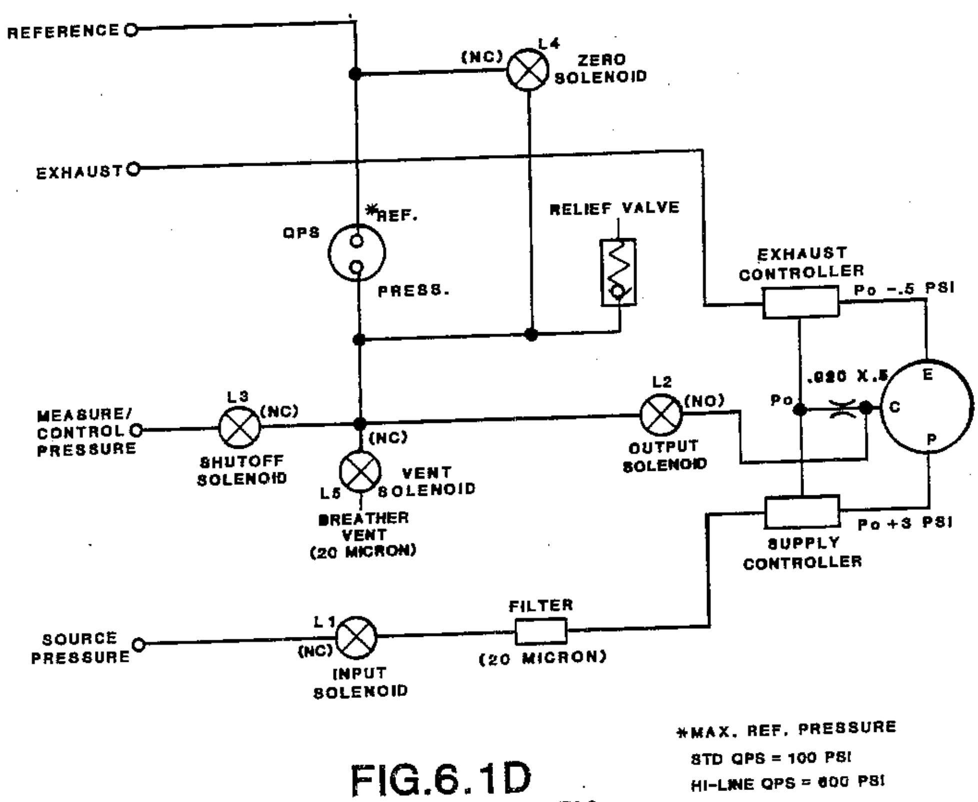


FIG.6.1D

PNEUMATIC SCHEMATIC
PCS-200 (DIFFERENTIAL)
HIGH PRESSURE

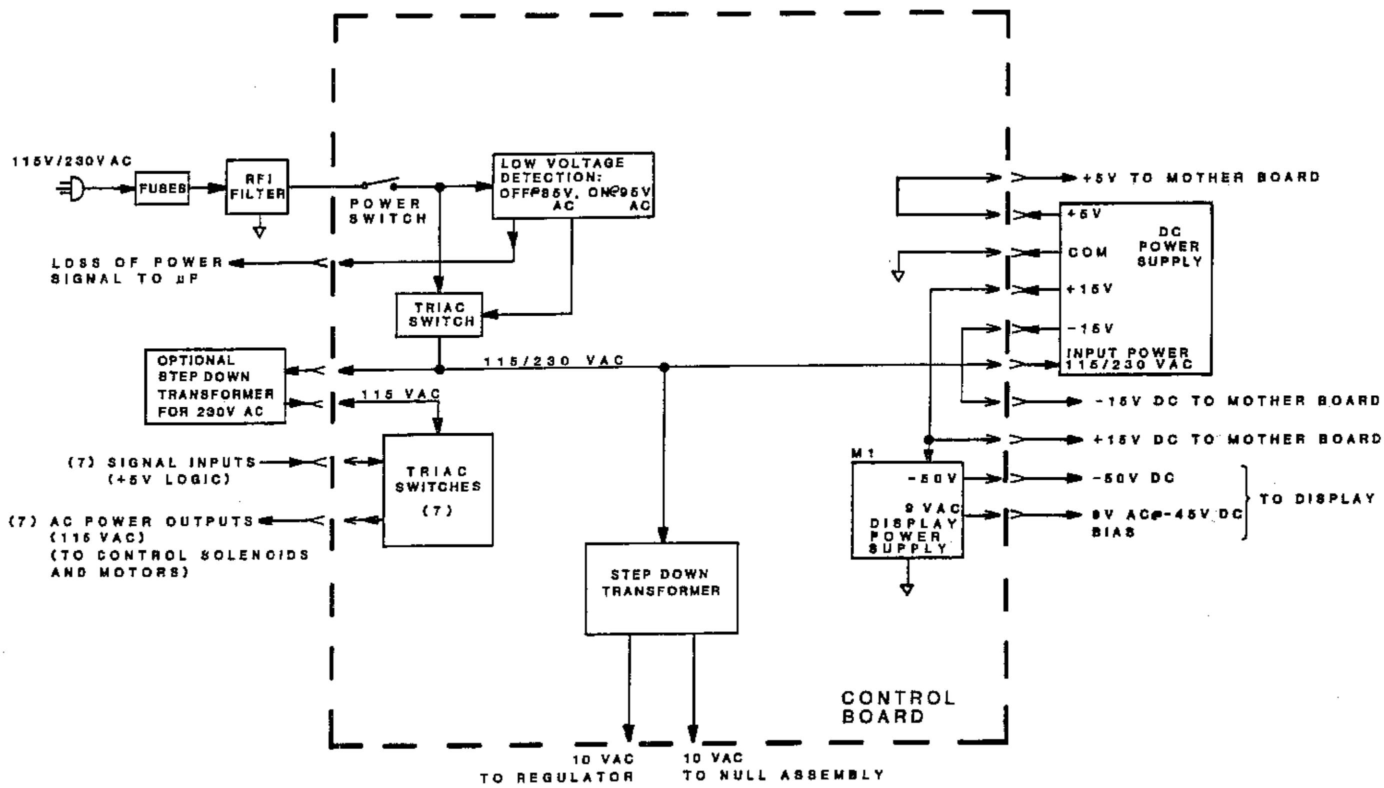
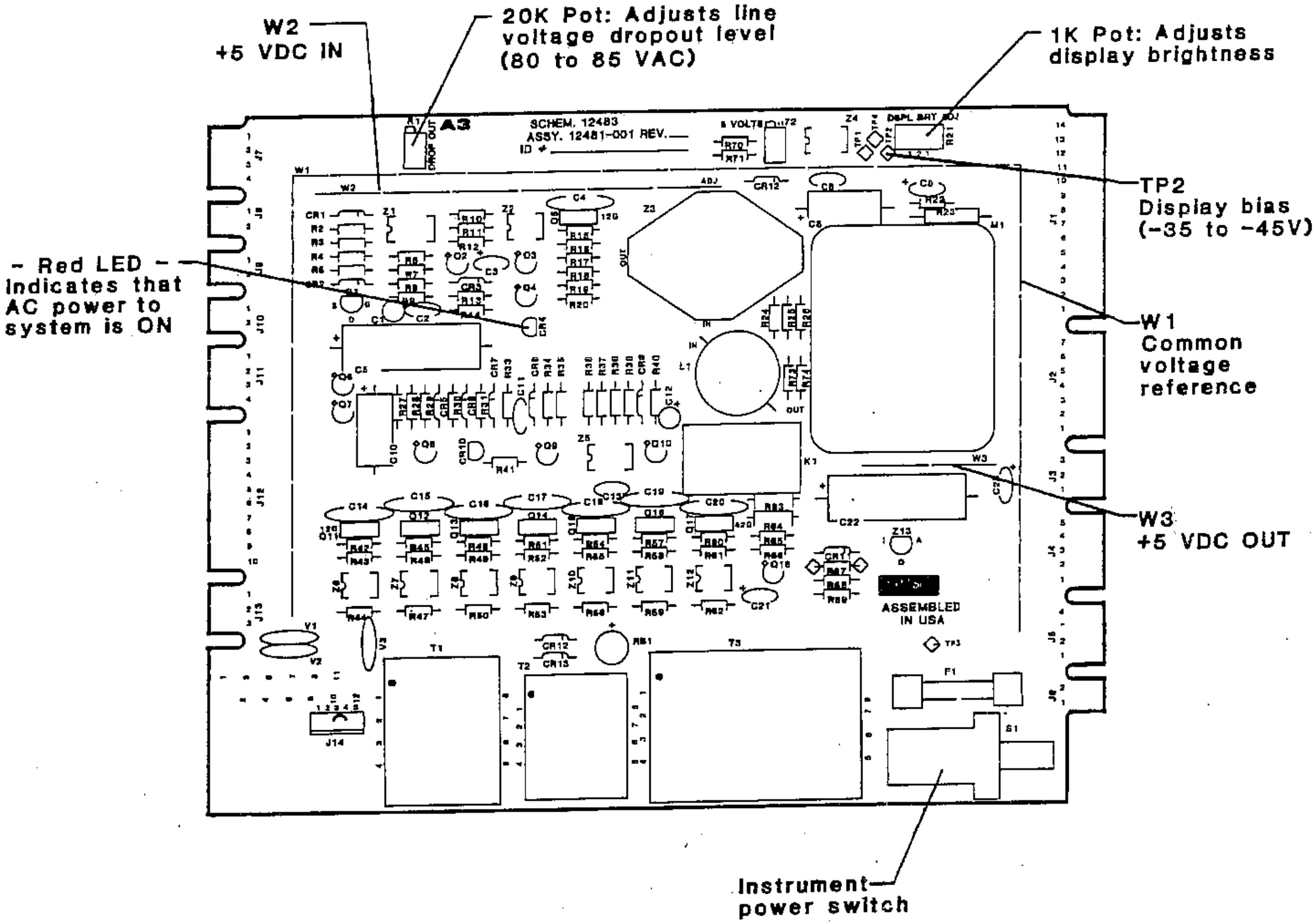


FIG. 6.3A
BLOCK DIAGRAM - POWER SUPPLY



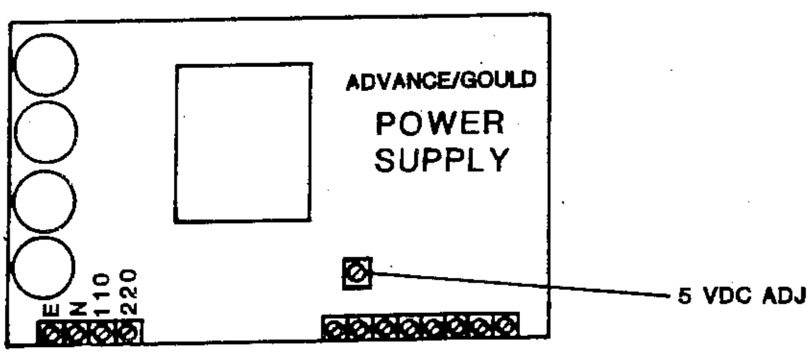
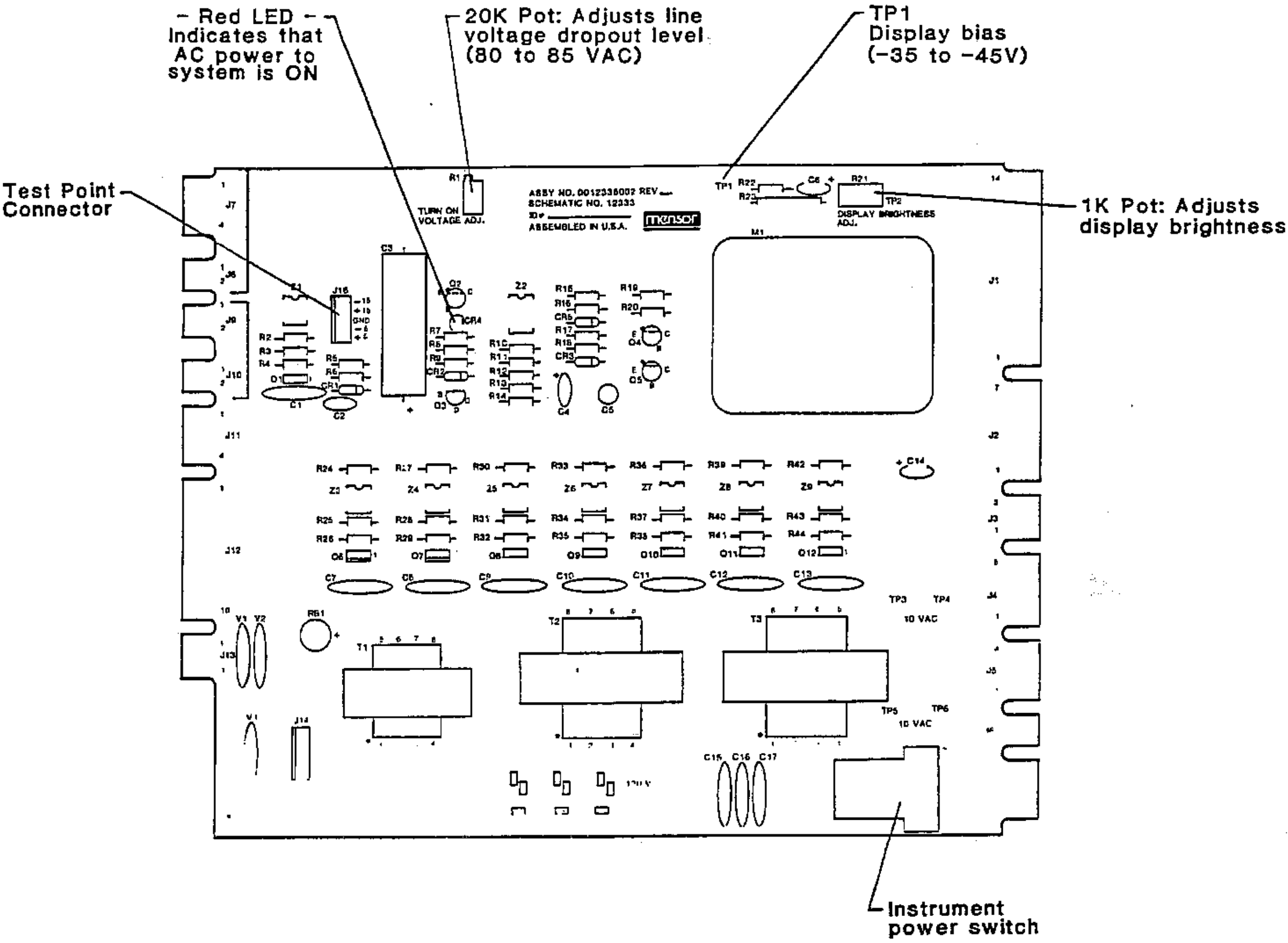


FIG. 6.3.1B

POWER SUPPLY - ADJUSTMENTS AND TEST POINTS

(SEE ALSO FIG. 6.3.1C)



POWER GENERAL

POWER SUPPLY

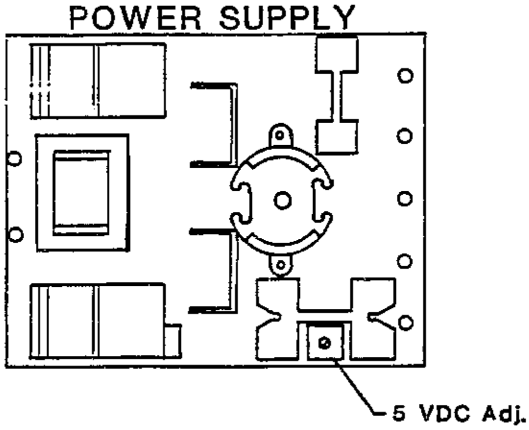


FIG. 6.3.1C

POWER SUPPLY - ADJUSTMENTS AND TEST POINTS

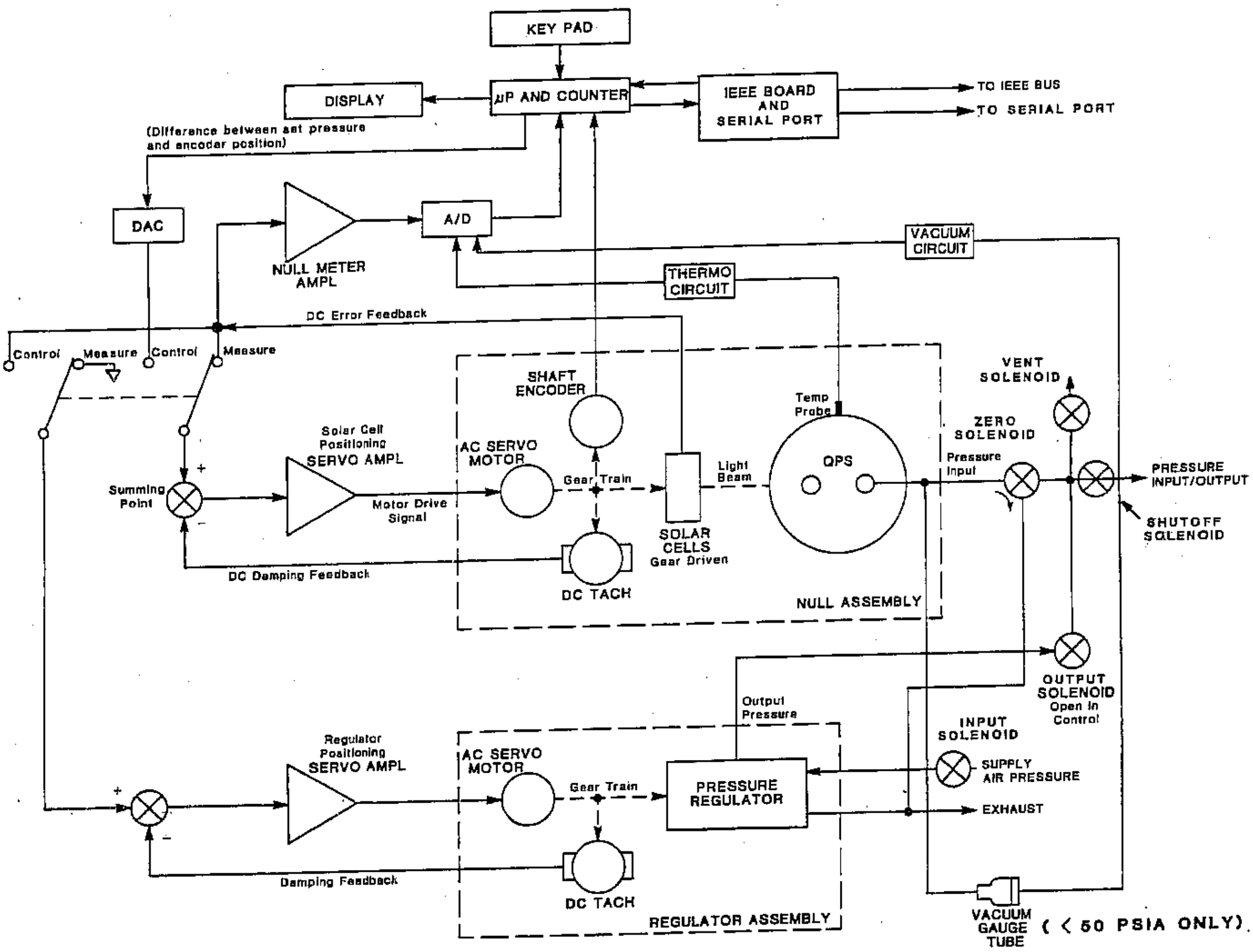


FIG. 6.4A

PCS-200 SERVO SYSTEM BLOCK DIAGRAM (ABSOLUTE PCS

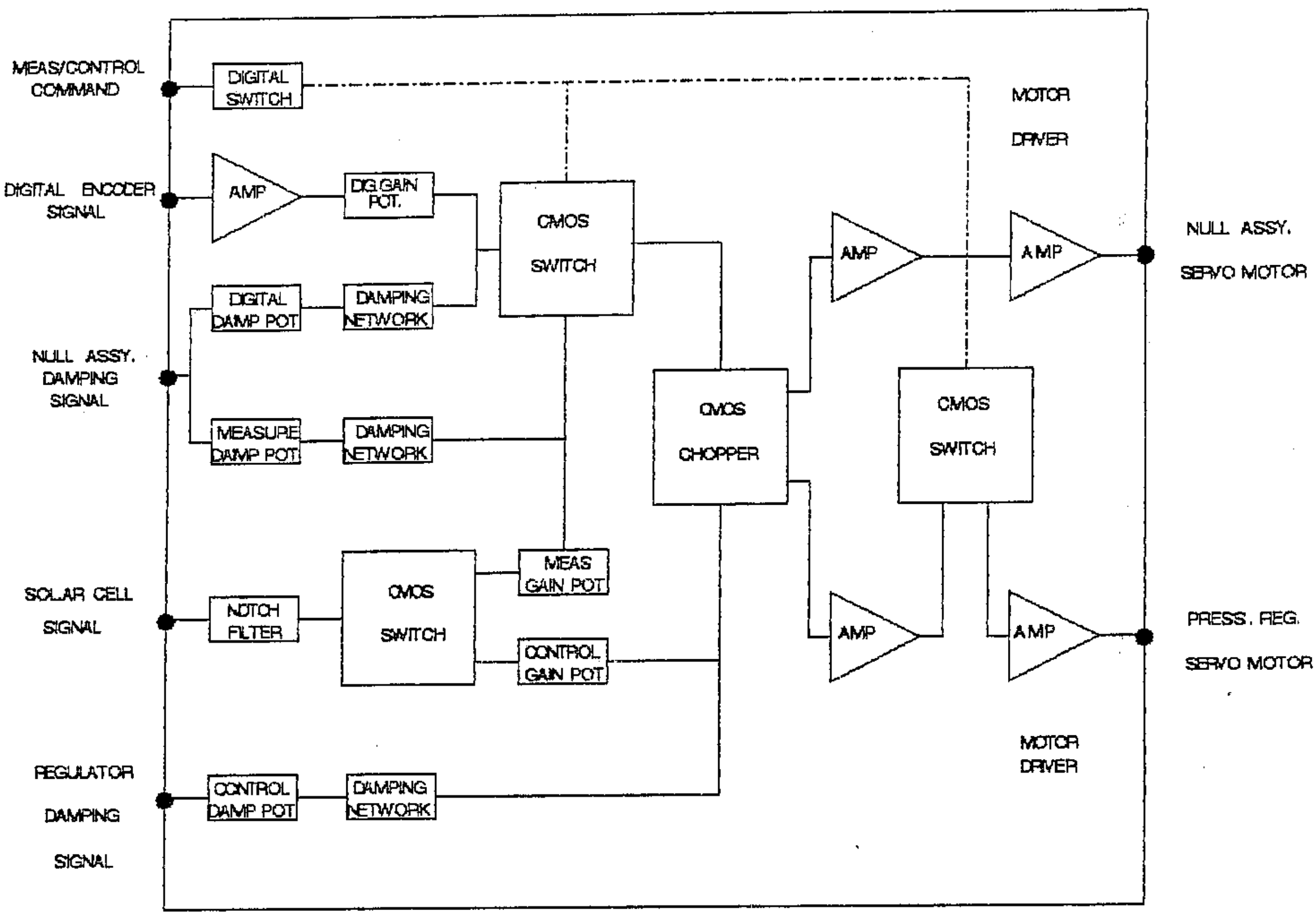


FIG. 6.4B

BLOCK DIAGRAM-SERVO AMPLIFIER

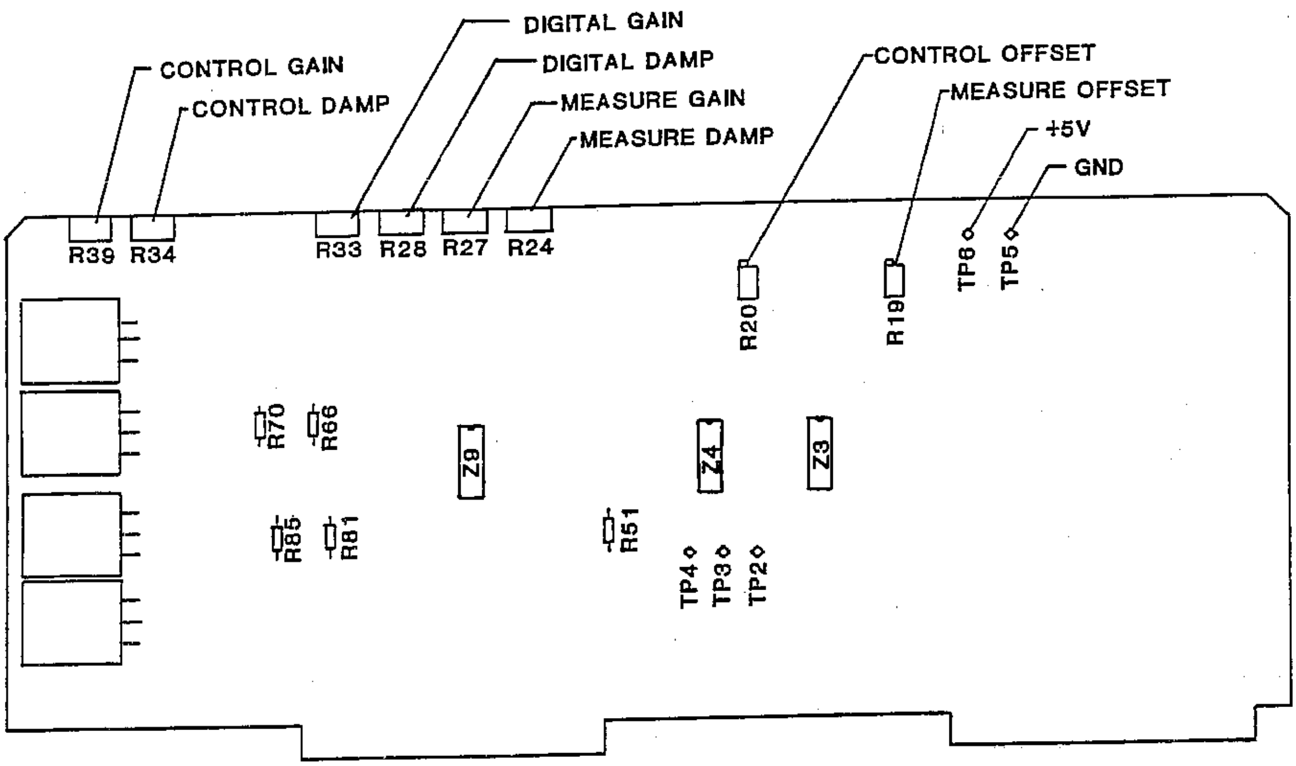


FIG. 6.4C

SERVO AMPLIFIER
ADJUSTMENTS AND TEST POINTS

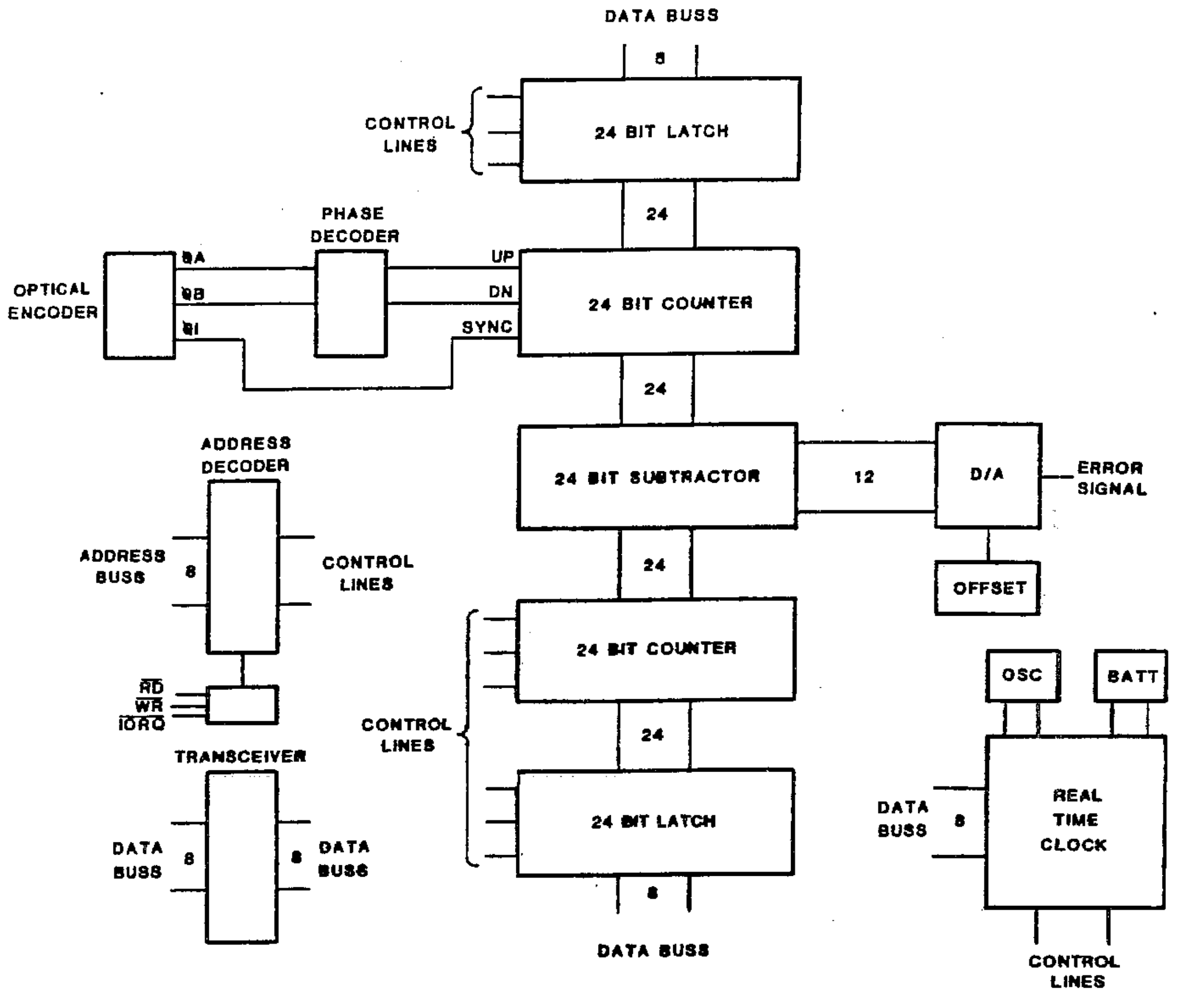


FIG. 6.5A

BLOCK DIAGRAM–ENCODER BOARD

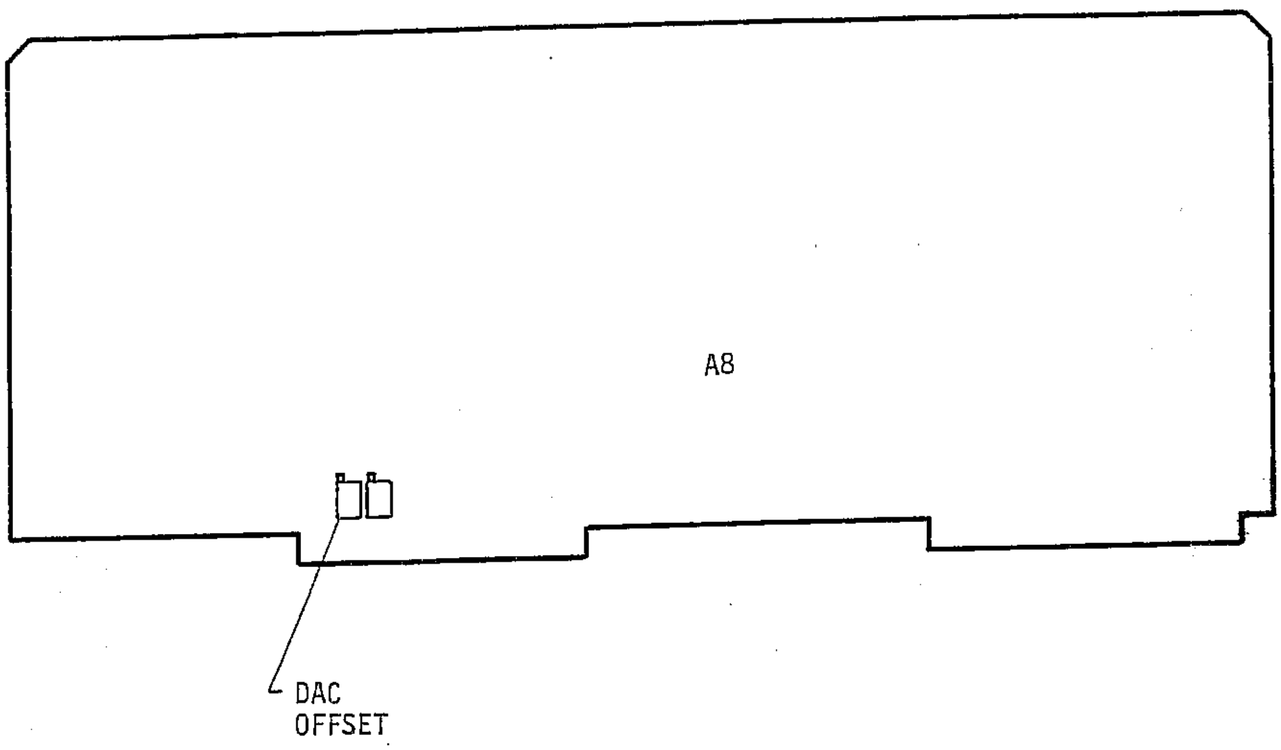


FIG. 6.5B
ENCODER BOARD - ADJUSTMENTS

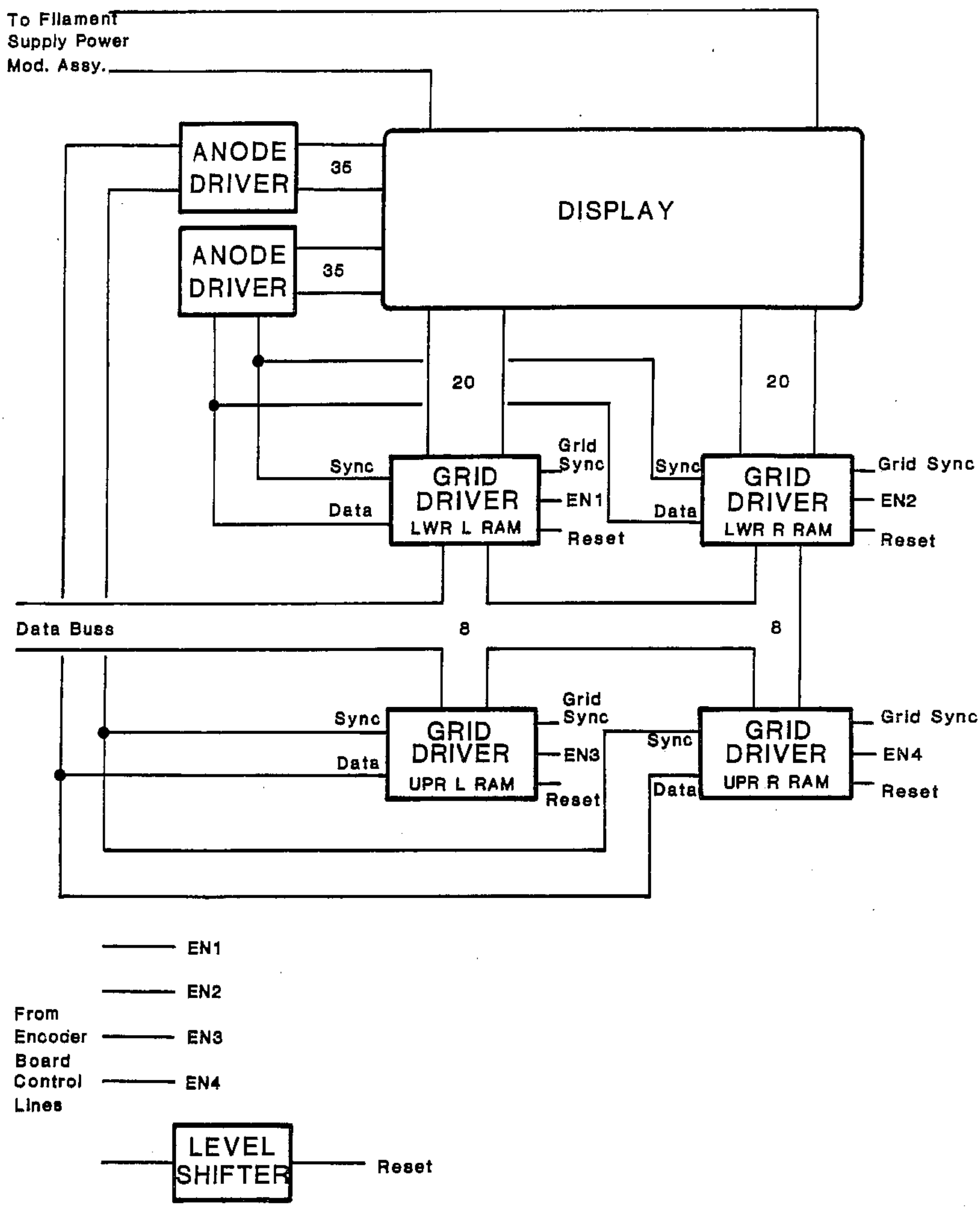
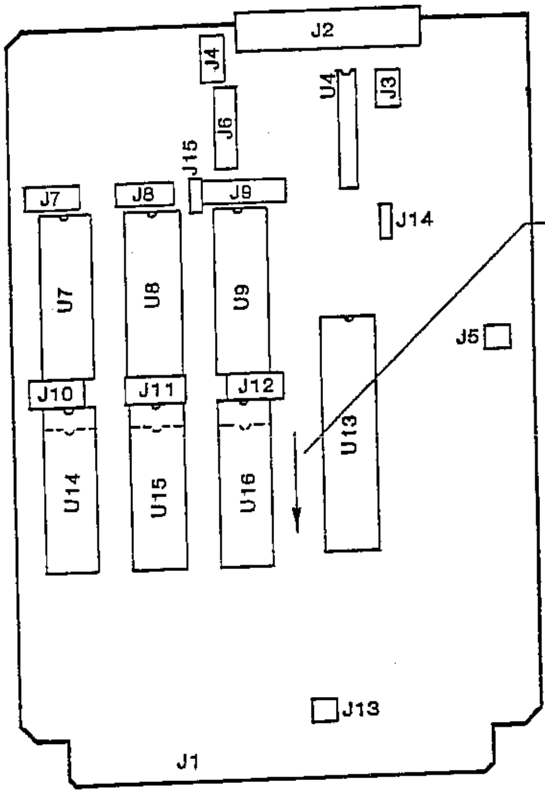


FIG. 6.6.1

BLOCK DIAGRAM - DISPLAY BOARD



NOTE

ON CPU-2A, ALL 24 PIN EPROM AND RAM CHIPS SHOULD BE SHIFTED TOWARD THE LOWER END OF THE SOCKETS [28 PIN]. THIS APPLIES TO SOCKETS U15 & U16.

HEADER	CONNECTIONS	REMARKS
J3, J4	NO CONNECTIONS	MEMORY ADDRESS
J7, J8	NO CONNECTIONS	DECODING
J5	1 O–O 2 3 O O 4	RESET ADDRESS SELECTION 0000H
J6	N.A.	
J9	1 O O O O O O O 13 2 O O O O O O O 14	27256 EPROM 32K X 8
J11, J12	1 O O O O O 9 2 O O O O O 10	48Z02 RAM 2K X 8
J13	1 O O 2 3 O–O 4	MEMEX [HI STATE]
J14	O 1 O 2 O 3	CTC I/O ADDRESS 7C-7F HEX.
J15	O 1 O 2 O 3	EPROM CONFIGURATION
J10	NO CONNECTIONS	CONFIGURED FOR 2K X 8 RAM

FIG. 6.7

CPU-2A CONNECTOR, HEADER AND STRAPPING DIAGRAM

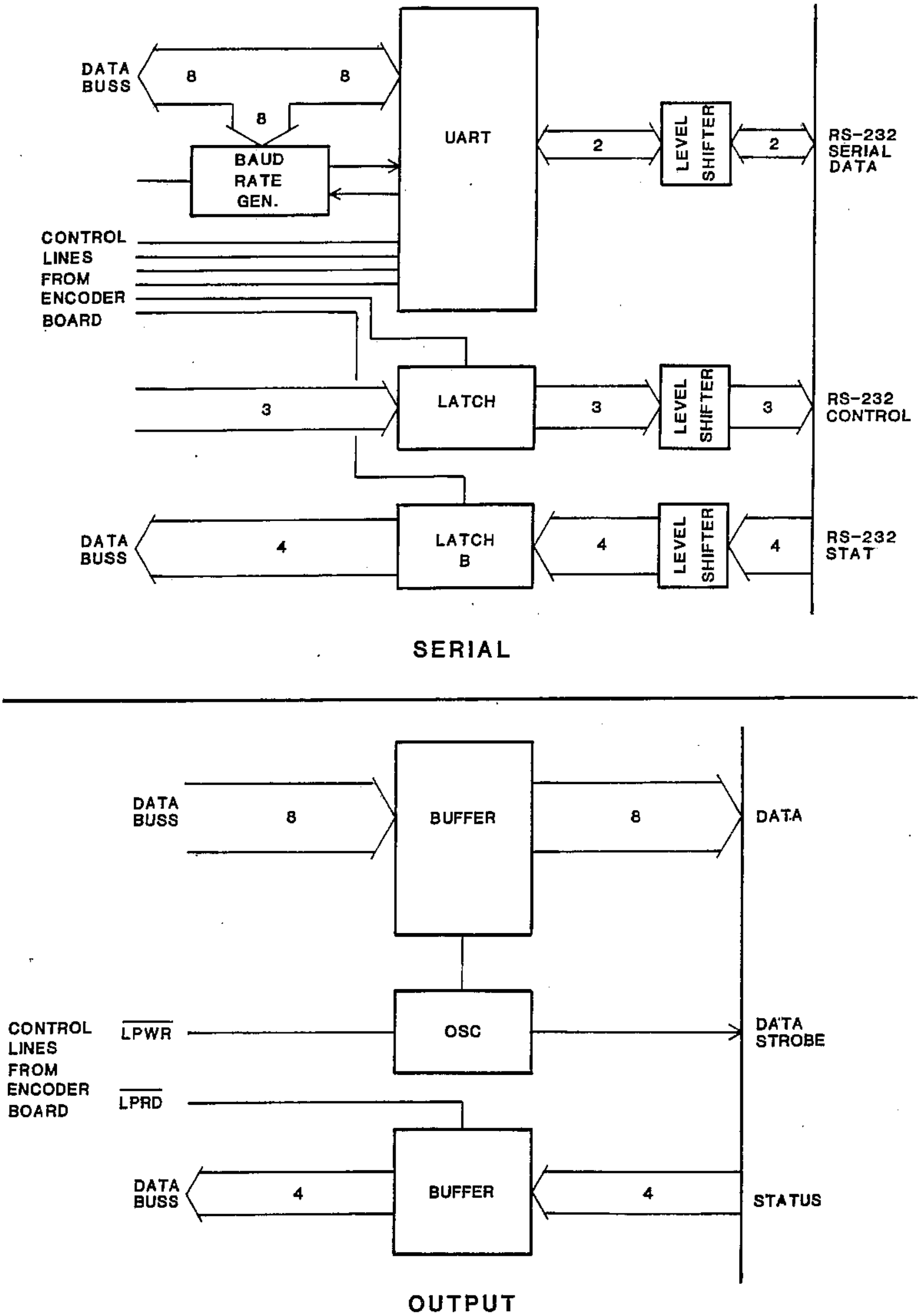


FIG. 6.8A

BLOCK DIAGRAM-I/O BOARD
DIGITAL FUNCTIONS

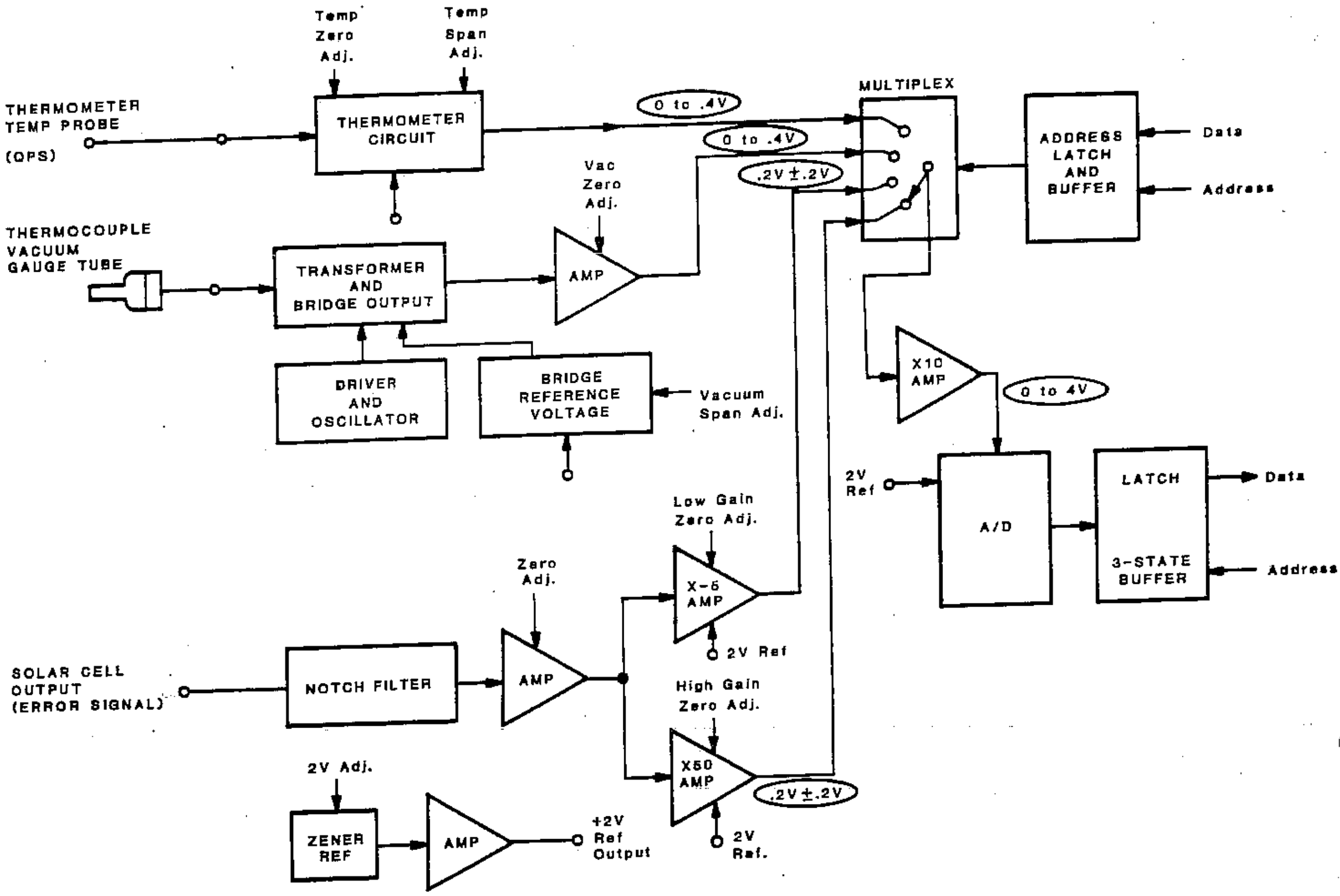


FIG. 6.8B

BLOCK DIAGRAM-I/O BOARD
ANALOG FUNCTIONS

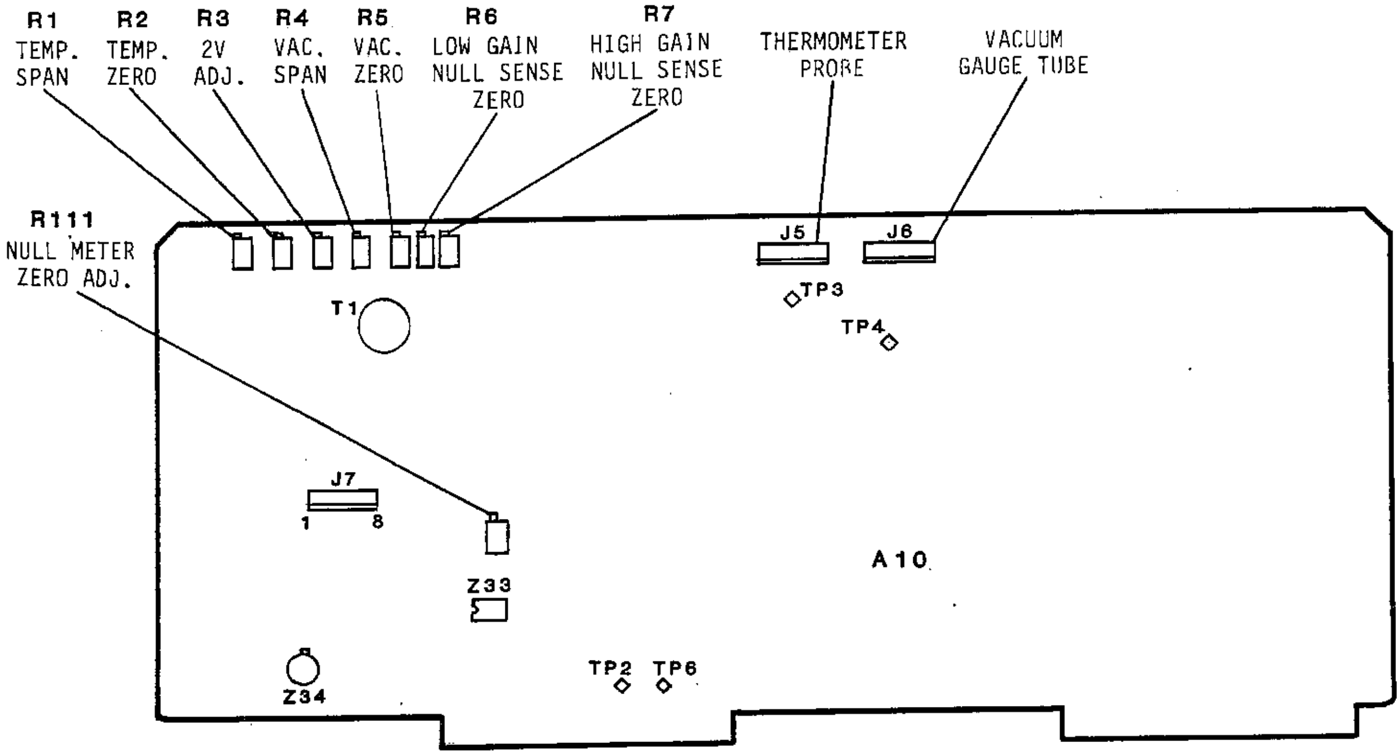


FIG. 6.8C

I/O BOARD – ADJUSTMENTS AND TEST POINTS

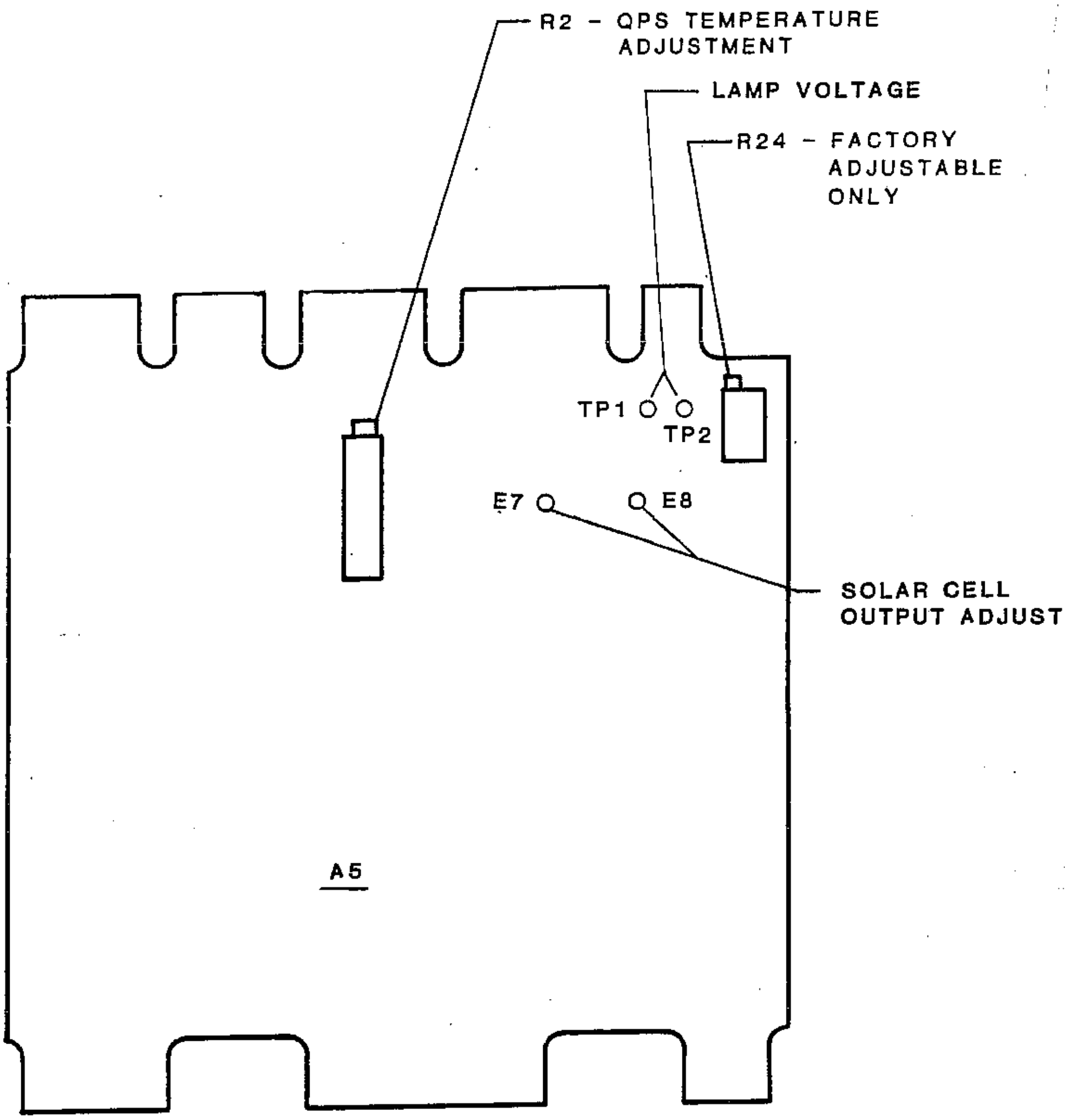


FIG. 6.9.1
NULL ASSEMBLY BOARD

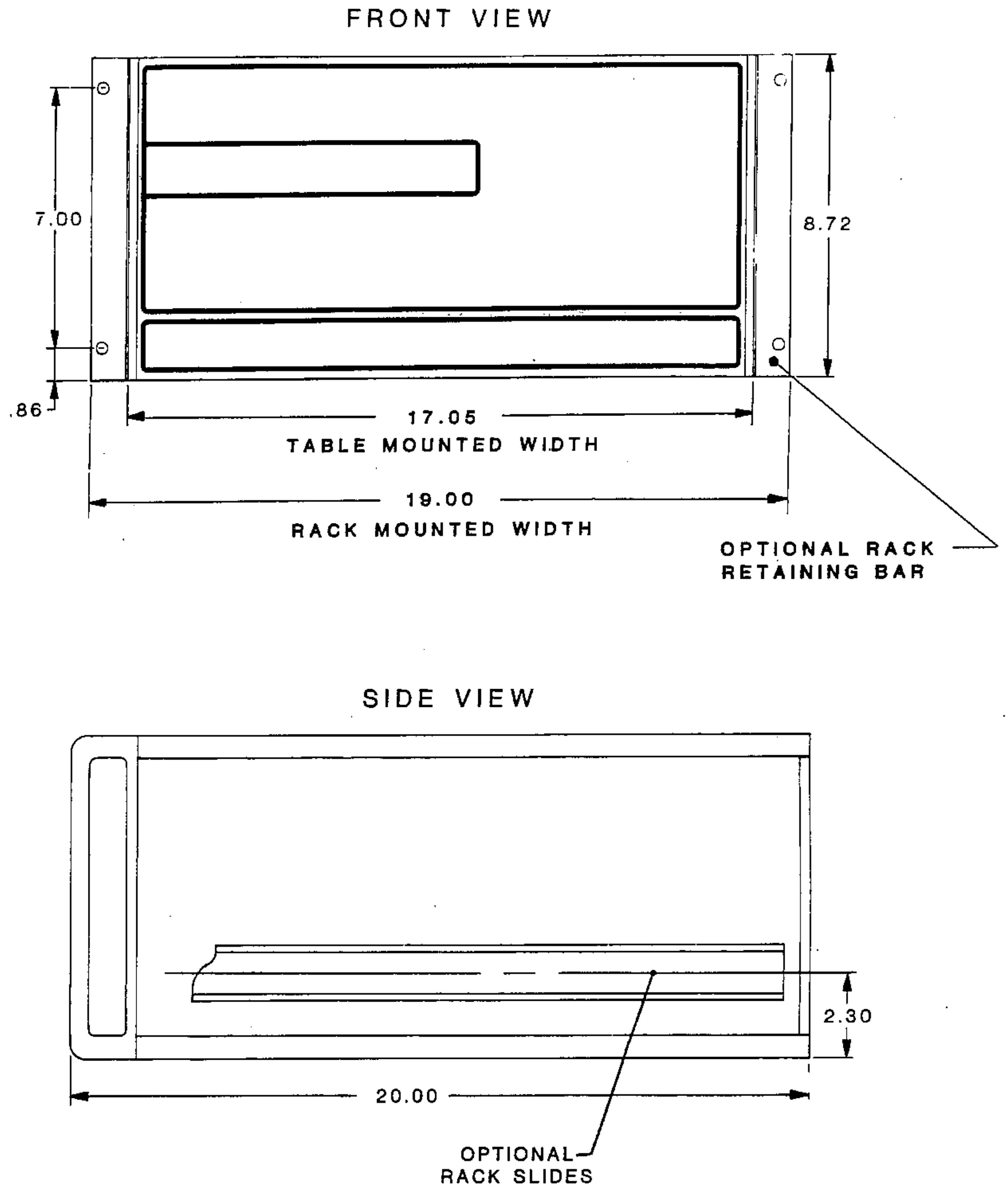
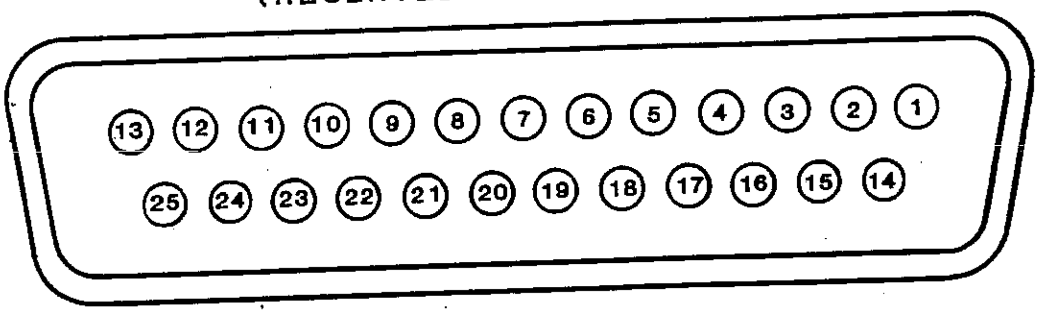
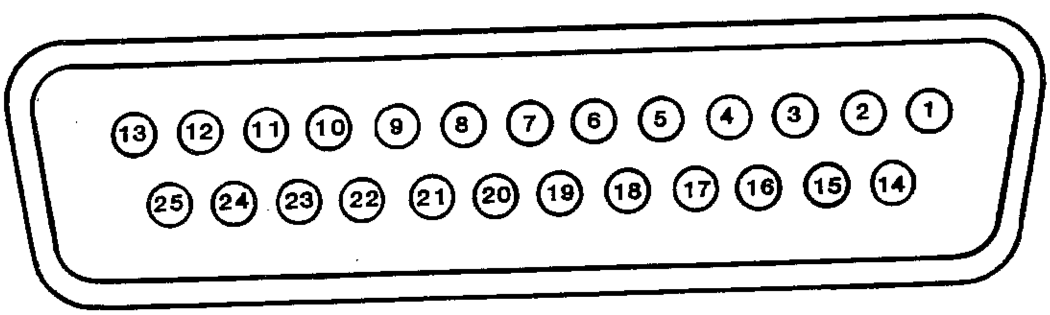


FIG. 7.5
PHYSICAL DIMENSIONS

OUTPUT PORT
REAR VIEW
(RESERVED FOR FUTURE USE)



SERIAL PORT
(RS-232-C SIGNAL LEVELS)
REAR VIEW



1 PGND	6	11	16 DSR	21
2 RD	7	12	17 CD	22 R1
3 CTS	8	13	18	23 DTR
4 SGND	9	14 TD	19	24
5	10	15 RTS	20	25

FIG. 8.1.3A

PCS TO TERMINAL OR COMPUTER WITHOUT HANDSHAKING (DTE CONFIGURED)

PCS (DTE) CONN.	PIN	TERMINAL (DTE) CONN. PIN	
PGND	1	1	PGND
TD	14	2	TD
RD	2	3	RD
SGND	4	7	SGND

PCS TO TERMINAL OR COMPUTER WITHOUT HANDSHAKING (DCE CONFIGURED)

PCS (DTE) CONN.	PIN	TERMINAL (DCE) CONN. PIN	
PGND	1	1	PGND
TD	14	2	RD
RD	2	3	TD
SEND	4	7	SEND

PCS TO MODEM CABLE

PCS (DTE) CONN.	PIN	MODEM (DCE) CONN. PIN	
PGND	1	1	PGND
TD	14	2	TD
RD	2	3	RD
RTS	15	4	RTS
CTS	3	5	CTS
DSR	16	6	DSR
SEND	4	7	SEND
CD	17	8	CD
DTR	23	20	DTR
RI	24	22	RI

FIG. 8.1.3B
SERIAL PORT TO RS-232-C CABLE CONNECTIONS

PCS TO TERMINAL OR COMPUTER WITH HANDSHAKING (DTE CONFIGURED)

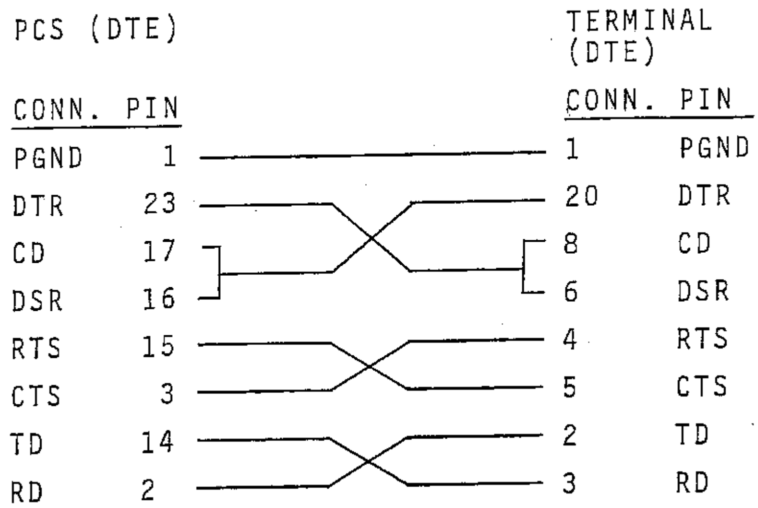
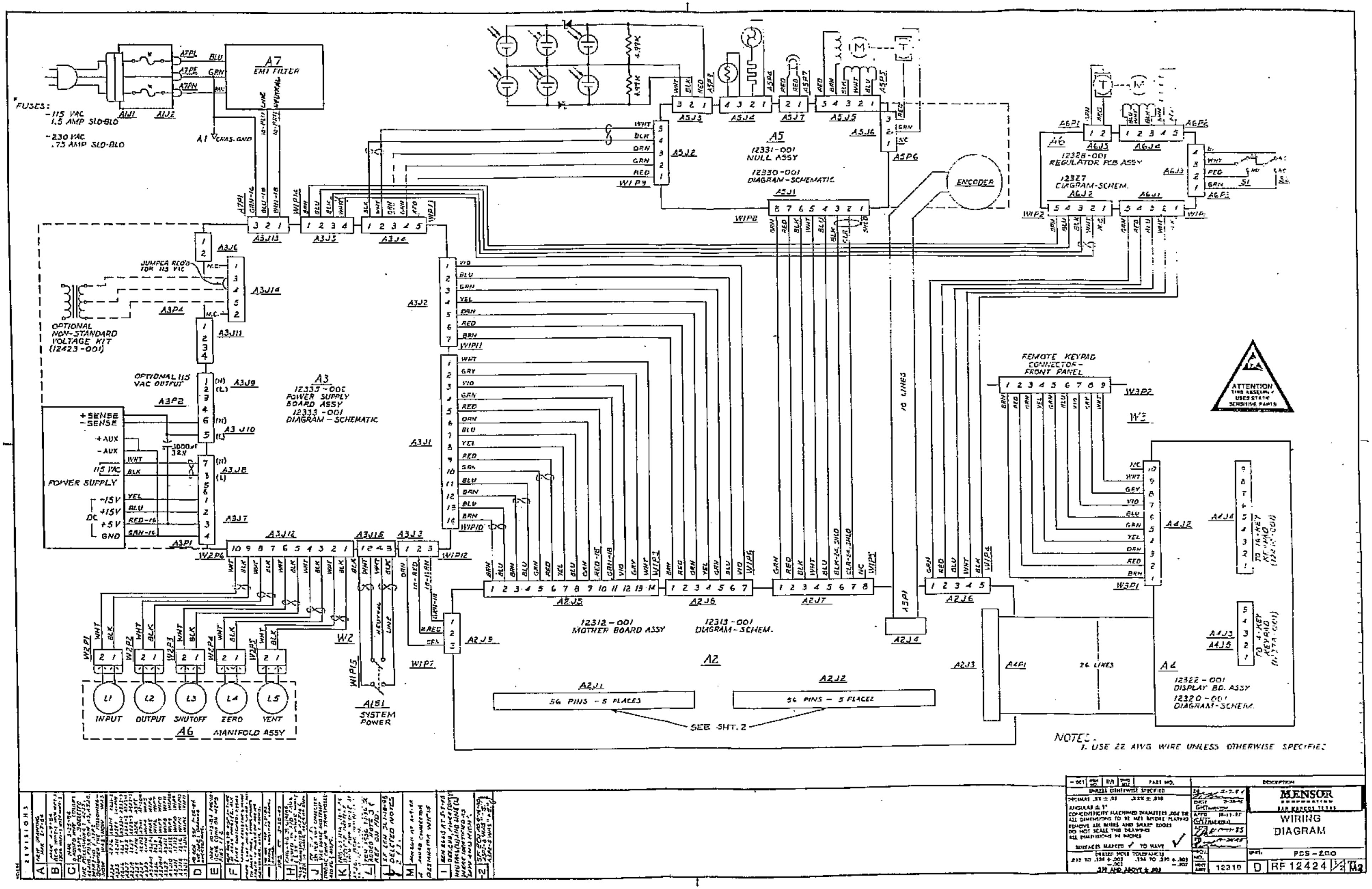
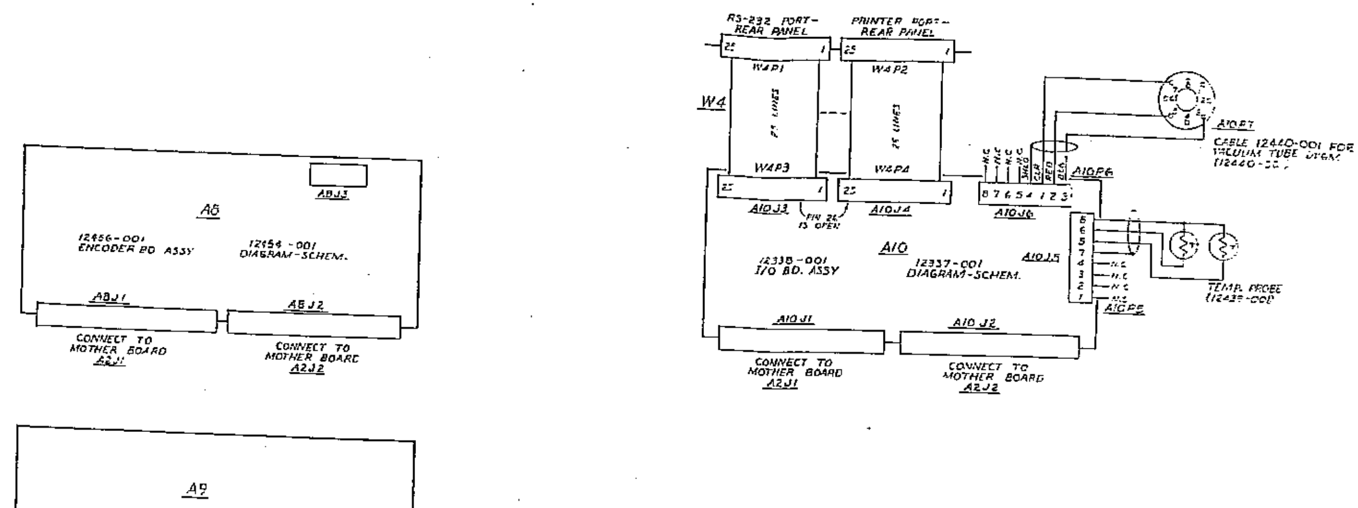
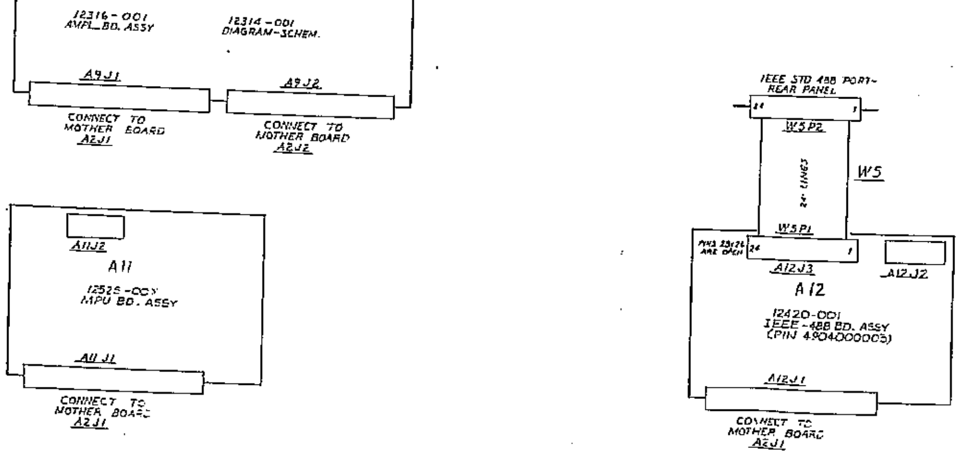


FIG. 8.1.3C
SERIAL PORT TO RS-232-C
CABLE CONNECTIONS

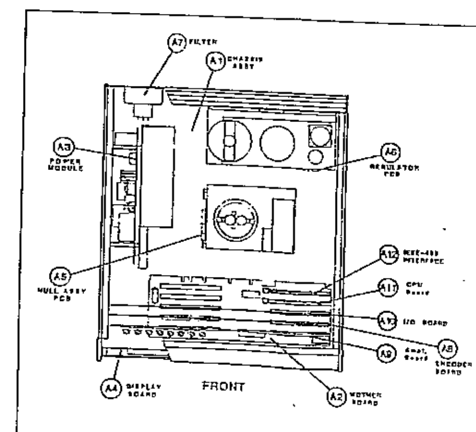


FUSES:
- 115 VAC 1.5 AMP SLO-BLO
- 230 VAC .75 AMP SLO-BLO
A7
EMI FILTER
A1 CHAS. GND
A5
12331-001
NULL ASSY
12330-001
DIAGRAM-SCHEMATIC
ENCODER
A6
12328-001
REGULATOR PCB ASSY
12327
DIAGRAM-SCHEM.
JUMPER REQ'D FOR 115 VAC
OPTIONAL NON-STANDARD VOLTAGE KIT (12423-001)
OPTIONAL 115 VAC OUTPUT
A3
12335-001
POWER SUPPLY BOARD ASSY
12333-001
DIAGRAM-SCHEMATIC
POWER SUPPLY
+SENSE
-SENSE
+AUX
-AUX
115 VAC
-15V
+15V
+5V
GND
DC
1000uF
10 LINES
REMOTE KEYPAD CONNECTOR-FRONT PANEL
ATTENTION
THIS ASSEMBLY USES STATIC SENSITIVE PARTS
INPUT
OUTPUT
SHUTOFF
ZERO
VENT
A6
MANIFOLD ASSY
A1S1
SYSTEM POWER
A2
12312-001
MOTHER BOARD ASSY
12313-001
DIAGRAM-SCHEM.
56 PINS - 5 PLACES
SEE SHT. 2
26 LINES
A4
12322-001
DISPLAY BD. ASSY
12320-001
DIAGRAM-SCHEM.
TO 16-KEY KEYPAD
TO 4-KEY KEYPAD
NOTES:
1. USE 22 AWG WIRE UNLESS OTHERWISE SPECIFIED
REVISIONS
MENSOR
WIRING
DIAGRAM
PCS-200
12310
D
RF 12424





REF. DESIG.	PART NO.	DESCRIPTION
A1	12309-001	CHASSIS ASSY
A2	12312-001	MOTHER BOARD ASSY
A3	12335-00[illegible]	POWER SUPPLY BOARD ASSY
A4	12322-001	DISPLAY BOARD ASSY
A5	12340-001	NULL ASSY - PCS
A6	12341/12342	PNEUMATIC ASSY
A7	12397-001	POWER INPUT ASSY
A8	12456-001	ENCODER BOARD ASSY
A9	12316-001	AMPL. BOARD ASSY
A10	12338-001	I/O INTERFACE BOARD ASSY
A11	12525-00[illegible]	MPU ASSY
A12	12420-001	IEE-488 INTERFACE ASSY
W1	12391-001	HARNESS ASSY-MAIN - PCS
W2	12391-002	HARNESS ASSY-SOLENOID
W3	12383-001	REMOTE CONN. ASSY
W4	12422-001	CABLE ASSY- I/O PORTS
W5	12421-001	CABLE ASSY-IEEE-488 PORT



TOP VIEW

ATTENTION
THIS ASSEMBLY
USES STATIC
SENSITIVE PARTS

REVISIONS

UNLESS OTHERWISE SPECIFIED
DECIMAL .XX ± .02 .XXX ± .010
ANGULAR ± 1°
CONCENTRICITY MACHINED DIAMETERS .004 TIR
ALL DIMENSIONS TO BE MET BEFORE PLATING
REMOVE ALL BURRS AND SHARP EDGES
DO NOT SCALE THIS DRAWING
ALL DIMENSIONS IN INCHES
SURFACES MARKED ✓ TO HAVE

MENSOR CORPORATION

WIRING DIAGRAM

PCS-200

12310 | D | RF12424 | M2

PCS-200 TROUBLESHOOTING GUIDE

PART A: SYSTEM ERRORS

Below is a list of the warning and error messages given by the PCS, their description, and expected remedies.

1. PENDING RAM BATTERY FAILURE 1

```
***** WARNING *********** WARNING ******
..... PENDING RAM BATTERY FAILURE 1
```

This warning occurs if one of the two internal batteries on RAM 1 is low. Generally the second battery will provide the needed backup for a long time but considerations should be made for obtaining a replacement RAM IC. Pressing 'CE' will allow continued use of the instrument but will not cure the problem. Contact the factory on this.

2. PENDING RAM BATTERY FAILURE 2

```
***** WARNING *********** WARNING ******
..... PENDING RAM BATTERY FAILURE 2
```

Same as above, except this is for RAM 2.

3. PENDING RAM BATTERY FAILURE 1&2

```
***** WARNING *********** WARNING ******
..... PENDING RAM BATTERY FAILURE 1&2
```

Same as above, except this is for both RAMs.

4. RAM 1 ERROR

```
****** ERROR ************* ERROR *******
                 .... RAM 1 ERROR
```

Indicates a read/write error on RAM 1. General cause of this is a bad RAM IC. Repeat the RAM test for verification and then contact the factory. Note: If a RAM chip is replaced, the instrument must be recalibrated.

5. RAM 2 ERROR

```
****** ERROR ************ ERROR *******
                 .... RAM 2 ERROR
```

Same as above, except this is for RAM 2.

6. NUMERIC OVERFLOW

****** ERROR ************* ERROR *******
....NUMERIC OVERFLOW

This is the error message given when the mathematical capabilities of the microprocessor are exceeded. In some cases this can be cleared with the 'CE' key, but generally the PCS must be powered down and back up again to clear.

7. DIVISION BY ZERO

****** ERROR ************* ERROR *******
......DIVISION BY ZERO

Error message given when doing an operation that requires the microprocessor to divide by zero. This is cleared by powering down and back up again.

8. CAL CHART ERROR

****** ERROR ************* ERROR *******
CAL ERRROR... SLOPE XX

This message indicates that calculated slope for point XX is beyond acceptable limits. Recalibration is required. Press 'CE' to continue.

9. CAL ENTRY WARNING

CAL ENTRY WARNING - PUSH 'CE' TO RE-TRY
#X XXXXX COUNTS XX.XXXX PSI

This message indicates the calculated slope for the calibration point being entered is beyond acceptable limits. Check entries and pressure from the standard and re-try.

PART B: GENERAL TROUBLESHOOTING

POWER-UP PROBLEMS:

1. Pressed power switch. No response.

A. Check power cord.
B. Check fuses.

2. Unit blows fuses.

A. Check for shorted coils on the solenoid valves.

3. Pressed power switch. The Display should clear then display "INITIALIZING..." on the lower line. Partial response obtained [i.e., can hear solenoid valves clicking in or servo motors running]. Press the power switch again to turn the power off and then remove the top cover to check the following:

   CAUTION: As long as the PCS is plugged in, there is line voltage to portions of the power supply module. Take proper precautions when working in this area.

   These PC assemblies contain devices sensitive to static electricity. These boards should therefore be handled only in static-safe situations. If the boards are to be removed from the instrument case for storage or shipping, they should have shorting bars placed on the connectors and should be placed in static-safe containers.

   A. Check contact condition and insertion of the Amplifier board, Encoder board, the I/O board, the CPU board, and [if included] the GPIB board. See Figure 2.2B for location of these boards.

   B. Check the connection between the display board and the motherboard.

   C. Check the connection between the optical encoder on the null assembly and the motherboard.

   D. Check connections on the rear of the motherboard.

   E. Remove the left side cover and check the connectors on the Power Module.

      CAUTION: High voltage is present in this area. Take proper precautions.

4. Unit never completes initialization and never starts RAM test.

   A. Press 'CE' key to continue to main menu.

   B. Check for active null meter reading. A null meter which reads a stable -640 counts indicates an I/O board problem.

5. Unit completes initialization but reads "-----" in MEASURE mode and will not respond to pressure.

   A. Check the lamp on the null assembly. Do this by removing the right side cover and then the gray plastic baffle from the right side of the null assembly. Look to see if the lamp is still on. If not, contact the factory. Note: DO NOT loosen the screws on the lamp clamp or the lamp block unless replacing the lamp. To do so will invalidate the calibration of the instrument.

6. Pressed power switch. PCS initializes and then displays one of the following system errors.

   ***** WARNING *********** WARNING ******
   ..... PENDING RAM BATTERY FAILURE 1

   ***** WARNING *********** WARNING ******
   ..... PENDING RAM BATTERY FAILURE 2

   ***** WARNING *********** WARNING ******
   ..... PENDING RAM BATTERY FAILURE 1&2

   ****** ERROR ************* ERROR *******
   .... RAM 1 ERROR

   ****** ERROR ************* ERROR *******
   .... RAM 2 ERROR

   ****** ERROR ************* ERROR *******
   CAL ERROR... SLOPE XX

   See Appendix D, Part A for information on these errors.

MEASURE MODE PROBLEMS:

1. Display continues to show SLEWING rather than MEASURED PRESSURE. Check the following:

   A. Check for leaks. [Even a small leak can cause pressure gradients large enough to prevent a stable measurement.]

   B. Check the null meter by going to the INTERNAL STATUS mode. Reading must not exceed ±20 counts [±5 counts is nominal] and should be stable within 1 or 2 counts. Adjust pot R111, null meter zero, on the I/O board for a reading of zero. [See fig. 6.8C]. See Section 6.8.2 for information on this.

   C. Check the null assembly servo motor for oscillation. If so, see Section 6.4.1.3 for information on gain and damp adjustments.

2. Display shows MEASURED PRESSURE but the value does not change when the pressure is changed. Check the following:

A. Check to make sure pressure is reaching the MEASURE INPUT port from the users line.

B. If pressure is reaching the PCS, then check the shutoff solenoid (see Figure 6.1A-D). Check the connection first and then check for a defective coil.

C. Check the lamp on the null assembly.

CONTROL MODE PROBLEMS:

1. Attempts to enter a control point results in one of the following system errors.

   ***** WARNING ********* WARNING ******
   ENTRY EXCEEDS ALLOWED UPPER LIMITS

   ***** WARNING ********* WARNING ******
   ENTRY EXCEEDS ALLOWED LOWER LIMITS

   See Appendix D, Part A for explanation.

2. Control point has been entered but the unit will not stabilize. It continues to show SLEWING rather than MEASURED PRESSURE. Check the following:

   A. Exit the CONTROL mode and make sure the PCS functions in the MEASURE mode. The PCS must be operable in the MEASURE mode to be able to function in the CONTROL mode.

   B. Check for leaks. The PCS can sometimes control against small leaks, but larger leaks will prevent the control pressure from stabilizing.

   C. Check the source pressure. Is it adequate? See Section 2.3.3 for requirements.

   D. If controlling near or below atmospheric pressure, is there a vacuum being pulled on the exhaust port? See Section 2.3.3 for requirements on this.

   E. If the pressure is oscillating about the control point, the Digital Gain and Damp and/or the Control Gain and Damp should be checked. See Section 6.4.1.5.

   F. Check the null meter by going into the INTERNAL status mode. The null meter must not exceed ±20 counts (±5 is nominal). Check the null meter in the MEASURE mode. If ok, there may be a need to adjust the DAC offset. As a temporary adjustment, locate R6 on the encoder board (bottom left). Adjust this pot until the null meter in control matches the null meter in MEASURE. See Section 6.8.2 for information.

3. Control pressure overshoots the control point excessively.

   The PCS is designed to perform adequately over a broad range of external volumes and plumbing arrangements. Sometimes improvement can be made by trimming the instrument to the specific environment it is to be used in. One method for reducing overshoot is to place a needle type valve at the MEASURE/CONTROL port between the PCS and the system being controlled. Command the PCS to control at several different pressures and observe the overshoot characteristics. If the overshoot is too great close down the restriction (needle valve) and repeat the test. Closing the restriction too far will drastically increase the slew time of the PCS between control points. There should be a point of adjustment where the overshoot will be greatly reduced while not extending the slew time excessively.

   A note of caution: A restriction can introduce a pressure gradient such that the PCS may indicate a stable pressure while the external system is still changing.

INTERNAL STATUS MODE PROBLEMS

1. None of the INTERNAL status functions are working.

   Assuming the PCS is powered up and warmed up, if the functions are not working (i.e., temperature is steady at 44.6°C and the null meter fixed on a number), then the problem is connected with the I/O board. See Figure 6.0. Check the insertion of the board into the motherboard. If this does not cure the problem, contact the factory.

2. Null meter functions, but the temperature shows a steady 44.6°C.

   Check the following:

   A. Has the PCS had time to warm up? The temperature readout will not display temperature until the temperature of the QPS is above 44.6°C.

   B. Remove the top cover. Is the temperature probe inserted into the temperature well of the QPS?

C. Is the connector end of the temperature probe connected to J5 on the I/O board?

D. If the above did not cure the problem, then the problem is probably on the I/O board. Contact the factory.

3. Null meter functions, temperature readout functions, but vacuum readout does not.

   Check the following:

   A. First determine if the PCS has vacuum readout capabilities according to the following:

      a) Absolute units with a range of 50 psia or less have vacuum readout capabilities at all times on the pressure side of the QPS.
      b) Differential units have a vacuum readout on an option basis only. Contact the factory on this.

   B. Remove the top cover and check the connections to the vacuum thermocouple gauge and to the I/O board.

   C. Check the insertion of the I/O board into the motherboard.

   D. If the above fails to cure the problem, contact the factory.

4. Null meter, temperature readout, and vacuum readout all work, but the time function in error.

   A. Reset timer and power-down. Power up and check time. If bad, clock battery may be low.

CALIBRATION PROBLEMS:

1. Large or non-linear calibration problems can be located using the CAL CHK mode.

1243

APPLICATION NOTE

Using a Mensor PCS-100 or PCS-200 configured for differential pressure to measure and/or control absolute pressures.

INTRODUCTION

The differential Pressure Calibration System (PCS) family of instruments are very flexible in the types of pressures that may be measured. Obviously differential or gage pressures may be readily measured with a high degree of accuracy, but absolute pressures may also be measured accurately with a differential PCS. To do this the zero point on the PCS must be set equal to absolute vacuum. Since it is impractical to reproduce a vacuum below the resolution of the PCS, a single-point calibration must be performed to adjust the instrument zero with respect to a known absolute pressure.

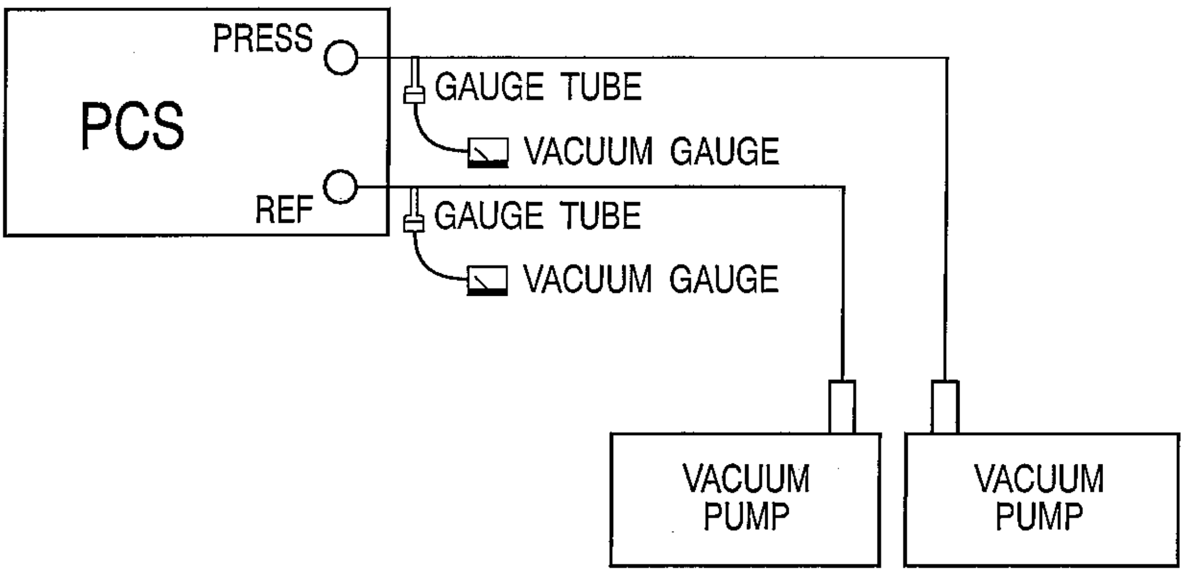
REQUIRED EQUIPMENT

The following items are required to measure absolute pressures with a differential PCS:

1. A differential PCS with a range of 15 psi or more.
2. Two vacuum pumps capable of better than 50 millitorr of stable vacuum, one to pump down the reference port of the PCS and one to pump down the pressure port.
3. Two vacuum gauges with ±5 millitorr uncertainty or better (Hastings DV-6), one for the reference port and one for the pressure port of the PCS.

SETUP

1. Connect one of the vacuum pumps to the reference port of the PCS. The second vacuum pump should be connected to the pressure system to be measured. Ideally, the tubing to the vacuum pumps should be as short as possible to help achieve a rapid pump-down of the pressure system. Larger size tubing also reduces the time required to pump the desired vacuum in a system. Longer tubing runs and smaller diameters of tubing will cause a pressure system to pump down slowly and may cause vacuum pressure gradients throughout the system.
2. Mount the vacuum gauges as close to the PCS as possible for accurate measurements of the vacuum pressure in the PCS. Mensor has learned through testing and experience that the vacuum inside the PCS at the sensor is 40 percent greater than that measured at the rear panel of the instrument due to the internal plumbing of the PCS. When taking a vacuum measurement, multiply the reading by 1.4 to correct for the difference.



PROCEDURE

1. Put the PCS into the measure mode and set the units to millitorr.
2. Turn on the vacuum pumps and begin to pump down the reference and pressure ports of the PCS. These ports must be allowed to pump until the reference port vacuum is stable and both vacuums are less than 100 millitorr after the the correction (1.4 × reading).
3. Enter the single-point calibration mode on the PCS when the vacuum is stable and at the required pressure. To do this from the main menu press "SPECIAL", then "OTHER", then "CAL", then "1 PT. CAL". The PCS then asks for the current pressure. Add the two ***corrected*** vacuum readings and enter the result. Since the PCS was set to millitorr at the start of the procedure the vacuum readings do not need to be converted to psi or any other units. After pressing "=" following the current pressure the PCS requires that you press "1" to put the calibration into effect. If you feel you have made an error you may press "M" to back out of the procedure without changing the calibration.
4. Press "1" to set in the zero adjustment when the PCS reading is stable.

ZERO ADJUSTMENT UNCERTAINTY

The uncertainty of the zero adjustment is the sum of the uncertainties of the two vacuum gauges and the stability of the vacuum on the reference port. If the vacuum on the reference port changes, any measurement made after the change will be biased as a result of the change. When the vacuum changes enough to significantly affect the accuracy of the measurement, the PCS should be readjusted per this procedure.

ADDITIONAL INFORMATION

Additional information on the calibration and zero adjustment of the PCS instrument may be found in the following locations:

PCS-100 Operating Instructions, p/n 12590-001C on pages 3-8 thru 3-13, 4-3 thru 4-7 and 5-1 thru 5-7.

PCS-200 Operating Instructions, p/n 12400-001F on pages 3-11 thru 3-15, 4-2 thru 4-5 and 5-1 thru 5-5.

CHECKLIST

- ☐ Check that the correct equipment is available.
- ☐ Connect the vacuum pumps to the PCS.
- ☐ Make sure the vacuum gauges are as close to the PCS as possible.
- ☐ Put the PCS into the measure mode.
- ☐ Set the PCS engineering units to millitorr.
- ☐ Start the vacuum pumps and begin to pump down the PCS.
- ☐ Verify that both vacuums are stable and less than 100 millitorr after the correction is applied.
- ☐ Enter the 1-PT. calibration mode on the PCS.
- ☐ Add the two corrected vacuum gauge readings.
- ☐ Enter the result as the current pressure, then press "=".
- ☐ Press "1" to confirm the zero adjustment, or press "M" to exit without making the adjustment.

REVISIONS

Rev	Description
A	NEW DWG JK 3/20/86
B	ECN 2440 4/25/86 RT Add note 7 to F/D & BOM.
C	ECN 2482 JF 7-24-86 1) DEL ITEM 8 FROM -002 WAS T354. 2) DEL NOTE 7 WAS ADD ERRATA SHT T354 TO MANUAL.
—	ECN 2544 JF 1/21/87 AW CHG.
D	SF ECN JK/GMT 6/2/87 ADD PN-DESC. TABLE. CHG SEC 8.0 AND FIG. CHANGES.
E	ECN 2647 JK 2-18-88 EXTENSIVE CHG'S TO TEXT. MARKED COPIES IN PES FOR REFERENCE.
F	ECN 2696, MAR, 11-15-88 EXTENSIVE CHG. TO TEXT MARK PRINTS IN ENG FOR REF
1	SF ECN RG/RWE 2-6-91. ERROR CORRECTION: "CLASSIC" WAS "COLONIAL".
2	SF ECN DC/JW 9-17-91. COLOR CHG FROM CLASSIC CREST BARONIAL IVORY. RE-WORD NOTES.
3	SF ECN JW/JJ 5-29-92 ADDED PUNCH SIZE TO NOTE 7, ADDED AW'S -985 AND -986 TO TABLE. REF C:\WPS1\JODY\12400

1. **Front & Back Cover:** *80# Kimberly Writing cover crystal blue wove finish, 8.5 x 11, 2-sided, black ink.*

2. **Text Pages:** *60# white offset smooth finish, 8.5 x 11, 2-sided, black ink.*

3. **Tabs:** *80# Kimberly Writing cover crystal blue wove finish, red ink, both sides, mylar at tabs and 3-hole side.*

4. **RF12424:** *(two 11x17's sheet 1 and 2), folded 'Z' to an 8.5 x 11, 60# white offset smooth finish. See drawing 0010427001.*

5. **Sample Manual:** *Send to printer for reference. Must be returned.*

6. **Printer:** *On back cover sheet, directly under the part number, put the quantity ordered and the date (month/year).*

   Example: MANUAL P/N 0012400001 F
   QTY:MO/YR

7. Collate, 3-hole punch (3/16" dia.), shrink wrap each set individually.

AW12400986	Manual-Sample
AW12400985	AW-Figures
AW12400984	AW-Back Cover
AW12400983	Packaging Instructions
AW12400982	AW-Front Cover
AW12400981	AW-Text Originals
0012400002	Manual-PCS 200 w/o Binder
0012400001	Manual-PCS 200
PART NO.	DESCRIPTION

QTY	ITEM NO.	U/I	DWG SIZE	PART NO.	DESCRIPTION

UNLESS OTHERWISE SPECIFIED
DECIMAL .XX ± .02 .XXX ± .010
ANGULAR ± 1°
CONCENTRICITY MACHINED DIAMETERS .004 TIR
ALL DIMENSIONS TO BE MET BEFORE PLATING
REMOVE ALL BURRS AND SHARP EDGES
DO NOT SCALE THIS DRAWING
ALL DIMENSIONS IN INCHES
SURFACES MARKED ✓ TO HAVE ✓

DRILLED HOLE TOLERANCES
.013 TO .136 + .003 − .002 .136 TO .250 + .005 − .003
.250 AND ABOVE ± .005

DR Jody Roque 3-20-86
ENGR GM THORNTON 3-27-86
APPD Jordan 3-27-86
APPD Hall 4-1-86
REL 4-1-86

12310
NEXT ASSY PL 10400

MENSOR CORPORATION
SAN MARCOS, TEXAS

MANUAL –

UNIT: PCS-200

A 12400 REV F3

mensor
CORPORATION

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P / N 0012400001F
50, 9/20/91