Swm # 409

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MASTER

02-13-02	William A. Coburn
DATE	SIGNATURE

Ser # for Equipment

Cal Std + Tester 19228

LIMITED WARRANTY

TERMS

Hagerty Technologies, Inc. warrants each new Model 1 Air Permeability Tester and accessories to be free from defects in materials and workmanship to the original purchaser. Our responsibility is limited to our repair or replacement of either the entire instrument and/or accessory or part thereof, at our option, for a period of one (1) year from the date of shipment, when such repair or replacement is covered by warranty. When the product is not so covered, it will be repaired at the standard repair rate in effect at the time.

This limited warranty does not extend to any defect, malfunction or failure caused by or resulting from improper service, operation, packing, maintenance or repair, abuse, neglect, accident, or any other cause beyond the control of Hagerty Technologies, Inc.

Except and to the extent provided herein, Hagerty Technologies, Inc. makes no warranty, either express or implied, including any warranty of merchantability or fitness for any purpose beyond the scope of which it is intended for.

Hagerty Technologies, Inc. shall not be liable to the purchaser or to any other person or firm for any specified or consequential damages of any kind which result from the use or misuse by any person or loss of profits or product resulting from any defect in or malfunction or failure of this product.

No person, agent, distributor, service facility or company is authorized to change, modify, or amend the terms of this limited warranty in any manner or fashion whatsoever.

WARRANTY PROCEDURE

If you cannot resolve your equipment problem, notify Hagerty Technologies giving the model and serial number or your equipment. Describe your problem in detail.

Upon receipt of this information, Hagerty Technologies will provide the necessary service information, or send parts, if the trouble is easily corrected. We will make every effort to provide field service whenever it is possible. If the trouble requires factory service, we will so advise you and provide further instructions on where to send the instrument for warranty service. We will make every effort to provide a "loaner" instrument for your use in the event problems are not easily and quickly solved.

Refer to the Warranty Terms and Packing and Shipping instructions before returning any equipment, or contact Hagerty Technologies for assistance.

****** NOTICE ******

THIS INSTRUCTION / SERVICE MANUAL CONTAINS PROPRIETARY INFORMATION THAT IS PRINTED AS A SERVICE TO THE END-USER TO FACILITATE MAINTENANCE AND TO OPTIMIZE INSTRUMENT PERFORMANCE AND CUSTOMER SATISFACTION. THIS INFORMATION MAY NOT BE DISCLOSED TO OTHERS WITHOUT WRITTEN PERMISSION FROM HAGERTY TECHNOLOGIES, INC.

****** WARNING ******

THIS INSTRUMENT IS DESIGNED TO BE OPERATED WITH THE INSTRUMENT CABINET INSTALLED AND USED ONLY WITH THE ACCESSORIES PROVIDED BY HAGERTY TECHNOLOGIES, INC. IT IS SUPPLIED WITH A GROUNDED POWER CABLE AND IN ORDER TO PREVENT ANY SHOCK HAZARD, THE USER MUST USE A 3-PRONG GROUNDED POWER RECEPTACLE.

ONLY QUALIFIED TECHNICIANS SHOULD BE ALLOWED TO APPLY POWER TO THE SYSTEM WITH THE INSTRUMENT COVER REMOVED. PLASTIC AND METAL SHIELDS ARE INSTALLED AT THE MOST ACCESSIBLE REGIONS, HOWEVER, THE POWER ENTRANCE CONNECTORS HAVE EXPOSED TERMINALS. AFTER TROUBLESHOOTING OR CALIBRATION ADJUSTMENTS ARE MADE, THE COVER MUST BE REPLACED BEFORE THE INSTRUMENT IS PLACED BACK INTO SERVICE.

****** CAUTION ******

THIS INSTRUMENT CONTAINS ELECTRONIC COMPONENTS THAT CAN BE DAMAGED BY STATIC ELECTRICITY. INSTRUMENT TECHNICIANS MUST FOLLOW THE RECOMMENDED PROCEDURES WHEN HANDLING "CMOS" INTEGRATED CIRCUITS. A THOROUGH GUIDE FOR THE RECOMMENDED HANDLING PROCEDURES OF STATIC SENSITIVE DEVICES IS GENERALLY FOUND IN THE DATABOOKS PUBLISHED BY THE MAJOR MANUFACTURERS OF INTEGRATED CIRCUITS. COPIES OF THESE PROCEDURES MAY ALSO BE OBTAINED FROM HAGERTY TECHNOLOGIES, INC.

SECTION 2
PACKING AND SHIPPING

1. Pack the unit in the original carton, if possible, using the original packing materials. If the original packing materials are not used, please be sure to pack the unit securely. Poor packaging may cause severe damage which is not covered by warranty, and will delay return of the repaired unit, and possibly increase the cost of such repairs.

   We recommend the following packaging procedure:

A- Place the instrument in a plastic bag and seal it. This will protect the system from moisture. (The 13 gallon size bags are ideal for this purpose).
B- Make a bottom crate liner (cushion) that is about 1.5" to 2" thick by partially filling a plastic bag with "styrofoam plastic peanuts", or other similar packaging materials. Expell the excess air and seal the bag with a tie-wrap or tape. Place this cushion in the bottom of the crate.
D- Place the wrapped instrument on top of the cushion, with the front of the cabinet about 2" from the inside wall of the crate.
E- Remove the air filter from the KNF air compressor. Wrap the KNF air compressor in plastic bubble-wrap, making an envelope about 1" thick, and place it in the cavity between the rear of the instrument cabinet and the inner crate wall.
F- Insert 3 empty plastic bags in the crate - one between the instrument and the front of the crate, and one on each side of the instrument. Fill the bags with styrofoam plastic peanuts until the gaps are filled and tie-wrap the bags to contain the packing materials. Use wood screws instead of nails to attach the top crate cover.
G- Package other large accessories is separate boxes. Please return the calibration plate so that the system can be fully evaluated and checked.
H- United Parcel Service (UPS) will ship packages that weigh less than 70 pounds. We designed the shipping crates so that the packaged weight, and crate dimensions conform to the UPS shipping guidelines for ground or air shipment.

2. Ship via United Parcel Service or your desired freight carrier, PREPAID. Insure the parcel in accordance with your normal procedures.

3. Enclose a description of the difficulty encountered (or describe the problem over the telephone), being as specific as possible. Reference the unit's model and serial number. If non-warranty repairs are requested, we will provide an estimate of the repair cost. Please provide the name of the person who is to be notified (direct phone numbers, and FAX phone numbers are helpful).

4. Please do not return an instrument before contacting Hagerty Technologies. We can notify a customer of a missing shipment only if we know the details of an item in transit.

SECTION 3
GENERAL INFORMATION

The Hagerty Technologies Model 1 Air Permeability Tester is manufactured in two basic versions:

1- Manual Feed Instrument, with or without a printer.
2- Auto-Feed System, generally shipped with a printer.

THE MANUAL FEED INSTRUMENT

With the Manual Feed version of the Model 1 Instrument, the operator inserts a sheet of paper in the slot between the base and the cabinet housing. When the "TEST" button is pushed, an instrument air compressor is started, and in a few seconds, the system is up to full pressure and testing begins. The measurement air is drawn in from the temperature and humidity-controlled laboratory environment, in order to avoid conditioning problems during measurement.

A separate clamping air pressure is required to ensure a tight seal of the paper that is clamped between an upper and lower rubber ring. The user must supply a source of compressed air, 35-100 psig (225 to 700 kPa). An externally mounted filter / regulator system, with overpressure protection, is provided with the instrument to facilitate the proper installation.

The measuring rings automatically clamp the sheet of paper and the measured value of air flow (that relates to air permeance) is displayed on the panel and stored in the microprocessor memory. The normal version of the Model 1 requires about 6 seconds per test; and the special version of the Model 1 for the highly impervious grades (like silicone release grades and heavily coated grades) requires about 17 seconds per test. The air compressor remains energized for a few moments after the last panel button operation, thus eliminating the initial start-up delay that was necessary for the first test.

Frequently, users of the Manual Feed version wish to obtain an RS-232 signal of the test results. The RS-232 communications port is a standard feature of the instrument, however, the software varies in accordance with the user's application. Some users wish to obtain each data point and analyze (or plot) the data with their own statistical programs; while others wish to receive only the average, high, low and standard deviation values as calculated by the instrument.

THE AUTO-FEED INSTRUMENT

The Auto-Feed attachment is designed to be attached to the Manual-Feed instrument, either as a factory-installed option, or later retro-fitted to the instrument. In addition to the Auto-Feed rubber roller drive mechanism, it includes optical paper sensors that detect the presence of paper at the front and rear of the measuring head. Also, a switch detects whether the rubber roller is engaged. When the roller is un-nipped, the instrument behaves like a Manual-Feed instrument, letting the operator control the feeding of paper and the timing of each test. When the roller is nipped, the system automatically performs a test, advances the paper to the next test zone, and performs another test.

This cycle repeats itself until the strip is fully tested, and then it generates a profile report on the printer. The spacing between tests can be set anywhere from 0 to 100 centimeters (0-40 inches). The optical sensors trigger the printing of the profile report when both sensors detect the absence of paper. If only one sensor detects the absence of paper, then testing stops and an alarm lamp and "beeper" alert the operator to check the paper feed. When the paper path is corrected, the operator presses the "TEST" button and automatic testing resumes at the point where it was interrupted. This system was designed to minimize the amount of re-testing that would otherwise occur when running poorly prepared paper samples. Even after the printed report is generated, the operator can edit the printed results and generate a second printout, as would be the case when there are valid reasons to reject data points.

The "throat" of the instrument is 6 1/4" deep, and over-width paper can protrude from the front of the cabinet. The center of the measuring head is about 3 3/4" from the rear of the throat opening.

***** HOW TO DETERMINE WHICH MODE IS SELECTED *****

Once the instrument is "booted-up" to operate in a certain mode, there is an easy way to determine which mode is active. Use the following procedure:

1- PRESS CLEAR MEMORY

a- A number will appear on the readout. The meaning of that first number is:

NUMBER	MODE
1	Model 1 engineering units (sccm)
460	Equivalent Oil Gurley Seconds (TAPPI T-460) (refer to master set-up chart for more details).
536	Equivalent Mercury Gurley Seconds (TAPPI T-536) (seconds per 2 1/2 ml displacement)
547	Equivalent Sheffield Porosity (TAPPI T-547) (refer to master set-up chart for orifice size)

b- The second number displayed is the barometric pressure. The displayed number will be something like:

29.92

which is the ambient barometric pressure in inches of mercury, corrected for sea level elevation.

c- The final number displayed will be a "0", which is to be expected when you press the CLEAR MEMORY button.

NOTE: THE TEST VALUE IS BAROMETRICALLY CORRECTED SO THAT THE READING IS NORMALIZED TO WHAT THE SAMPLE WOULD READ AT SEA LEVEL CONDITIONS, i.e., 29.92" Hg ABSOLUTE PRESSURE.

HAGERTY TECHNOLOGIES MODEL 1 AIR PERMEABILITY TESTER

RANGE OF MEASUREMENT CAPABILITIES

BOOT-UP MODE REFERS TO THE POSITION OF CERTAIN SWITCHES WHEN THE INSTRUMENT IS POWERED UP. THE SOFTWARE PROGRAM WILL ALLOW THE OPERATOR THE CAPABILITY OF SELECTING CERTAIN CONVENTIONAL REPORTING UNITS. IN SOME CASES, THE REPORTING IS BASED ON THE EXACT PHYSICAL TEST PARAMETERS, AND FOR OTHER OPTIONS, THE RESULTS ARE MATHEMATICALLY EXTRAPOLATED USING THE POISEUILLE-HAGEN FORMULAS. THESE FORMULAS YIELD SURPRISINGLY EXACT RESULTS WHEN THE STRUCTURE OF THE SHEET CREATES LAMINAR AIR FLOW. SOME GRADES, SUCH AS THIN, PINHOLED SHEETS ARE NOT ACCURATELY EXTRAPOLATED, AS TURBULENT FLOW OCCURS AT HIGHER TEST PRESSURES. WE WORK CLOSELY WITH EACH CUSTOMER TO RECOMMEND THE APPROPRIATE INSTRUMENT CONFIGURATION TO AVOID EXTRAPOLATION ERRORS.

********* EQUIVALENT GURLEY MODE *********

BOOT-UP MODE: Turn rear power switch ON with the Calibrate switch in the DOWN position.

PRESSURE / RANGE CONFIGURATION:

LOW PRESSURE 4.90" w.g. - EQUIVALENT OIL GURLEY SECONDS
57 ------------------------3%---------------------------9997

MEDIUM PRESSURE 12.33" w.g. - EQUIVALENT SECONDS PER 2.5 ml MERCURY
1.5 ---------3%-----------392-----------5%--------------980

HIGH PRESSURE 41.5" w.g. - EQUIVALENT SECONDS PER 2.5 ml MERCURY
RESULTS ARE EXTRAPOLATED - NORMALIZED TO GURLEY MERCURY READINGS

5 ----------3%-----------1378-----------5%--------------3415

********* ENGINEERING UNITS MODE *********

NOTE: This mode is primarily used for diagnostics (detailed calibration check-out, etc.)

BOOT-UP MODE: Turn rear power switch ON with the Calibrate switch in the UP position AND the Test pushbutton DEPRESSED. After 8888 appears, then move the Calibrate switch to the DOWN position for normal operation.

0.3------5%--------0.75--------3%----------200 ml/minute flow

NOTE: <--5%--> AND <--3%--> range limits refer to the accuracy levels (maximum deviation from actual) based as a percentage of the displayed reading.

SECTION 4

PREPARATION FOR USE

WARNING: THIS INSTRUMENT USES LINE VOLTAGE POWER SUPPLIES THAT OPERATE AT VOLTAGE LEVELS THAT CAN BE LETHAL. The instrument cabinet housing protects the operator from any exposed wiring connections, however, the following precautions must be observed:

* Use a 3-prong grounded outlet that is properly grounded.
* Use the grounded power cord supplied with the instrument.
* Use only the factory-supplied air compressor system for the measurement air supply.
* Only TRAINED, QUALIFIED TECHNICIANS should remove the instrument cabinet to service the internal electronic components. Refer to the maintenance section for further information.

1- UNPACKING AND INSPECTION

Unpack the instrument as follows:

a- Inspect the shipping container for any signs of damage. If any shipping damage is noted, please file a claim with the freight carrier, not with Hagerty Technologies. We will help determine, or how to assess damage, if we are contacted.

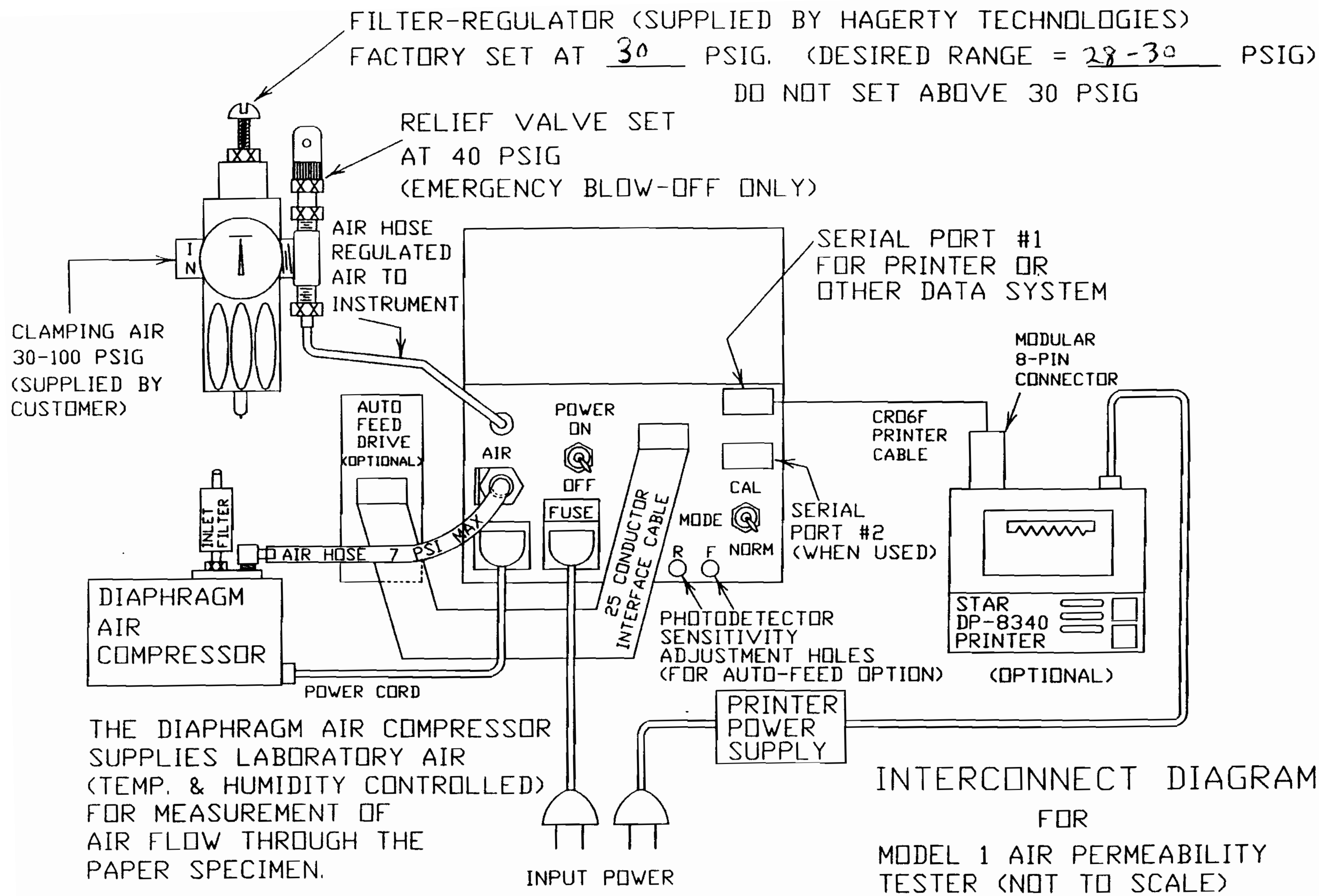
b- Move the instrument in its shipping container to the location where it is to be used. Make sure that the shipping container is right side up. If the instrument is cold when received, allow several hours for it to come up to room temperature before removing the plastic bag that it is sealed in. This is important because the cold surfaces will condense moisture in the air. A film of moisture on the circuit boards could cause problems due to short circuiting.

c- Remove all of the smaller packages until just the instrument remains. Grasp the instrument and lift it straight out.

d- Place the instrument on a flat, firm surface. Remove all packaging materials. Inspect the instrument thoroughly.

e- Check the received items against the packing list. If a shortage is noted, contact Hagerty Technologies immediately.

f- Save the packing material for possible reuse in shipment of the instrument. United Parcel Service (UPS) will ship packages that weigh less than 70 pounds. We designed the shipping crates so that the packaged weight, and crate dimensions conform to the UPS shipping guidelines for ground or air shipment. Also, the wood crate that we supply for shipping the instrument can withstand substantial abuse from shipping companies.



INTERCONNECT DIAGRAM
FOR
MODEL 1 AIR PERMEABILITY
TESTER (NOT TO SCALE)

2- POWER AND AIR COMPRESSOR CONNECTIONS

a- This instrument is designed to operate on a 120 vac, 60 Hz power supply; however, options for 220 vac, 50 Hz; or 240 vac, 50 Hz are available. The maximum power consumption is about 130 watts with the air compressor running, 10 watts on stand-by.

b- Make sure that the ON/OFF switch at the rear of the instrument is set to OFF (downwards), and that the "MODE" switch is set to NORMAL (downwards).

c- Connect the air compressor discharge tubing (quick-disconnect fitting) to the air fitting on the rear panel. Plug the power cord from the air compressor into the receptacle on the rear panel labeled "COMPRESSOR POWER". It is important to use the "COMPRESSOR POWER" outlet ONLY for the compressor SUPPLIED WITH THE INSTRUMENT, because the instrument must be the controlling factor in operating the compressor.

d- Connect the clamping air supply as shown in the reference drawings.

e- Connect the instrument to the ac power source using the power cord supplied. Make sure that the voltage rating of the power source is the same as the voltage rating of the instrument.

3- INTERFACE CONNECTIONS.

There are (3) D-25 Subminiature connectors that may appear on the rear panel plate. In the absence of these connectors, a cover plate may be installed over a machined opening, thus making future installation of options easier.

a- Serial Port 1: This port is connected to the RS-232 connector on the microprocessor board. It is the only port that has "handshaking" capabilities (X-ON, X-OFF) for interface to a serial printer. This port can be used to send data to a host computer. Refer to the section on RS-232 communications for more comprehensive information.

b- Serial Port 2: This port is for data output, one direction only, no handshaking capabilities. This port would be used to send information to a host computer. Also, this serial port could also be used to transmit test data to a serial line printer, but it would not be able to respond to printer alarms, such as paper feed or ribbon feed problems, or "off-line" commands.

c- Auto-Feed: This port is used to control the Auto-Feed system and to receive data from the digital switch that sets the spacing between the test zones. Do not attempt to use this port for any other use.

4- AUTO-FEED OPTION:

Attach the Auto-Feed drive mechanism. The drive mechanism is shipped with the eye-bolts inserted in the drive mechanism and held by shoulder cap screws.

a- Remove the socket head shoulder screws and screw the eye-bolts into the instrument base plate (right-hand side).

b- Turn the eye-bolts until the "O"-ring is slightly compressed and the eye-bolt faces are vertical, allowing the drive mechanism to move into place.

c- Slide the guide pin attached to the drive mechanism into the clearance hole that aligns it to the instrument baseplate. Insert the socket head shoulder screws into the holes of the drive mechanism baseplate, passing through the holes of the eye-bolts. Tighten the shoulder screws with moderate torque.

d- Adjust the leveling feet so that the instrument is level. It is not critical for this instrument to be perfectly level, other than for the Auto-Feed drive to load properly. When the instrument is used with the Auto-Feed system, three leveling feet are used on the main instrument, and one leveling foot is used on the drive unit.

e- Next adjust the leveling foot on the drive unit so it is approximately level. The Auto-Feed leveling foot should be adjusted to support the weight of the Auto-Feed only, and not support the main instrument base plate. The guide pin should not be heavily stressed.

f- Connect the Auto-Feed interface cable from the instrument to the drive unit. This is a 25 conductor ribbon cable that has D-25 male sub-miniature connectors on the ends. This cable is symmetric, so it makes no difference which end is connected to the instrument or to the drive unit.

g- Connect the printer to the instrument, as described elsewhere in this manual.

OPERATING INSTRUCTIONS

MODEL 1 INSTRUMENT WITHOUT AUTO-FEED OPTION

WARM-UP (RESET)

1. Turn calibrate mode switch to NORMAL (down); this is the small switch on the back panel. Turn the power switch ON (upwards); this is the large switch on the back panel. Refer to other information sheets that describe the "boot-up" sequence to obtain results in other reporting systems.

2. Turn the power switch ON (upwards); this is the large switch on the back panel.

3. During the 10 second warm-up, the display will run through the "8888" digit check and then display the barometric pressure at your location, referenced (corrected) to sea level pressure. A number such as 29.92 will appear if it is calibrated in inches of mercury; or a number such as 760 will appear if it is calibrated in millimeters of mercury.

4. When the WAIT lamp goes off, the unit is ready for testing.

TEST PROCEDURE

1. Press CLEAR MEMORY button at beginning of test series. The barometric pressure will be displayed for a short period of time.

2. Select the desired operating pressure, either LOW, MEDIUM, or HIGH. If a 9999 flashes rapidly on the display, it means that an improper pressure change was made; that is, a pressure change should be made ONLY after CLEAR MEMORY was pushed. This is an error trap to prevent the accumulation of test results in memory that were made under different test conditions. To clear the flashing display, return the pressure selection to its first setting, or press CLEAR MEMORY.

3. Insert the test specimen at opening at the base. The paper MUST cover the bottom rubber ring. The measuring rings are offset to the right-hand side of the instrument.

4. Press the TEST button. The WAIT light will go on. The test number flashes. When the WAIT light goes off, the test result is displayed.

NOTE: FLASHING MESSAGES

9998 OR BELOW RAPIDLY FLASHING means that measured value is outside of the recommended range of the instrument configuration. If the test value is too low, then "LOW" indicator lamp will flash - if too high, then the "HIGH" indicator lamp will flash. If the test specimen is within the range of another pressure setting, change to it. If you continue testing under the flashing condition, you may obtain meaningful test results, but they will not be at the highest accuracy.

5. For additional tests, advance the specimen to a new test zone and press the TEST button again.

STATISTICS REPORTING

1. Press the REPORT SELECT button until the desired report function lights up; i.e. AVERAGE, HIGH, LOW, or STANDARD DEVIATION. After you pass STANDARD DEVIATION, the number of tests will flash momentarily (number of tests used in statistics), then the last specimen test value will appear. For fewer than five tests, STANDARD DEVIATION will be reported as zero. After five tests, the STANDARD DEVIATION calculation is performed.

REJECTING BAD TESTS

1. Immediately after a test, pressing the REJECT button will reject the current test value. If the REPORT SELECT is in HIGH, the REJECT button will reject the highest value; if in LOW it will reject the lowest value in memory.

OPERATING INSTRUCTIONS

MODEL 1 INSTRUMENT WITH AUTO-FEED OPTION

WARM-UP (RESET)

1. Turn calibrate mode switch to NORMAL (down); this is the small switch on the back panel. Turn the power switch ON (upwards); this is the large switch on the back panel. Refer to other information sheets that describe the "boot-up" sequence to obtain results in other reporting systems.

2. Turn the power switch ON (upwards); this is the large switch on the back panel.

3. During the 10 second warm-up, the display will run through the "8888" digit check and then display the barometric pressure at your location, referenced (corrected) to sea level pressure. A number such as 29.92 will appear if it is calibrated in inches of mercury; or a number such as 760 will appear if it is calibrated in millimeters of mercury.

4. When the WAIT lamp goes off, the unit is ready for testing.

TEST PROCEDURE

USING THE AUTO-FEED SYSTEM AS A MANUAL INSTRUMENT:

1. Raise the Auto-Feed drive roller (using the thumb-wheel lifting screw) so that the drive roller is NOT NIPPED (i.e., the drive wheel is raised upwards). The green lamp on the drive unit cover should NOT BE ILLUMINATED.

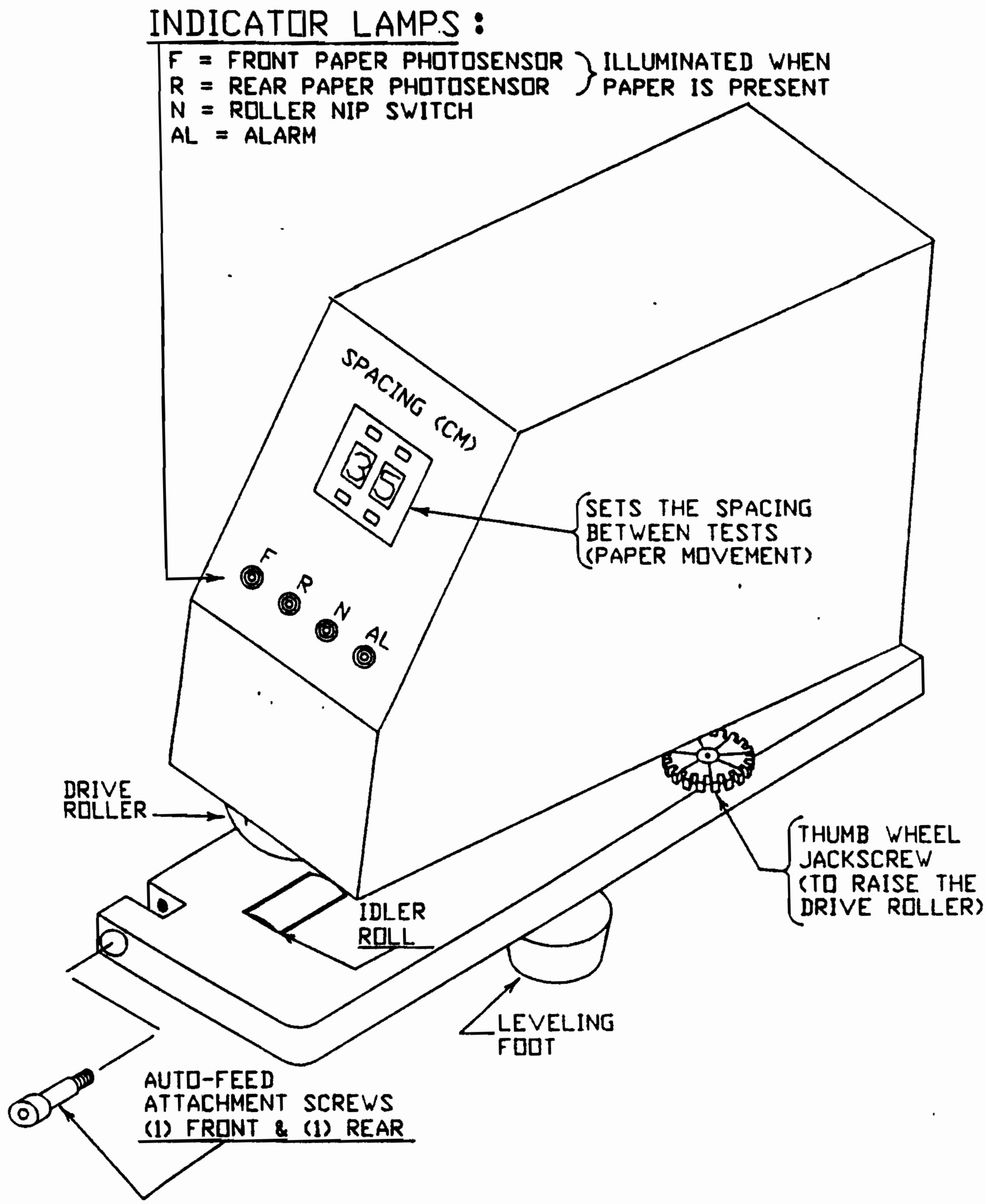
2. Press CLEAR MEMORY button at beginning of test series. If data was in memory, the wait lamp will be on and it may take a few moments to send information to the printer. If no printer is connected, the data transmission will still take place. On the software programs written for printers with print buffers, the transmission is faster. The barometric pressure will be displayed for a short period of time.

3. Select the desired operating pressure, either LOW, MEDIUM, or HIGH. If a 9999 flashes rapidly on the display, it means that an improper pressure change was made; that is, a pressure change should be made ONLY after CLEAR MEMORY was pushed. We feel that it is not proper to accumulate test results in memory that were made under different test conditions. To clear the flashing display, return the pressure selection to its first setting, or press CLEAR MEMORY.

4. Insert the paper specimen at opening at the base. The paper MUST cover the bottom rubber ring.

5. Press the TEST button. The WAIT light will go on. The test number flashes. When the WAIT light goes off, the test result is displayed.

AUTO-FEED DRIVE MECHANISM



NOTE: FLASHING MESSAGES

9998 OR BELOW RAPIDLY FLASHING means that measured value is outside of the recommended range of the instrument configuration. If the test value is too low, then "LOW" indicator lamp will flash - if too high, then the "HIGH" indicator lamp will flash. If the test specimen is within the range of another pressure setting, change to it. If you continue testing under the flashing condition, you may obtain meaningful test results, but they will not be at the highest accuracy.

6. For additional tests, advance the specimen to a new test zone and press the TEST button again.

STATISTICS REPORTING

1. Press the REPORT SELECT button until the desired report function lights up; i.e. AVERAGE, HIGH, LOW, or STANDARD DEVIATION. After you pass STANDARD DEVIATION, the number of tests will flash momentarily (number of tests used in statistics), then the last specimen test value will appear. For fewer than five tests, STANDARD DEVIATION will be reported as zero. After five tests, the STANDARD DEVIATION calculation is performed.

REJECTING BAD TESTS

1. Immediately after a test, pressing the REJECT button will reject the current test value. If the REPORT SELECT is in HIGH, the REJECT button will reject the highest value; if in LOW it will reject the lowest value in memory.

<u>USING THE AUTO-FEED SYSTEM AS AN AUTOMATIC INSTRUMENT:</u>

First, become familiar with the controls and indicator lamps associated with the Auto-Feed drive unit, as shown on the opposite page.

INDICATOR LAMPS:

F: This is the lamp that is "on" when paper is present in the path towards the FRONT side of the measuring head. (Photosensor device).

R: This is the lamp that is "on" when paper is present in the path towards the REAR side of the measuring head. (Photosensor device).

N: This lamp is "on" when the drive roller is NIPPED, or engaged against the lower idler roller. (This is a mechanical switch actuated by lowering the drive assembly onto a rod which protrudes upwards from the base plate).

AL: This lamp is "ON" when an alarm condition is encountered. A piezo beeper is also actuated during the first 10 seconds on an alarm condition. Both the lamp and the beeper will de-activate when the fault is corrected.

DIGITAL SELECTOR FOR TEST SPACING:

The digital selector switch sets the spacing between the test zones. It has a range from 00 to 99, where the units are in CENTIMETERS. When the switch is set at 00, the test spacing will be 100 centimeters; otherwise, the test spacing is exactly as indicated. Zero spacing would be meaningless in an auto-feed mode, because if the paper never advanced, the system would be running forever.

THUMBWHEEL JACKSCREW:

This is a mechanical lifting device that will keep the drive roller in a raised position. When the drive roller remains in a raised position, the Model 1 instrument behaves like a manual testing instrument, as if it was never equipped with the Auto-Feed system. This feature allows the operator to perform tests on single sheets or smaller sizes of paper that are too small to trigger the photosensors and reach the rubber roller feed mechanism. The NIP-UP lamp "N" will be OFF when the drive roller is raised.

RUNNING TESTS IN THE AUTO-FEED MODE:

a- The POWER switch on the rear panel should be ON (upwards position). There is a 10 second warm-up period after this switch is turned ON. This power switch is also used to RESET the system in the event of a suspected malfunction, such as those that would be caused by power interruptions.

b- Press the CLEAR MEMORY switch on the instrument panel. This will ensure that there is no data in memory. Select the desired PRESSURE setting for the test.

c- The MODE switch on the rear panel should be in the "NORMAL" position (downwards). If it is in the "CALIBRATE" (upwards) position, the instrument will not be ready to test paper.

d- Check to see that the printer is powered-up and set to be "on-line". The printer paper should be set at "top-of-sheet".

e- The direction of paper movement is from left to right. Insert a strip of paper through the test instrument and nip-up the leading edge in the rubber roller (the thumbwheel jackscrew must be in a lowered position). At this point, you should see all three GREEN lights turned ON (referring to Figure 6). That means that there is paper on both sides of the measuring head, and that the rubber roller is properly nipped. If you do not see all three green lights turned on, do not proceed further until this condition is satisfied.

f- Next, set the desired test spacing. The digital selector sets the spacing between test zones.

g- Press the TEST pushbutton. The air compressor will start, and the first test will be performed where the paper is first set in place. A flashing number on the display indicates the test in process (i.e., a flashing "1" indicates the first test). After the completion of the first test, the test value will be displayed for that zone. Next, the Auto-Feed system will advance the paper to a new test position, and the next test will be performed. This procedure will repeat itself as long as the three green lamps on the Auto-Feed unit are turned ON. After each test, the system monitors the conditions of the three green lamps and behaves as follows:

CONDITION	INDICATOR LAMP "F"	"R"	"N"	NOTES
1	ON	ON	ON	AUTO TESTING WILL RESUME
2	OFF	OFF	ON	END OF TEST SHEET, PRINT REPORT
3	OFF	ON	ON	ALARM; STRAIGHTEN PAPER PATH, PRESS
4	ON	OFF	ON	TEST BUTTON TO RESUME AUTO TESTING
5 RESUME	ON	ON	OFF	ENGAGE NIP OF DRIVE UNIT, PRESS TEST TO AUTO TESTING.

h- When CONDITION 2 is reached, the printer will automatically print a profile report. If the operator detects bad data points (for valid reasons, such as torn paper, severe creases, etc.) he can obtain a second printed profile display, excluding any number of the highest or lowest test values. This can be accomplished by understanding the following functions:

STATISTICS REPORTING:

Press the REPORT SELECT button until the desired report function lights up; i.e. AVERAGE, HIGH, LOW, or STANDARD DEVIATION. After you pass STANDARD DEVIATION, the number of tests will flash momentarily (number of tests used in statistics), then the last specimen test value will appear. For fewer than five tests, STANDARD DEVIATION will be reported as zero. After five tests, the STANDARD DEVIATION calculation is performed. Flashing test values, accompanied by a flashing HIGH or LOW indicator, means that the value displayed is not within the optimum range of the test instrument.

REJECTING BAD TESTS:

If the REPORT SELECT is in HIGH, the REJECT button will reject the highest value; if in LOW it will reject the lowest value in memory. After a value is rejected, the next value in the REPORT SELECT category will be displayed. Pressing the REJECT button again will reject that value, also. This rejection process can continue until all values in memory are rejected.

OBTAINING A SECOND, EDITED PRINTOUT:

After the operator is satisfied with the edited results, a second printout is generated when the CLEAR MEMORY button is pushed. If there was no rejection of data, pressing the CLEAR MEMORY button will just clear the memory without generating a second (redundant) report. It is important for an operator to get into the habit of clearing the memory after each strip is tested so that the next operator will not accidentally test a new strip with old data in the memory. If a "1" does not flash at the beginning of each new test strip, it means that the memory was not clear and that old data will appear on the upcoming printout, merged with the current data.

PRINTOUT SYMBOLS:

A question mark (?) that appears on the printout means that the value graphed is not within the optimum high-accuracy range of the instrument.

PRINTER REPORTS

If your system uses a printer with no autofeed, these instructions apply:

1. The printer interface cable must be plugged into SERIAL PORT 1 and the printer must be turned on.

2. The printer has indicator lamps for POWER and ON-LINE. The ALARM indicator must not be illuminated, or the system will not operate. Refer to the Printer manual if further details are needed.

3. Press CLEAR MEMORY button at beginning of test series. If data was in memory, the wait lamp will be on and it may take a few moments to send information to the printer. If no printer is connected, the data transmission will still take place. On the software programs written for printers with print buffers, the transmission is faster.

4. TEST the paper samples. The test values will be stored in memory, and the data will be printed upon pressing the CLEAR MEMORY button. If you wish to edit the data (i.e., reject any high or low values, that must be done prior to pressing the clear memory button. Immediately after a test, pressing the REJECT button will reject the current test value. If the REPORT SELECT is in HIGH, the REJECT button will reject the highest value; if in LOW it will reject the lowest value in memory.

5. If the Model 1 appears to be "HUNG-UP", it may be that the printer has an alarm message, such as running out of paper. The printer can send a message back to the Model 1 to suspend further activities until the error is cleared. If a printer ever malfunctions, try removing the printer cable and resetting the Model 1 by turning the power off, then back on again.

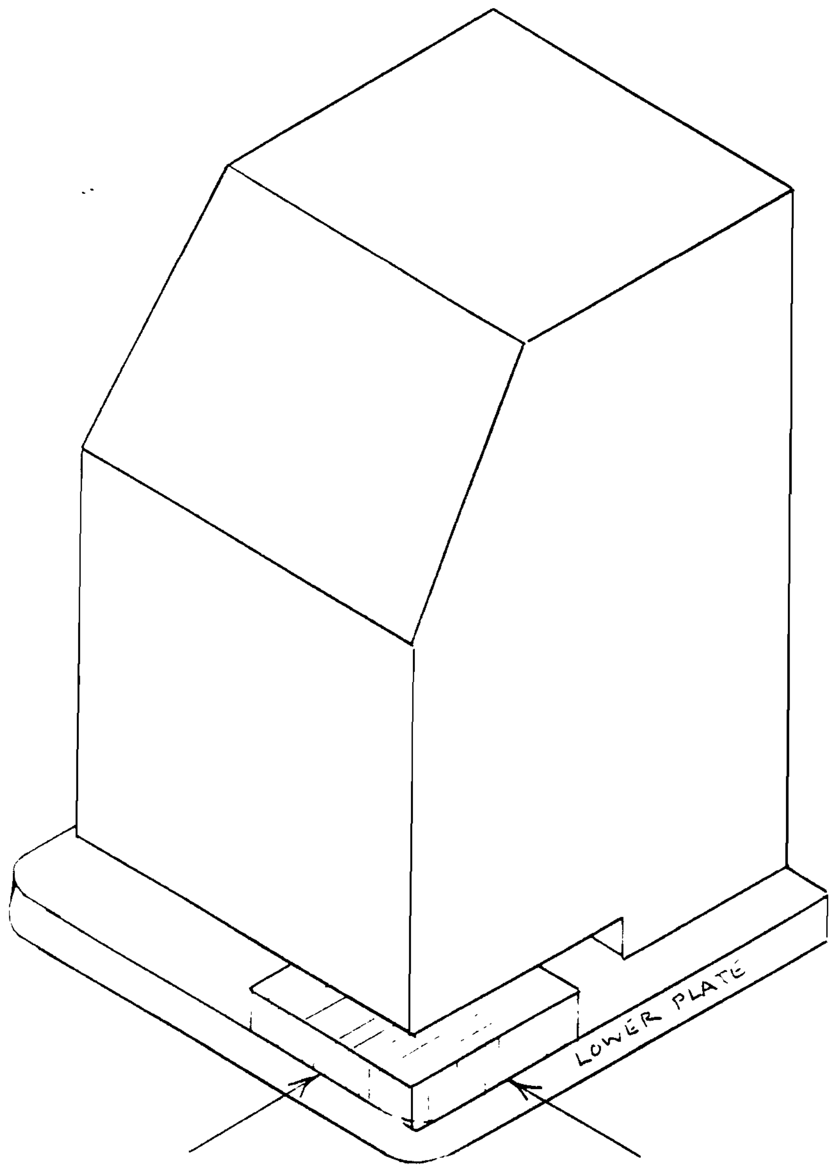
SECTION 7
CALIBRATION

CALIBRATION CHECKS:

Included with the instrument is a test plate that has stable flow restrictors that will allow the operator means to check the instrument at various flow values, by using various pressures. Insert the test plate into the measuring slot so that the front edge of the test plate is even with the front edge of the bottom flange plate of the instrument. Also align the right-hand edge of the test plate such that the side edge of the test plate is even with the right-hand side of the bottom flange plate of the instrument. With the Auto-Feed attachment, this will be the "gap" between the Auto-Feed and the instrument baseplate. There is a number stamped on the calibration plate that is visible in the right-hand corner when the plate is properly in place. That number corresponds to the restrictor identification number of the restrictor.

To check the reading, first set the PRESSURE setting to LOW. Set the CALIBRATION switch (the smaller one on the rear panel) upwards, to the calibrate position. After a few readings, the flow value should stabilize. Record the reading and then increase the pressure to MEDIUM, take readings; and then increase the pressure to HIGH, and record those readings. Compare the readings to the factory values and determine if the system is reading properly. Keep a log sheet of how they compare, and also record the displayed barometric pressure. Some of the values will flash, indicating that they are out of range, but record them anyway.

MODEL 1 AIR PERMEABILITY TESTER - CALIBRATION



A calibration plate containing three circular disks (laminar flow elements) is supplied with the instrument. To check the calibration, insert the calibration plate as shown in the above diagram. The plate must be placed so the edges line up with the front and side edges of the BOTTOM PLATE edges, as shown by the above arrows. Notice that you can rotate the plate to align the various restrictors under the clamping rings, including the undrilled portion which can be used to check for zero flow.

SECTION 8
MAINTENANCE

CLEANING THE MEASURING HEADS - RUBBER RINGS

1. Turn the power switch to OFF and unplug the power cord. (This prevents accidental nip-up).

2. Shine the beam of a flashlight, or other light source, through the measuring head slot.

3. Observe the cleanliness of the rubber ring surfaces. If there is some contamination on the surfaces, use a solvent such as alcohol, saturating a cotton swab, to clean the surfaces. If the surfaces are cracked, or not seating properly, replace them.

POWER SUPPLY VOLTAGE SETTINGS

Refer to the wiring diagram on page 9.15, and the information on page 9.14. The connections on the power supply can easily be identified by the color codes of the wires soldered to the output pins. First check the voltage outputs to see if adjustments are necessary. A small diameter probe can be inserted into the connector shell to pick up a voltage at the contact. Connect the voltmeter common lead to the Grounding "lug" located at the base of the power supply.

There are recommended techniques for disconnecting the low voltage power connectors BEFORE making adjustments so that the circuits will not be subjected to accidental over-voltages that could occur during adjustments. If adjustments are necessary, follow the procedures outlined below:

1. Turn the main power switch off and disconnect all of the power connectors from the circuit boards.

2. Turn the main power switch to the ON position and perform the following adjustments:

5 VOLT SUPPLY (Red wire):

RANGE: 5.100 to 5.200 volts.

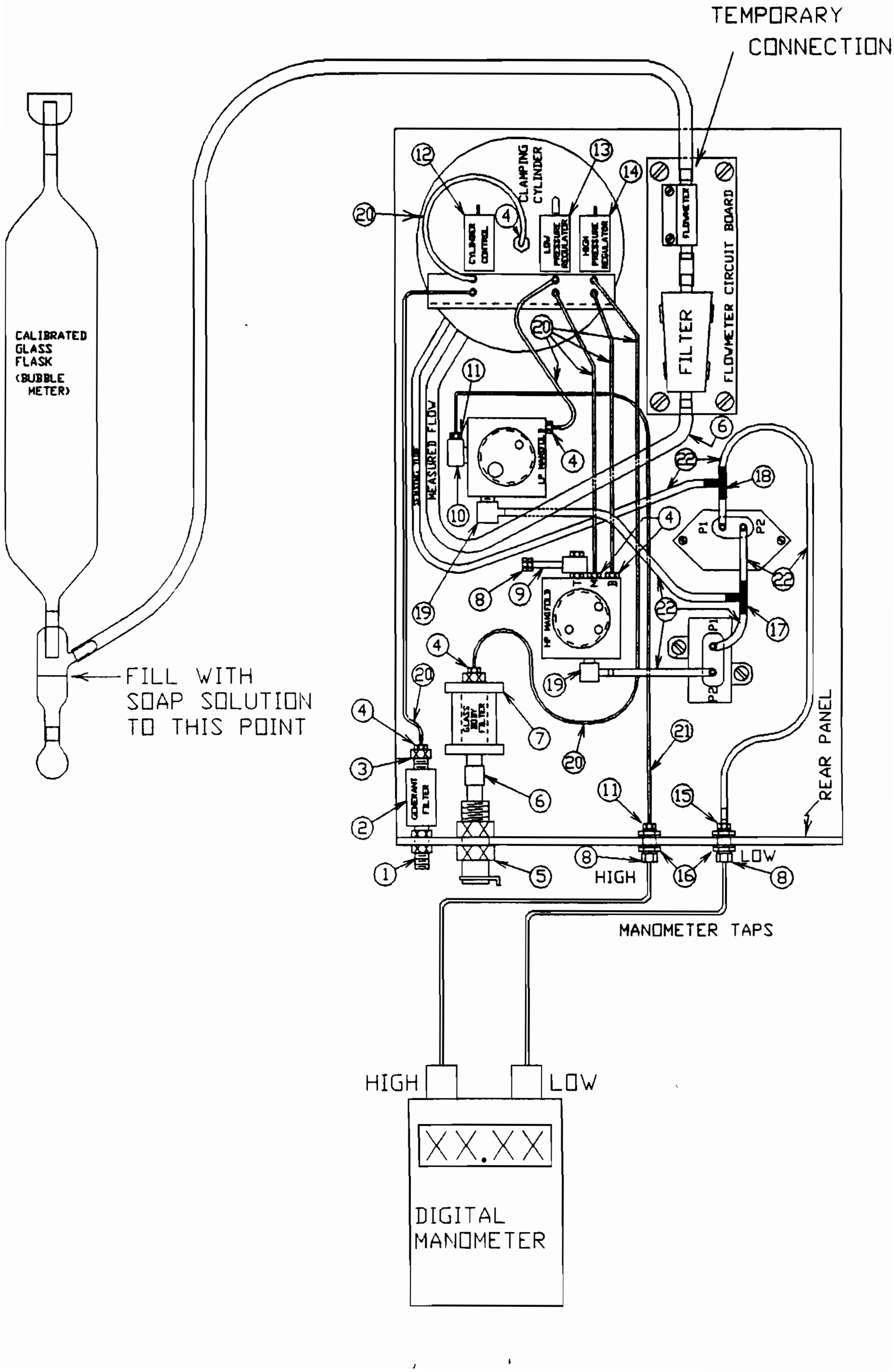
********* CAUTION - MAXIMUM VOLTAGE: 5.200 volts *********

+ 15 VOLT SUPPLY (Yellow wire):

The voltage should be adjusted to the range of +14.9 to +15.1 volts by turning the +12V POT.

- 5 VOLT SUPPLY (Orange wire):

The voltage should be adjusted to the range of -3.5 to -4.0 volts by turning the -12V POT. There is a special jumper on the power supply that changes the normal - 12 volt output to a lower range.


TEMPORARY CONNECTION
CALIBRATED GLASS FLASK (BUBBLE METER)
FILL WITH SOAP SOLUTION TO THIS POINT
CLAMPING CYLINDER
CYLINDER CONTROL
LOW PRESSURE REGULATOR
HIGH PRESSURE REGULATOR
FLOWMETER
FILTER
FLOWMETER CIRCUIT BOARD
MEASURED FLOW
SENSING TUBE
LP MANIFOLD
HP MANIFOLD
GLASS BODY FILTER
GENERANT FILTER
P1
P2
REAR PANEL
HIGH
LOW
MANOMETER TAPS
XX.XX
DIGITAL MANOMETER

+12 VOLT SUPPLY (White/Blue tracer wire):

This voltage is not adjustable. It is fixed by the LM340KC-12 voltage regulator IC. An acceptable range is 11.8 to 12.2 volts.

3. Turn the power switch OFF. Reconnect all low voltage power connectors. Turn the power switch back to the ON position and check the output voltages UNDER THE RUNNING LOAD. There should be no significant change from the UNLOADED vs. LOADED conditions.

AIR PRESSURE ADJUSTMENTS

Take the time to become familiar with the TUBING / PIPING DIAGRAMS on pages 9.12 and 9.13; and the MOTHERBOARD INTERFACE/ ADJUSTMENTS drawings on pages 9.18 and 9.19. They will be of great assistance in understanding the maintenance procedures outlined in this section.

NOTE: The opposite page shows the proper manometer connections. A soap-film bubble meter can be used in conjunction with the digital manometer, if one is available. On those systems equipped with a solenoid valve on the discharge of the flowmeter, connect the soap-film bubble meter to the outlet port (center port) of the valve.

CAUTION: When using a digital manometer, be sure that it has the accuracy, sensitivity, and resolution necessary to perform the adjustments. If you make changes and desire to go back to the factory settings, refer to page 9.18 for the test pin locations and refer to the pre-shipment adjustment measurements.

1- Connect a digital manometer to the MANOMETER PORTS located on the rear panel, observing the location of the HIGH pressure port and the LOW pressure port. The manometer should be a differential manometer. The maximum pressure of either port should not exceed 2 psig, so a very sensitive digital manometer can be used.

2- Insert the appropriate calibration plate restrictor that creates an air flow that is in the working range of the pressure setting, starting with the LOW pressure setting. Set the instrument in the CALIBRATE mode.

3- Check the manometer reading and compare it the the specified value. When the system is set in the LOW pressure mode, POT 1 on the mother board will be active, and adjustments can be made, as guided by the digital manometer.

4- Switch the instrument out of the CALIBRATE mode and return to STEP 2 above; this time using the appropriate restrictor for the MEDIUM pressure. Now, POT 2 on the mother board will be active, and adjustments can be made, as guided by the digital manometer.

5- Finally, return to STEP 2, and use the appropriate restrictor for the HIGH pressure. Now, POT 3 on the mother board will be active, and adjustments can be made, as guided by the digital manometer.

AIR FILTER MAINTENANCE

Installed at the inlet of the air compressor is a combination air filter / noise silencer (this is ITEM 8 on Page 9.24). The service life of this filter depends upon the duty cycle of the air compressor and the amount of dust that is present in the environment when the compressor is running. An obvious sign of filter plugging is insufficient high pressure air pressure when air is flowing through the flow restrictor. This filter can be replaced simply by unscrewing the old one and screwing on a new one.

AIR COMPRESSOR MAINTENANCE

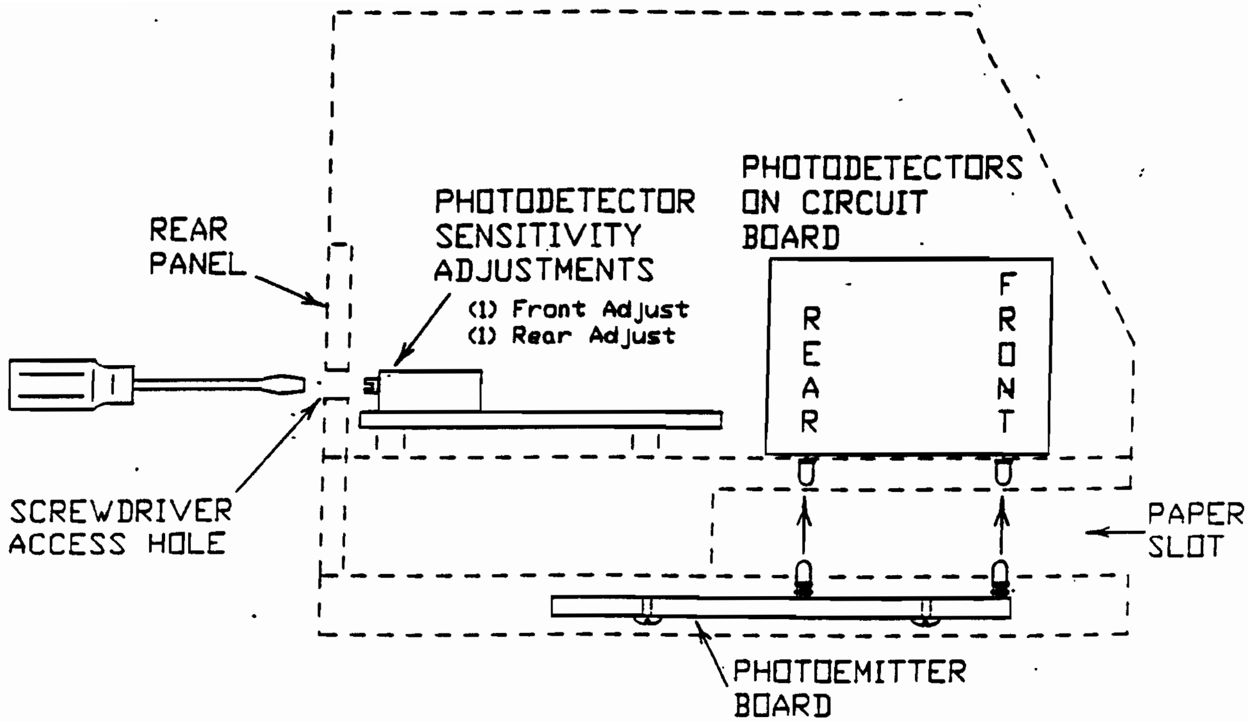
The service bulletin concerning the air compressor is included in the APPENDIX. Replacement parts (diaphragm and valve plate service kits) are avaliable for the air compressor (see Page 9.14).

CALIBRATION PLATE RESTRICTORS

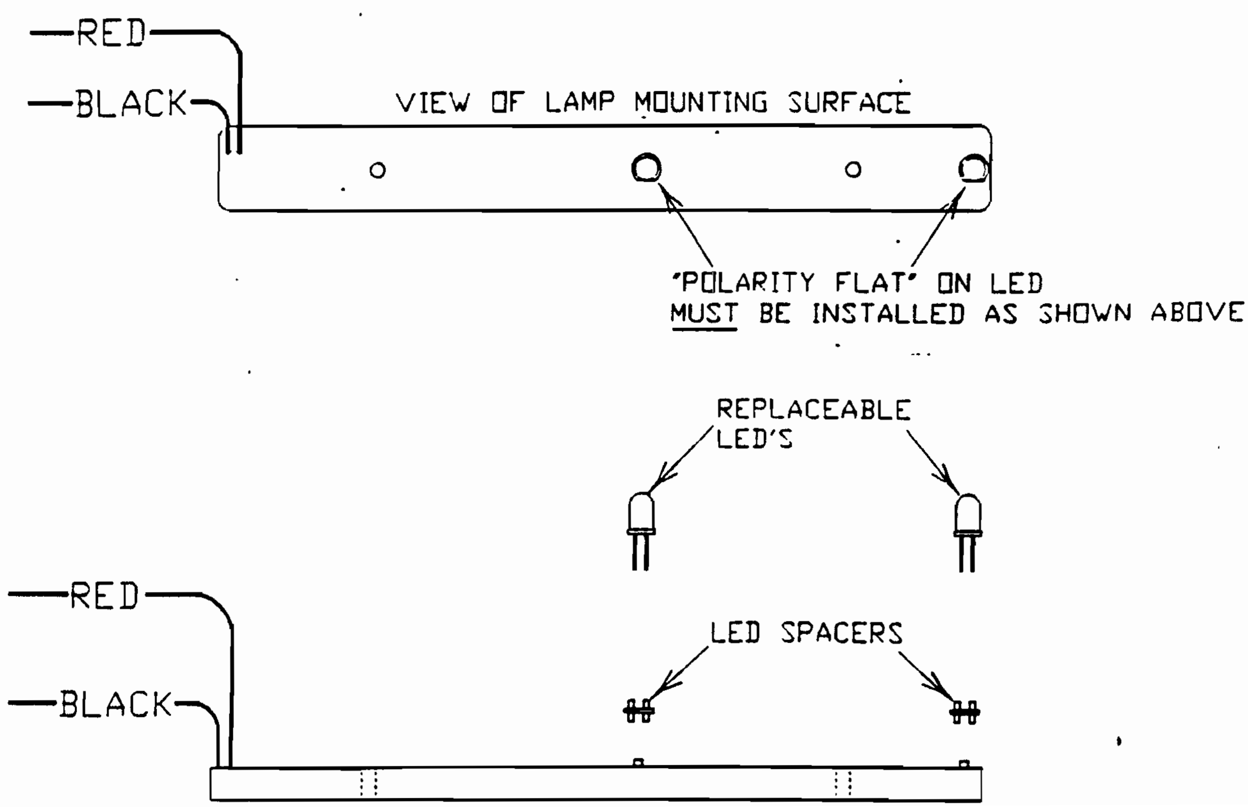
The calibration bleed restrictors are made from a sintered stainless steel media. The air flow that passes through the restrictors is laminar flow, and the Poiseuille-Hagen formulas apply. They serve as a very stable "transfer standard" to measure air flow, provided that they are clean. We have no cleaning techniques, other than to use dry compressed air to blow off surface dust. If they ever become wet, with substances like oil or coffee, they will probably change in characteristics from the factory calibration values. Replacement plates with transfer values are the only solution to a contamination problem.

AUTO-FEED SYSTEM PAPER SENSORS

The AUTO-FEED system uses photo-optic sensors to detect whether paper is present to the front and rear of the measuring head. Periodically, it may be necessary to clean out the accumulated paper dust from the bottom LED light source transmitter. In order to expose the light path holes, simply tip the instrument on its side (power turned off) and remove the two screws that hold the circuit board to the bottom main plate. Swing the light source board away from the holes and blow the dust out of the cavitys. Replace the light bar and the screws.



PHOTODETECTOR SYSTEM
TRANSMISSION - TYPE



PHOTODETECTOR SENSITIVITY ADJUSTMENTS:
(for all transmission-type systems)

Locate the PHOTODETECTOR SENSITIVITY ADJUSTMENTS area on the back (rear) panel of the instrument. The FRONT and REAR designations on the back panel correspond to the sensitivity settings that activate the two green lamps on the AUTO-FEED cabinet, marked "F" and "R", respectively. Use the rear panel adjustments in conjunction with the indicator lamps as follows:

PAPER PRESENT in the PAPER SLOT:

Select a lightweight grade of paper (lowest opacity tested) and insert it deeply into the paper slot.

Find adjustment setting at which the indicator lamp goes from ON to OFF. (Do this for BOTH the F and R lamps).

If the lamp is ON, adjust the potentiometer in the counterclockwise direction. If the lamp is OFF, adjust the potentiometer in the clockwise direction. This will be the starting point for the next step.

NO PAPER PRESENT in the PAPER SLOT:

Remove the paper from the instrument paper slot. If an indicator lamp remains ON at this time, replace the appropriate emitter on the bottom-mounted photoemitter board., and repeat the previous steps.

Starting at the "trip-point", count the number of clockwise turns on each potentiometer required to make each indicator lamp go from OFF to ON. Record this information on each adjustment for the final step.

If the number of complete turns for either sensor is less than two, replace the appropriate emitter and return to the beginning steps on this page.

MAKING THE FINAL ADJUSTMENT:

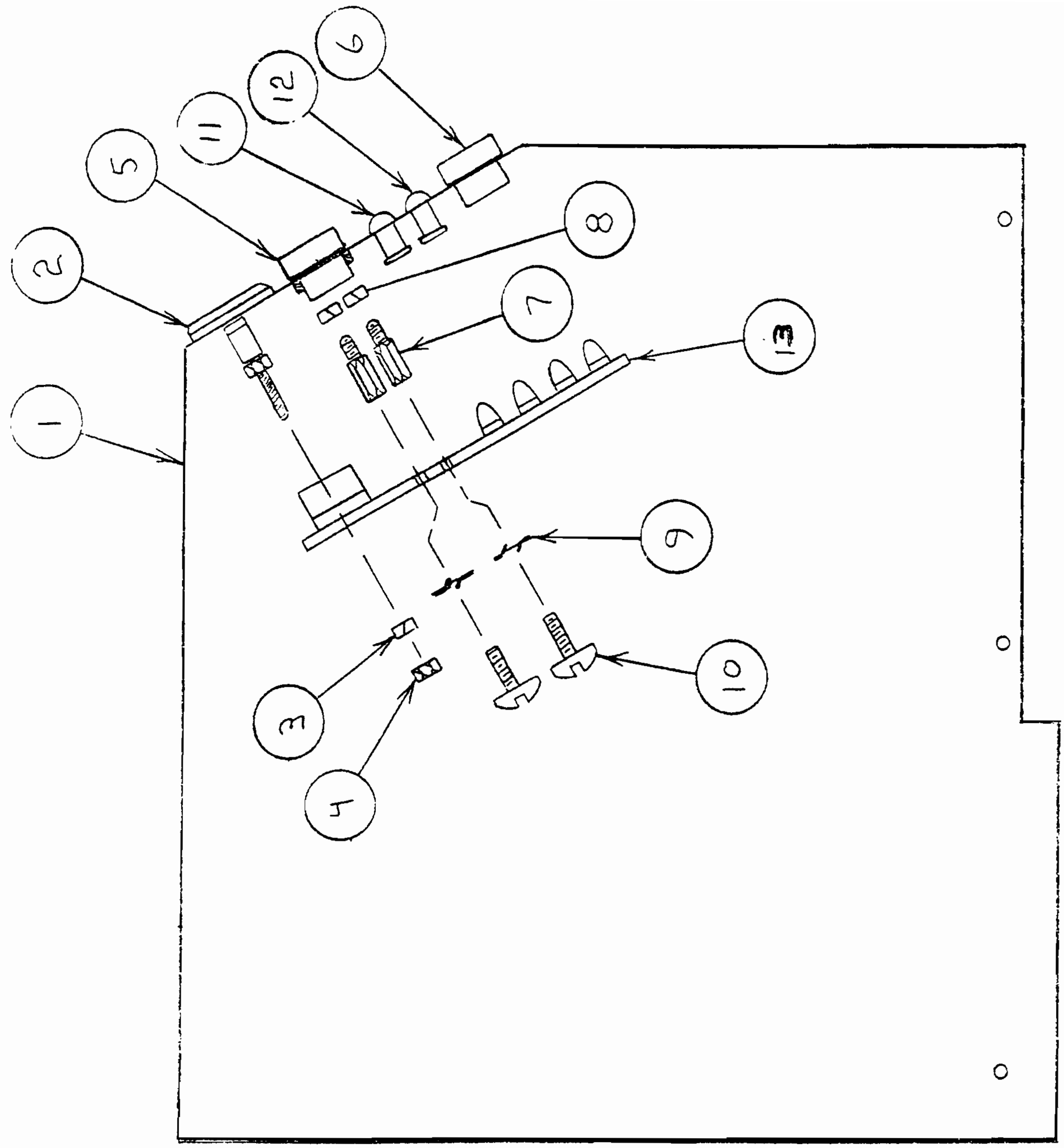
For EACH sensor, adjust the potentiometer in the counterclockwise direction, ONE-HALF the number of turns made in the previous step. The sensitivity adjustment of the two sensors should now be set at the mid-point between the "paper-in" and "paper-out" transition points.

SECTION 9

DRAWINGS FOR PARTS AND MAINTENANCE

PARTS LIST - CABINET HOUSING ASSEMBLY

ITEM	QTY	PART NO.	DESCRIPTION
1	1	M1-100	CABINET HOUSING
2	1	538-101	DISPLAY BEZEL, RED FILTER
3	2	538-451	LOCKWASHER, 4-40, SPLIT-TYPE
4	2	538-462	NUT, 4-40, CAD. PLATED STEEL
5	2	538-102	SWITCH, PUSHBUTTON, RED MEMBRANE
6	3	538-103	SWITCH, PUSHBUTTON, GREEN MEMBRANE
7	10	538-104	STANDOFF, 4-40, 3/16" HEX, 3/16" LONG
8	10	538-451	LOCKWASHER, 4-40, SPLIT-TYPE
9	10	538-463	LOCKWASHER, 4-40, INTERNAL TOOTH, SS
10	10	538-414	SLOTTED RD. HD. SCREW, 4-40 x 3/16", BRASS
11	6	538-105	LENS FOR LED LAMP, GREEN
12	1	538-106	LENS FOR LED LAMP, RED
13	1	M1-019	PANEL PC BOARD, FULLY POPULATED & TESTED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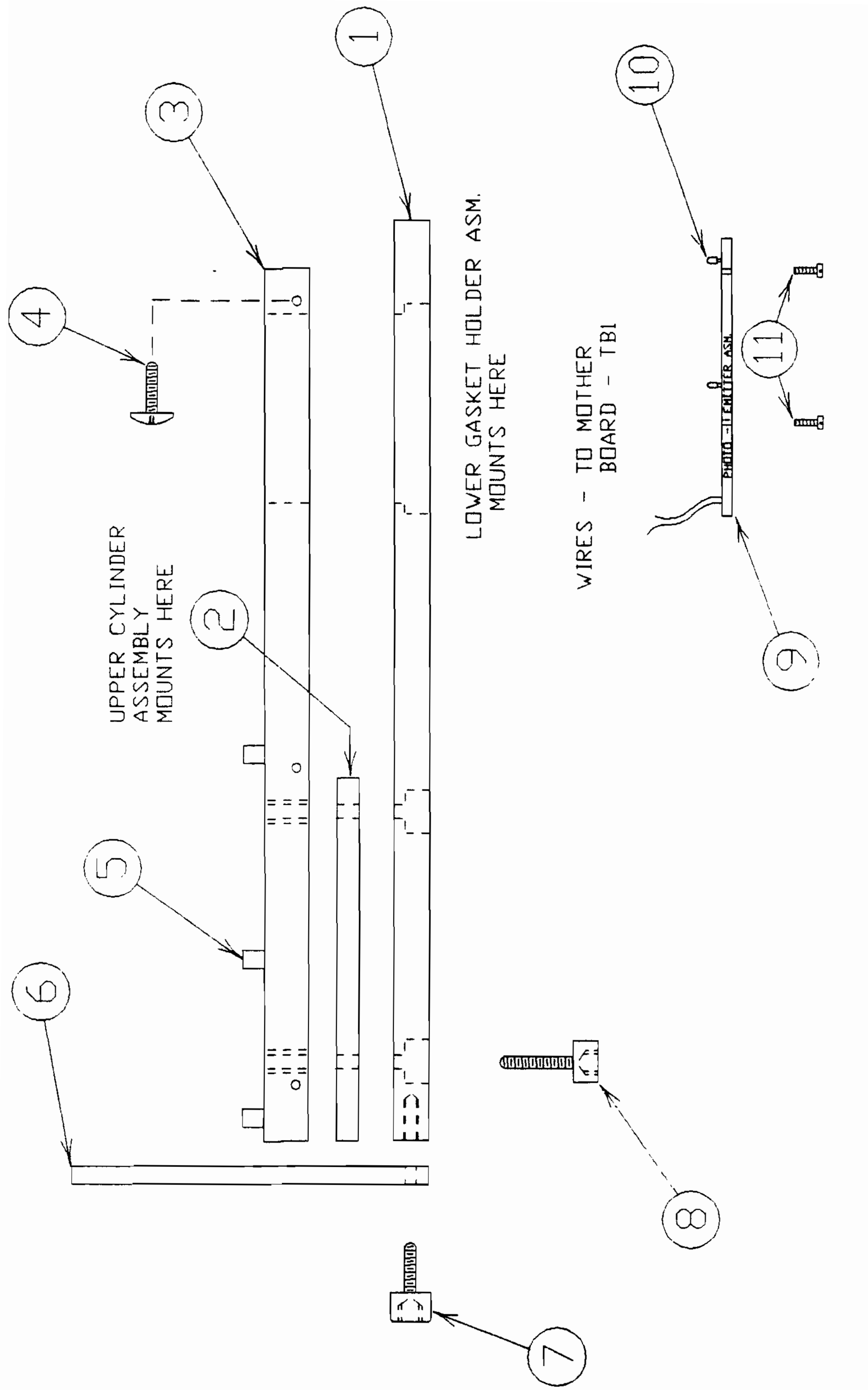
PARTS LIST - MAIN INSTRUMENT FRAME ASSEMBLY

ITEM	QTY	PART NO.	DESCRIPTION
1	1	M1-200	BASE PLATE - 12 5/8" x 10 1/4" x 1/2"
2	1	M1-212	SPACER PLATE - 6" x 9" x .313"
3	1	M1-214	MAIN COMPONENT MOUNTING PLATE 9"x12"x 5/8"
4	6	538-406	BUTTON HD. SCREW, 6-32 x 3/8" LONG, COATED
5	9	538-239	PEMSERTS, 4-40 x 3/8" LONG
6	1	M1-227	POWER ENTRANCE PLATE - REAR PANEL
7	2	538-411	SOC. HD. CAP SCREW- 10-32 x 5/8" LONG
8	8	M1-412	SOC. HD. CAP SCREW- 1/4-20 x 1 1/4" LONG
		NOTE: WHEN TRANSMISSION PHOTOSENSORS ARE USED, ITEMS 9 & 10 ARE:	
9	1	M1-970A	PHOTOEMITTER BOARD; TRANSMISSION-TYPE
10	2	M1-970A1	REPLACEMENT PHOTOEMITTER IR-LED
		NOTE: WHEN REFLECTIVE PHOTOSENSORS ARE USED, ITEMS 9 & 10 ARE:	
9	1	M1-970B	PHOTOEMITTER/RECEIVER BOARD; REFLECTIVE-TYPE
10	2	M1-970B1	REPLACEMENT PHOTOEMITTER/RECEIVER IR SENSOR
11	2	M1-420	SLOTTED HEAD MACHINE SCREW; 4-40 X 1/2" LONG
12	3	538-240	RUBBER FEET - 5/16-24 STUD
13	3	538-461	JAM NUT - 5/16-24


UPPER CYLINDER ASSEMBLY MOUNTS HERE
LOWER GASKET HOLDER ASM. MOUNTS HERE
WIRES - TO MOTHER BOARD - TB1
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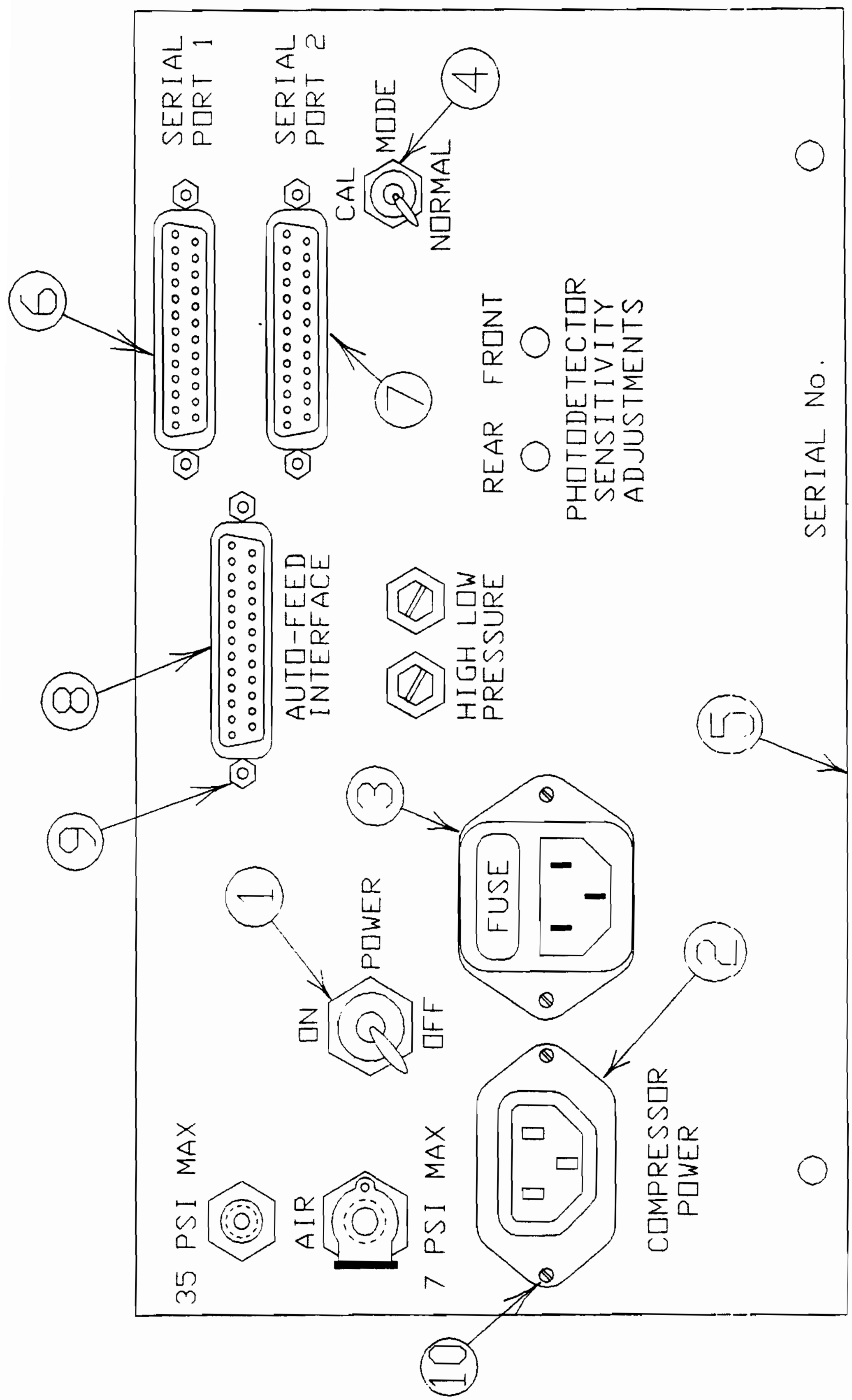
PARTS LIST - COMPONENTS ON POWER ENTRANCE PLATE / REAR PANEL

ITEM	QTY	PART NO.	DESCRIPTION
1	1	538-709	SWITCH, SPST; 120 VAC, 6 AMP; 240 VAC, 3 AMP
2	1	538-708	SOCKET, POWER OUTPUT
3	1	538-706	POWER RECEPTACLE WITH FUSE HOLDER
	NOTE: FOR 120 VAC, 50/60 HZ; USE A 5-AMP FUSE		
		538-707	FUSE- 5 AMP, 120VAC, 5 mm dia. x 20 mm
	NOTE: FOR 220-240 VAC, 50/60 HZ; USE A 2.5 AMP FUSE		
		538-707A	FUSE- 2.5 AMP, 220-240 VAC, 5 mm dia. x 20 mm
4	1	538-710	SWITCH, SPST
5	1	M1-227	REAR PANEL PLATE 5" X 9" X 1/4"
6	1	M1-653	SERIAL PORT CONNECTOR: D-25 MALE EACH END
7	1	M1-654	SERIAL PORT CONNECTOR: D-25 MALE; 2 x 10 SOCKET POLARIZED FOR CONNECTION TO MICROPROCESSOR BOARD
8	1	M1-655	AUTO-FEED INTERFACE - INTERNAL CABLE ASSEMBLY D-25 FEMALE EACH END
9	6	538-104A	HEX STANDOFF, 4-40, 5/16" LONG, PLATED STEEL
	NOTE: TO ATTACH ITEMS 2 & 3 TO THE PANEL, THE FOLLOWING ARE USED:		
10	4	538-413	SLOTTED FLAT HD. SCREW, 4-40 x 3/8" LONG



SERIAL PORT 1
SERIAL PORT 2
CAL
MODE
NORMAL
REAR
FRONT
PHOTODETECTOR SENSITIVITY ADJUSTMENTS
SERIAL No.
AUTO-FEED INTERFACE
HIGH LOW PRESSURE
FUSE
ON
POWER
OFF
35 PSI MAX
AIR
7 PSI MAX
COMPRESSOR POWER
1
2
3
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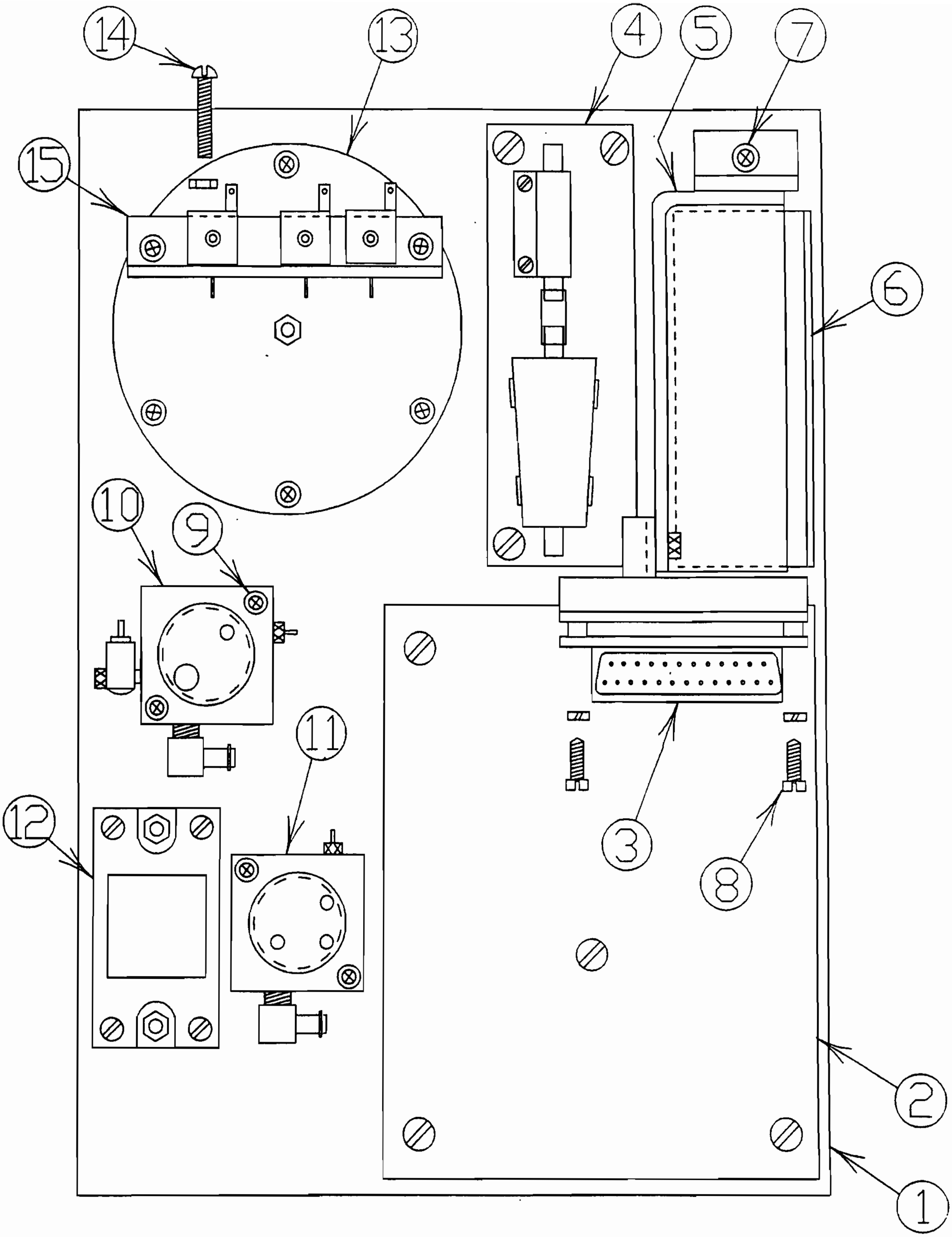
PARTS LIST - PRIMARY COMPONENTS ASSEMBLY

ITEM	QTY	PART NO.	DESCRIPTION
1	1	M1-214	MAIN MOUNTING PLATE
2	1	M1-011	MOTHER BOARD-COMPLETE
3	1	M1-012	MICROPROCESSOR BOARD
4	1	M1-013	MASS FLOWMETER CIRCUIT BOARD (AIR FLOW)
5	1	M1-016	POWER SUPPLY 5V,-5V,+12V,+15V W/HARNESS
6	1	538-229	SAFETY SHIELD- TRANSFORMER PRIMARY WIRING
7	2	M1-413	SOC. HD. CAP SCREW 8-32 x 5/8" LONG
8	2	538-405	SLOTTED HD. MACH. SCREW, 4-40 x 1/4" LONG
	2	538-451	LOCKWASHER, # 4, SPLIT-TYPE
9	4	538-400	SOC. HD. CAP SCREW 8-32 x 1.5" LONG
10	1	M1-226	LOW PRESSURE ACCUMULATOR MANIFOLD
	1	538-230	ACCUMULATOR TANK - 360 ml VOLUME
	1	538-231	"O"-RING SEAL FOR ACCUMULATOR TANK
11	1	M1-225	HIGH PRESSURE ACCUMULATOR MANIFOLD
	1	M1-230	ACCUMULATOR TANK - 180 ml VOLUME
	1	538-231	"O"-RING SEAL FOR ACCUMULATOR TANK
12	1	538-701	SOLID STATE RELAY, 120 VAC OUT, 5 VDC IN
			NOTE: FOR 220-240 VAC, 50-60 HZ; USE:
	1	538-701A	SOLID STATE RELAY, 240 VAC OUT, 5 VDC IN
			NOT SHOWN: THE FOLLOWING PARTS ARE FASTEN TO, AND MOUNT ABOVE THE RELAY:
	1	538-232	PLASTIC SAFETY SHIELD FOR SS RELAY WIRING
	1	538-233	MOUNTING CLIP FOR AIR FILTER
	1	538-406	BUTTON HD. SCREW, 6-32 x 3/8" LONG, COATED
	1	538-454	LOCK NUT W/ NYLON INSERT, 6-32
	2	538-234	STANDOFF, 8-32, 3/8" HEX, 1" LONG
13	1	M1-300	CYLINDER ASSEMBLY
14	6	538-404	SLOTTED HD. MACH. SCREW, 4-40 x 3/4" LONG
	6	538-451	LOCKWASHER, # 4, SPLIT-TYPE
15	1	538-328	SOLENOID VALVE MOUNTING BRACKET



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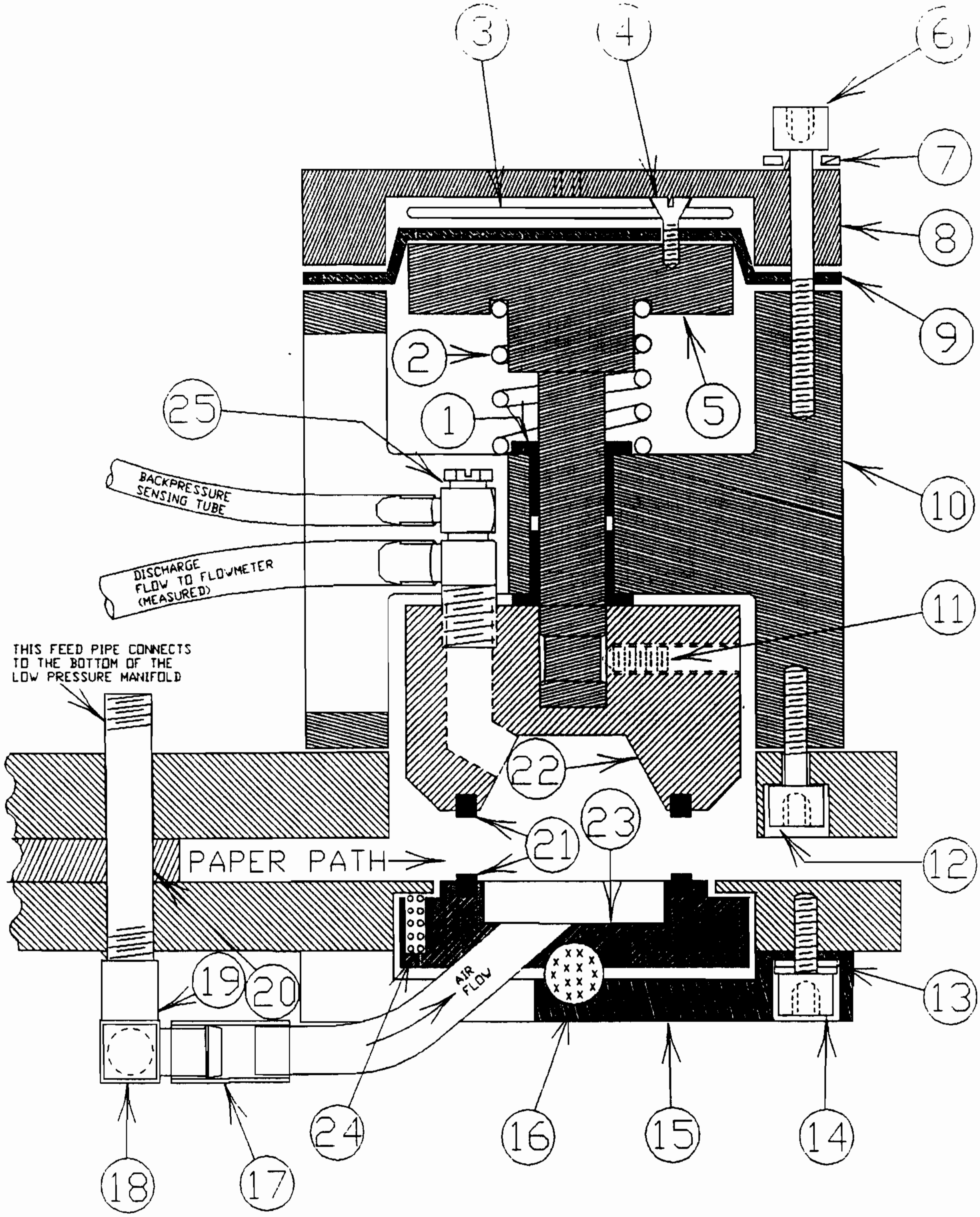
PARTS LIST - MEASURING HEAD CYLINDER ASSEMBLY

ITEM	QTY	PART NO.	DESCRIPTION
1	2	538-331	PLASTIC GUIDE BUSHING; 1/2" I.D.
2	1	538-330	COMPRESSION SPRING
3	1	538-310	PISTON CAP
4	4	M1-414	SLOTTED FLAT HD. MACH. SCREW, 8-32 x 3/8"
5	1	M1-309	PISTON ASSEMBLY; INCLUDES PRESSED SHAFT
6	6	538-409	SOC. HD. CAP SCREW, 10-32 x 1 1/4" LONG
7	6	538-460	LOCKWASHER, SPLIT-TYPE, #10
8	1	538-301	CYLINDER CAP
9	1	538-329	RUBBER ROLLING DIAPHRAGM
10	1	M1-300	CYLINDER BODY
11	2	M1-415	SOC. HD. SET SCREW, 1/4-28 x 1/4" LONG
12	6	M1-416	SOC. HD. CAP SCREW, 10-32 x 3/4" LONG
13	4	M1-465	1/4" ID LOCKWASHER 2 PIECE SET; RAMP-TYPE
14	4	M1-417	SOC. HD. CAP SCREW, 1/4-20 x 5/8" LONG
15	1	M1-320	BOTTOM PIVOT BALL SUPPORT CAP; 1/2" THICK
			(used for 3/4" orifice sizes, and larger)
			NOTE: FOR LESS THAN 3/4" DIAMETER ORIFICE USE THE FOLLOWING PART INSTEAD:
	1	M1-320A	BOTTOM PIVOT BALL SUPPORT CAP; 3/4" THICK
16	1	M1-321	PIVOT BALL; 1/2" DIAMETER, NYLON
17	1	538-176	TYGON TUBE, 1/4" ID X 3/8" OD; 2" LONG
18	1	538-155	AIR FITTING 1/8" NPT x 1/4" ID TUBE
19	1	M1-151	BRASS PIPE ELBOW, 1/8" NPT
20	1	M1-152	BRASS PIPE NIPPLE; 1/8" NPT, 2" LONG
21	2	M1-330-___	RUBBER CLAMPING GASKET; SELECT THE FOLLOWING:
			M1-330-9/16 FOR 9/16" INSIDE DIAMETER RING
			M1-330-3/4 FOR 3/4" INSIDE DIAMETER RING
			M1-330-1 FOR 1" INSIDE DIAMETER RING
			M1-330-1 1/8 FOR 1 1/8" INSIDE DIAMETER RING
			M1-330-1 3/8 FOR 1 3/8" INSIDE DIAMETER RING
			M1-330-1 1/2 FOR 1 1/2" INSIDE DIAMETER RING
22	1	M1-331-___	UPPER GASKET HOLDER - MEASURING HEAD
			M1-331-9/16 FOR 9/16" INSIDE DIAMETER RING
			M1-331-3/4 FOR 3/4" INSIDE DIAMETER RING
			M1-331-1 FOR 1" INSIDE DIAMETER RING
			M1-331-1 1/8 FOR 1 1/8" INSIDE DIAMETER RING
			M1-331-1 3/8 FOR 1 3/8" INSIDE DIAMETER RING
			M1-331-1 1/2 FOR 1 1/2" INSIDE DIAMETER RING
23	1	M1-332-___	LOWER GASKET HOLDER - WITH PIVOT BALL CAVITY
			M1-332-9/16 FOR 9/16" INSIDE DIAMETER RING
			M1-332-3/4 FOR 3/4" INSIDE DIAMETER RING
			M1-332-1 FOR 1" INSIDE DIAMETER RING
			M1-332-1 1/8 FOR 1 1/8" INSIDE DIAMETER RING
			M1-332-1 3/8 FOR 1 3/8" INSIDE DIAMETER RING
			M1-332-1 1/2 FOR 1 1/2" INSIDE DIAMETER RING
24	3	M1-325	COMPRESSION SPRING TO PRELOAD THE PIVOT BALL
25	1	M1-153	DISCHARGE FITTING ASSEMBLY - 1/4" & 3/16" OUTLETS
			NOTE: SPECIAL LOW-FLOW VERSIONS USE THE FOLLOWING:
	1	M1-153A	DISCHARGE FITTING ASSEMBLY FOR VERY LOW FLOWS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10
BACKPRESSURE SENSING TUBE
DISCHARGE FLOW TO FLOWMETER (MEASURED)
11
THIS FEED PIPE CONNECTS TO THE BOTTOM OF THE LOW PRESSURE MANIFOLD
22
23
21
12
PAPER PATH
AIR FLOW
19
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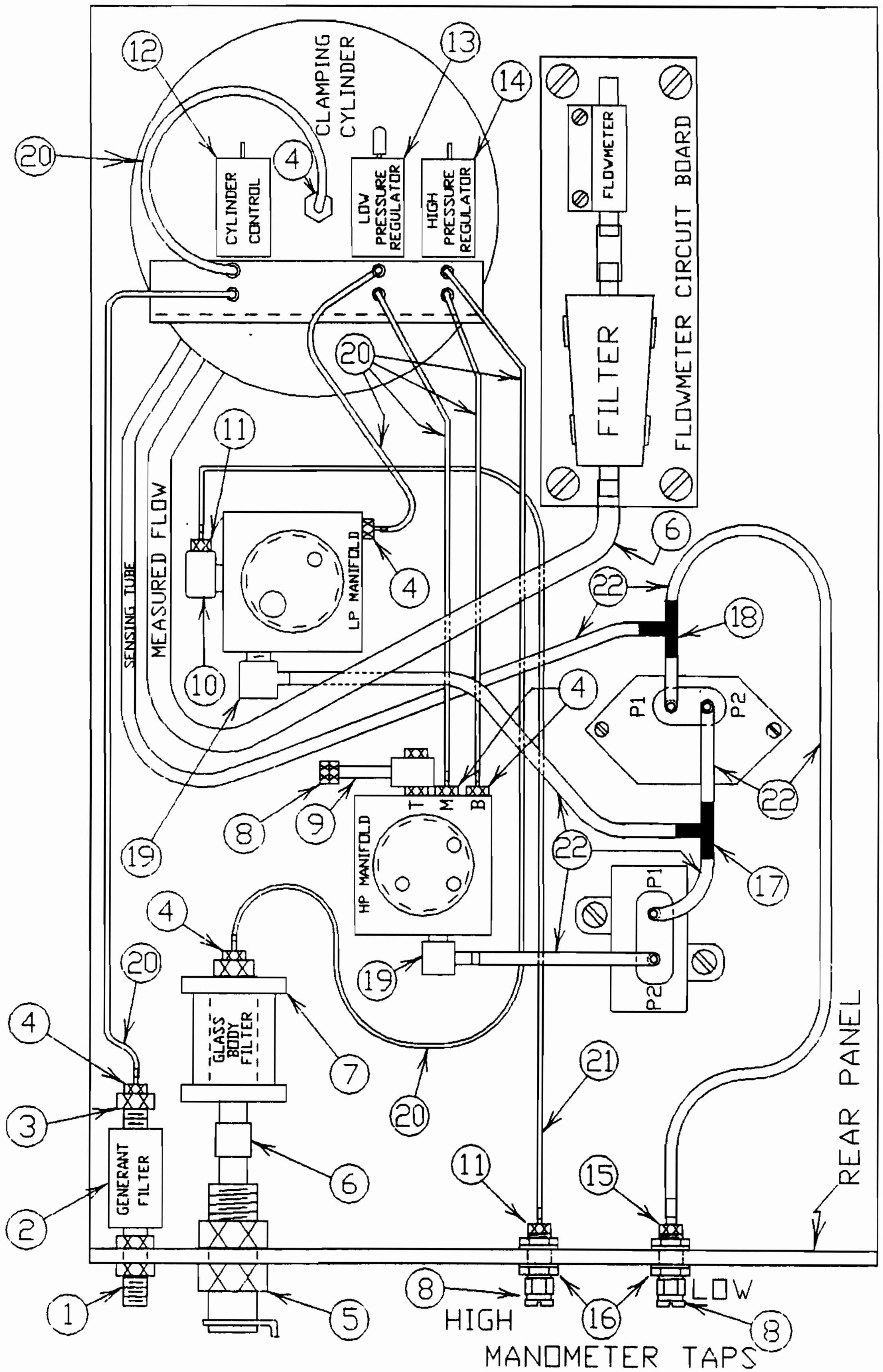
17

TUBING / PIPING DIAGRAM

ITEM	QTY	PART NO.	DESCRIPTION
1	1	M1-154	BULKHEAD FITTING; FOR CLAMPING AIR
2	1	M1-155	AIR FILTER (GENERANT)
3	1	M1-156	ADAPTOR; 1/8 NPT X 10-32
4	6	538-159	AIR FITTING 10-32 x 0.078" ID TUBE
	6	538-160	FIBER GASKET FOR 10-32 TUBE FITTING
5	1	538-173	COLDER QUICK-DISCONNECT AIR FITTING
6		538-176	TYGON TUBE, 1/4" ID X 3/8" OD; AS NECESSARY
7	1	M1-157	AIR FILTER ASSEMBLY 1/4" TUBE X 10-32
8	3	538-175	PLUG, 10-32, WITH O-RING SEAL
9	1	M1-158	10-32 EXTENSION PIPE
10	2	M1-160	10-32 RIGHT ANGLE FITTING
11	2	538-157	AIR FITTING 10-32 x 1/16" ID TUBE
	2	538-160	FIBER GASKET FOR 10-32 TUBE FITTING
12	1	M1-161	SOLENOID VALVE - 3 WAY, 12 VDC
13	1	538-151	SOLENOID VALVE - 3 WAY, EXH PLUGGED
		538-180	PLASTIC PLUG FOR ABOVE SOLENOID VALVE EXHAUST
14	1	538-152	SOLENOID VALVE - 3 WAY, N.C., 12 VDC
15	1	M1-166	10-32 X 3/16" ADAPTOR FITTING
	1	538-160	FIBER GASKET FOR 10-32 TUBE FITTING
16	2	M1-167	BULKHEAD FITTING - 10-32
17	1	M1-168	TEE FITTING - 3/16" TUBE, PLASTIC
18	1	M1-169	TEE FITTING - 3/16" TUBE, BRASS
19	2	538-156	AIR FITTING 1/8" NPT x 3/16" ID TUBE
20		538-179	0.078" ID x 3/16" OD POLYURETHANE TUBING AS REQUIRED
21		538-178	1/16" ID x 1/8" OD POLYURETHANE TUBING AS REQUIRED
22		538-177	3/16" ID x 5/16" OD TYGON TUBING AS REQUIRED
		538-181	PLASTIC CLAMPS FOR 5/16" OD TUBING (8 are used per instrument)
		M1-170	TEST ADAPTOR KIT (2 HOSES) CONSISTING OF: 10-32 FITTINGS WITH O-RING SEALS FOR TEST PORTS 24" LENGTH OF 1/16" INSIDE DIAMETER HOSE 1/16" X 10-32 FITTINGS, WITH 1/8" NPT ADAPTOR

NOTE: THE MANOMETER TAPS ARE 10-32 FEMALE FITTINGS THAT ARE EXPOSED WHEN THE PLUGS ARE REMOVED. "HP" AND "LP" ARE THE HIGH PRESSURE AND LOW PRESSURE, RESPECTIVELY, PRESSURE PORTS THAT CAN BE CONNECTED TO A DIGITAL MANOMETER TO CHECK THE PERFORMANCE OF THE PRESSURE REGULATION SYSTEM. THE MANOMETER READINGS WILL BE THE PRESSURE DIFFERENTIAL ACROSS THE TEST SPECIMEN, WHEN THE SPECIMEN IS UNDER TEST. WHEN THE CALIBRATE SWITCH IS IN THE "UP", OR "CAL" POSITION, THE PRESSURE DROP ACROSS THE SPECIMEN WILL BE SUSTAINED FOR A LONG DURATION, MAKING THE PRESSURE TEST EASIER. EITHER PAPER OF THE PROPER AIR PERMEANCE, OR THE APPROPRIATE CALIBRATION PLATE RESTRICTOR MUST BE IN PLACE.



CLAMPING CYLINDER
CYLINDER CONTROL
LOW PRESSURE REGULATOR
HIGH PRESSURE REGULATOR
FLOWMETER
FILTER
FLOWMETER CIRCUIT BOARD
MEASURED FLOW
SENSING TUBE
LP MANIFOLD
HP MANIFOLD
T
M
B
P1
P2
GLASS BODY FILTER
GENERANT FILTER
REAR PANEL
HIGH
LOW
MANOMETER TAPS

POWER SUPPLY ASSEMBLY

ITEM	QTY	PART NO.	DESCRIPTION
1	1	538-700	POWER SUPPLY
2	1	538-223	POWER SUPPLY MOUNTING BRACKET
3	2	M1-413	SOC. HD. CAP SCREW 8-32 x 5/8" LONG
	2	538-452	LOCKNUT W/ NYLON INSERT 8-32
4	1	538-013A	1 1/4 ANGLE BRACKET, 1 1/4" LONG
5	1	M1-418	SLOTTED PAN HEAD SCREW 8-32 x 1/2" LONG
	1	538-452	LOCKNUT W/ NYLON INSERT 8-32
6	1	M1-801	VOLTAGE REGULATOR IC - 12 VOLTS; TO-3
	1	M1-701	TO-3 IC SOCKET ASSEMBLY
7	1	538-233	MOUNTING CLIP FOR CAPACITOR
8	1	M1-781	ELECTROLYTIC CAPACITOR
9	1	538-013B	1 1/4" ANGLE BRACKET, 3 1/4" LONG
10	1	M1-802	RECTIFIER, FULL WAVE BRIDGE, 6 AMP @ 50 VOLT
11	1	M1-651	CONNECTOR, 7 TERMINALS

NOTE: THIS IS A UNIVERSAL POWER SUPPLY RATED FOR INPUT FREQUENCIES OF 47 TO 63 HERTZ. THE AIR COMPRESSOR MUST MATCH INPUT POWER.

FOR 120 VOLTS INPUT: JUMPER 1 & 3 AND ALSO JUMPER 2 & 4
APPLY 120 VAC AT TERMINALS 1 & 4

FOR 220 VOLTS INPUT: JUMPER 2 & 3 ONLY
APPLY 220 VAC AT TERMINALS 1 & 5

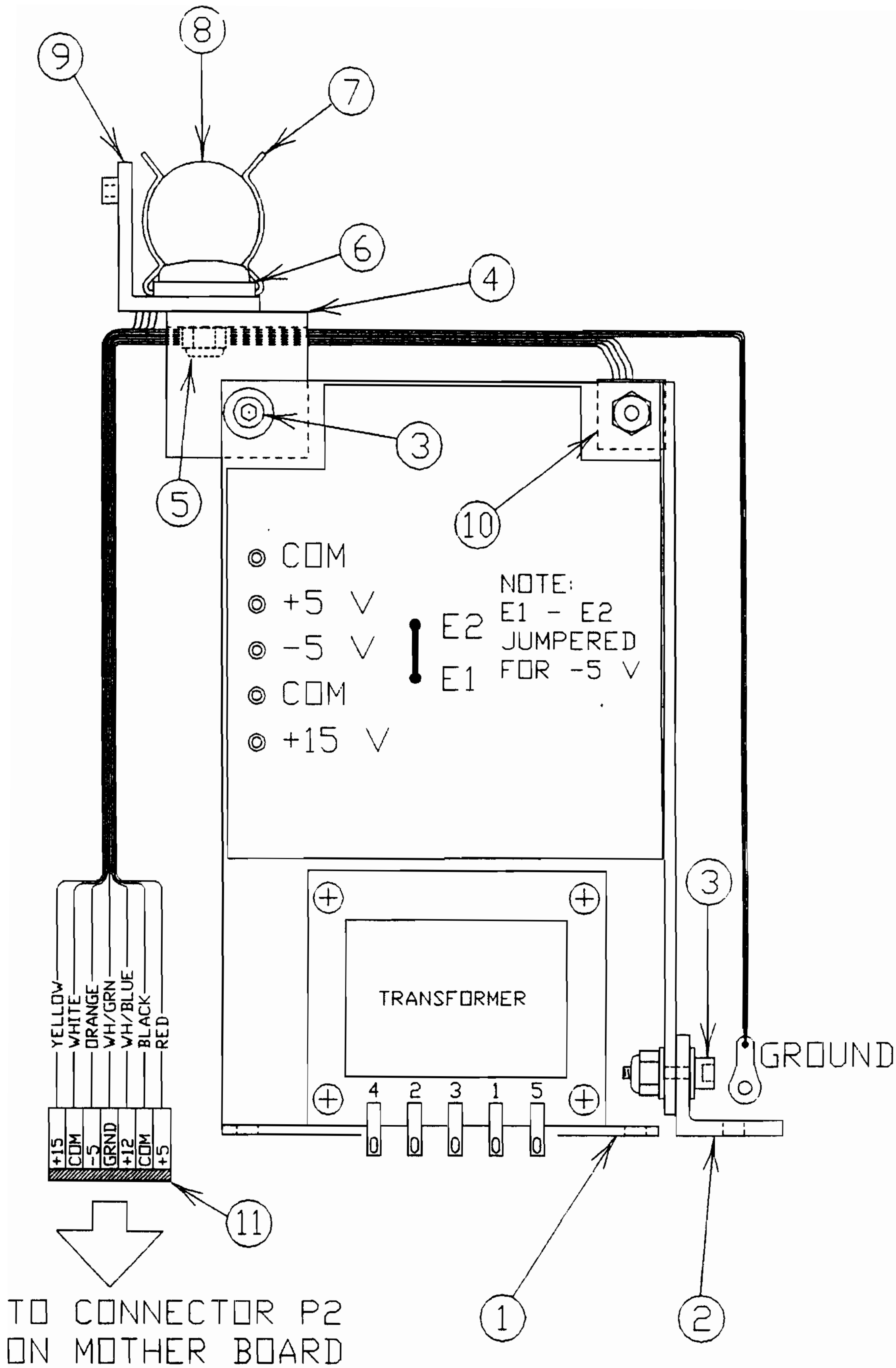
FOR 240 VOLTS INPUT: JUMPER 2 & 3 ONLY
APPLY 240 VAC AT TERMINALS 1 & 4

TO ADJUST DC VOLTAGES:
1) TURN POWER OFF AND REMOVE POWER SUPPLY CONNECTOR FROM PC BOARD.
2) TURN AC POWER ON AND CHECK DC VOLTAGES AT THE CONNECTOR PINS.
3) MAKE ADJUSTMENTS WITH DC CONNECTOR UNPLUGGED TO AVOID ACCIDENTAL OVERVOLTAGE AT THE MOTHER BOARD.
4) TURN AC POWER OFF; PLUG DC POWER CONNECTOR INTO MOTHER BOARD; AND TURN AC POWER BACK ON.
5) RECHECK DC VOLTAGES UNDER LOAD (INSERT VOLTMETER PROBE @ CONNECTOR PINS)

DC OUTPUT VOLTAGE SETTINGS:

+15: 14.9 TO 15.1 VOLTS (DROPPED TO REGULATED 12 VOLTS ON MOTHER BOARD)
-5: -3.5 TO -4.0 VOLTS (AMPLIFIER NEGATIVE BIAS)
+12: NOT ADJUSTABLE; TYPICALLY 11.8 TO 12.2 VOLTS (SOLENOID VALVE POWER, AND STEPPER MOTOR POWER, WHEN FITTED WITH AUTO-FEED).
+5: 5.100 TO 5.200 VOLTS (MICROPROCESSOR BOARD SUPPLY)

CLIP THE VOLTMETER "COMMON" LEAD TO THE GROUND LUG, AS IT IS THE COMMON NODE FOR THE POWER SUPPLY DC VOLTAGES.



9
8
7
6
4
3
5
10
3
COM
+5 V
-5 V
COM
+15 V
E2
E1
NOTE:
E1 - E2
JUMPERED
FOR -5 V
TRANSFORMER
4 2 3 1 5
GROUND
YELLOW
WHITE
ORANGE
WH/GRN
WH/BLUE
BLACK
RED
+15
COM
-5
GRND
+12
COM
+5
11
1
2
TO CONNECTOR P2
ON MOTHER BOARD

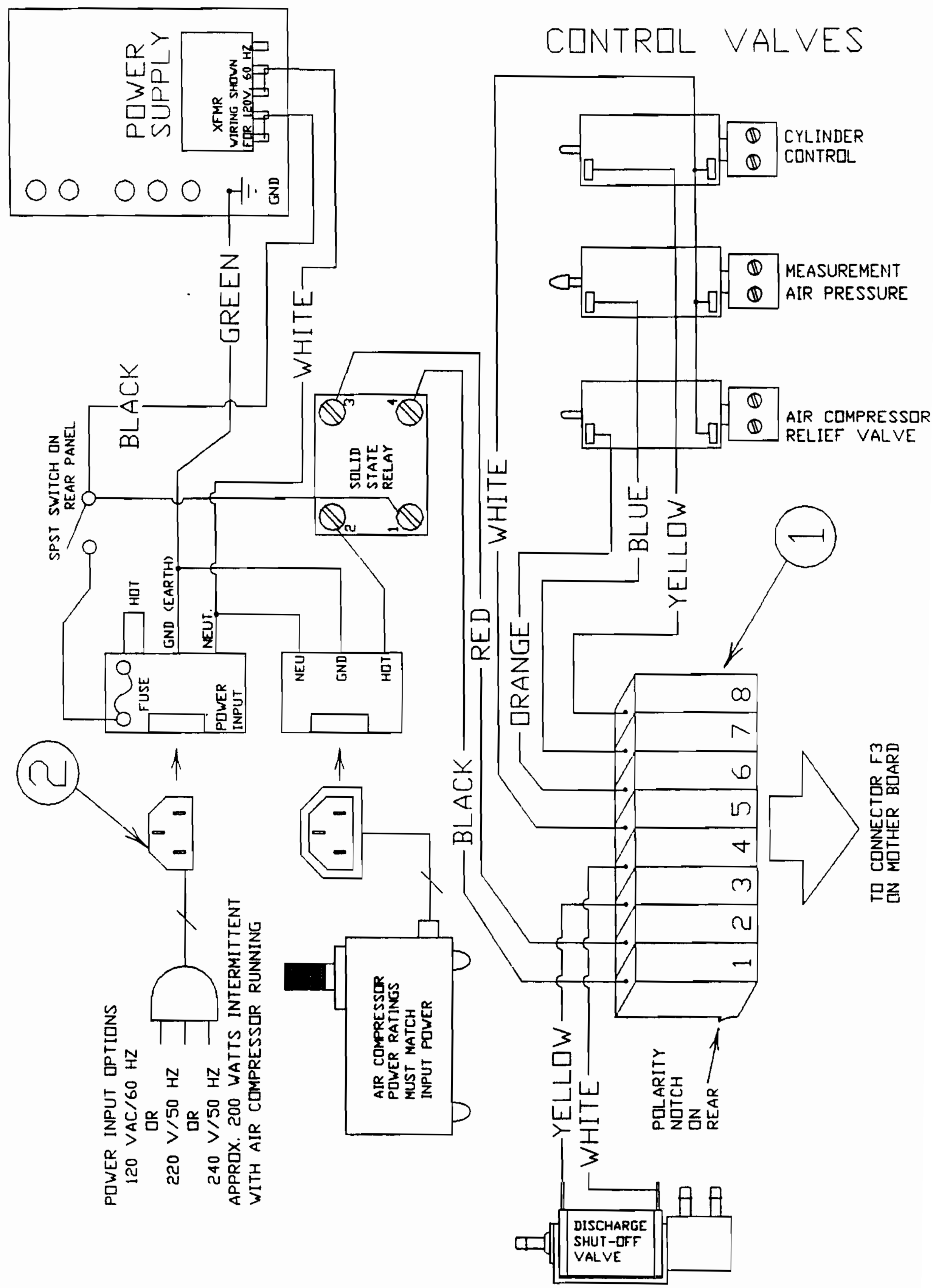
INPUT POWER / CONTROL VALVE WIRING

ITEM	QTY	PART NO.	DESCRIPTION
1	1	M1-652	CONNECTOR; 8 POSITION, WITH HARNESS
2	1	538-711	DETACHABLE POWER CORD, 6 FEET LONG, 3-WIRE

NOTES:

DO NOT CONFUSE THE WHITE WIRE FROM THE 8-PIN CONNECTOR WITH THE OTHER POWER SUPPLY WHITE WIRES. THIS WHITE WIRE CONNECTS TO ONE SIDE OF THE SOLENOID VALVE COILS, AND IT IS A 12 VOLT DC "PULL-UP" SUPPLY; OR THE SOURCE OF POWER FOR THE COILS. TO ACTIVATE THE SOLENOID VALVE COILS, THE MOTHER BOARD HAS CIRCUITRY THAT "SINKS" THE OTHER TERMINAL OF THE SOLENOID VALVE COIL, THUS A 12 VOLT DROP WILL OCCUR ACROSS THE COIL WHEN ACTIVATION IS DESIRED. THE CONTROL IC ON THE MOTHER BOARD HAS DIODE SPIKE SUPRESSION FOR THE COILS.

THE SOLID STATE RELAY CONTROLS THE AIR COMPRESSOR. WHEN THE AIR COMPRESSOR OPERATION IS DESIRED, THE INPUT SIDE OF THE SOLID STATE RELAY IS RAISED TO 5 VOLTS.


CONTROL VALVES
POWER SUPPLY
XFMR
WIRING SHOWN
FOR 120V, 60 HZ
GND
GREEN
WHITE
BLACK
SPST SWITCH ON
REAR PANEL
SOLID
STATE
RELAY
HOT
GND (EARTH)
NEUT.
FUSE
POWER
INPUT
NEU
GND
HOT
CYLINDER
CONTROL
MEASUREMENT
AIR PRESSURE
AIR COMPRESSOR
RELIEF VALVE
WHITE
BLUE
YELLOW
RED
ORANGE
BLACK
1
2
TO CONNECTOR F3
ON MOTHER BOARD
POWER INPUT OPTIONS
120 VAC/60 HZ
OR
220 V/50 HZ
OR
240 V/50 HZ
APPROX. 200 WATTS INTERMITTENT
WITH AIR COMPRESSOR RUNNING
AIR COMPRESSOR
POWER RATINGS
MUST MATCH
INPUT POWER
YELLOW
WHITE
POLARITY
NOTCH
ON
REAR
DISCHARGE
SHUT-OFF
VALVE

PARTS LIST - OPTIONAL DISCHARGE SHUT-OFF VALVE ASSEMBLY

ITEM	QTY	PART No.	DESCRIPTION
1	1	M1-171	RUBBER MOULDED ELBOW
2	1	M1-172	TUBING - 3/32" ID X 5/32" OD
3	1	538-152	SOLENOID VALVE 12 VDC

THEORY OF OPERATION

This option is used on certain instruments that measure extremely low flows. When measuring extremely low flows, a small amount of zero point drift in the flowmeter output could be a significant percentage of the measured signal. Zero point drift can be caused by the aging of the sensor and amplifier circuit; or due to changes in ambient barometric pressure, especially if the instrument is factory calibrated at a different altitude than its final operating altitude.

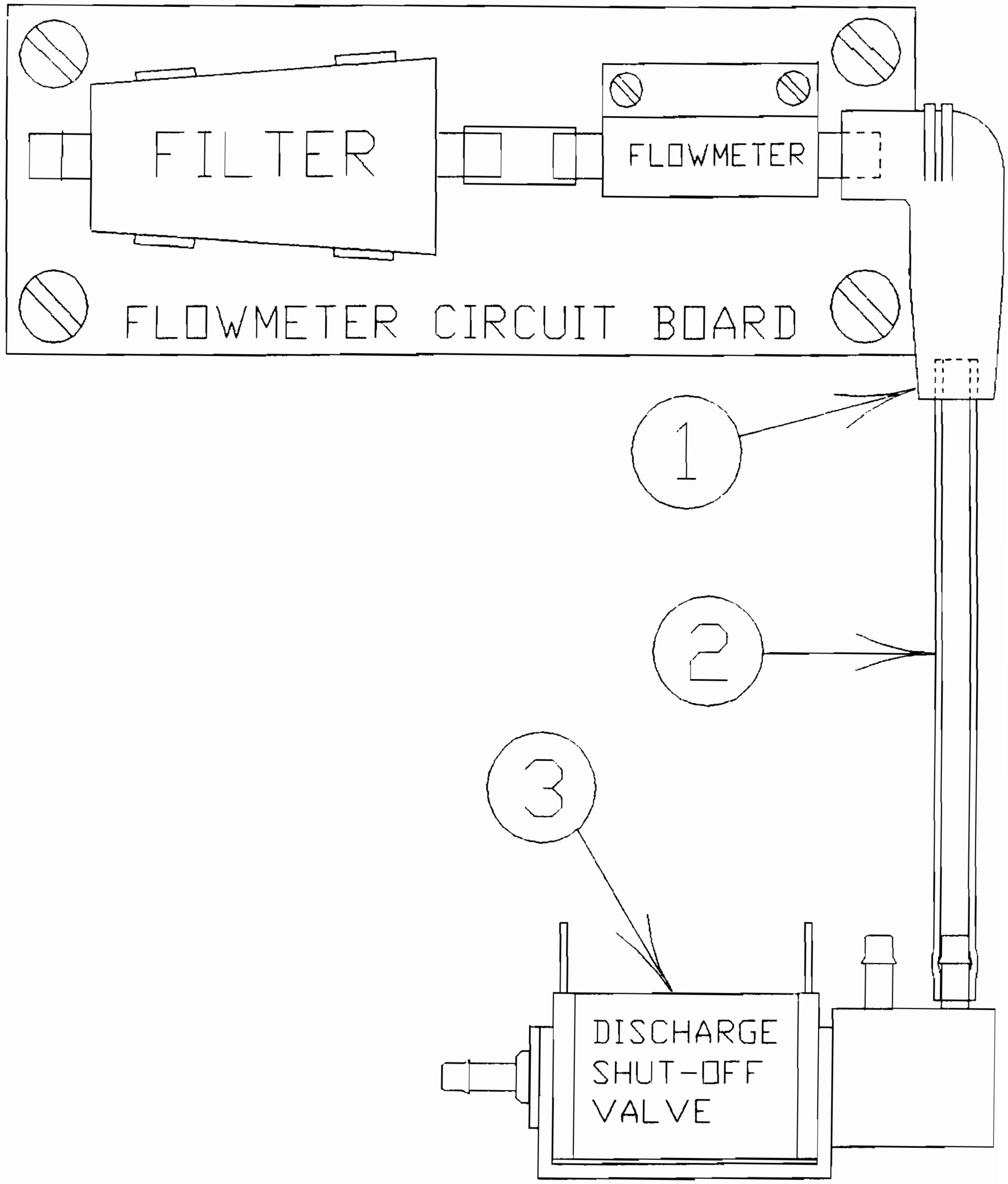
Instruments that use this "prevailing zero point compensation" option have a software program that samples the flowmeter signals prior to running a series of tests. In order to ensure that there is no flow through the sensor, the solenoid valve (Item 3) is closed to a shut-off condition when the zero point is sampled. During the normal test mode, the valve is energized to an open condition.

MAINTENANCE

Use extreme caution if it is necessary to remove the rubber elbow connector from the flowmeter. Use finger pressure to squeeze the flowmeter body together while gently twisting the rubber elbow back and forth. The plastic body of the flowmeter should not be overstressed, as it can be damaged and affect the calibration curve.

We do not recommend frequent changeout of the filter that is located next to the flowmeter. The measurement air is very clean, and a small amount paper dust that migrated to the filter would still allow the passage of air through such a dust layer. The air flows being measured are extremely low relative to the total surface area of the filter media. If there is any small increase in pressure drop, it is not a problem because the differential pressure sensor maintains a constant pressure drop across the test specimen. If the calibration plates are reading within the specified tolerances, do not perform preventative maintenance on this filter by changing it out.

OPTIONAL DISCHARGE SHUT-OFF VALVE ASSEMBLY



MOTHERBOARD INTERFACE / ADJUSTMENTS

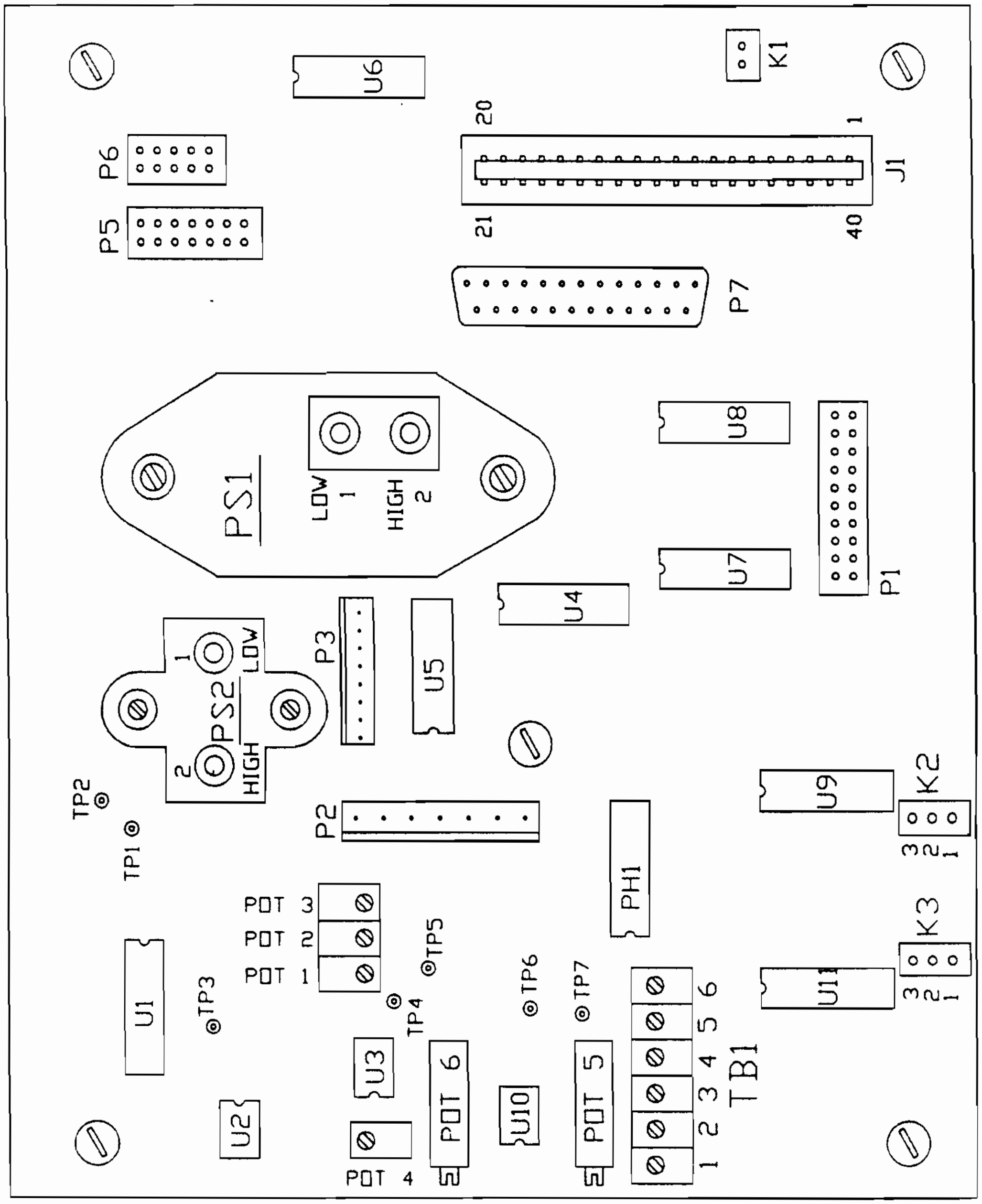
PLUG IDENTIFICATION		DESCRIPTION / FUNCTION
P1	20 PIN (2X10)	20 COND. RIBBON CABLE TO PANEL DISPLAY BOARD
P2	7 PIN (IN-LINE)	FROM POWER SUPPLY - 7 CONDUCTOR
P3	8 PIN (IN-LINE)	TO SOLENOID VALVES & COMPRESSOR RELAY
P4	4 PIN	NOT CURRENTLY USED
P5	14 PIN (2X7)	ANALOG CABLE TO MICROPROCESSOR BOARD (14 PIN DIP MALE CONNECTOR ON RIBBON CABLE, 14 PIN DIP SOCKET ON MICROPROCESSOR BOARD)
P6	10 PIN (2X5)	ANALOG CABLE TO FLOWMETER BOARD 10 CONDUCTOR RIBBON CABLE W/IDC SOCKETS
P7	D25 MALE	INTERFACE FOR AUTOFEED DRIVE SYSTEM
TB1	6 PIN - SCREW LOCK TERMINAL BLOCK	PINS 1 & 2: TO "MODE" SWITCH - CALIBRATE/NORMAL PINS 3 & 4: USED ONLY FOR REFLECTIVE PHOTOSENSORS PIN 5: BLACK WIRE FROM PHOTOEMITTER BOARD PIN 6: RED WIRE FROM PHOTOEMITTER BOARD NOTE: THE PHOTODETECTOR SYSTEM IS USED FOR AUTO-FEED SYSTEMS TO DETECT THE PRESENCE OF PAPER.
PH1	16 PIN DIP	SOCKET FOR INSTALLING PHOTODETECTOR CIRCUITRY 3 STYLES: TRANSMISSION PULSED, TRANSMISSION NON-PULSED, AND REFLECTIVE SENSOR PULSED.
J1	40 PIN (2X20)	MICROPROCESSOR BOARD EDGE-CARD CONNECTOR
K1	2 PIN JUMPER	JUMPER INSTALLED ENABLES BAROMETRIC PRESSURE CORRECTION FACTORS.

TEST PINS

TP1	MOTHER BOARD REGULATOR VOLTAGE: 12 VOLTS +/- FIXED VALUE
TP2	PRESSURE SENSOR OUTPUT: TEST AIR PRESSURE SENSOR
TP3	MULTIPLEXED VOLTAGE FROM POTS 1, 2, AND 3. (SERVES AS REFERENCE VOLTAGES FOR LOW, MEDIUM, AND HIGH TEST PRESSURE SETTINGS).
TP4	HIGH PRESSURE REFERENCE POT SETTING (POT 4)
TP5	PRESSURE SENSOR OUTPUT: HIGH PRESSURE SENSOR
TP6	REAR PHOTODETECTOR SENSITIVITY - SET BY POT 6
TP7	FRONT PHOTODETECTOR SENSITIVITY - SET BY POT 5

THEORY OF OPERATION:

THE KNF AIR COMPRESSOR, CONTROLLED BY THE MODEL 1, GENERATES A SOURCE OF TEST AIR PRESSURE (THE AIR THAT PASSES THROUGH THE TEST SPECIMEN). THE EXCESS AIR IS VENTED TO ATMOSPHERE THROUGH THE OPEN PORT OF THE HIGH PRESSURE SOLENOID VALVE. THE HIGH PRESSURE ACCUMULATOR TANK OPERATES AT A PRESSURE, MEASURED BY SENSOR PS2, AND SET BY POT 4. GENERALLY, THIS PRESSURE IS SET AT 20" WATER GAUGE ABOVE THE PRESSURE IN THE LOW PRESSURE ACCUMULATOR TANK. THE LOW PRESSURE ACCUMULATOR TANK SETS THE TEST AIR PRESSURE, AS MEASURED BY SENSOR PS1, AND SET BY THE VOLTAGE PRESENT AT TEST POINT TP3. TEST POINT TP3 WILL GIVE THREE DISTINCT VALUES - ONE VALUE FOR WHEN THE INSTRUMENT IS SET AT "LOW" PRESSURE; ANOTHER VALUE FOR WHEN IT IS SET AT "MEDIUM", AND A THIRD VALUE FOR WHEN IT IS SET AT "HIGH" PRESSURE. POT 1, POT 2, AND POT 3 DETERMINE THE LOW, MEDIUM, AND HIGH PRESSURES, RESPECTIVELY.



FOR TRANSMISSION PHOTO-OPTICS JUMPER K2: 1 TO 2
" " " JUMPER K3: 1 TO 2
FOR REFLECTIVE PHOTO-OPTICS JUMPER K2: 2 TO 3
" " " JUMPER K3: 2 TO 3

FLOWMETER BOARD ASSEMBLY

THE FLOWMETER USED IN THE MODEL 1 AIR PERMEABILITY INSTRUMENT IS A NON-LINEAR THERMAL MASS FLOWMETER. IT IS NOT POSSIBLE TO CALIBRATE THIS SENSOR USING THE TRADITIONAL "ZERO / SPAN" ADJUSTMENTS, AS USED FOR LINEAR INSTRUMENTS.

THE MODEL 1 FLOWMETER CIRCUITBOARD CONTAINS EXCITATION VOLTAGES FOR THE FLOWMETER, AND HAS INSTRUMENT AMPLIFIER CIRCUITS TO INCREASE THE VOLTAGE LEVELS TO THE MORE COMMONLY USED VOLTAGE LEVELS. THIS DEVICE IS FACTORY CALIBRATED ON A SPECIAL TEST RACK AND SEVERAL MULTI-POINT CALIBRATION CURVES ARE GENERATED. SIMULTANEOUSLY, A BAROMETRIC PRESSURE SENSOR IS CALIBRATED. THE PROGRAM IS TRANSFERRED TO AN EPROM MEMORY INTEGRATED CIRCUIT. THIS EPROM IS INSTALLED ON THE MICROPROCESSOR BOARD IN THE MEMORY SOCKET.

THE ONLY WAY TO REPAIR A FLOWMETER BOARD THAT IS DETERMINED TO BE OUT OF CALIBRATION IS TO REPLACE IT, ALONG WITH THE EPROM MEMORY CHIP. THESE ARE SOLD AS A MATCHED SET. THERE IS ONLY ONE AIR HOSE AND ONE INTERFACE CABLE TO DISCONNECT (AND REINSTALL ON THE NEW FLOWMETER BOARD. USE DIAGONAL CUTTERS TO BREAK THE OLD HOSE CLAMP. DO NOT SHORTEN THE HOSE, AS IT IS AT THE OPTIMUM LENGTH FOR THE CYLINDER TO STROKE UP AND DOWN.

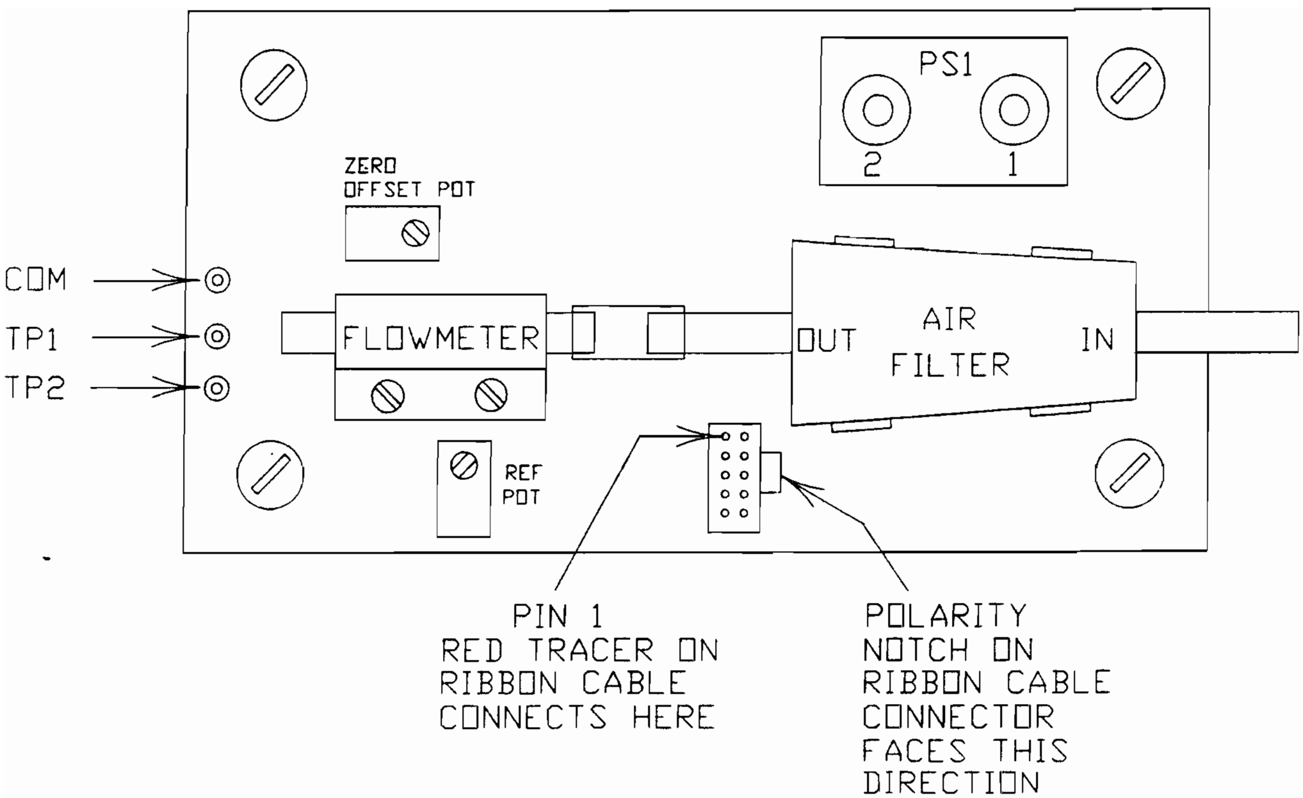
IF THE INSTRUMENT IS EQUIPPED WITH THE AUTO-FEED SYSTEM, THE PHOTODETECTOR SENSITIVITY ADJUSTMENTS MAY HAVE TO BE RE-ADJUSTED, AS THE PHOTORECEIVER DEVICES ARE LOCATED ON THE FLOWMETER BOARD.

WE DO NOT RECOMMEND THAT THE AIR FILTER ON THE FLOWMETER BOARD BE CHANGED. THE FILTER HAD A GREAT CAPACITY FOR PAPER DUST. VERY FEW CONTAMINANTS WILL PASS THROUGH IT, AS THE PAPER UNDER TEST WILL REMOVE OTHER TYPES OF CONTAMINATION. THE INLET PORT OF THE FLOWMETER CAN NOT WITHSTAND HIGH FORCES, SUCH AS THOSE NECESSARY TO TWIST THE HOSE FROM THE INLET. FOR THAT REASON, WE PLACED THE FILTER IN LINE SO THAT THE INLET OF THE FILTER WOULD BE STRESSED, RATHER THAN THE FLOWMETER.

WE DO NOT RECOMMEND THAT THE "ZERO OFFSET" POT OR THE REFERENCE VOLTAGE POT BE ADJUSTED. CHANCES ARE OTHER THINGS ARE WRONG IF THOSE ADJUSTMENTS DRIFTED. FOR DISCUSSIONS WITH FACTORY SERVICE; HOWEVER, REFERENCE TEST POINTS WERE INSTALLED. THE COMMON PROBE OF THE VOLTMETER CAN BE CLIPPED TO THE "COM" TEST POINT AND THE OTHER TEST POINTS ARE AS FOLLOWS:

TP1: FLOWMETER OFFSET VOLTAGE - TYPICALLY 0.103 VOLTS WITH THE DISCHARGE END OF THE FLOWMETER BLOCKED. GENTLE FINGER PRESSURE WILL SEAL THE ROOM AIR CURRENTS. THIS TEST SHOULD BE PERFORMED WITH THE INSTRUMENT IN NEITHER THE TEST MODE, NOR IN THE CALIBRATE MODE.

TP2: THIS IS THE A/D CONVERTER REFERENCE VOLTAGE. IT SHOULD BE 2.500 VOLTS. A READING OF 2.475 OR 2.525 VOLTS WOULD REPRESENT ONLY A 1% ERROR (1% OF 2.500 VOLTS IS 0.025 VOLTS).



THIS INTERFACE CABLE CONNECTS TO P6 ON THE MOTHER BOARD.

The microprocessor board contains the program EPROM, RAM chips, and the A/D converter. The top connector is the RS-232 INTERFACE, which is normally connected to SERIAL PORT #1.

The power for the microprocessor card comes from the edge card connector. As shown on the drawing, there is a 5 volt connector, near the RS-232 connector, that can be used to measure the +5 volt supply voltage. It should measure in the range of 5.050 to 5.200 volts.

Occasionally the instrument may appear to be "HUNG-UP"; or error messages may appear on the printer, when installed. To reset the system, simply turn the power switch off for 5 seconds, then turn it back on. If this happens frequently, it may be due to bad connections where the IC pins insert into the sockets. An experienced technician, working in an electro-static free environment (such as a humidified paper test lab without carpeting), may solve the problem by removing, and reinstalling the IC chips that are plugged into sockets. OBSERVE THE POLARITY NOTCHES, and work on only one chip at a time to avoid a mix-up. Of course, the power must be off before performing this type of service.

The program may also have difficulty in running if the power feed is extremely "noisy". If this is suspected, try running the instrument on a known "good" source of power to see if the problem goes away. If so, a power line filter / stabilizer may be necessary.

CHANGING THE EPROM

1) Locate the EPROM on the microprocessor board. It is usually the only chip that has a paper identification label on it.

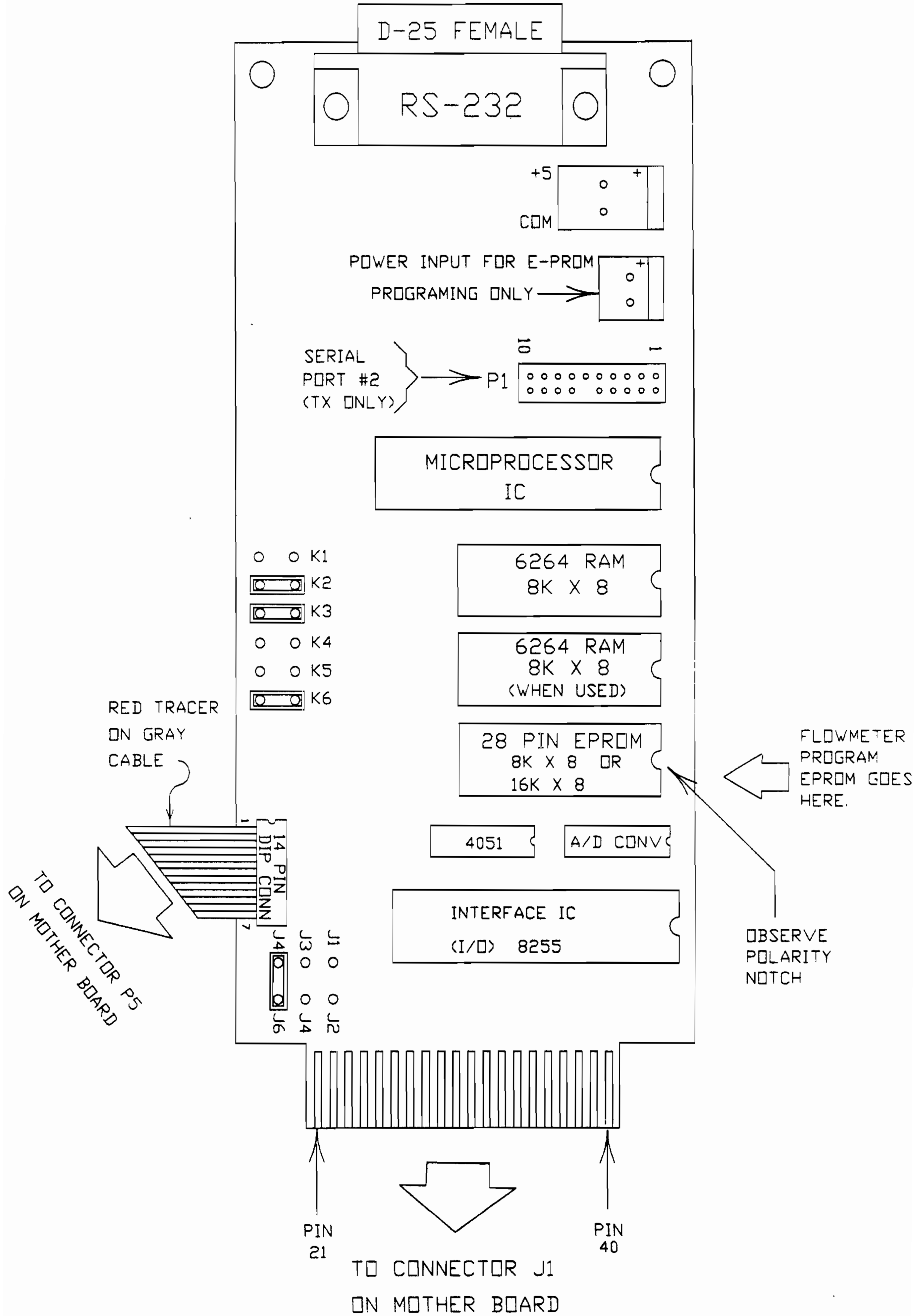
2) Unplug the instrument to be sure the power is OFF.

3) Insert a small flat-bladed screwdriver between the chip and the chip socket. Twist the screwdriver blade to "wiggle" the chip out of its socket.

4) Keep the new EPROM stored in the conductive foam pad until it is ready for insertion. Do not expose the open pins to electrostatic discharge.

5) Align the polarity notch of the new EPROM. Insert all 28 pins into each of the 28 socket openings before pushing it firmly in place.

6) Re-check the polarity notch, then reconnect the power to the instrument, and test the new EPROM.



D-25 FEMALE
RS-232
+5
+
COM
POWER INPUT FOR E-PROM
PROGRAMING ONLY
SERIAL
PORT #2
(TX ONLY)
P1
10
1
MICROPROCESSOR
IC
K1
K2
K3
K4
K5
K6
6264 RAM
8K X 8
6264 RAM
8K X 8
(WHEN USED)
28 PIN EPROM
8K X 8 OR
16K X 8
FLOWMETER
PROGRAM
EPROM GOES
HERE.
RED TRACER
ON GRAY
CABLE
14 PIN
DIP CONN
1
7
4051
A/D CONV
INTERFACE IC
(I/O) 8255
OBSERVE
POLARITY
NOTCH
J1
J2
J3
J4
J4
J6
TO CONNECTOR P5
ON MOTHER BOARD
PIN
21
PIN
40
TO CONNECTOR J1
ON MOTHER BOARD

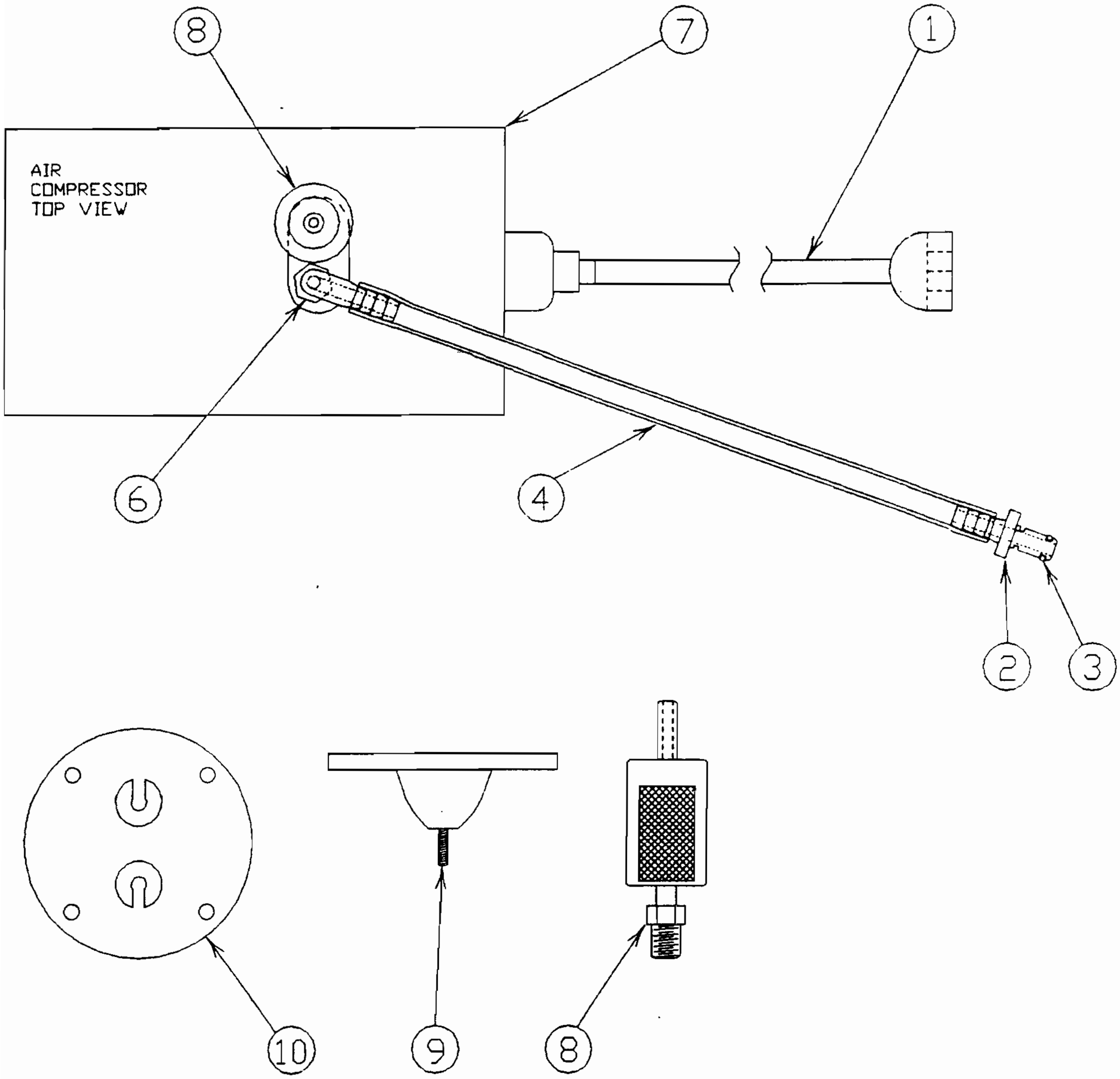
PARTS LIST - AIR COMPRESSOR ASSEMBLY

ITEM	QTY	PART No.	DESCRIPTION
1	1	538-702	DETACHABLE POWER CORD
2	1	538-168	MALE QUICK-DISCONNECT AIR FITTING
3	1	538-169	REPLACEMENT "O"-RING FOR ABOVE (538-168)
4	1	538-170	TYGON TUBING- 1/4" ID x 29" LONG
5*	1	538-171	TUBING CLAMP - (* if used)
6	1	538-155	AIR FITTING 1/8" NPT x 1/4" ID TUBE
7	1	538-703	AIR COMPRESSOR (DRY DIAPHRAGM)
8	1	538-172A	AIR FILTER / NOISE SILENCER 1/4" NPT
		538-006	COMPLETE AIR COMPRESSOR ASSEMBLY CONSISTING OF ITEMS 1 THROUGH 8 ABOVE Specify operating voltage and frequency.

SPARE PARTS FOR AIR COMPRESSOR:

8	*	538-172A	AIR FILTER / NOISE SILENCER 1/4" NPT
9	*	538-704	DIAPHRAGM PISTON ASSEMBLY
10	*	538-705	VALVE PLATE - NEOPRENE RUBBER

NOTE: To test the air compressor, unplug the power cord, air compressor cord, and air fitting from the rear instrument panel. Plug the power cord that normally powers the instrument into the cord that powers the air compressor. The air compressor should operate. The air discharge fitting can be momentarily blocked off, and the tygon tubing will bulge slightly from the backpressure.


AIR
COMPRESSOR
TOP VIEW
8
7
1
6
4
2
3
10
9
8

NEUBERGER

Diaphragm Compressors and Vacuum Pumps

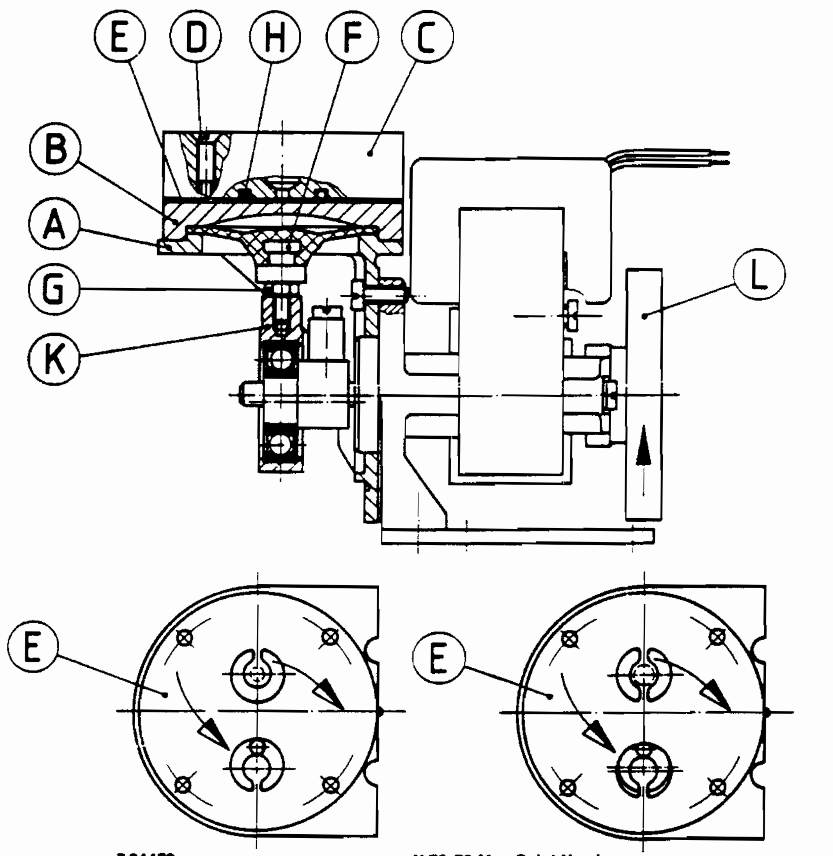
Operating Instructions

Types:

N 72 MNI	N 75 MNI	N 72 MNP	N 75 MNP
N 72 MVI	N 75 MVI	N 72 MVP	N 75 MVP
N 73 MNI	N 79 MNI	N 73 MNP	N 79 MNP
N 73 MVI	N 79 MVI	N 73 MVP	N 79 MVP

Replacement parts

Letter	Description	Order-No.
C	headplate	N75-5.04522
D	countersunk screw	11.043
E	valveplate N 72 – N 79 KN N 72 – N 79 KV	N79-5.04411 N79-5.04860
F	diaphragm Neoprene	NV 75.11 E 5.00310
F	diaphragm Viton	NV 75.10.01-6.00010
H	O-ring Neoprene	21.044
H	O-ring Viton	21.104



7.04473
Standard Version

N 72-79 M... Quiet Version

Kit numbers

N 72, N 73	Neoprene	diaphragm, valveplate, spacer nut	= PK 72-001
	Viton	diaphragm, valveplate, spacer nut	= PK 72-002
N 75	Neoprene	diaphragm, valveplate, spacer nut	= PK 75-001
	Viton	diaphragm, valveplate, spacer nut	= PK 75-002
N 72, N 73, N 75	Repl. head	headplate, intermediate plate, screw	= PK 75-015
	Connecting rod Assembly	connecting rod, excenter, bearing, counterweight with screw	= PK 72-020 = PK 73-020 = PK 75-020
N 79	Neoprene	diaphragm, valveplate, spacer nut	= PK 79-001
	Viton	diaphragm, valveplate, spacer nut	= PK 79-002
	Repl. head	headplate, intermediate plate, screw	= PK 79-015
	Connecting rod Assembly	connecting rod, excenter, bearing, counterweight with screw	= PK 79-020

We've recently relocated to a new facility:

KNF NEUBERGER, INC.
Two Black Forest Road
Trenton, New Jersey 08691-9428
Fax: 609/890-8323 • Phone 609/890-8600

******NOTICE******
SOME PART NUMBERS MAY HAVE CHANGED. PLEASE CONSULT THE FACTORY.

NEUBERGER

Diaphragm Compressors and Vacuum Pumps

Types:

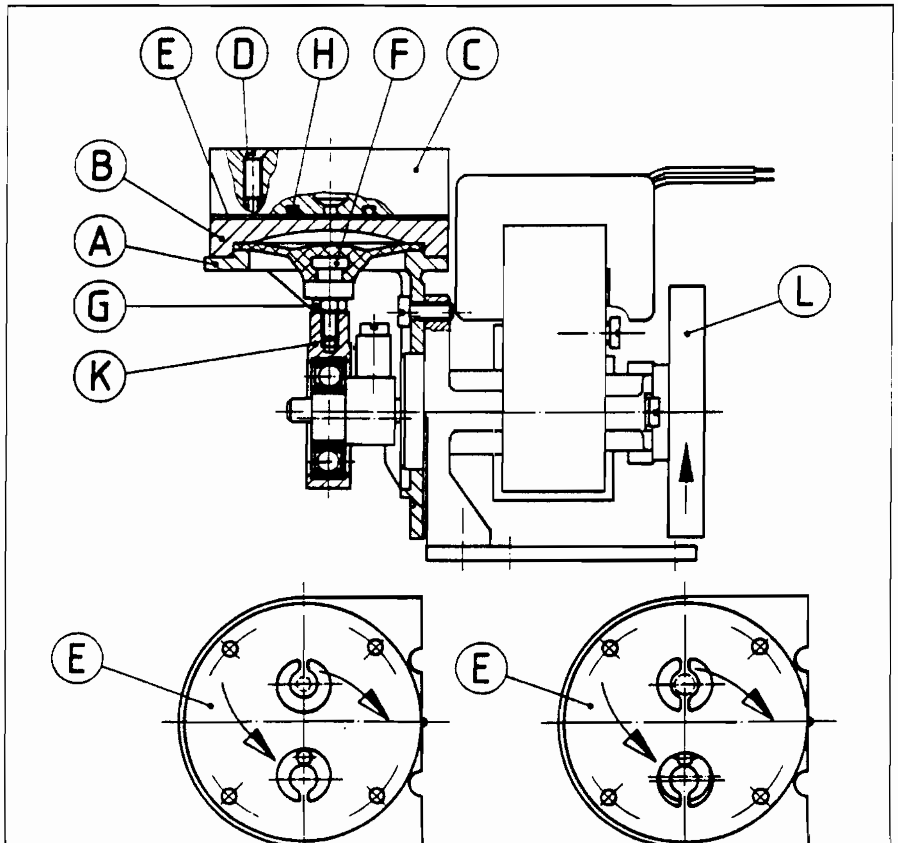
N 72 MNI	**N 75 MNI**	**N 72 MNP**	**N 75 MNP**
N 72 MVI	**N 75 MVI**	**N 72 MVP**	**N 75 MVP**
N 73 MNI	**N 79 MNI**	**N 73 MNP**	**N 79 MNP**
N 73 MVI	**N 79 MVI**	**N 73 MVP**	**N 79 MVP**

Operating Instructions

KNF Neuberger compressors and vacuum pumps are designed to yield maximum, troublefree performance under all conditions. To assure safe and proper operation and to maximize the life of the unit, the following guidelines should be carefully observed:

1) Be sure that the available electric power matches specification of the electric motor.
2) Care should be taken to ensure that the temperature of the compressor or vacuum pump environment remains between 40° and 100°F. This is particularly important when the unit is installed in a confined space.
3) Unit should be started against atmospheric pressure only, not under load (pressure or vacuum). Care must be taken to eliminate load when pump is turned off for any reason.
4) Be sure that the pump is installed at the highest point within the system to prevent possible condensation from entering the unit.
5) Use only to pump air or gas, not liquids. In the event that corrosive gases are to be pumped, be certain that a corrosion-resistant model is used.
6) Always install the pump in such a location that it is protected from direct (or indirect) moisture contact.
7) Avoid operating the unit in very dusty conditions. If this cannot be prevented then be sure to install an inlet filter and inspect and change it frequently.
8) If flow is throttled for any reason, care must be taken to not exceed the maximum continuous operating design pressure of the unit.

Exchanging diaphragm and valveplate
Diaphragm and valveplate, the only parts which may wear out, are easily and quickly replaced.
a) Mark with a pencil the position between the housing A, the intermediate plate B and the headplate C.
b) Loosen the 4 countersunk screws D and remove the headplate C, the valveplate E and the intermediate plate B. Remove O-ring H from the headplate C.
c) Loosen the diaphragm F by turning it counterclockwise! (Caution: If a spacer nut is present, it must be screwed back on top of the plug bolt of the diaphragm when reassembling the unit).
d) Screw on new diaphragm F and tighten by hand.
e) Turn the fan L until connecting rod K is in mid-position and replace intermediate plate B according to the pencil marking on the housing A.
f) Now place the new valveplate E (as shown on the drawing) on top of the intermediate plate B and the headplate C (with a new O-ring H) on top of the valveplate. Tighten the countersunk screws D uniformly in a criss-cross fashion. Check easy run by slightly turning the fan L.



7.04473
Standard Version

N 72-79 M... Quiet Version

Spare parts see back side.

AUTO-FEED DRIVE ASSEMBLY

The Auto-Feed is an accessory designed to be attached to the base instrument, either as a factory-installed option, or later retro-fitted to the instrument. In order for the system to work properly in the automatic test mode, it uses optical paper sensors that detect the presence of paper at the front and rear of the measuring head. Also, a switch detects whether the rubber roller is "nipped-up".

The status of the paper sensors, possible alarm conditions, and engagement of the roller (nip-engaged) is displayed on the indicator lamps located on the Auto-Feed cabinet. Refer to the previous section on operating instructions for a detailed explanation of the meaning of the Auto-Feed lamps.

When the roller is un-nipped, the instrument behaves like a Manual-Feed instrument, letting the operator control the feeding of paper and the timing of each test. When the roller is nipped-up, the system automatically performs a test, advances the paper to the next test zone, and performs another test, as long as the three green lamps are illuminated. Refer to the maintenance instructions for the photo-optic paper sensors if they are not working properly.

If the "N" lamp (nip-up detection switch) is not working properly, refer to the drawing on the next page. Item 18 is the switch located on the printed circuit board, and Item 17 is a section of tygon tubing on the switchpost shaft that activates the switch. Tygon tubing is used because it is compressible, and prevents excessive force from damaging the switch. As the upper cabinet housing is lowered towards the baseplate, the switch contacts and slightly compresses the short length of tygon tubing. Item 19, the thumbwheel jackscrew, can be used to assist in the adjustment of the switchpost shaft, Item 15.

1- The Auto-Feed drive assembly can be detached from the test instrument frame, leaving the interface cable connected, and the power on.

2- Turn the thumbwheel jackscrew downwards (disengaged) until the rubber roller contacts (nips) the idler roller. The green "N" lamp should be illuminated.

3- Insert a spacer of about 0.030" to 0.035" between the rubber roller and the idler roller. A stack of 4 or 5 index cards, or a tablet notepad backing generally works fine for a spacer. The "N" lamp switch should be at the trip-point with this thickness - the lamp should flicker between on and off when the upper cabinet assembly is pressed gently to engage the roller nip.

4- If adjustment is necessary, loosen the locknut, Item 14, using a 7/16" open end wrench. Insert the 0.030" to 0.035" spacer between the rubber roller and the idler roller and using light hand pressure, nip it firmly. Turn the thumbwheel jackscrew (Item 19) until it contacts the upper cabinet frame. This will hold the proper clearance, so the spacer can now be removed. Maintain cabinet frame pressure on the head of the thumbwheel jackscrew and adjust the switchpost shaft (Item 15) until the trip point of the switch is reached - it has a screwdriver slot at the bottom end. Maintain the screwdriver slot position and tighten the locknut. Back off on the thumbwheel jackscrew, and recheck the switch operation.

NOTE: If the material tested is thicker than 0.030", consult with Hagerty Technologies for assistance. Special parts may facilitate this adjustment.

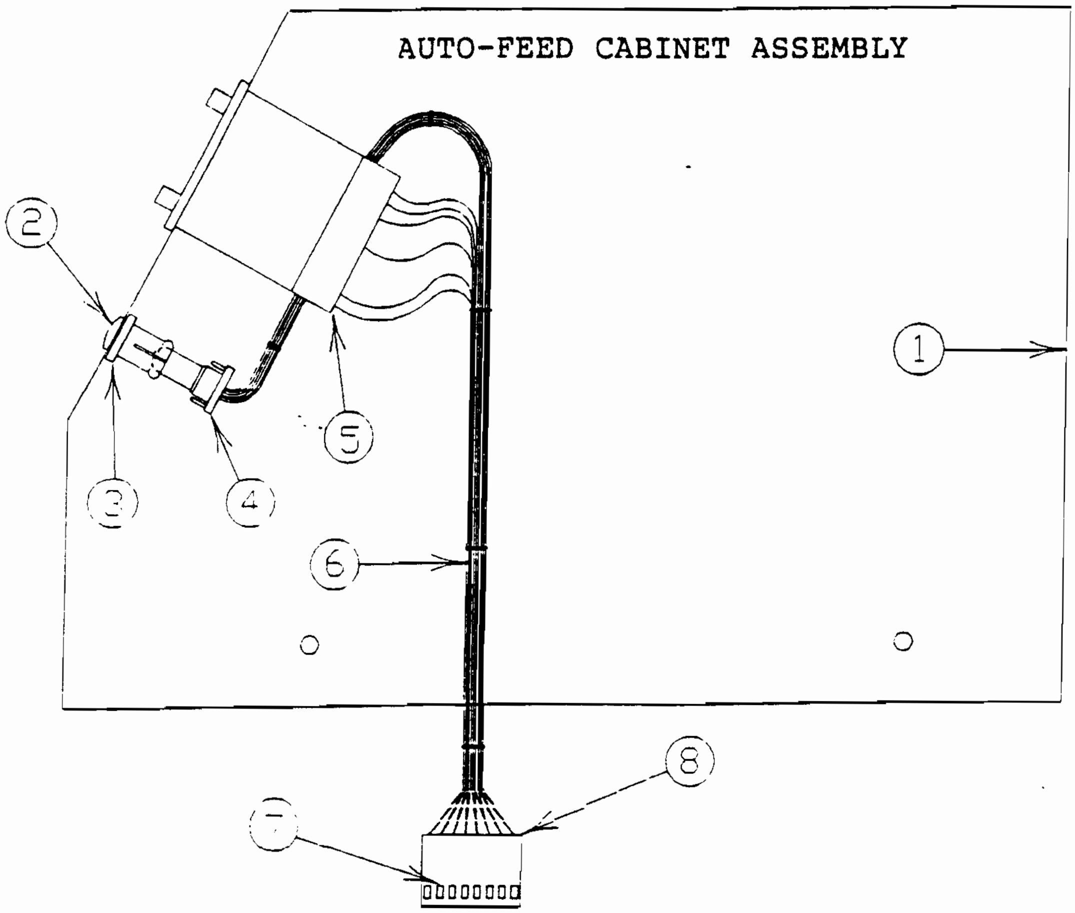
PARTS LIST - AUTO-FEED CABINET ASSEMBLY

ITEM	QTY	PART No.	DESCRIPTION
1	1	AF-101	AUTO-FEED CABINET
	4	538-406	CABINET SCREWS, 6-32 X 3/8" LONG, COATED
2	1	538-106	RED LENS FOR LED
	3	538-105	GREEN LENS FOR LED
3	4	AF-107	PLASTIC LOCKING COLLER FOR LENS, ABOVE
4	1	AF-951	CIRCUIT BOARD FOR LEDs
5	1	AF-702	BCD SELECTOR SWITCH (for setting spacing)
6	1	AF-650	CABLE ASSEMBLY
7	1	AF-703	POLARIZING KEY FOR SOCKET
8	1	AF-540	SOCKET HOUSING
**	*	AF-540	BCD SELECTOR SWITCH / LED ASSEMBLY Includes all items 4-8, above

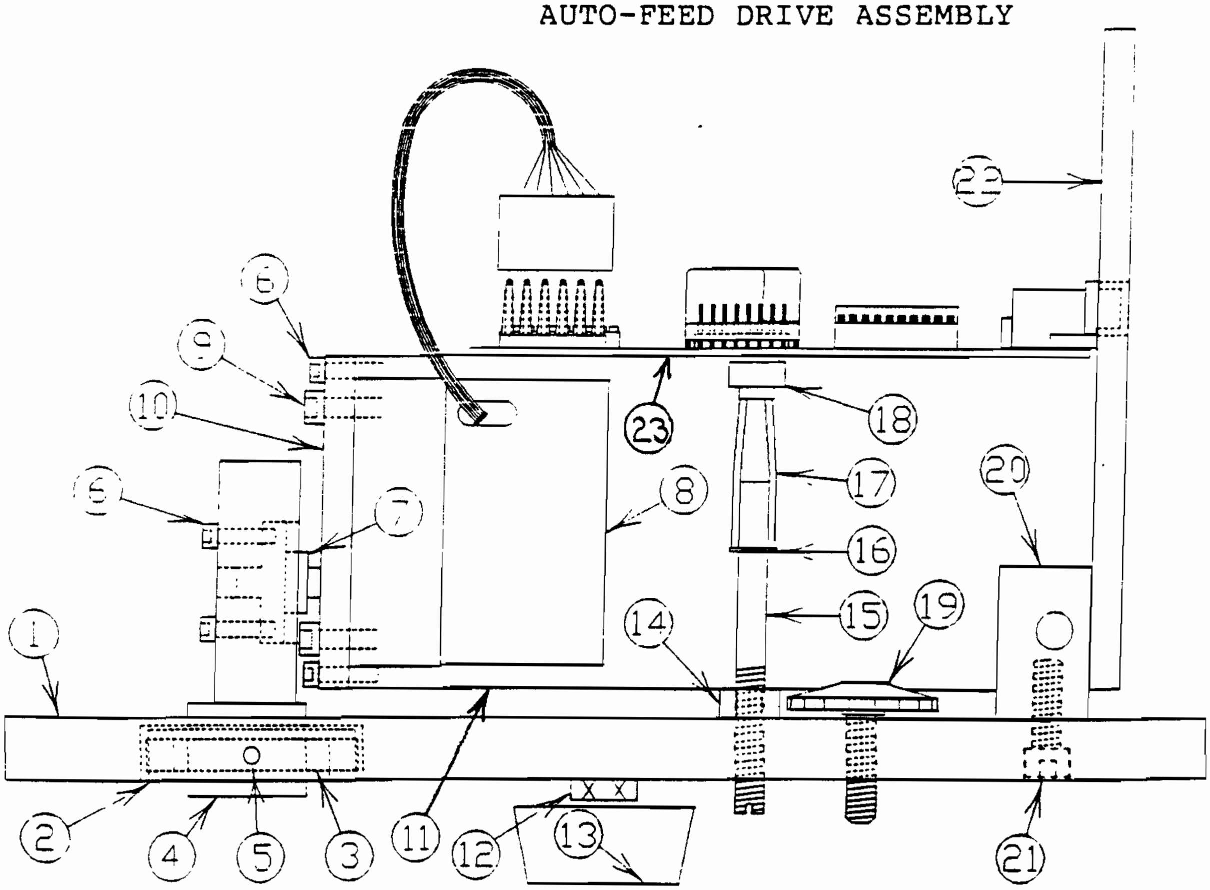
PARTS LIST - AUTO-FEED DRIVE ASSEMBLY

ITEM	QTY	PART No.	DESCRIPTION
1	1	AF-501	AUTO-FEED BASEPLATE
2	1	AF-502	GYMBAL RING FOR IDLER ROLLER SHAFT
3	1	AF-503	CROSS SHAFT, 1/4" DIA, FOR IDLER ROLLER
	2	AF-411	1/4" SNAP RING FOR CROSS SHAFT
4	1	AF-504	IDLER ROLLER WITH BEARINGS
5	1	AF-505	PIVOT PIN, SHORT, 1/8" DIA X 7/8" LONG
	1	AF-506	PIVOT PIN, LONG, 1/8" DIA X 1" LONG
	2	AF-507	"O-RING" USED FOR PIVOT PIN / GYMBAL SPACER
**	*	AF-500	AUTO-FEED BASEPLATE ASSEMBLY CONSISTING OF ALL OF THE ABOVE ITEMS 1-5
6	12	AF-401	5-40 X 1/2" LONG SOCKET HEAD CAP SCREW
7	1	AF-520	DRIVE HUB, 1/4" BORE, FOR RUBBER WHEEL
	1	AF-521	6-32 X 1/8" ALLEN SET SCREW, FOR ABOVE HUB
	1	AF-522	RUBBER DRIVE WHEEL
8	1	AF-530	STEPPER MOTOR, 12.625 PULSES PER CENTIMETER (FOR NORMAL AND LIGHTWEIGHT WEB TRANSPORT)
		ALTERNATE STEPPER MOTOR - HIGHER TORQUE	
	1	AF-531	STEPPER MOTOR, 30.300 PULSES PER CENTIMETER (FOR HEAVIER WEIGHT WEB TRANSPORT)
9	4	538-402	8-32 X 1/2" SOCKET HEAD CAP SCREW
10	1	AF-540	STEPPER MOTOR MOUNTING PLATE
11	2	AF-541	SIDE PLATES
12	1	538-461	LOCKNUT, 5/16"-24
13	1	538-240	RUBBER FOOT
14	1	AF-450	LOCKNUT, 1/4"-28, FOR SWITCH SHAFT
15	1	AF-410	SHAFT, SWITCH ACTIVATION (nip-up status)
16	1	AF-411	1/4" SNAP RING FOR TUBING SLEEVE STOP
17	1	AF-412	TYGON TUBING SLEEVE (for switch activation)
18	1	AF-701	PUSHBUTTON SWITCH (nip-up status) (Soldered to printed circuit board)
19	1	AF-420	THUMBWHEEL JACKSCREW (to raise the drive roller)
20	1	AF-542	PIVOT BLOCK, with 5/16" pins installed
21	2	AF-421	1/4"-28 X 3/4" LONG SOCKET HEAD CAP SCREW
22	1	AF-543	REAR PANEL PLATE
23	1	538-980	AUTO-FEED CIRCUIT BOARD ASSEMBLY

AUTO-FEED CABINET ASSEMBLY



AUTO-FEED DRIVE ASSEMBLY



SECTION 10

RECOMMENDED SPARE PARTS

PAGE	ITEM #	PART #	DESCRIPTION
9.4	10	M1-970A1	Replacement photoemitter IR-LED. (Package of 4)
9.6	3	538-707	Fuse, 5 Amp @ 120 vac 5 mm dia. x 20 mm long (538-707 is for a box of 10)
ALTERNATE:		538-707A	Fuse, 2.5 Amp @ 240 vac 5 mm dia. x 20 mm long (538-707A is for a box of 10)
9.8	10, 11	538-231	O-rings for air accumulator tanks (pt. # 538-231 = package of 2)
9.10	2	538-330	Cylinder return spring
9.24	8	538-172A	Air filter / Noise Silencer
9.24	9, 10	538-724	Air Compressor Rebuild Kit Consists of the following: (1) 538-704 Diaphragm piston (1) 538-705 Valve plate

NOTE: YOU MAY WISH TO USE PART # M1-001 TO ORDER ALL OF THE ABOVE SPARE PARTS AS ONE KIT. WHEN USING THIS PART NUMBER WE WILL SHIP (2) OF PART # 538-172A INSTEAD OF (1).

M1-001 SPARE PARTS KIT FOR MODEL 1 AIR PERMEABILITY TESTER

RS-232 COMMUNICATIONS PROGRAM FOR SERIAL PORTS # 1 & # 2

SERIAL PORT #1:

When a system is purchased with an Auto-Feed and printer, Serial Port #1 is programmed to print a graphic report in accordance with the operating instructions outlined in Section 6.

Serial Port #1 can also be programmed for other data transmission functions that require bi-directional communications.

BAUD = 2400, 8 BIT WORD LENGTH, NO PARITY, 1 STOP BIT
X-ON/X-OFF MODE OF HANDSHAKING

RS-232 CABLING:

	D-25 PIN	D 25-PIN	CUSTOMER CONN D-25 MALE
Black	2	2	2 receive from printer
Red	3	3	3 data x-mit to printer
White	7	7	7 ground

SERIAL PORT #2:

When Serial Port #2 is NOT COVERED and a D-25 Male connector is installed (rather than a blank cover), the following applies:

After each test, the instrument microprocessor board transmits the individual test value, and other data that may be necessary to define test conditions. This port can send data to a host computer (data acquisition system).

Sometimes this port is programmed to send graphic reporting data to a printer.

BAUD = 2400, 8 BIT WORD LENGTH, NO PARITY, 1 STOP BIT
NO HANDSHAKING - DATA OUTPUT ONLY

RS-232 CABLING:

	D-25 PIN	D 25-PIN	CUSTOMER CONN D-25 MALE
Red	3	3	3 data x-mit to printer
White	7	7	7 ground

Design of a modern air permeability instrument comparable to Gurley-type instruments

George A. Hagerty, John W. Walkinshaw, and Paula M. Foley

ABSTRACT: Air permeability measurements by the Gurley method may take from several seconds to many hours to complete. Previously, the authors established the feasibility of using electronic pressure sensors and flow transducers to rapidly measure air permeability in the equivalent of Gurley seconds. Here, a new air permeability instrument is compared with the Gurley-type instrument. The measurement values are shown to be in agreement with those of the Gurley instrument. This technology can be used to test most grades of paper.

KEYWORDS: Air permeability, design, Gurley testers, instruments, paper tests, test methods.

The main drawback with the Gurley-type instrument for the measurement of air permeability is the amount of time required for the test. In its current version, the instrument measures the time it takes for a certain volume of air to flow through the specimen as timed by marks on the side of the cylinder; the results are reported as Gurley seconds (*1, 2*). However, for tightly bonded or closed sheets, it may take much longer than just a few seconds to make the measurement—perhaps even several hours.

In a previous article (*3*), we reviewed the operational parameters of the Gurley instrument and proved the feasibility of using electronic pressure sensors and flow transducers to rapidly measure air permeability in the equivalent of Gurley seconds. Drawbacks encountered in the prototype instrument were mainly with the air supply requirements because the mechanical-diaphragm air regulator used was unable to hold pressures within 1/100th of a kilopascal. This shortcoming is believed to have contributed to some of the 7% error encountered between the actual Gurley seconds and the converted values of measurements made with the flow transducers in the air resistance test range of 50–80 Gurley seconds. This error can be reduced to less than 5% with pressure adjustments made for each sample tested.

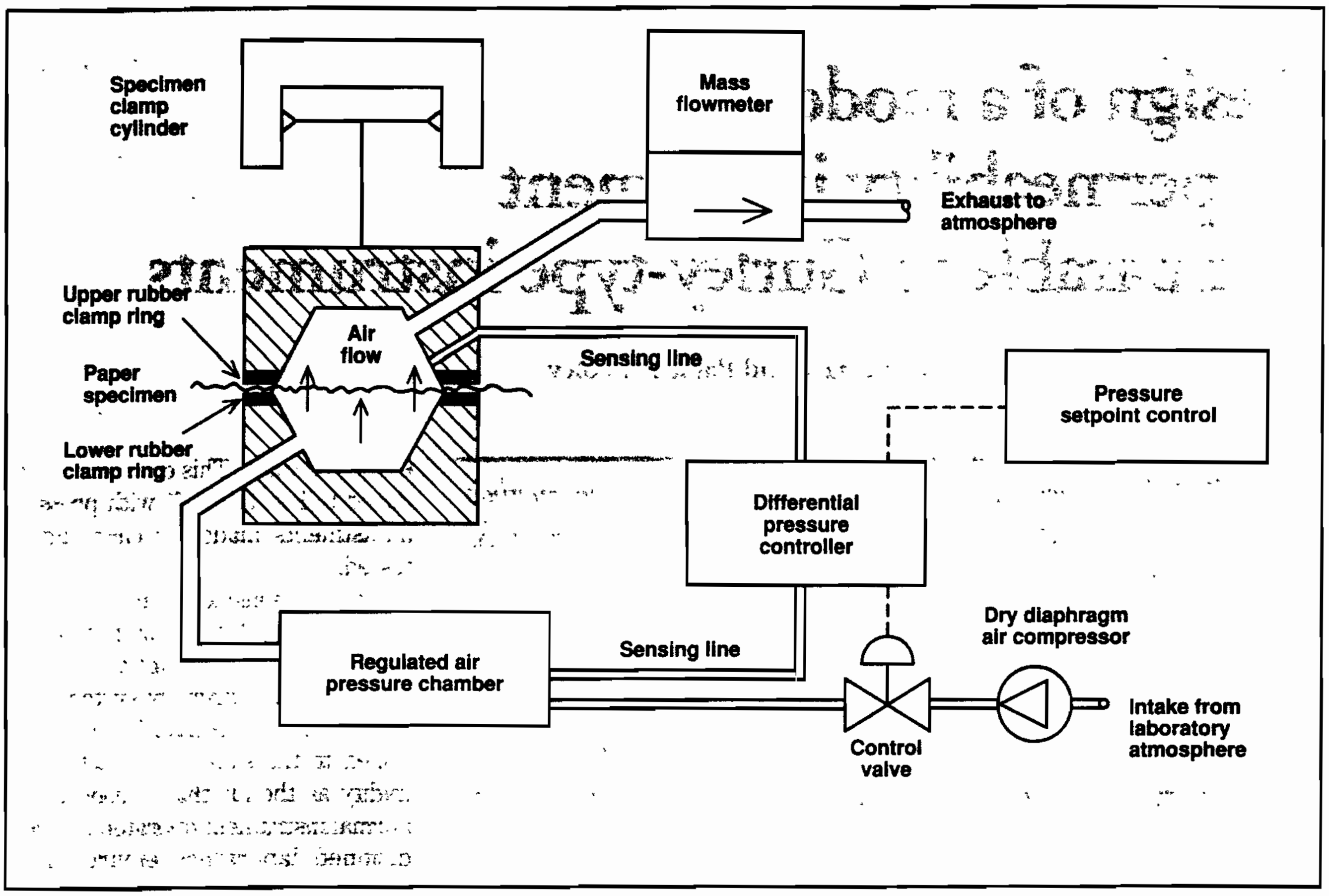
Another consideration in the error analysis is that "shop" compressed air was being passed through the sheet as part of the measurement system. This air would not necessarily be conditioned to the same 50% relative humidity as the air that is used in the normal instrument operated in a conditioned laboratory environment. Work with woven mercerized cotton broadcloth (*4*) indicated that air permeability is influenced significantly by the humidity of the air used in the test. For cotton cloth evaluated over the range of 0–95% RH, the scaled air resistance changed in a nonlinear fashion from 1.0 to 1.36. Because of the hygroscopic nature of cellulose, paper should likewise be sensitive to the humidity of the air used in the test.

Design of the air permeability test instrument

Figure 1 shows the design of the Hagerty Technologies Model 1 Air Permeability Tester. It uses a thermal mass flow sensor to measure the air flow that passes through the paper specimen. The specimen is clamped between an upper and lower rubber ring, loaded by means of an air pressure cylinder. The bottom rubber ring is self-aligning to the top ring to ensure a good seal under heavy loading conditions. The clamping rings have an inside diameter of 28.6 mm (1.125 in.).

Hagerty is president of Hagerty Technologies Inc., RR No. 1, 34A Lyndon Rd., Queensbury, NY 12804. Walkinshaw is a professor in the Chemical Engineering Department, University of Massachusetts—Lowell, Lowell, MA 01854. Foley is technical director, Newark Atlantic Paperboard Co., 250 Canal St., Lawrence, MA 01842.

1. Model 1 air permeability tester



According to the manufacturer's specifications (*5*) for the W. & L. E. Gurley, Gurley–Hill S.P.S. Tester located at the University of Massachusetts—Lowell, with which the Model 1 is compared here, the Gurley instrument utilizes an exposure diameter of 1.128 in. This difference of 0.003 in. in diameter results in a loss of 0.5% of the area in going from the Gurley instrument to the Model 1 instrument. The software program in the Model 1 makes a correction using an area ratio factor to compensate for this difference.

A low-pressure source used for the measurement air is positioned within the testing environment. The purpose of this arrangement is to maintain a consistent relative humidity between the measurement air and the conditioning atmosphere, thus minimizing changes within the specimen. The air source for the measurement air is directed at the bottom side of the specimen.

The chamber above the specimen, sealed by the upper rubber ring, is connected to the inlet of an electronic mass flowmeter. To maintain a constant pressure drop across the specimen, a differential pressure sensor measures the pressure drop across the specimen and in turn controls electropneumatic valves in the air flow network. This arrangement eliminates the problem of pressure loss in piping.

This configuration is not as sensitive to surface leakage to the atmosphere (resulting from specimen roughness) as the Gurley-type instrument. Surface leakage along the bottom rubber ring (the high-pressure side) is neglected because it is not included in the measurement. Surface leakage along the upper rubber ring (the low-pressure side) could affect the measurement. However, this leakage is thought to be very small because the pressure in the upper discharge chamber is close to atmospheric pressure; hence, the pressure differential across the seal is slight.

A microprocessor board with an analog to digital converter is used for data acquisition for the flowmeter and pressure signals and for control of the sequence of mechanical operations. The results are displayed digitally, with each test requiring about 6 s.

Test results

About 100 paper samples of various permeabilities were tested on both Lowell's Gurley instrument and the Model 1 air permeability tester with a test head pressure set at 1.22 kPa (4.90 in. H_2O at 60°F). In many cases, one single specimen was selected for evaluation on the Gurley–Hill S.P.S. instrument (because of long test times), whereas five specimens from each sample were tested and averaged for the Model 1 tester. The flow transducers were calibrated in milliliters per minute per square inch of test area at 1 atmosphere pressure and 23.1°C.

Poiseuille–Hagen equation for the grades of paper tested for this study. Caution must be observed in applying the same approach to those grades of paper that have pinholes or relatively large passageways that do not restrict the air flow through the sheet to the laminar flow region.

Figure 4 shows this relationship in units of measurement that most people are familiar with, namely Gurley seconds, or seconds per 106 mL (corrected). The data analysis indicates that the inverse of the slope of the regression line is 5.31 (regression coefficient, $r^2 = 0.995$); the inverse is used to correct for the inverted relationship of Gurley seconds to air flow rate. This is an error of the 3.7% from the slope of 5.12 predicted from the Poiseuille–Hagen equation.

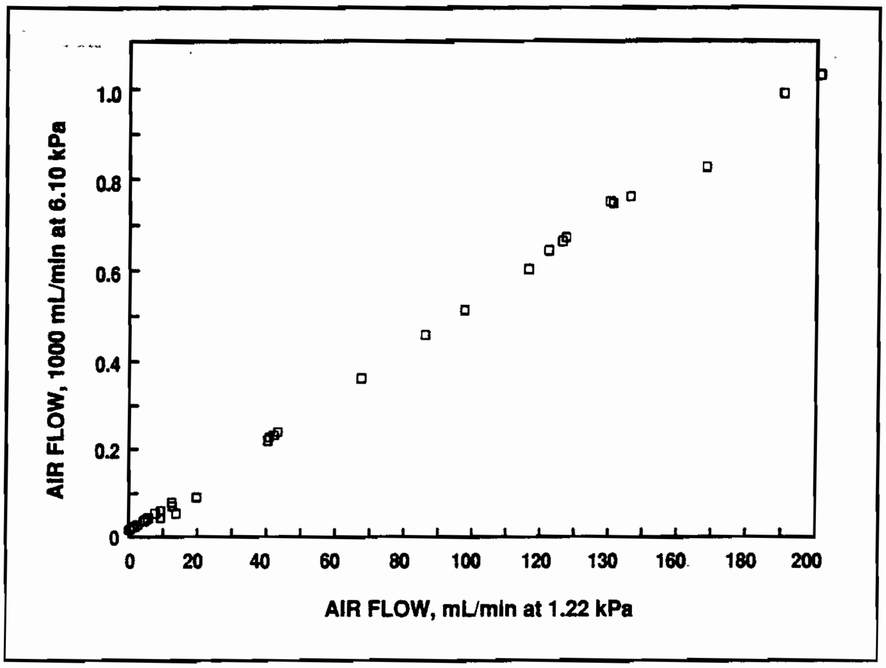
Conclusions

Instruments that use mass flow sensors can be used to measure air permeability at a much faster rate than possible with the Gurley-type liquid column devices, with the measurement values in substantial agreement with those of the Gurley instruments. To convert such measurements of flow rates into the more familiar units of "seconds per 100 mL," it is critical to measure and/or control the upstream and downstream pressures across the specimen.

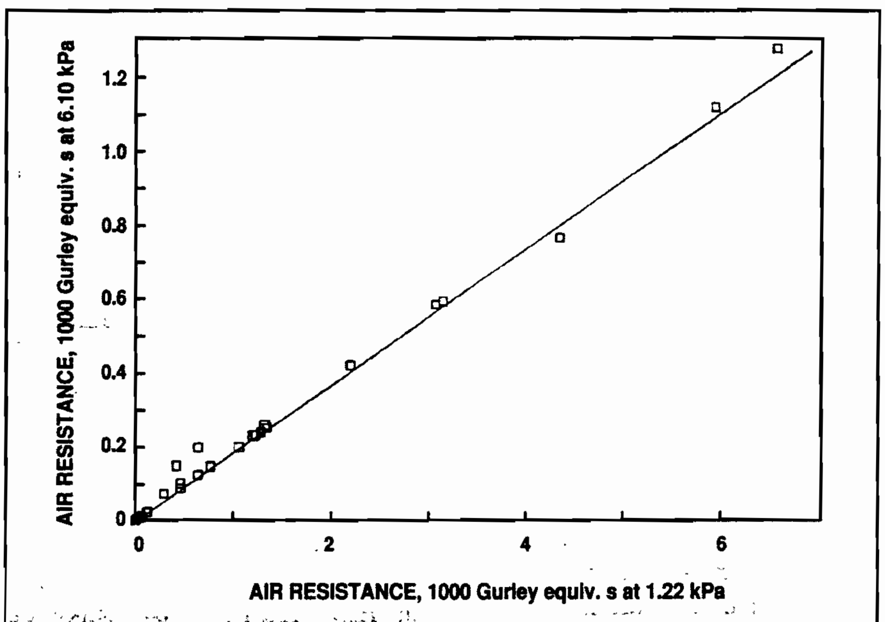
The Poiseuille–Hagen formulas seem to work well in converting the measured air flows back to the "Gurley seconds" as measured by the liquid column instruments in the ranges that we tested. By using mass flow sensors to measure the flow discharged from the specimen, personnel can significantly reduce the uncertainty of test results pertaining to errors caused by surface leakage across the specimen. The range of the instrument can be extended by performing the tests at elevated pressures and normalizing the test results back to what would be expected at the lower pressures.

With the proper selection of the flowmeter range, the test pressure setting, and the clamping ring area, this technology can be used to test almost every grade of paper made today.

3. Air permeability measurements at normal and elevated air pressures



4. Gurley equivalent permeability measurements at normal and elevated air pressures



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Analysis of Gurley-type air permeability measurement and the use of electronic flow sensors

John W. Walkinshaw
Chemical Engineering Dept., University of Massachusetts Lowell, Lowell, MA 01854

George A. Hagerty
Hagerty Technologies Inc., 34A Lyndon Road, Glens Fall, NY 12801

ABSTRACT *The Gurley-type instrument is described in TAPPI Test Method T 460 om-88 for measuring air permeability. Based on a full understanding of the instrument parameters and the measurement process, an electronic flow sensor equivalent to the Gurley permeability instrument was developed. Direct comparisons were made between the two testers. The two instruments are similar in their accuracies of measurement. However, the electronic version produces a result in seconds as compared to minutes or even hours for the traditional instrument.*

KEYWORDS
Air permeability
Analysis
Electronic instruments
Flow measurement
Gurley testers
Measuring instruments
Test equipment
Test methods
Testing

With the Gurley-type instrument for measuring air permeability, the length of time required for the test is a drawback. The current version of the instrument relies on the time it takes for a certain volume of air to flow through the specimen as timed by marks on the side of the cylinder. The results are reported in seconds per 100 mL of air. Samples with a low permeability yield high Gurley readings. Thus, the instrument is more correctly considered to measure the air resistance of the specimen under test (*1*). For many papers, the test times are reasonable; that is, under 30 s for 100-mL of air to pass through a test specimen. However, there are grades that require longer times—from several minutes to several hours to complete the test.

Here, we will look at the instrument currently used and the parameters that affect the measurement. Based on this understanding of the mechanisms of the measurement of permeability, an instrument has been developed that performs the same task in a much shorter time.

Understanding the Gurley-type instrument

The low-pressure Gurley-type instrument as described in TAPPI Test Method T 460 om-88, "Air Resistance of Paper," consists of two cylinders. The outer cylinder and a center feed tube provide a volume for an oil seal, while the second cylinder traps a volume of air within the instrument (*2*). The air pressure required to generate flow through the specimen is provided by the weight of the inner cylinder, which acts on the volume of air trapped inside the cylinder, pushing it through the exposed 6.4-cm^2 (1-in.^{2}) area of the specimen (*3*).

The complete history of the instrument is not necessary for a full understanding of the mechanism of the test. However, two points of its development are important. First, the instrument was developed with the moving inner cylinder, the one that traps the air, being calibrated at intervals of 0 (at the bottom of the cylinder), 25, 50, 75, 100, 150, 200, 250, 300, 350, and 400 mL (at the top of the cylinder). The elapsed time is measured between the first two consecutive 50-mL marks to pass the rim of the outer cylinder (*2*). For relatively impervious papers, the time is measured at the end of the first 50-mL mark and is then doubled.

Thus, permeability is reported as seconds per 100 mL, as measured from the bottom gradations of the cylinder.

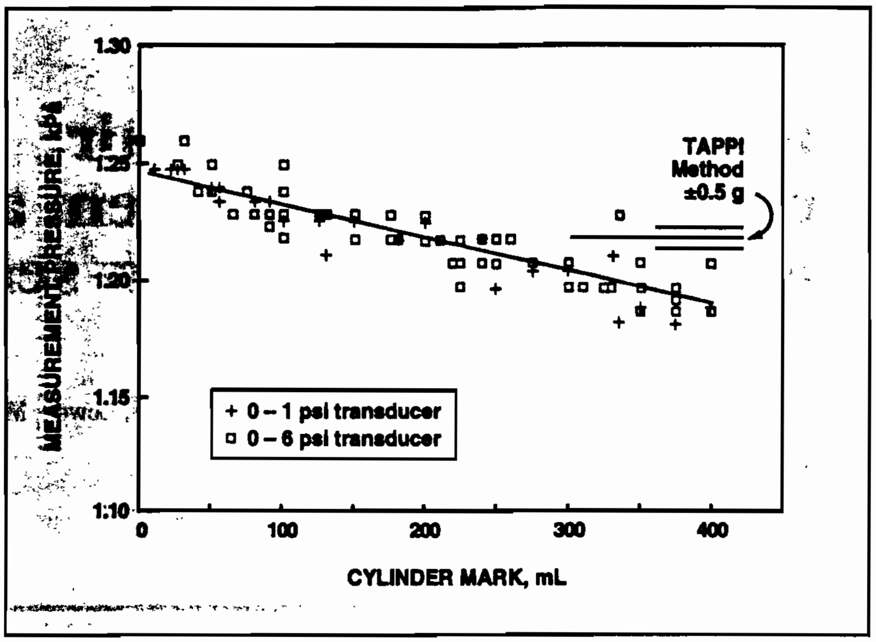
Second, the air pressure required for the test was provided by the weight of the cylinder, thus requiring the initial specifications for the instrument to include the cylinder weight and its tolerance (*3*, *4*). In subsequent versions of the method (*2*), the cylinder weight of 567 ± 0.5 g was supplemented by the addition of a pressure specification of 1.22 kPa. The pressure estimated by the manufacturer was reported as 4.89-in. $H_2O\cdot$ 60°F, or 1.217 kPa (*4*). The question that arises concerns the verification of the pressure value reported and the significance of the weight tolerance of the cylinder in affecting the pressure change.

The oil used to provide the air seal must be considered as well. This oil also acts to provide a buoyant force on the inner cylinder, thus reducing the effective force exerted by the cylinder weight.

There is also a consideration that must be made for the newer instruments that have automatic timing devices that are activated by timing marks on the inner cylinder wall. The problem is to determine the pressure that corresponds to the measured volumes. The buoyant effect of the oil decreases the effective pressure as the cylinder lowers into the oil. The reported pressure of 1.22 kPa may apply for one point in the measurement scale, but which point? If the test is conducted according to the TAPPI method, the average effective pressure would be measured when the cylinder first comes in contact with the oil, and the timing would be done through the first two consecutive 50-mL marks. In the case of the newer electronic timer versions, the timing takes place when the cylinder passes through the middle of the measurement range. Hence, the average effective pressure during the test is less for the electronic timer version than for the TAPPI method.

The last factor to determine is the actual volume of air that passes through the specimen under test. In the past, this has been assumed to be that volume that was marked by the scale on the inner cylinder. However, no allowances have been made for the volume change that results as the cylinder wall displaces oil in the seal and for the change in the oil level (manometer effect) in the inner cylinder as the internal pressure changes.

1. The effect of cylinder buoyancy on pressure



Development of a prototype conversion instrument

With any type of instrument conversion from a manual to automatic readout, an understanding of the fundamentals of the measurement mechanism and instrument operating conditions is necessary. In the case of this instrument, the question of the effective air pressure during the test must be resolved.

The instrument chosen for the initial trials is located at the University of Massachusetts Lowell and is a Gurley-Hill SPS tester manufactured by W. & L. E. Gurley Co. It is equipped with a bottom specimen clamp that holds the test specimen against the bottom of the cylinder and is loaded with the 2.0-lb dead weight, thus producing a clamp pressure of 40.5 psi (*4*). The dead weight and lever arm are primarily for use with the smoothness and softness tests as a means of controlling clamp pressure. However, the use of the fixed pressure loading method was adopted for the air permeability test. This method allows the lower clamp to self align and reduces any possibility of deforming the base alignment, which would cause air leakage. The cylinder weight on the instrument chosen for the tests was weighed and found to be 567.04 g, which is almost in the center of the weight range allowed for in the test method (567 ± 0.5 g) (*2*).

For determining the actual air pressure as a function of cylinder position, a new bottom clamping plate was machined to fit in the instrument. The plate was made to seal off the bottom and to prevent any air leakage. Next, two ports were added. The first was used as a pressure tap, while the second was connected to a regulated source of low-pressure air. As the pressure was increased into the instrument through the tap in the special bottom plate, the cylinder rose. Over several days, we executed a series of runs using two electronic pressure transducers, using both increasing and decreasing air pressures (to include any effects of hysteresis), and measuring the height of the inner cylinder by the volume marks.

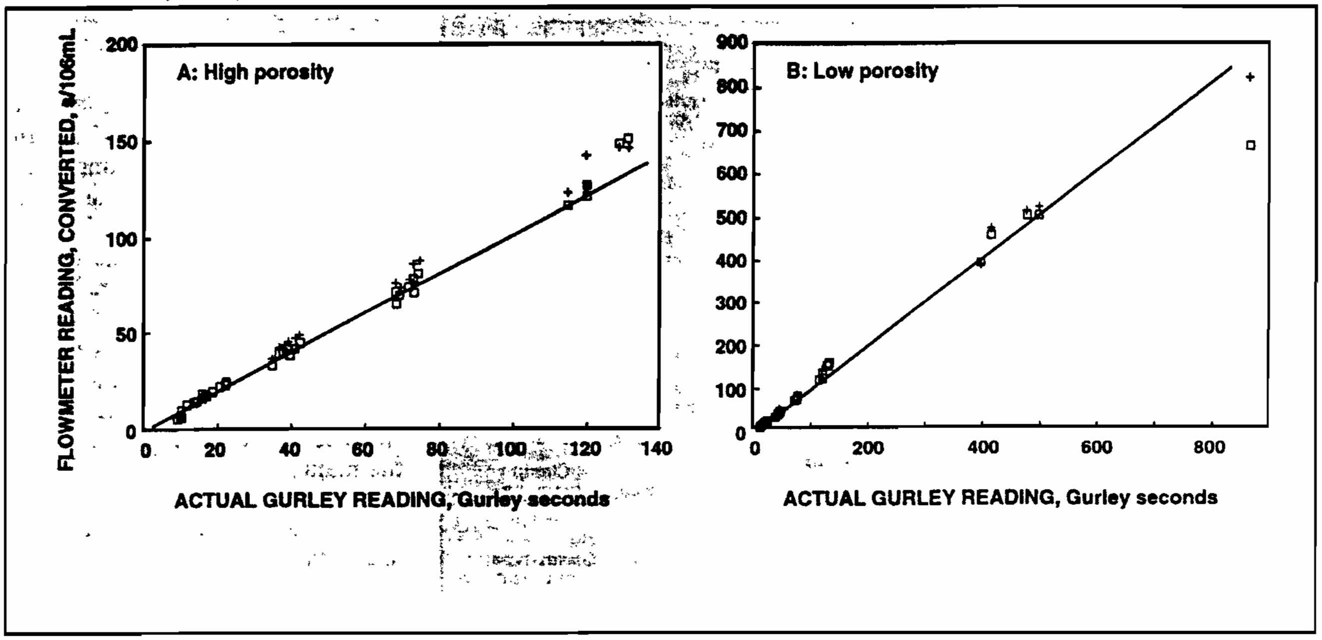
The results are shown in **Fig. 1**. The slope of the line shows the effect of buoyancy of the "floating" cylinder wall in the oil. The negative slope of this line results as more of the cylinder mass is immersed in the oil and its effective weight is reduced, requiring less air pressure to maintain equilibrium. A linear regression analysis of the data yields this equation:

$$P = 1.247 - 1.418 \times 10^{-4} V \qquad (1)$$

where

P = test pressure, kPa

3. Gurley readings vs. prototype instrument readings for the high-porosity and low-porosity samples. The pressure was set at 1.22 kPa under static conditions (no flow)



Conversion of the instrument to electronic flow measurement

The Gurley instrument located at the University of Lowell was chosen to be modified to a full sensor measurement system. The criteria for conversion were simple. No permanent change would be made that would effect the normal two-cylinder operating mode, and it had to be easy to switch the unit between the two configurations, because the standard method is used frequently.

The air supply and flow measurement system was assembled in one cabinet. The design was kept flexible to allow for substitution on both the Sheffield and Gurley instruments. Figure 2 shows a flow sheet for the unit. Included are two transducers for pressure (0 to 1 psi and 0 to 6 psi differentials) and two flow transducers (0 to 200 std. cm^3/min and 0 to 3000 std. cm^3/min). The electronic thermal mass flowmeter operates on the principle of heat transfer: the mass flow of air carries heat from an upstream heat source (with temperature measurement) to a downstream temperature sensor. The connections between the various valves and transducers were made with compression fittings on the high-pressure sides of the regulators and barbed fittings and flexible tubing on the low-pressure side of the final regulator. The system was extensively tested for leaks to ensure that there would be no side effects to the flow measurement when the system was attached to the test instrument.

The design shown in Fig. 2 allowed for a three-way valve to be closed off to check the zero point on the flow transducers. The concept worked well with the Sierra flow transducer, but the Honeywell showed fluctuations in output in the no-flow position of the three-way valve. Later, when the flow system was attached to the instrument supply tube and the end of that tube was blocked off, the output fluctuations from the Honeywell transducer increased significantly. We later learned that this type of transducer tends to measure a form of resonance in the piping system when there is no flow. Thus, the only valid way to measure the zero-flow state was to use a short piece of shunt tubing from inlet to outlet, or to use tubing clamps close to both inlet and outlet, which is the same thing. The Sierra flow transducer was apparently immune to this situation.

To meet the criteria that no permanent change be made to the base unit, the feed tube from the air supply unit had to be easy to connect and leak proof. For this purpose, a rubber stopper was bored and fitted with a hose barb connection. The rubber stopper was fitted into the feed tube in the center of the Gurley instrument. A plastic tubing was used to connect the air supply unit to the instrument (Fig. 2). The entire system was leak tested with a piece of impervious film clamped in place of the normal test specimen. Any flow measurement or pressure loss in a closed system would be attributed to leaks in the modified instrument.

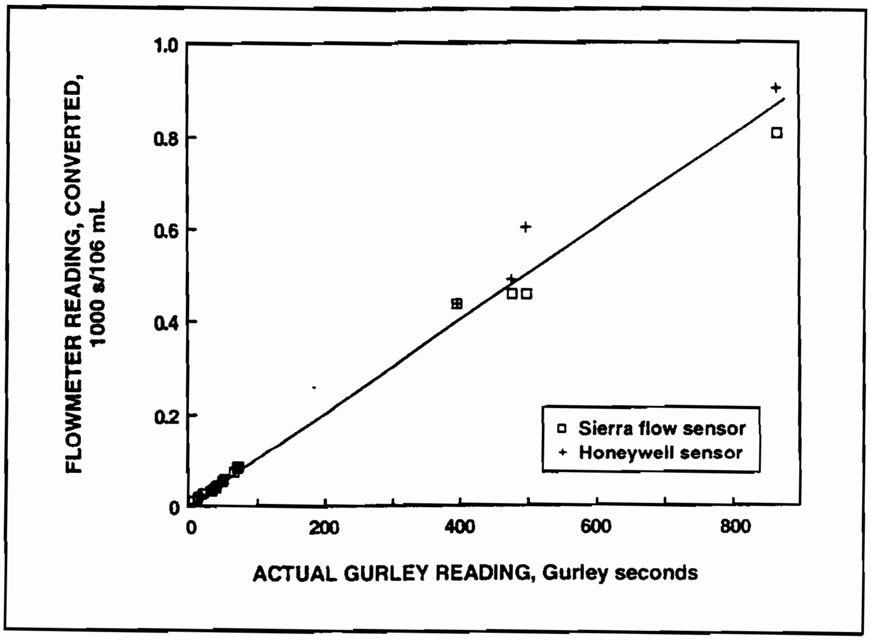
Comparisons between the Gurley unit and the electronic flow sensor unit

Since the instrument could be switched easily to act as either a standard Gurley unit or a unit enhanced for electronic measurement, it was fairly easy to run "side-by-side" comparisons. Groups of specimens were evaluated first on the standard unit and then on the unit with flowmeters attached.

In the latter case, the instrument air pressure was set under a no-flow condition, and the volume flow rate was measured through the sample. With high-porosity specimens, there was some slight loss of pressure from the static situation; however, for the trials reported first, no attempt was made to readjust the air pressure back to the 1.22-kPa setpoint.

The flow transducers were calibrated in cubic centimeters per minute at 1 atm pressure and 60°F. Values were converted for time, temperature, and pressure (1.22 kPa gauge) and were corrected for the

4. Gurley readings vs. prototype instrument readings for the trial in which the air pressure regulator was adjusted to 1.22 kPa each time a sample change was made.



actual volume of 106 mL at the 1.22-kPa pressure by Eq. 2:

$$\text{Gurley, s} = [(60\ \text{s/min})\ 106\ \text{mL} / \text{Flow, std. cm}^3\text{/min}]\ (520°\text{R}/532°\text{R})\ (102.52\ \text{kPa}/101.13\ \text{kPa}) \qquad (2)$$

Also, the volume of 107 mL could be used without any additional correction needed for pressure. The results for the first trials are reported in two ranges in **Fig. 3**, high porosity and low porosity. The lines in both graphs represent an exact correlation between the two measurement systems. The actual Gurley seconds are reported from timing between the 100-mL and 200-mL marks, while the readings from the flow transducers are corrected by Eq. 2 to give the time for the flow of 106 mL, to match the mathematical model for the instrument.

For the graph in Fig. 3 for the high-porosity samples, data points were predominantly taken with the higher ranging Sierra transducer, which can measure to 3000 std. cm^3/min. The measurement capability of this transducer decreases with the measurement of samples with porosities of greater than 10 Gurley seconds. Some slight differences were noted between the two transducers, as a the result of different sources being used for the calibration between the two units. The Sierra unit flow calculations were based on the reported factory conversions. In the case of the Honeywell transducer, which has a nonlinear relationship, a look-up table was developed for the flow calibration based on a Brooks flow controller. In the higher porosity range, the high-flow-rate Sierra transducer appeared to provide better correlation.

The graphs in Fig. 3 show that there is some deviation from an ideal fit between the Gurley instrument and the electronic flow sensor modification. For the high-porosity samples, the mean error at midrange is less than 7%, as contrasted to a mean error of 5% at midrange for low-porosity samples.

A regression analysis on the data shown in Fig. 3B revealed a best-fit slope ($r^2 = 0.965$) of 0.931 as contrasted to an ideal slope of 1. Some of this error may be associated with the problems of the measurement not being repeated on the same area as specimens were tested by the manual and electronic instrument configurations. A second source of error may be the mechanical pressure regulator. While this is a special unit with a maximum output of 2 psi, it still suffers from some drift (about 0.5% absolute pressure) as the flow rate changes.

A second trial was performed using the air pressure regulator to adjust the pressure to 1.22 kPa each time a sample change was made. The results are shown in **Fig. 4.** A comparison with Fig. 3B indicates a somewhat better fit achieved with the pressure adjustment in both the low- and high-porosity samples. In fact, the regression analysis for the data in Fig. 4 indicates an $r^2 = 0.990$ with a 1.01 slope to the regression line. Not evident in Fig. 4 is the same sensor "drop-off" below 10 Gurley seconds that was indicated in Fig. 3A.

Conclusions

The Gurley instrument has operating parameters that may have gone unnoticed through years of use. First, there is a steady loss of pressure as the test is allowed to go to completion. Second, the pressure reported in the TAPPI Method corresponds to the middle of the scale of measurement. Third, the volume delivered is 106 mL measured at the operating pressure of 1.22 kPa, not the assumed amount of 100 mL.

These results show that a reliable method is available to convert the Gurley-type permeability method into a fast measurement method with reasonable accuracy.□

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COMPARISON OF AIR PERMEABILITY MEASUREMENTS AMONG COMMONLY USED TAPPI METHODS

George A. Hagerty
Hagerty Technologies, Inc.
RR#1 34A Lyndon Road
Queensbury, NY 12804
(518) 793-2834

John Walkinshaw, Ph.D
Prof. of Chem. Engr.
University of Lowell
Lowell, MA 01854
(508) 934-3159

ABSTRACT:

This report analyzes the results obtained from the mercury-column Gurley instrument, and the "Sheffield Porosity" instrument. Paper specimens are also tested on an instrument that can regulate air pressure at various intensities, and air flow is measured with flowmeters calibrated to NIST-traceable methods. The air flow through many of the specimens is laminar within the range of pressures tested, whereby the Poiseulle-Hagen formulas are highly accurate in predicting the test value obtained using the conventional methods.

INTRODUCTION:

There are many grades of paper that have low air permeability, where the time required to test such samples using the "Gurley oil-type" test apparatus, as described in TAPPI T 460 om-88 (1), is very long. The alternate methods in common use are the mercury-column Gurley test apparatus, as described in TAPPI T 536 om-88 (2); and the "Sheffield Porosimeter" instrument, as described in TAPPI T 547 pm-88 (3).

In a previous study, the operating parameters of the Gurley oil-type were analyzed (4). In order to obtain a better understanding of the operating parameters of the mercury-column Gurley and the Sheffield Porosimeter, a digital manometer was installed in the pressurized chamber that clamps the paper specimen, while the air flow that passes through the specimen discharges to atmosphere. TAPPI Test Method T 536 om-88 (mercury-column Gurley) states that the test pressure is 12.33 inches water gauge (3.07 kPa); however, measurements using the digital manometer revealed that the actual test pressure generated by the instrument was significantly less. Similarly, TAPPI Test Method T 547 pm-88 (Sheffield-type) states that the test pressure is 10.3 kPa, but it contains a footnote stating "that the pressure is not maintainable as flow increases." The results of these pressure measurements are contained in this paper.

UNDERSTANDING THE MERCURY-COLUMN GURLEY INSTRUMENT:

The mercury-column Gurley instrument as described in TAPPI Method T 536 om-88 "Resistance of paper to passage of air (high pressure method)" consists of two cylinders - where the outer cylinder (with a center feed tube) is partly filled with mercury; and the inner cylinder, having a closed top, traps a volume of air within the instrument. The air pressure required to generate flow through the specimen is provided by the weight of the inner cylinder, which exceeds the buoyant force. The specimen has an exposed test area of 6.4 square centimeters (1 square inch). The inner cylinder has scale markings at intervals of 0 (at the bottom of the cylinder), 2.5, 5, 10, 15, 20, 25, and 30 ml. When this instrument is equipped with the electronic timing apparatus (photocell & timer system), it is common practice to measure the time for displacement between the 0 and 2.5 ml markings, and for the higher permeance grades, 0 to 5 ml or 0 to 10 ml.

Figure 1 shows the test pressure as a function of inner cylinder position. There was a noticable difference for the measured pressure at a given interval, depending on whether the cylinder was in a gravity descent mode; or if air pressure was applied to the inner chamber, causing the cylinder to rise. This phenomenon plotted a very distinct hysteresis curve, and perhaps it is related to the surface tension of mercury, or friction in the cylinder movement.

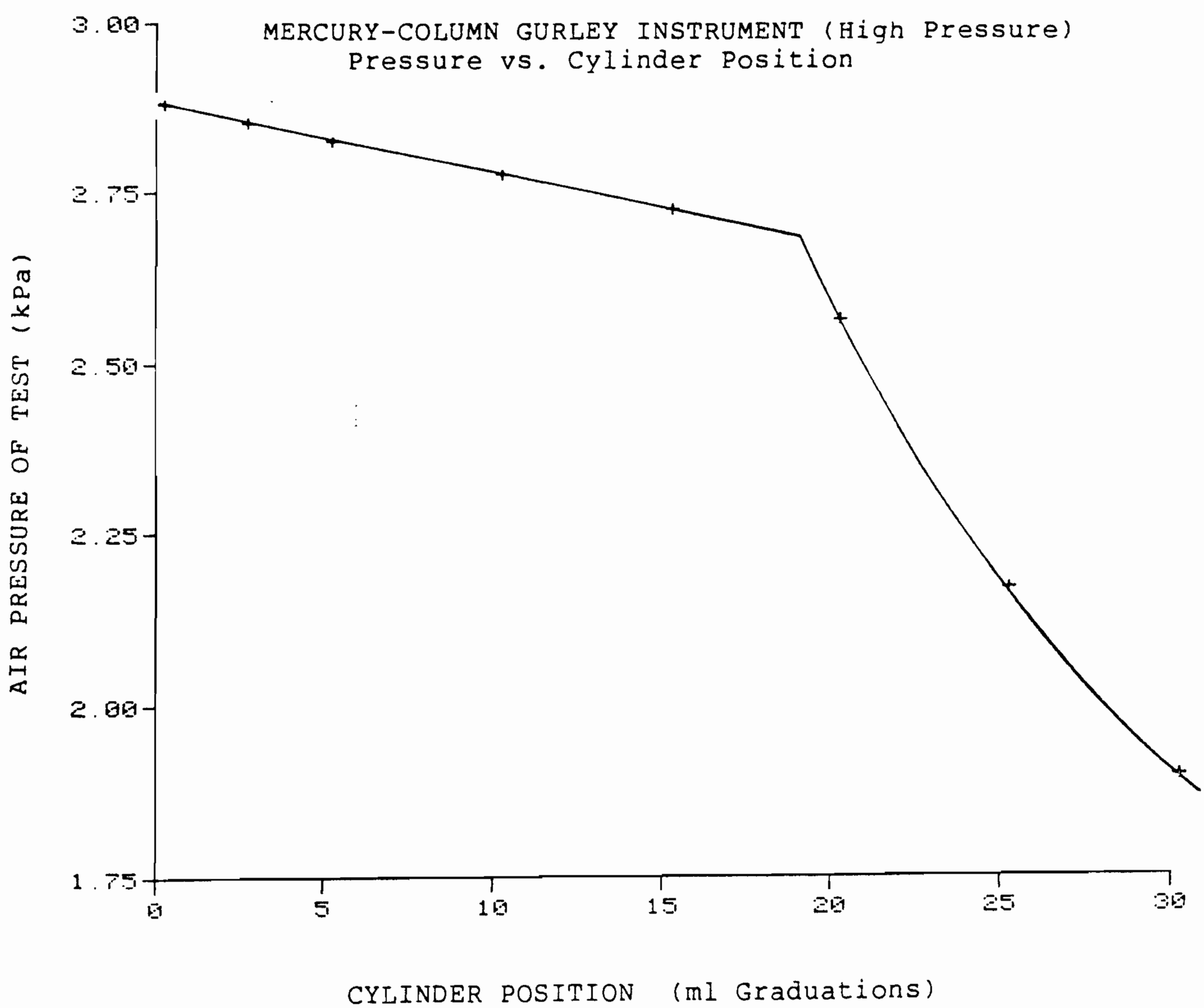
Since all measurements using the apparatus are performed in the gravity descent mode, Figure 1 displays only those data points generated in the descent. Equation 1 applies for the range from 0 to 15 ml displacement:

Equation 1: $P = 2.88 - (0.01595)ml$

Where:

P = specimen pressure differential (kPa) (discharge to atmosphere)
ml = cylinder graduation marking

FIGURE 1



A very interesting change in pressure occurs between the 15 ml and 20 ml cylinder marks. The pressure decays rapidly, and it occurs at a region in the inner cylinder where the wall thickness greatly increases. As this transition submerges into the mercury seal, there is a greater buoyant force (the cylinder wall displacing the liquid mercury seal), and the air pressure required to keep the cylinder in equilibrium decreases.

Figure 2 shows the design features of the Hagerty Technologies Model 1 Air Permeability Tester that uses a thermal mass flowmeter to measure the air flow that passes through the paper specimen. The specimen is clamped between an upper and lower rubber ring, loaded by means of an air pressure cylinder.

The bottom rubber ring is self-aligning to the top ring to assure a good seal under heavy loading conditions. The clamping rings had an inside diameter of 38.1 mm (1.50 inches) for comparative testing with the mercury-column Gurley apparatus; and for comparative testing with the Sheffield Porosimeter the inside diameter was 19.05 mm (0.75 inches). Regulated air pressure is directed to the bottom side of the specimen and the chamber above the upper rubber ring is connected to the inlet of an electronic mass flowmeter. In order to maintain a constant pressure drop across the specimen, a differential pressure sensor and electronic control valves were used to measure and control the pressure.

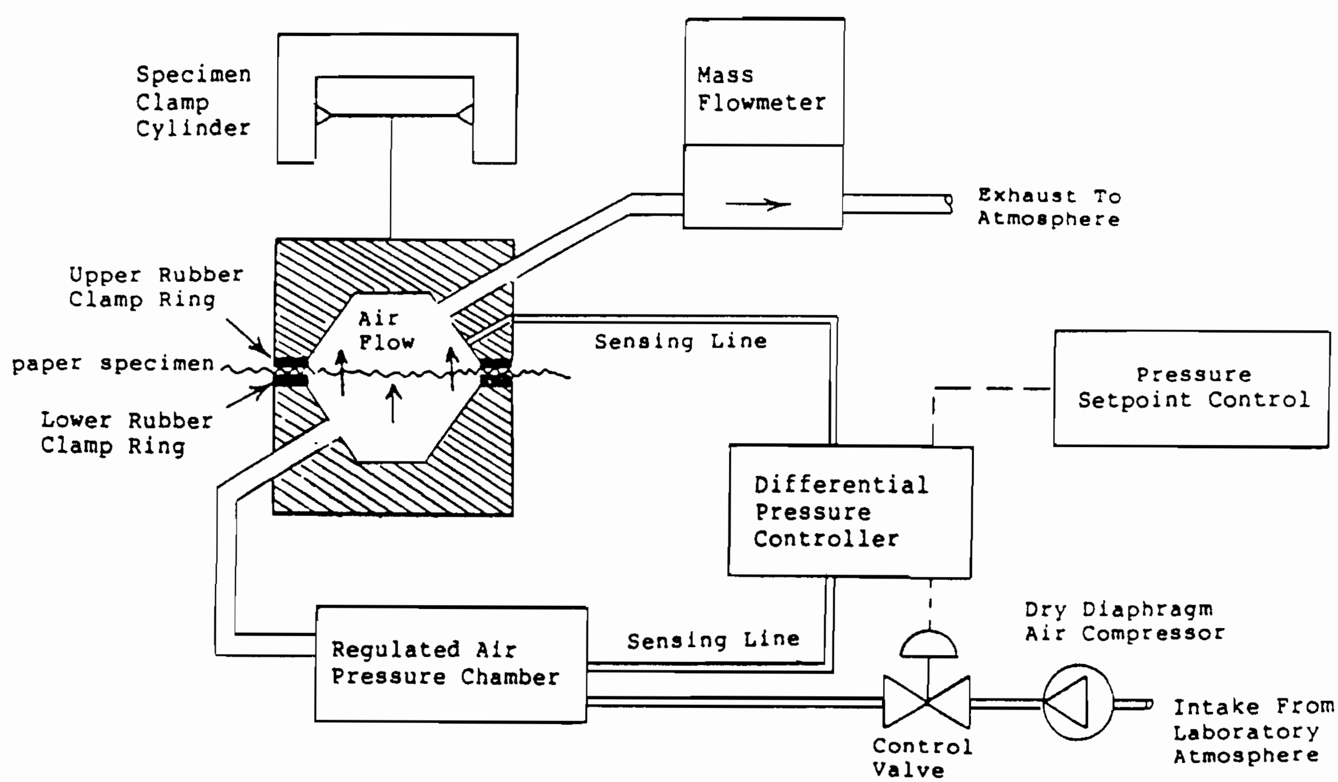
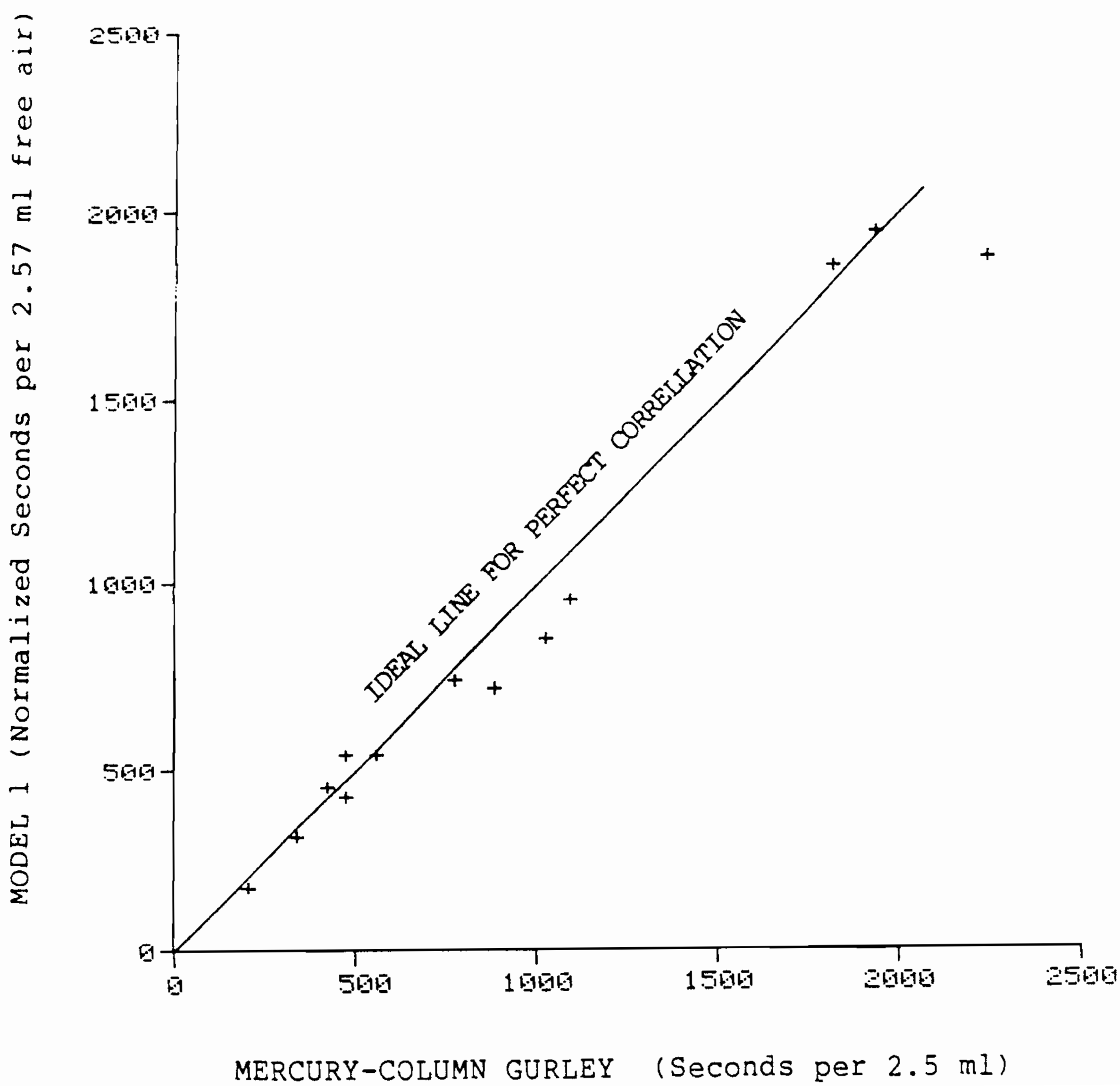


FIGURE 2: HAGERTY TECHNOLOGIES MODEL 1 AIR PERMEABILITY TESTER

At the paper testing laboratory at Lowell University, 13 specimens of very low permeance were first tested using the Model 1 instrument, and then tested using the Model 4120 High Pressure Gurley Densometer. The results are shown in Figure 3. It is reasonable to expect some scattered data points, as the mercury column Gurley tested only 56% of the area that the Model 1 tested, in the same region. The x-axis shows the Gurley test results, as measured, in seconds per 2.5 ml cylinder displacement. The test air volume, expanded to 1 atmosphere, is actually 2.57 ml.

The y-axis shows the normalized test results from the Model 1 instrument, expressed in equivalent seconds per 2.57 ml free air. The Poiseuille-Hagen formulas were used to correct for the test pressure differences, as the Model 1 tested specimens at 10.34 kPa and the Gurley instrument averaged 2.86 kPa between the 0 ml and 2.5 ml cylinder marks. Also, the Model 1 was normalized to a 6.45 square centimeter area to match the Gurley test area. The testing time for the Model 1 reached stability in 16.5 seconds, while the Gurley test results required testing times varying from 200 to over 2000 seconds per specimen.

FIGURE 3: MODEL 1 vs. MERCURY-COLUMN GURLEY



UNDERSTANDING THE SHEFFIELD POROSIMETER

In TAPPI Test Method T 547 om-88, there is a chart, accompanied by conversion formulas to convert "Sheffield Units" to engineering units. This research is fully described in another technical paper (5). In the paper testing laboratory at Lowell University, the flow / pressure drop relationship of the Sheffield Porosimeter was studied. Using regression analysis, the best curve fit was a straight line, as follows:

Equation 2: $P = 9.86 - (0.4166)F$

Where:

P = specimen pressure differential (kPa)

F = Sheffield flow (SLPM @ 1 atm , 21° C)

Equation 2 does not change when different orifice cup diameters are used. Now that the parameters of the Sheffield test were converted to engineering units (flow at a defined pressure), the Model 1 Air Permeability Tester was programmed to normalize and express the results in "equivalent Sheffield Units". The measuring head diameter of the Model 1 was changed from 38.1 mm (1.50 inch) to 19.05 mm (0.75 inch) diameter. Figures 4, 5, and 6 show the correlation between the conventional Sheffield Porosity instrument and the Model 1, which was programmed to normalize the reporting units to a 19.05 mm (0.75 inch) diameter Sheffield Porosimeter measuring head.

FIGURE 4: MODEL 1 @ 1.22 kPa vs. CONVENTIONAL SHEFFIELD

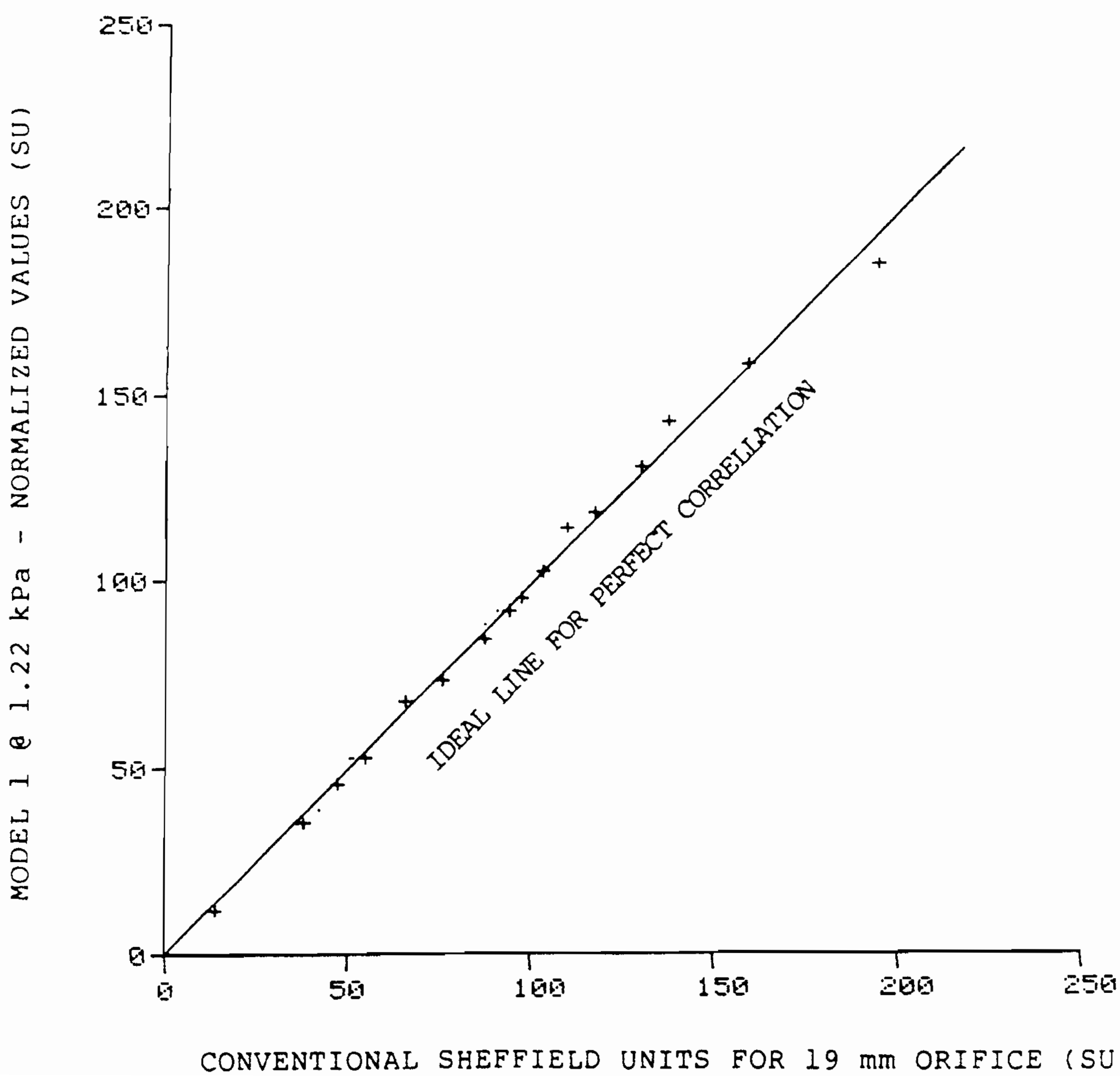


FIGURE 5: MODEL 1 @ 3.07 kPa vs. CONVENTIONAL SHEFFIELD

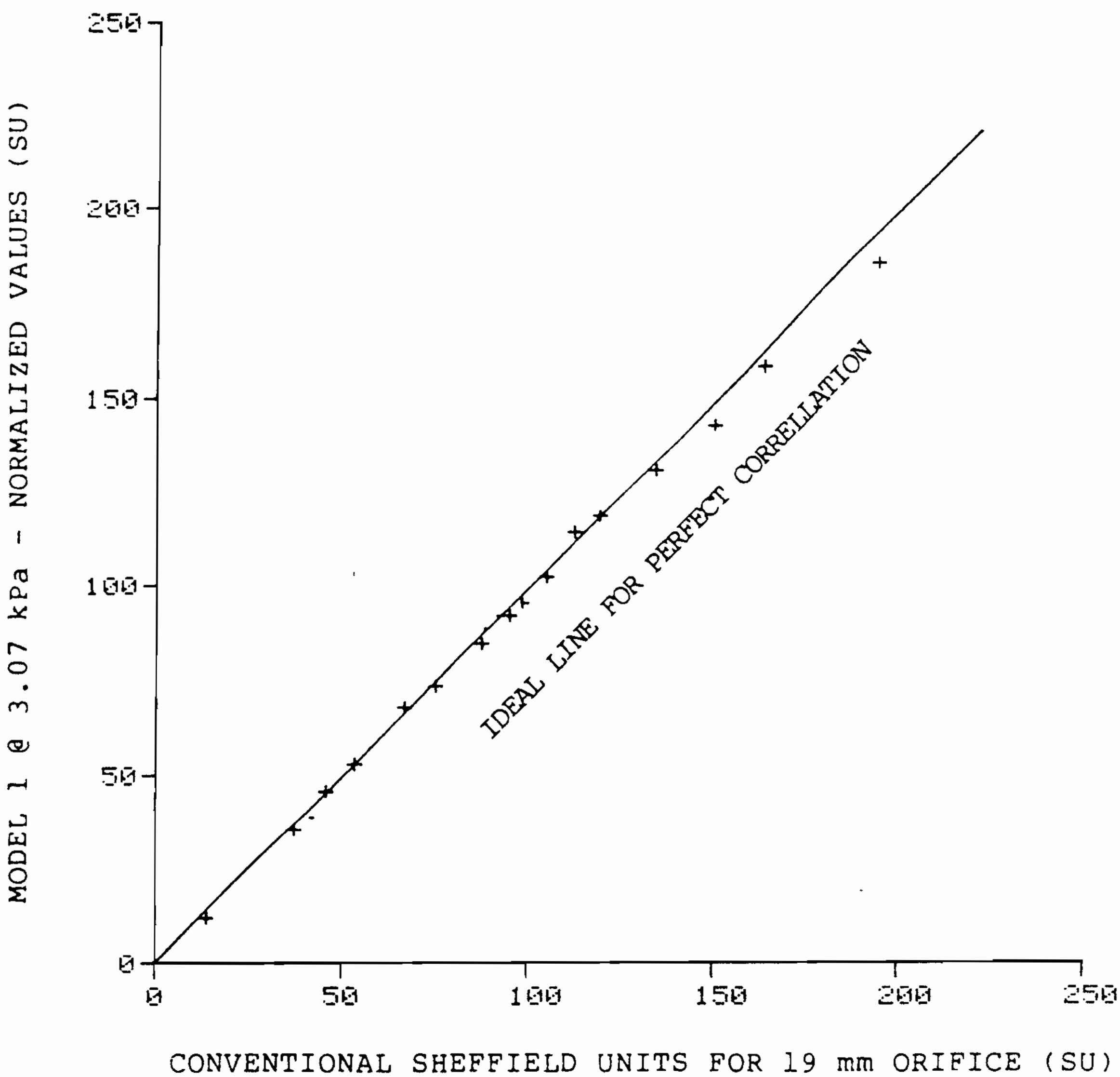
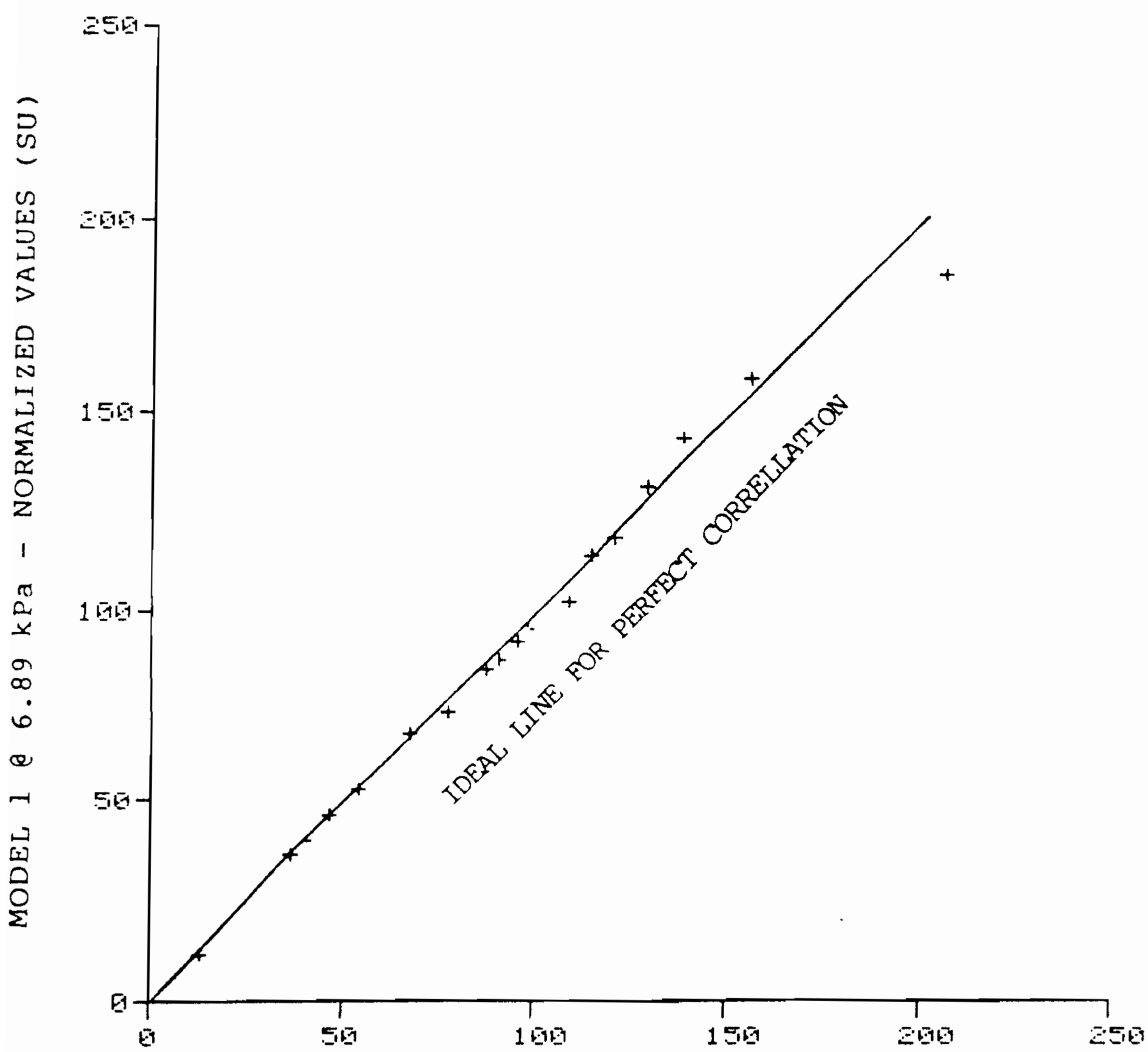


FIGURE 6: MODEL 1 @ 6.89 kPa vs. CONVENTIONAL SHEFFIELD



CONVENTIONAL SHEFFIELD UNITS FOR 19 mm ORIFICE (SU)

The Model 1 test pressure was 1.22 kPa in Figure 4; in Figure 5 it was 3.07 kPa; and in Figure 6 it was 6.89 kPa, while the Sheffield test pressure followed Equation 2 for all tests (an approximate range of 8.5 to 9.8 kPa), and the conventional Sheffield test orifice size was also 19.05 mm (0.75 inch) diameter. The pressure ratios of Figures 4, 5, and 6, compared to the conventional Sheffield Porosimeter, were 8:1, 3.2:1, and 1.4:1, respectively. Regardless of the pressure ratio, these samples of linerboard and corrugated medium extrapolated nicely to the measured Sheffield values.

SUMMARY:

Several varieties of air permeability test instruments are commonly used. In the past, there were many attempts to correlate a particular model instrument with different model, with different levels of success. Most of the correlations seem to have been based on statistical analysis of comparative testing, rather than using calculations based on known flows and pressures. The current technology in flow sensors, pressure controls, and microprocessors has led to a new generation of test instruments that can easily generate test results in "NIST-traceable" measurement values, along with having the capabilities of matching historical data bases.

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HAGERTY PERMEABILITY TESTER

TO CHANGE TO GURLEY

~~go~~ down
up
down
up

1 TURN REAR SWITCH OFF

2 CAL SWITCH IN UP POSITION

3 TURN REAR SWITCH ON

4 AFTER 8888 APPEARS , TURN CAL SWITCH DOWN TO THE OPERATE POSITION

TO .CHANGE BACK TO SHEFFIELD

go down
leave it

1 TURN REAR SWITCH OFF

2 CAL SWITCH IN DOWN POSITION

3 TURN REAR SWITCH ON

IF DISPLAY FLASHES

1 TURN REAR SWITCH OFF

2 CAL SWITCH IN UP POSITION

3 TURN REAR SWITCH ON HOLD THE TEST BUTTON IN UNTIL 8888 APPEARS

4 MOVE CAL SWITCH TO DOWN POSITION