# Dynamic HPHT® Filtration System
# Model 90

# Instruction Manual

**Manual No. 204233, Revision F**
**Instrument No. 209113**

fann®
Fann Instrument Company

# Dynamic HPHT® Filtration System, Model 90 Instruction Manual

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Houston, Texas, USA

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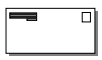
## Contact FANN

### Phone

TELEPHONE: 281-871-4482
TOLL FREE: 800-347-0450
FAX: 281-871-4358



### Mail

Fann Instrument Company
P.O. Box 4350
Houston, Texas, 77210 USA

### Location

Fann Instrument Company
14851 Milner Road, Gate 5
Houston, Texas, 77032, USA

### Online

www.fann.com
fannmail@fann.com

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# 1 Introduction

The Fann Dynamic HPHT® Filtration System is the industry's only true dynamic filtration system for measuring filtration properties of drilling fluids and breakers at elevated temperatures and pressures.

The system is fully automatic with a built-in computer controller and menu-driven software for programming test variables.

The LCD display allows monitoring of real-time test data, which can be recorded in a laboratory notebook or printed. The Dynamic HPHT® also features an interface port for downloading data directly to a personal computer.

This high-pressure, high-temperature (HPHT) unit closely simulates downhole conditions. It uses ceramic filter cores ranging from 5 to 190 microns and offers twenty sequence steps for temperature, pressure, differential pressure and shear rate, ensuring reliable test results. Built-in safety features include a pressure relief valve, an automatic over-temperature shutdown, an automatic heater and motor cut-off interlock door.

The filter core is a thick-walled cylinder with formation-like characteristics comparable to a borehole. Filtration occurs radially, flowing from the center outward of the filter core. Simultaneously, the filter cake is forms on the inside of filter core the same way a filter cake forms on the walls of a borehole. A polished stainless steel shear bob runs through the central axis of the filter core. The shear bob is rotated to produce a concentric cylinder-type shear across the filtration surface. The fluid loss volume and rate can be easily measured and recorded.

## 1.1 Document Conventions

The following icons are used as necessary in this manual.

**NOTE.** Notes emphasize additional information that may be useful to the reader.

**CAUTION.** Describes a situation or practice that requires operator awareness or action in order to avoid undesirable consequences.

**MANDATORY ACTION**. Gives directions that, if not observed, could result in loss of data or in damage to equipment.

**WARNING!** Describes an unsafe condition or practice that if not corrected, could result in personal injury or threat to health.

**ELECTRICITY WARNING!** Alerts the operator that there is risk of electric shock.

**HOT SURFACE!** Alerts the operator that there is a hot surface and that there is risk of getting burned if the surface is touched.

**EXPLOSION RISK!** Alerts the operator that there is risk of explosion.

# 2 Safety

To safely operate the instrument, the user must understand how the equipment works and how to correctly assembly it. Improper assembly, operation, or the use of defective parts, may cause of cell leakage or failure that could result in serious injury and damage.

The cell and other components are hot during operation. The operator should be aware of these hot areas and avoid contact with them. Burns can result from touching hot parts of the equipment during normal operation.

These instruments are electrically heated. As with any electric device, the wiring should be regularly checked for bad connections. These instruments should always be used on a grounded circuit.

The system uses elevated pressures and temperatures, and appropriate precautions should always be exercised.

## 2.1 Safe Pressurization

The connection to the Model 90 is made with a hose assembly capable of 3000 psig (20,685 kPa). A rupture disc within the pressure connection port protects the equipment from overpressurization. A relief valve on the cell also protects from overpressurization.

The instrument cannot be pressurized unless the collector and the cell are both in place.

Only substitute the fittings or hoses on the high pressure connection with parts rated for at least 3000 psig (20,685 kPa) working pressure.

All standard safety precautions for using high pressure gas should be followed when connecting or disconnecting the high pressure gas source.

Always use nitrogen ($N_2$) gas. Never connect this instrument to compressed air, oxygen or other non-recommended gas. Nitrogen must be supplied in an approved nitrogen gas cylinder or the nitrogen supply system must be built into the laboratory. Nitrogen cylinders must be secured to meet safety standards.

Maintain the pressure regulators in good condition. Never use oil on pressure regulators. Leaking pressurizing systems should be repaired or replaced. Gauges, fittings and hoses should be kept in good condition and any leaks should be promptly located and corrected.

## 2.2 Safe Heating

The heaters will not operate unless there is sufficient pressure for the test, and the collector and cell are in place, and the door is closed. If the door is opened during a test, intermittent beeping will indicate that the door must be closed to continue. If the door is not closed within several minutes, the test will stop and the system will start cooling down.

Caution should be exercised by all personnel operating or working near the instrument while it is in operation to avoid accidental injury. The heaters and parts of the cell get very hot when high temperature tests are run. Although the built-in safety feature disconnects the heater power when the door is opened, these heaters and the cell will remain extremely hot if the door is opened before the normal cool down has taken place. Use extreme caution should the door have to be opened before proper cool down.

After the test ends, the instrument cools down to a set point.

These features ensure safe operation at high temperatures and pressures.

Seals are maintained by O-rings that must be replaced when they are torn, stuck, or hard due to high-temperature testing. Properly maintaining o-rings is especially important when testing flammable samples.

Serious burns could easily occur.

## 2.3 Safe Electrical Operation

The shear shaft is driven by external magnets rotated by a motor and V- belt drive. The motor is disconnected when the door is opened to prevent injury. If it becomes necessary to temporarily bypass this safety interlock, beware of the un-shielded V-belt drive.

Make sure that the electrical source is fused and grounded. Verify that the power cord is in good condition and that it has the proper ground connection.

Electrical problems in the wiring or heater may not be obvious by looking at the equipment. If the unit blows fuses or trips breakers, the heating time seems longer than normal, or the temperature controller does not reliably maintain temperature, then electrical repair may be required.

## 2.4 Safe Reservoir Maintenance

Seals are maintained by O-rings and must be replaced when they become damaged, worn, or brittle due to high temperature exposure. Replacing the O-rings is especially important if the sample is flammable.

These safety precautions should be followed to assure safe operation.

- The cell body and cap material should be compatible with the test sample.
- Cell bodies with cracks, severe pitting, or damaged threads must not be used.
- Cell caps with damaged threads must not be used.

# 3 Features and Specifications

Dynamic HPHT® Filtration System consists of an external yoke cell, thick-walled cylinder with rock-like characteristics, a built-in computer controller, and an LCD display. See Figure 3-1 for an illustration and Table 3-1 for specifications.

The system is fully automatic, complete with menu-driven software. The user can define up to 20 sequence steps to program the temperature, pressure, differential pressure, and shear rate.

The external yoke cell is a unique pressure vessel that does not require threaded or bolted closures on its ends. This feature makes it easy to open and close, but almost impossible to open when pressurized.

The controller is an 8-bit computer with some ram memory sustained by an internal battery that lasts approximately seven years. The programs running the instrument are stored in read-only-memory (ROM) and coded in VBASIC. The major components of the system are described in the following sections.

The line voltage can be set at 115 volts or 230 volts, making the Model 90 ready for operation anywhere.

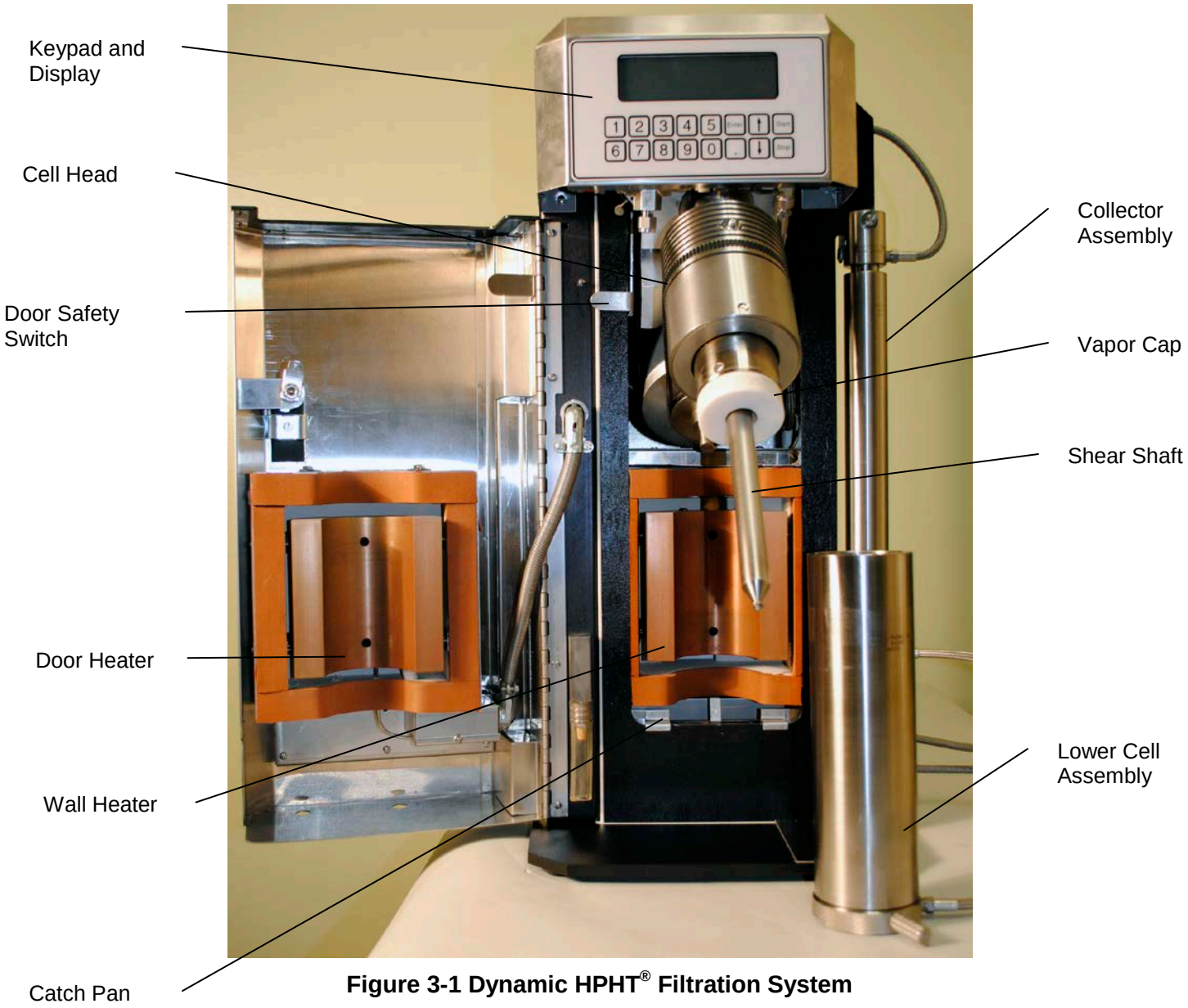



**Figure 3-1 Dynamic HPHT® Filtration System**

## 3.1 Pressure Control

Pressure is maintained using an external pressure source, usually bottled nitrogen, and a group of solenoid valves. The solenoid valves typically work in pairs to increase the pressure by allowing supply pressure in, or to decrease the pressure by venting to the atmosphere. The atmospheric vent is located inside the heater door, at the bottom left. The vent is external so that if a sample fluid is vented due to overfilling or boiling, it will be seen and easier to clean. Refer to Figure 9-2 for the flow schematic.

The pressures are measured with two pressure transducers by a microprocessor-based module. The module transmits the pressure measurement to the computer via an RS-485 link when commanded. A mechanical relay selects which pressure transducer is used.

During a test, the target pressure will be the highest of either the programmed pressure or a calculated pressure that is based on the current sample temperature. The calculated pressure (kPa) is determined as follows:

$$\text{Calculated Pressure (kPa)} = 26 \times \text{Sample Temperature } (^{o}C)$$

when the temperature is above $50^{o}C$

This pressure and temperature combination is sufficient to prevent boiling for typical sample fluids.

## 3.2 Heating and Cooling

Heating is accomplished with a split cylindrical block heater. Each half has two cartridge heaters, for a total capacity of 1200 watts. The heater halves contact the cell wall and transfer heat to it. One half of the heater is attached to the door and has a thermocouple embedded in it. A microprocessor-based module continuously monitors the temperature measured by the thermocouple. If it senses an over-temperature condition, it opens a safety interlock relay that mechanically disconnects the power from the heaters. This independent safety feature prevents damaging temperatures if the computer fails. The module also transmits the heater temperature to the computer on demand.

The heater is surrounded by an insulated case. Cooling air flows around the heater block through a gap between the case and the heater. Cooling air is drawn from inside the instrument and forced into the heater case by a blower. The hot air is exhausted at the top sides of the door half of the case. The cooling rate is a function of the ambient temperature and the current heater temperature. The greater the differential, faster the cooling rate.

The sample temperature is measured by means of a resistance temperature detector (RTD) which fits inside of the shear shaft. It is monitored by another microprocessor based module, which also transmits the value to the computer on demand.

The computer uses a combination of the block temperature and sample temperature to calculate heating and cooling power requirements. The heater is controlled by a solid state relay in series with the mechanical safety interlock relay. Another solid state relay controls the cooling blower.

## 3.3 Shear Rate Control

A D.C. motor drives powerful magnets that rotate about the upper section of the cell. The motor speed is reduced and conveyed by a V-belt. A bushing supports the external rotating magnets, which connect to a magnetic piece on the shear shaft inside of the cell. The shear shaft is supported by a Rulon® bushing at the top and a small angular contact bushing at the bottom.

Shear shaft speed is sensed by magnets located at the top of the shear shaft and by a magnetic field sensor, which is mounted outside of the cell on a heat sink. The speed sensor output is sent to a microprocessor-based module, where it is counted. The count is sent to the computer when commanded.

The computer calculates an output voltage, which is sent to an analog voltage output module. The calculated voltage is based on the desired shear rate and the geometry of the shear shaft and filter core. The module's output voltage is sent to the motor speed controller.

## 3.4 Purge System

The purge system removes air from the filtrate system and flushes filtrate from a previous test. It consists primarily of a magnetically-driven, positive displacement, gear pump and a check valve. The purge fluid is drawn into a port on the right side of the instrument and into the suction side of the pump. The fluid is then forced out of the pump through the check valve and into the filtrate system. The purge fluid and the filtrate flow in opposite directions. This back flushes much of the filtrate system, aiding in cleaning.

The purge fluid flows through the filtrate valve, the hoses, and into the filter core holder, pushing any air along with it. Purge fluid is normally forced through a filter core in the holder to remove air from its pores.

Some purge fluid flows directly to the bottom of the filtrate collector below the filtrate piston. Opening the collector bleed valve fluid releases the purge fluid and vents air from that part of the system. During the purge, the top of the filtrate collector, above the piston, is pressurized to hold the filtrate piston at the bottom of its stroke.

**Table 3-1 Dynamic HPHT Filtration System Specifications**

| Category | Specification |
|---|---|
| Maximum Temperature | 500°F (260°C) |
| Maximum Differential Pressure | 500 psig (3447 kPa) |
| Working Pressure | 2500 psig (7238 kPa) maximum |
| Heating Rate | 10°F/minute (5.6°C/minute) |
| Cooling Rate | 2.8°F/minute (1.5°C/minute) from 300°F (149°C) avg<br>5.0°F/minute (2.8°C/minute) from 500°F (260°C) max |
| Filtrate Volume | 50 ml max |
| Sample Volume | 250 ml |
| Dimensions<br>(Width x Depth x Height) | 12.5 x 17.75 x 28.00 inches<br>31.75 x 45.10 x 71.12 centimeters |
| Weight | 170 lb (77 kg) |
| Heater Power | 1200 watt |
| Power Supply | 120/240, 50/60 Hz |
| Shear Bob Drive | 1/4 hp motor with belted magnetic drive |

# 4 Installation

A Fann representative is available to install the instrument.

## 4.1 Model 90 Installation

The Model 90 Dynamic Filtration System is shipped with certain parts of the cell and accessory items, such as filter cores, special tools, and power cable packed separately.

1. Choose the location for the instrument using the following considerations:

**Counter Space**

- One to two feet (30 to 60 cm) of counter space is desirable on the right-hand side of the instrument for the hose loops of the cell and collector, the hose to the pressurizing gas source, power cable, and cables that may be connected to a printer or computer.
- It is also convenient to have sufficient counter space when disassembling the cell or collector. Some of this space is also required for a container of purge fluid. This container will hold one-half to two gallons (2 to 8 liters).

**Pressure Supply**

- The laboratory should be equipped with high pressure nitrogen outlets or gas cylinders. Approximately 1000 psig (6.89 MPa) is required. A 6 foot (1.8 m) long high pressure hose is provided for this connection.
- If using a gas cylinder, provide a suitable location on the floor against a wall or bench for a standard gas cylinder. Safety straps should be provided to prevent cylinder from falling over.
- The gas cylinder or the gas outlet should be within reach of the high pressure hose.

**Power Source**

- Instrument comes with a 7 foot power cable.
- The electrical outlet should be within reach of the cable**.**

The instrument weighs approximately 170 lb (77 kg). Use the proper techniques when lifting and moving it to avoid back injuries.

2. Unpack the instrument and set it on the bench where it is to be used.

If the pressure supply exceeds the 2500 psig rating for the instrument, use an external pressure regulator.

3. Connect the high pressure hose and gauge to the high pressure gas cylinder as follows:
   - Make sure the cylinder pressure is not in excess of 2500 psig (17,238 kPa).
   - Cylinder connector, CGA 580 screws into the cylinder valve.
   - Tighten the nut to 40-50 ft-$lb_f$ (54-68 N·m).
   - Connect the other end of the hose to the HP-Supply port on the right side of the Model 90.
   - Tighten the nut to 10-15 ft-$lb_f$ (14-20 N·m).
   - If high pressure nitrogen outlets are available, make sure the pressure at these outlets is not more than 2500 psig (17,238 kPa). Connect the high pressure hose and gauge into this outlet.

If the pressure supply exceeds the 2500 psig rating for the instrument, use an external pressure regulator. A suitable regulator rated at 6000 psig (41,369 kPa), the maximum inlet pressure, is available as an option.

Using a regulator rated at 6000 psig (41,369 kPa) also requires a higher inlet pressure gland. The CGA 580 connector cannot be used in excess of 3000 psig (20,685 kPa). However, the hoses and fittings are suitable with this regulator.

4. If necessary, set the instrument's operating voltage. You can choose either 115 or 230 volts. The voltage setting can be viewed in the small window located just above the power inlet module on the right side of the instrument. Use the following procedure if it must be changed:
   - Lift the tab on the bottom of the fuse drawer located on the power inlet module, and remove the drawer.

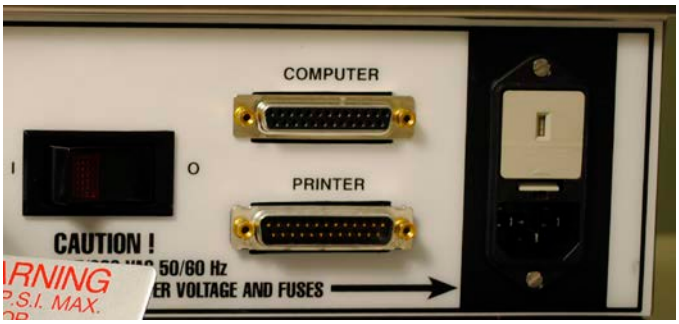



**Figure 4-1 Fuse Drawer**

- Pull the voltage selector out of the module, rotate it to the desired voltage setting, and place it back in the module.

**Figure 4-2 Voltage Selector**

- There are two fuse drawers: 1) one fuse drawer holds the long 20 amp 1/4 x 1 1/4 -in fuses for 115 volt operation; 2) the second fuse holds the short 10 amp 5 X 20 mm European fuses for 230 volt operation. See Figure 4-3.

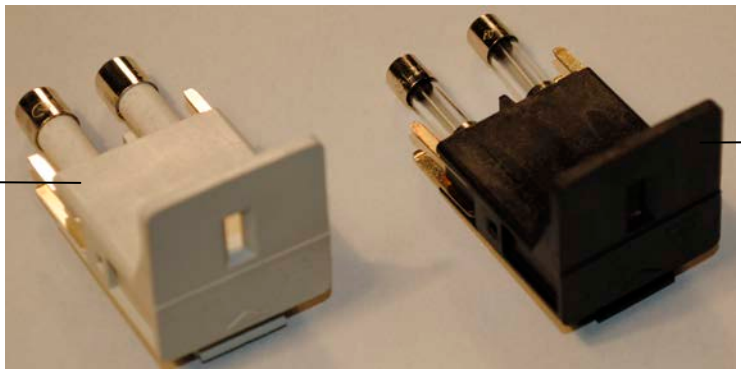



**Figure 4-3 Fuse Drawers**

- Replace the fuse drawer with its fuses.

5. Put the power switch in the off position (**O**).

6. Connect the power cable to the instrument. The instrument is shipped with a 115 volt power cable.
   - If the power source is 115 VAC and can supply 20 amperes, connect the power cable to it.
   - If the power source is 230 VAC, an appropriate 230 volt power cable must be obtained. It should be rated for 10 amperes.
7. Provide a clean purge fluid container.
   - It should have an opening large enough for the 1/4-in. plastic tubing (provided) and inlet weight.
   - The opening should not be so large that debris can fall in and contaminate the fluid.
8. Connect the tubing from the container to the purge port. The purge fluid is used to purge air from the filtrate system and to pre-purge when the test starts.
9. Remove the shipping retainer from the top of the collector tube on the right side of the instrument.
10. Open the door by pulling the bottom of the door latch outward and then rotating it about 90 degrees.
11. Remove the shipping retainer from near the top of the cell assembly.
12. Grasp the knurled handle at the bottom of the cell. Lift the bottom of the cell upward while firmly bumping the top of the cell inward with the other hand to release it from the bottom of the yoke. This may take considerable pressure on a new machine.
13. Holding the cell up, pull the **Tilt Lock Release** located between the cell and the yoke on the left side of the cell. It may be necessary to push the cell slightly in to relieve the pressure on the latch. Now swing the bottom of the cell out until it latches. The latch will hold the cell in the tilted position.
14. The cell telescopes from the pivoted drive head. Slide it down until it releases and place it on the bench.

*The Model 90 is now ready to be tested for proper operation.*

15. Place the main power switch on the lower right side to the **On** position (**I**).
    - The screen will display **Please Wait** for several seconds. Next, the screen will display copyright information for several seconds.
    - The **Main Menu** screen will display. This screen will remain until one of the options of the menu is selected and entered. See Section 5.1 Understanding Basic Functions for details about using the instrument controls.
16. Follow the procedures in Section 5.4 Calibrating the Model 90 before running a test.

## 4.2 Printer Installation

The Model 90 requires a serial printer capable of operating at 9600/8-N-1 baud. The protocol is serial, RS-232C, 8 data bit, 1 stop bit with no parity check. Since no output flow control is used, the printer must have a minimum 4 kilobyte input buffer.

The cable supplied with the unit is suitable for connecting a standard serial printer to the printer port (right side of the instrument). No additional steps are required to enable the printing feature of the instrument.

Connections to the printer and the instrument should be made with both devices turned off.

The Model 90 does not check the status of the printer. If the printer is offline or out of paper, no warnings will be given. However, if the data is not printed during the test, it can be printed after test ends. Go to **Data Access Menu**.

If the printer is online and connected to the Model 90, it will print. From the **Test Menu** or the **Data Access Menu**, you can press decimal key (**.**) to print a header at the top of the page. Whenever a test is started, the header will print. It will give general information about the test, including the date and time of start, and the geometry of the filter core and the shear shaft.

After the header, a data point will print at the beginning of each step and every 5 minutes after the test starts. A data point is also printed after every 0.3 milliliters (ml) of total collected filtrate. This method minimizes the number of data points saved. The filtrate collector has a nominal capacity of 50 milliliters. Approximately 175 data points will be printed along with the current conditions of the test.

# 5 Operation

## 5.1 Understanding Basic Functions

### 5.1.1 Keypad

Use Table 5-1 as a guide for using the non-number keys.

A short, firm push is sufficient. Expect a delayed response after pushing a key. The computer responds in a few seconds, but the display may not change immediately.

**Table 5-1 Keypad Functions**

| Key | Functions |
|---|---|
| Enter | Same as computer keyboard |
| Arrow Keys ↑ ↓ | Same as computer keyboard.<br>During a test, to skip to the next step or go back to previous step.<br>Move to next data set or data summary in Data Access |
| Start | To start.<br>To open a filtrate valve – **On**, in Test Sequence Edit screen. |
| Stop | To stop.<br>To close a filtrate valve – **Off**, in Test Sequence Edit screen.<br>To exit from Test Sequence Edit screen in top line. **Stop – Exits**<br>To change a value to zero. |
| Decimal Point . | As a decimal point.<br>To send Form Feed to printer in Test Menu or Data Access Menu. |


**Figure 5-1 Keypad**

### 5.1.2 Menu Options

The Model 90 software presents a series of menu choices. After the instrument is turned on, the message, **Please Wait**, is displayed while the instrument initializes. After a few seconds, the copyright notice appears. Next, in the upper left corner, the total testing time (hours) of the instrument is displayed. In the upper right corner, the total testing time is displayed in thousand degree hours or *kChr*, where *k* is one thousand, *C* is degrees Celsius, and *hr* is hours. For example, a one hour test at 200°C would add 0.2 kChr to the total testing time. This information is useful for maintenance purposes.

After a few seconds, the **Main Menu** appears. In addition to the date and time, the **Main Menu** screen lists three operations for selection:

1. **Calibrate**

   The purpose of this operation is to set up infrequently changed operating parameters, such as:

   - The units of measure, either English Engineering or International (SI)
   - The current date and time
   - The filter core, shear shaft dimensions, and mean pore size

   To calibrate the filtrate collector, please follow calibration procedures outlined in Section 5.4.

After setting these parameters, you do not need to repeat this step unless parameter changes.

You should calibrate the filtrate collector once every five to ten tests to ensure that the volume is accurately measured.

Perform these quick checks. Note that the collector volume is zero at start of test and total volume displayed is same as the volume measured in a graduated cylinder.

## 2. Test

The purpose of this operation is to set test conditions and run a test.

Selecting **Test** will display the **Test Menu**. From the **Test Menu**, you can also choose from the following operations:

- **Run Test** – Displays the target values and real time conditions of the test as it progresses. See Figure 5-2. The computer will run the latest test sequence in the memory. If no editing has been done, the test conditions will be the same as the previous test sequence. If editing was done, the test conditions will be different. The date of the last edit is shown to help identify the test sequence. See Section 5.1.3 for details.

| STEP 3 | HP (psig) | dP (psig) | SAMPLE (F) | SHEAR (1/s) |
|---|---|---|---|---|
| CURRENT | 595 | 503 | 296 | 99 |
| TARGET | 600 | 500 | 300 | 100 |
| TOTAL | (ml) | -0.12 | ST | 1.5 |
| RATE | (ml/s*m^2) | 0.0 | ET | 23 |

**Figure 5-2 Run Test Screen**

- **Setup Test Sequence** – Useful for programming the steps and step conditions. Note that if **Standard Test** is selected from the **Test Sequence Menu**, it is considered edited whether or not any values in the test are changed. It is now the latest test sequence.
- **Print Test Sequence** - To print the current test sequence either before a test is run to check for accuracy or after the test is run to verify the sequence and target values.
- **Cool and Vent** – To return the machine to ambient conditions after a test has been stopped in a heated and pressurized condition.
- **Purge System** - To initiate the purge sequence. The filtrate system must be purged of gases before each test. The purge expels all air that flows between the outside of the filter core in the cell to the bottom side of the floating piston in the collector. A floating piston, connected to the transducer, measures the filtrate volume. The flow path must be full of purge fluid (no air bubbles) at the start of each test. See Section 5.7.2 for purging the system.

The high pressure supply must be connected and pressurized before the **Cool and Vent** or **Purge** functions can operate.

**3. Data Access**

When this menu option is chosen, the procedure will collect and store test data. The results can be printed for each step or transferred to a computer. See Sections 4.2 for printing data and 5.7 for transferring data to a computer.

An **Exit** from any menu will return to the parent menu.

### 5.1.3 Test Sequence Function

A test sequence is a sequence of steps, each having the target conditions and the time to reach or maintain them. The maximum number of steps is 20. The Model 90 can slow ramp the controlled variables. For example, it can steadily increase the temperature. Ramping is limited by the system's ability to respond. For instance, if a steep ramp rate is programmed, the system will respond as best as it can.

When all of the desired step conditions are met, and the **Step Time** has expired, the instrument will proceed to the next step. It is possible to program conditions that are not attainable. If that happens, the instrument will stay on the invalid step until the operator terminates the test or moves the program to another step. Transition to another step can be forced by pressing any arrow key.

Use a standard test sequence as often as possible to make it easier to compare tests. A recommended standard test has been programmed into the instrument. This standard test can be changed only with the use of an external computer. See Section 5.3 Changing a Test Standard.

The following information describes the target conditions that can be programmed into the instrument. The instrument will retain this information as the **Last Test** until it is edited. A test consists of the following five **Test Steps**:

**Step 1** - Establishes the static conditions

In this step, static pressure is applied and the sample is heated to the desired temperature. The step time is set to zero (0) to obtain test conditions in the minimum time. During this step, the sample is agitated by the shear shaft which rotates at a velocity that gives a shear rate of 100 reciprocal seconds (1/s). Since the step conditions have not stabilized, filtrate should not be collected during this step. The differential pressure should be set to zero (0) and the filtrate flow should be turned **Off**.

**Step 2** - Sets the differential pressure

This step starts after all the conditions of **Step 1** have been met. Usually, the target temperature will be the last condition that is achieved. A few seconds are required to adjust the collector pressure. Zero time is programmed for this step. The target static pressure, shear rate, and filtrate flow are usually the same as in **Step 1**.

**Step 3** - Allows the differential pressure to stabilize

This is a step that gives time for all the conditions established in **Steps 1** and **2** to stabilize before starting filtration. A two-minute step time is usually adequate. The target static pressure, shear rate, and filtrate flow are usually the same as in **Steps 1** and **2**.

**Step 4** - Collects dynamic filtration data

In this step, all test conditions are held constant while filtrate is collected. This step lasts 45 to 90 minutes. The conditions of this step are usually the same as **Step 3**, except that the filtrate flow is turned **On**.

**Step 5** - Cools down and vents the pressure

During this step, the cell is cooled to a temperature in which it can be handled safely, and the pressure is vented. The **Step Time** should be set to zero (0) for minimum cooling time. The target static pressure should also be set to zero (0). The instrument will maintain sufficient pressure on the cell during cool down to prevent boiling. The pressure ramp will be 6.79 psig/$^{o}$F (26 kPa/$^{o}$C) above 122$^{o}$F (50$^{o}$C). The instrument reduces the pressure as the cell temperature drops and will completely vent the cell by the time the target temperature is reached. This temperature setting is usually 115$^{o}$F (46$^{o}$C). The target shear rate is 100 1/s. Since no filtrate is collected during cool down, the filtrate flow is turned **Off.**

For each step within the **Test Sequence**, six test variables must be established as follows:

1. **Step Time** is the time it takes the step conditions to be met or held. For steps in which minimum time is desired, the step time is set to zero (0). The instrument will advance to the desired conditions at its best rate. When all conditions are within acceptable tolerances, the instrument will proceed to the next step.
2. **Static Press** (pressure) is the pressure on the sample in the cell. It is the pressure applied to inside diameter of the filter.
3. **Differential** is the differential pressure through the wall of the filter core and any filter cake. It is equal to the static pressure minus the pressure in the filtrate collector (back pressure).
4. **Temperature** is the sample temperature inside the cell when the step ends.
5. **Shear Rate** is the rate at which the sample is sheared in the annulus between the inside diameter of the filter core and the rotating shear shaft. This shear rate

assumes a Newtonian fluid and no filter cake. It is a function of the geometry of the annulus. For the instrument to reach the correct shear rate, the dimensions of the filter core and the shear shaft must be entered. See Section 5.4 Calibrating the Model 90 for detailed instructions. The shear rate is proportional to the shear shaft's rotation speed. The program calculates the correct rotational speed based on the target shear rate using the filter core and shear shaft geometry.

6. **Filtrate** (valve) is the position of the filtrate valve at the beginning of the step. In the **Off** position, filtration does not occur during the step. In the **On** position, filtration occurs during the step.

Twenty steps may be programmed. For example, the sample could be heated to an intermediate temperature, held there for a target time, then raised to a second higher temperature, and then filtered. Also, the shear rate could be changed from one step to another, or a step could be added for a different shear rate. These are only examples; other combinations are possible.

## 5.2 Programming a Test Sequence

1. From the **Main Menu**, select **Test**.
2. From the **Test Menu**, select **Set Up Test Sequence**.
3. From the **Test Sequence Menu**, select **Standard Test**, **New Test**, or **Last/Edit.**

- **Standard Test** is a pre-programmed, short test sequence. You can select the test temperature. The sample is heated to the selected temperature as quickly as possible while holding a suitable pressure. Filtration is conducted at constant conditions, followed by cool down. A screen will appear with a message asking for the test temperature. The default temperature is 300°F (149°C). Entering another temperature overrides the programmed temperature. The **Edit** screen will appear in case additional changes are required.
- **New Test** changes all the times and target values to zero (0) for all steps (sample temperatures will be 32°F in English units). The filtrate valve will default to the **Off** position. Use this option when a radically different test sequence is required. Selecting **New Test** will bring up the **Edit** screen where the new test sequence can be entered.
- **Last/Edit** makes it possible to change the most recently edited (last) test sequence. Selecting **Last/Edit** will bring up the **Edit** screen where the changes can be made.

| | | |
|---|---|---|
| STEP 1 | ('STOP' - Exits) | |
| STEP TIME (M) | 0 | |
| | Current | -- Target |
| STATIC PRES.(psig) | INITIAL | 600 |
| DIFFERENTIAL(psig) | INITIAL | 0 |
| TEMPERATURE (F) | INITIAL | 300 |
| SHEAR RATE (1/s) | INITIAL | 100 |
| FILTRATE | OFF | OFF |

**Figure 5-3 Edit Screen**

4. The **Edit** screen will display the first step of the current test sequence. If there are no changes, press **Stop** to exit. An arrow (→) must be next to the step number in order to exit the editor.

The arrow (→) will display after the step in the top line. Use the arrow keys on the keyboard to move the arrow (→) to the left of the value to be changed. When the **Enter** key is pressed after a new value is entered, the arrow (→) moves to the next value. The remaining instructions in this programming procedure are written with the assumption that step changes are necessary.

5. Move the arrow (→) next to the step number that needs changing.
6. Enter the step number and press **Enter**. The screen will show the current conditions of this step. Under **Current** label (center of the screen), you will see the target step conditions of the previous step. These are the conditions that must be reached before the next step begins. The **Current** conditions are also the **Initial** conditions if this is step one (1). The pointer will move to the right of the **Step Time** (**M**) label.
7. Enter the planned step time. The arrow (→) will move to the target static pressure value.

Instead of pressing **Enter** to enter a value, you may also press an arrow key (↑↓) after entering a value. The arrow (→) on the screen moves to the next or previous condition. You may also use the arrow keys (↑↓) to move past any value that does not need changing.

8. Enter the planned step **Static Pressure**.

It is possible to reach differential pressures that would crack the filter core. Many filter cores are limited to about 500 psig (3500 kPa) differential pressure.

9. Next, the arrow (→) moves to the target **Differential Pressure**. Enter the planned step **Differential Pressure**. If more than 2500 psig is entered, the system will reduce the value to 2500 psig (17,237 kPa).
10. Next, the arrow (→) moves to the temperature value. Enter the planned step sample **Temperature**. If a temperature greater than 500°F (260°C) is entered, the system will reduce it to 500°F (260°C). The lowest temperature should be at least 10°F (6°C) above ambient conditions.
11. At the arrow prompt (→), enter the planned step **Shear Rate**. The maximum rotational speed is 1000 revolutions per minute (rpm). The shear rate limit depends on the geometry of the shear shaft and filter core. The dimensions previously entered in **Calibration** are used to determine the limit. For the standard configuration, the limit is 286 reciprocal seconds (1/S).
12. At the arrow prompt (→), enter the filtrate valve position by pressing **Start** for **On** (**open**), or **Stop** for **Off** (**closed**). This is the desired valve position at the start of the test step. The pointer will move to the **Step Number** on the top line of the display.
13. Repeat steps 4 through 12 as required until all test sequence steps have been programmed.
14. Exit the editor by pressing **Stop** while the pointer is on the **Step Number** in the top line of the screen. The screen will be updated to show the **Test Menu**.

*The Test Sequence has now become the current **Last/Edit** sequence in the computer.*

The unchanged standard test is also still in the computer. It cannot be removed or changed by the use of the keyboard on the instrument.

## 5.3 Changing a Test Standard

The standard test sequence is preprogrammed into the memory when the instrument is manufactured. It is sufficient for testing common fluids. Using a standard testing procedure makes it possible to compare dynamic filtration data from different operators.

Use the following procedure to change the standard test sequence that is stored in the system memory:

1. Connect the Model 90 to a computer using the RS-232 port on the computer and the computer port on the Model 90. See Section 5.7 Transferring Data to a Computer.

2. Run a general purpose communication program on the computer. The program must be configured so that it uses the correct RS-232 port (usually COM1). The baud rate should be set at 9600, data bits at 8, and stop bits at 1with no parity check.
3. Turn on the Model 90.
4. Program the desired test sequence. See Section 5.2 Programming a Test Sequence.
5. On any steps where the operator can choose the target temperature, use a target temperature of 41°F (5°C). An operator who selects the **Standard Test** can choose a temperature (default temperature is 300°F or 149 °C). The operator's selected temperature replaces the 41°F (5°C) temperature.
6. Use the **Stop** key to exit and go to the **Test Menu**.
7. When the **Test Menu** is displayed, hold down the **Control** (**Ctrl**) key and press the **C** key. This breaks the normal operating program. The Model 90 screen will display the message, "**Stop in line...,**" followed by "**>Ready**."
8. Type **CALL6015H** and press **Enter**. This transfers the screen output to the external computer. A prompt will appear on the computer screen.
9. Next, type **RROM2** and press **Enter**. The characters will be repeated on the computer screen. The Model 90 will store the recently edited test as the standard test in protected memory. It will then restart the normal operating program. The Model 90 screen will go through the same sequence of displays as if it had just been turned on. This completes the process.

## 5.4 Calibrating the Model 90

The **Calibration Menu** allows changes in parameters that do not change very often. The filtrate collector sensor should be calibrated every five to ten tests. If the instrument has been in operation for awhile and the same general procedures are being used, it may not be necessary to change the **Geometry**, **Set Time/Date**, and **Select Units**.

To reach the calibration routines, select **Calibrate** from the **Main Menu**. The **Calibrate Menu** will display. The following is a brief description of each option in **Calibrate Menu**.

### 5.4.1 Select Units

From the **Calibrate Menu**, choose **Select Units**. Select either **Exit**, **International** (SI), or **English Engineering**.

The **International** (SI) option shows the temperature in degrees centigrade (°C), the pressures in kilopascals (kPa), and length in centimeters (cm).

The total filtrate volume is in milliliters (ml) and the filtering rate is in milliliters per second · square meter (ml/s · $m^2$).

The **English Engineering** system shows the temperature in degrees Fahrenheit (°F), the pressure in pounds per square inch (psig), and length in inches (in).

### 5.4.2 Set Time/Date

From the **Calibrate Menu**, select **Set Time/Date**. Follow the **Date/Time** entry prompts to enter the correct date and time. The date is entered in the month, day and year format, using two digits each. The time is entered in 24 hour format (hour, minute, second), using two digits each.

### 5.4.3 Set Geometry

From the **Calibrate Menu**, select **Set Geometry**, and then select the measurement that needs to be changed.

The choices are **Shear Rotor Diameter**, filter **Core Inside Diameter**, filter **Core Length**, and filter core **Mean Pore Size** (microns). The shear rotor diameter, filter core inside diameter, and core length are used to calculate the shaft speed required to attain the target shear rate. The **Mean Pore Size** is kept as a record and is printed with the test results.

### 5.4.4 Calibrate Collector Sensor

From the **Calibrate Menu**, select **Calibrate Collector Sensor**. The sensor is calibrated at two points on its span: empty (0 ml) and 45.05 ml. The calibration uses a metal volume calibration slug and requires gas pressure to the instrument.

The following steps refer to Figure 5-5 Collector Assembly. The filtrate collector must be assembled in its normal position.

1. Open the bleed valve about two turns.
2. Lift and swing the collector tube and the inlet cap out and away from the yoke.
3. While holding the collector tube up onto the pivot cap, remove the collector inlet cap.
4. Make sure that the filtrate piston is in the collector tube.
5. Insert the volume calibration slug into the collector tube below the piston so that the tube holds the piston up and away from the collector cap.
6. Replace the collector inlet cap on the bottom of the collector tube and swing the collector tube back in place. Push it down so that it fully engages the hole in the sill.
7. Press any key to continue. The collector will be pressurized, forcing the filtrate piston down onto the volume calibration slug. After a few seconds the instrument will vent the pressure.
8. After the collector has stopped venting, follow the prompt and remove the slug from the collector tube. Leave the piston in place and reassemble the collector as before.

9. Press any key to continue. Once again, the collector will be pressurized, forcing the filtrate piston to the bottom of the collector tube (empty condition). After a few seconds, the instrument will vent the collector. The screen will return to the **Calibration Menu**. Calibration of the collector sensor is complete.

## 5.5 Running a Test

Before performing a test, calibrate the collector as described in Section 5.4.

### 5.5.1 Install the Filter Core

Refer to Figure 5-4 Cell Assembly for the following procedure.

1. Turn on the instrument by moving the power switch (lower right) to the **I** position. After a delay, the **Main Menu** screen will appear.
2. If necessary, disassemble the cell by following the procedure in Section 5.6.1 Cleaning the Cell Assembly.
3. Confirm that the cell and collector O-rings are in good condition. See Section 5.6 Cleaning after a Test.
4. Next, install the filter core. This is best accomplished with the cell cap and filter core holder assembly held by the cell holder at the right front of the instrument. Set the end cap over the pins and rotate slightly to lock it in place.
5. Confirm that the bushing in the bearing support is in good condition. There should be no missing balls and the balls should be free to rotate. Clean if necessary. If it must be replaced, refer to Section 7.2.8.
6. Place the bearing support into the slot in the filter core clamp with the ears of the bearing support pointing down.
7. Screw the filter core holder upward on the filter core clamp as far as possible.
8. Wipe a coating of grease on the O-ring in the filter core cap.
9. Place into the filter core holder the following, in the order listed:
   a. Filter Core Gasket
   b. Filter Core
   c. Filter Core Gasket
   d. Filter Core Cap with O-ring installed
10. Use the retainer ring pliers to place the retainer ring in the groove above the filter core cap.
11. Screw the filter core holder until filter core is clamped in place. Use the special wrench to tighten the filter core clamp to 30 to 35 ft-$lb_f$ (40 to 47 N·m). It must be tight enough to prevent leakage, but not so tight that it will crush the filter core.
12. Lubricate the large O-ring near the base of the cell cap assembly with the grease. Also, apply a film of grease to the threads below the O-ring.

13. Wipe a thin film of grease on the threaded end of the cell casing, just above the threads, on the inside where the O- ring will sit.
14. Screw the cell casing onto the cell cap assembly.
15. Lubricate the area of the O-ring at the top of the cell casing with the grease. A thin film of lubricant should be applied from the inside top edge to about 3/4 inches (2 cm) below the O-ring.

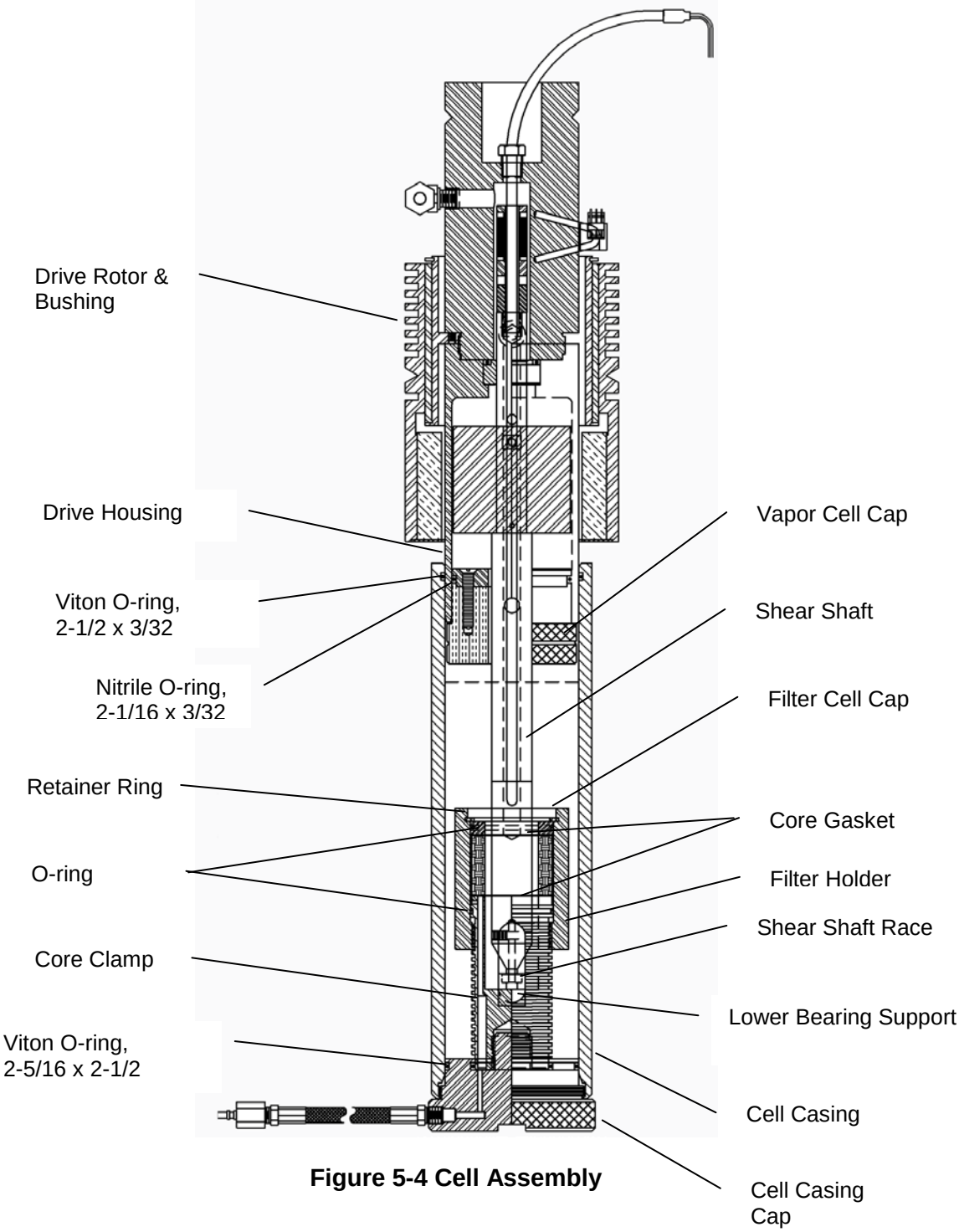



**Figure 5-4 Cell Assembly**

High pressure supply gas must be connected and pressurized before the system can be purged.

### 5.5.2 Purge Air from the System

Refer to Figure 5-5 Collector Assembly.

1. Make sure the parts of the collector assembly are clean.
2. Wipe a heavy film of grease into each end of the filtrate collection tube to about 1.5 inches (4 cm) inside.
3. Lubricate the filtrate piston and its O-ring and push it completely into one end of the filtrate collection tube.
4. Remove the cell assembly from the holder and place it on the bench.
5. Connect the cell assembly hose into the quick disconnect on the end of the hose coming from the port labeled cell.
6. Connect the hose from the filtrate inlet cap of the collector into the quick disconnect labeled collector on the right side panel.
7. Place the filter inlet cap of the collector into the collector tube end nearest to the filtrate piston.
8. Slide the open end of the filtrate collection tube over the collector sensor and its connection magnet. Push it all the way up past the O-ring on the pivot cap.
9. Hold the filtrate inlet cap against the filtrate collection tube and swing it in and then down to engage the hole in the collector sill.
10. Verify that the end of tubing connected from the **Purge Port** in the right side panel is below the surface in the container of purge fluid. It must be submerged so that no air can be sucked into the pump. Usually the purge fluid is distilled or demineralized water.
11. From the **Main Menu** select **Test**.
12. From the **Test Menu** select **Purge System**.
13. Enter the time desired to purge the system. The default value is 5 minutes.
14. A warning will be displayed that estimates the amount of fluid that will be required in the purge time selected. Follow the prompts to start the purge.

    The top of the collector above the piston will be pressurized to prevent the piston from moving up the collector tube. Then the purge pump will start pumping purge fluid into the lower sections of the collector and cell assembly. The cell assembly will gradually fill with purge fluid.

The purge cycle can be stopped at any time by pressing **Stop**. It may be necessary to pour off some of the fluid to prevent overflowing.

When pouring the purge fluid out of the cell, do not tip it toward the ends of the bearing holder in the bottom of the cell. The bearing holder may shift out of position. This may require removal of the cell casing for correction.

15. Place a small beaker or other suitable container below the collector bleed valve and open the valve about two turns.
16. When no more air bubbles are observed coming from the collector bleed valve, close the valve tightly.

Failure to properly close the collector bleeder valve could cause inaccurate filtrate measurements.

17. Hold the cell assembly up and shake the hose coming from the base of it to dislodge any bubbles in the hose, quick-disconnect, and the inline filter.
18. Check the fluid in the cell assembly after it covers the filter core holder. If bubbles are still coming out, the purge may need to be extended.
19. When the purge time has expired and the purge pump has stopped, empty all the purge fluid from the cell.
20. Be sure that the bearing holder is still properly positioned, flat on the core clamp.

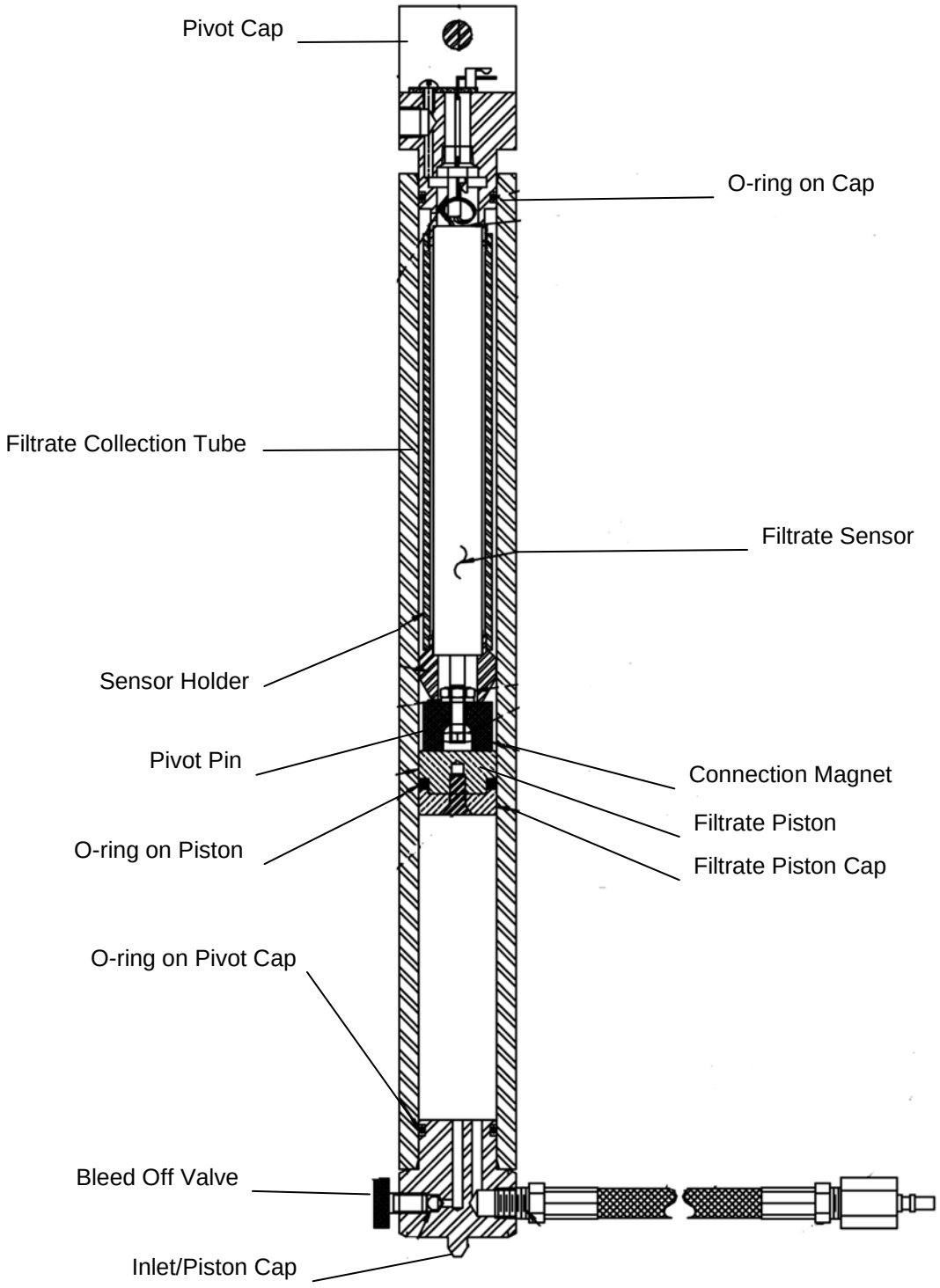



**Figure 5-5 Collector Assembly**

### 5.5.3 Load the sample

Refer to Figure 5-4 cell assembly.

1. Hang the fill gauge over the top lip of the cell casing with the long end inside the cell.
2. Fill the cell assembly with the sample to be tested to the bottom of the fill gauge. Remove the fill gauge.
3. Open the door by pulling the bottom of the door latch outward and then rotating it about 90 degrees in either direction.
4. Release the cell position latch on the left side of the yoke opening by pulling it out. Pivot the cell head out to the locked position.
5. Make sure that the cell head is clean and properly assembled.
6. Inspect the shear shaft race on the pointed end of the shear shaft to make sure it is in good condition.
7. Fill the hole in the center of the shear shaft with purge fluid. The purge fluid lubricates the areas where the temperature sensor rubs on the inside of the shear shaft.
8. Insert the square end of the shear shaft into the cell head until it is held by the drive magnets.
9. Install the vapor cap over the shear shaft into the upper part of the cell. Do not lubricate its O-ring or the inside of the cell head. The friction of the O-ring holds the vapor cap in place.

Proper lubrication of the joint between the cell head and the cell assembly is very important. Both surfaces that mate must be lubricated to ease the assembly and disassembly. Lubrication of the O-ring only is insufficient. If the surfaces are not clean and lubricated, it will be difficult to close the cell and lock it into the yoke.

10. Apply grease on the outside lower end of the drive housing that fits into the cell casing when it is assembled. The grease film should extend up from the lower end about 1 inch (2.5 cm).
11. Slowly slide the cell assembly over the shear shaft and onto the lower end of the drive housing. Push it up all the way to the bottom of the drive rotor. Make sure that the cell assembly is in line with the cell head. If the cell assembly cannot be pushed all the way up, the shear shaft is not connected to the bearing at the bottom. To get a better connection, slide the cell assembly down a little and try

again. Another reason for not getting a connection is that the bearing holder has shifted out of position.

12. Hold the cell assembly up and rotate it until the knurled handle points outward, away from the instrument. This roughly aligns the slot in the bottom of the cell cap.
13. Holding the cell assembly up against the drive rotor, release the cell tilt lock lever and swing the cell assembly into place in the yoke. Align the slot on the bottom of the cell cap so that it will fit over the yoke. Press the cell assembly downward by pushing on the handle on the cell cap and at the same time bumping the top of the cell casing inward with the other hand. This is required to overcome the resistance of the heater gasket. Make sure that the slot in the cell cap slides all the way down over the bottom of the yoke.

If the cell assembly is not all the way down on the yoke, a safety switch will prevent the starting of a test.

14. Close and latch the door.

### 5.5.4 Run the Test

Before running a test, clean the cell and cell collector and calibrate the instrument.

1. Select **Test Menu** from the **Main Menu**.
2. Select **Run Test** if this test is the same as the last test or if the test has already been edited as desired. To make any changes in the test sequence, follow the procedure in Section 5.3 Changing a Test Standard. After the appropriate revisions have been made on the edit screen, select **Run Test**.
3. A warning message will state that starting this test will destroy the results of the last test. If you want to save the data from the last test, print or transfer the data to a computer before continuing as described in Section 5.7 Transferring Data to a Computer.
4. When ready to start the test, press **Start** as directed on the warning screen.

The test can be stopped at any time by pressing **Stop**.

5. Observe the instrument for a few minutes to make sure that it is operating correctly. It will beep intermittently until the shear shaft is up to speed.

6. After the test ends, print the data or transfer it to a computer. To transfer data, follow the steps in Section 5.7 Transferring Data to a Computer.
7. From **Test Menu**, select **Cool and Vent.**
8. Shut off the high pressure gas supply and turn off the instrument if another test is not immediately started.

### 5.5.5 Check Filtrate Volume

Compare the total filtrate volume measured by the instrument to the actual fluid volume accumulated in the filtrate collector. Refer to Figure 5-5 Collector Assembly.

1. Lift the filtrate tube and filtrate inlet cap upward to release the cap from the collector sill, and then swing them outward.
2. Slide the inlet cap and filtrate tube down and off the pivot cap.
3. Invert the inlet cap and filtrate tube so that the inlet cap is up.
4. Loosen the bleed valve on the inlet cap, and then pull the inlet cap off while holding the filtrate tube vertically.
5. Pour the filtrate found in the filtrate tube into a graduated cylinder. The filtrate volume should be approximately the same as the final volume reported in the data.
6. Reassemble the filtrate tube and inlet cap and put them back in the normal operating position on the instrument.

## 5.6 Cleaning after a Test

### 5.6.1 Cleaning the cell assembly

Refer to Figure 5-4 cell assembly.

1. Open the door.
2. Lift upward on the cell handle on the bottom of the cell cap, while bumping the top of the cell casing with the other hand. This releases the bottom of the cell from the yoke.
3. Once released from the yoke, push the bottom end of the cell inward and then pull and hold the cell position latch.
4. Swing the bottom of the cell outward into the tilted position and release the cell position latch.

Some sample fluid will drip from the shear shaft when the cell is removed. A container should be available to catch it.

5. Carefully slide the lower cell assembly off the cell head, being careful not to spill the sample when the cell comes free.
6. Pour out the sample.
7. Set the lower cell assembly over the cell holder pins at the right front of the instrument base and rotate to lock.
8. Pull the vapor cap out of the cell head and set aside for cleaning.

The shear shaft may be filled with a fluid that will spill out if tipped or laid down.

9. Pull the shear shaft from the cell head and set it aside for cleaning.
10. Unscrew the casing from the cell cap and set aside for cleaning.
11. Using the filter core holder wrench loosen the filter core clamp.
12. Remove the retainer ring using retainer ring pliers.
13. Screw the filter core holder downward (clockwise), using the filter core holder wrench if necessary, until the filter core cap is pushed out. Remove the filter core gaskets and filter core.

The filter cake deposited during the test will be on the inside surface of the filter core.

14. Make any required observations of the filter cake then discard the filter core.
15. Remove the bearing holder and set it aside for cleaning. Remove the cell cap assembly from the cell holder and place it in a shallow tray.
16. From **Test Menu**, select **Purge System**. Let enough purge fluid flow through the filtrate lines to flush filtrate from the system. If the purge fluid does not flow, check the filter in the hose that runs from the instrument to the cell cap for plugging. See Section 7 Troubleshooting and Maintenance.
17. Disconnect the hose from the instrument to the cell cap at the quick-disconnect.
18. Empty the tray and set it aside.
19. Remove all O-rings. Inspect them for flatness (no longer a round cross section), cuts, nicks, swelling, and hardness. Replace any defective O-rings.
20. Clean the cell parts. Compressed air can be used to blow out passages in the cell parts and to aid drying. Take care to clean packed solids from around the balls of

the bearing in the bearing holder. They must be free to roll. Dry the bearing thoroughly to prevent rusting.

21. Usually the cell cap, core clamp, and filter core holder can be cleaned as an assembly; however, they can be disassembled if necessary. Refer to Section 7 Troubleshooting and Maintenance.
22. Inspect the ball bearing in the bearing holder for condition of the balls. If any of the balls are rusted, stuck, or missing, the bearing should be replaced. Refer to Section 7 Troubleshooting and Maintenance.
23. Inspect the bearing race on the tapered end of the shear shaft. Replace it if it is broken or damaged. Refer to Section 7 Troubleshooting and Maintenance.
24. Reassemble the cell assembly.
25. Lift the filtrate tube and filtrate inlet cap upward to release the cap from the collector sill, and then swing them outward.
26. Slide the inlet cap and filtrate tube downward off of the pivot cap.
27. Use a wooden or plastic rod to push the filtrate piston out of the filtrate tube.
28. Wash and dry the filtrate tube, filtrate piston, and inlet cap. The bleed valve should be opened about two turns so that wash water can rinse any debris from these passages. If the bleed valve is separated from the inlet cap, the ball can fall out.
29. Inspect the sensor holder for sample fluid contamination. If necessary, disassemble and clean. Refer to Section 7 Troubleshooting and Maintenance for disassembly and assembly details.
30. Inspect the O-rings on the inlet cap, pivot cap, and floating piston for cuts, flatness, or hardening.
31. If the O-ring on the floating piston needs replacing, remove the screw, and then separate the piston and piston cap.
32. Leave the filtrate tube off the instrument so that the collector sensor can dry between tests.

### 5.6.2 Cleaning the Internal Filtrate System

The filter core occasionally will crack or break during a filtration test. When this happens, the unfiltered sample is forced into the filtrate flow system. This could also happen if the core holder is not properly tightened or a gasket is left out. A filtrate line filter (screen) near the cell hose quick-disconnect helps prevent plugging downstream. Sample debris that bypasses this filter may plug small passages in the quick-disconnects, solenoid valve, and tubing runs.

It is important to clean the filtrate system as quickly as possible to prevent the debris from caking. This is best accomplished by purging with an appropriate cleaning

fluid. Cleaning fluids may be water-based (water, or water with detergent) or oil solvents depending on the type of sample in the system.

1. Open the cell, pour out the sample, and purge.
2. If a clear flow of purge fluid at normal flow rate is obtained, the system is adequately cleaned. The following steps should be omitted.
3. Disassemble and clean the filter in the hose from the instrument to the cell cap. Refer to Section 7.2.17 for instructions on cleaning or replacing the filtrate line filter.
4. Remove and clean the filtrate collector.
5. Remove the left side/back panel as outlined in Section 7.2.1.
6. Disassemble filtrate solenoid valve B12. This valve is on the lower right when looking at the back panel. Refer to Section 7.2.14 for details.
7. Use a squirt bottle to force cleaning fluid through the off-center hole in the filtrate solenoid valve. It should flow out of the disassembled filtrate filter at the end of the cell hose. Flush until clean. If flow cannot be obtained, disconnect and clean or replace the tubing from the filtrate solenoid valve to the cell port.
8. Connect the collector inlet cap hose to the collector port. This opens the quick-disconnect valve.
9. Use a squirt bottle to force cleaning fluid through the small orifice in the center of the filtrate solenoid valve seat. The fluid should flow out of the center hole of the collector inlet cap. Flush until clean. If flow cannot be obtained, disconnect and clean or replace the tubing from the tee on the top of the valve to the collector port.
10. Re-assemble the filtrate solenoid valve, filtrate filter, and the left side/back panel.
11. Perform a purge, without the filter core, to check for proper operation of the system. See Section 5.7.2 Purge Air from the System.

## 5.7 Transferring data to a computer

Data is transferred by serial RS-232C communication through the connector that is labeled computer. The data is in a format that can be imported into popular spread sheet programs. The numbers are separated by commas.

A suitable cable for transferring data is provided with the instrument, along with an adapter that will allow conversion from the 25 pin configuration to the 9 pin configuration. The same cable can be used to connect the Model 90 to a serial printer. The only pins on the 25 pin connector that are used are pins 2, 3, and 7. A correct cable would conduct from pin 2 on one end to pin 3 on the other. Conversely, pin 3 would conduct to pin 2 on the other end. Pin 7 on one end must conduct to pin 7 on the other. Follow these steps to transfer data.

If the 25 pin to 9 pin adapter is connected, pin 2 on the 25 pin connector conducts to pin 2 of the 9 pin connector. Similarly, pin 3 conducts to pin 3 and pin 7 conducts to pin 5.

1. Turn the Model 90 and the computer off (**O**) in order to make the RS-232 connection.
2. Connect the supplied cable, or a suitable substitute, to the connector on the Model 90 labeled computer and to an available RS-232 serial port on a personal computer.
3. Turn on the computer and the Model 90.
4. Run a standard communications program on the computer. This would be the same type of program used to communicate with a modem. A program that works well is Procomm Plus (Datastrom Technologies, Inc.) Configure the program as follows:

| | |
|---|---|
| Baud Rate | 9600 |
| Data Bits | 8 |
| Stop Bits | 1 |
| Parity | None |

5. From the **Data Access Men**u, select **Download- RS232:9600,N,8 1**.
6. A message will tell you to press **Start** or **Ctrl Q** from the computer.
7. On the computer, prepare for downloading ASCII data. If using Procomm, download with the **Page Down** key. A file name will have to be assigned for the data storage file.
8. Press **Ctrl Q** on the computer keyboard or press **Start** on the Model 90 keypad. The data will be displayed on the computers screen as it is transferred. This takes less than a minute.
9. Close the file that was opened for the data on the Model 90. If using Procomm, press the **Escape** (**Esc**).

This completes the transfer. The original data will remain in the Model 90 until another test is run, or until the instrument goes into a cool down and vent mode.

# 6 Test Analysis

## 6.1 References

Currently, there are no standard methods for interpreting the dynamic filtration data.

## 6.2 Results

Four filtration characteristics can be observed or measured using the data:

1. Spurt-loss volume - The volume of filtrate obtained within the first 10 seconds of filtration. It is desirable to have a low spurt loss volume.
2. Particle plugging of pore spaces - The primary factor controlling spurt-loss volume. If the particle size distribution of the sample solids is optimized for a specified pore size, plugging will occur and the spurt- loss volume will be minimized.
3. Dynamic filtration rate – A rate that is calculated as the rate of change in the filter volume versus time (ml/min). It can be evaluated over any interval during the filtration process. It is desirable to have a low filtration rate. The rate should be less than 0.2 ml/min for most oilwell drilling fluid systems.
4. Cake Deposition Index (CDI) – A value that is calculated as the rate of change in the filtration rate versus time [(ml/hr)/hr]. A low CDI indicates that the formation of the filter cake has almost reached steady state. New cake is being deposited at almost the same rate that cake it is being washed away or the additional cake has no effect on filtration. For most oilwell drilling fluid systems, a CDI of 10 $ml/hr^2$ or less is desired.

# 7 Troubleshooting and Maintenance

## 7.1 Troubleshooting

**Table 7-1 Troubleshooting Guide**

| Problem | Causes |
|---|---|
| Purge flow is low or stopped. | No purge fluid in the reservoir.<br>Purge valve is plugged or damaged.<br>Purge valve is not being energized.<br>Purge fluid inlet is plugged.<br>The in-line filter in the hose from the cell to the cell port is plugged.<br>The purge pump is damaged or not running. |
| The Cell is difficult to engage or disengage with the yoke. | The joint between the cell head and the cell assembly is dirty or not properly lubricated. |
| The displayed filtrate volume is much less than the volume of filtrate found in the collector. | The bleed valve on the bottom of the collector is leaking.<br>The check valve located in the discharge tubing of the purge pump is leaking.<br>The collector filtrate piston O-ring is leaking.<br>The collector has not been properly calibrated.<br>The collector sensor has been damaged. Look for pinched wires.<br>The O-rings in the cell or collector hose quick-disconnects are leaking.<br>The filtrate filter is plugged. |
| The collector will not calibrate. | The collector sensor is damaged.<br>The connector at the top of the collector pivot cap is disconnected or damaged.<br>The volume calibration slug was not removed after the first step.<br>The filtrate piston is stuck. |
| The filtrate rate is very erratic. | All the air has not been purged from the filtrate system. Repeat purge.<br>The collector tube bore has not been properly lubricated, and the filtrate piston has a jerky motion.<br>The collector sensor has been damaged. |
| A test is automatically terminated and the Main Menu is displayed. | The power failed.<br>The internal DC power supply has erratic output.<br>An intermittent short or overload is occurring in the internal DC power circuit.<br>An intermittent open circuit is occurring in the power supply circuit to the internal computer. |

| Problem | Causes |
|---|---|
| A test is automatically terminated and the Test Menu is displayed. | The drive motor exceeded the rpm limit. The number 1 will be the last thing printed on the printer.<br>The temperature limit has been exceeded in the sample. The number 2 will be the last thing printed on the printer.<br>The temperature limit has been exceeded on the heater. The number 4 will be the last thing printed on the printer.<br>The target shear rate was not achieved. The instrument executed an automatic step 99 cool and vent. |
| Step 99, automatic Cool & Vent was initiated. | The target shear rate was not achieved. The instrument will beep intermittently before cooling. |
| The sample temperature is very erratic, usually going high. | The RTD temperature device is failing.<br>The sample temperature module is defective. |
| The instrument is slow in reaching sample temperature or fails to do so. | The door heater is not aligned; it does not have full contact with the cell when the door is closed.<br>The door heater thermocouple has failed.<br>The door heater temperature module is defective. |
| The instrument fails to reach target HP pressure. | The HP supply pressure is too low.<br>There is a leak in the system.<br>The relief valve on the head of the cell is leaking. |
| The instrument fails to reach or has trouble maintaining the differential pressure. | One or more of the valves are leaking.<br>The electrical feed through at the top of the collector pivot cap is leaking. |
| The HP supply cylinder pressure drops when the instrument is not running a test. | There is a leak in the hose connection to the instrument or the cylinder.<br>There is a leak in the internal tubing up to solenoid valves.<br>One or both of the solenoid valves and are leaking. |
| The instrument fails to reach target shear rate, but the drive motor can be heard turning. | The shear shaft was not put in the instrument before starting the test.<br>The shear shaft is binding due to damaged bearings.<br>The shear shaft has been locked by a filter cake build up on the surface of the filter core.<br>The speed sensor on the back of the head of the cell has failed or is disconnected.<br>The wiring from the speed sensor has been damaged.<br>The speed sense module has failed.<br>The drive belt is too lose, oily, or has come off.<br>The magnets on the blunt end of the shear shaft have been damaged. |
| Excessive noise is heard from the cell while testing. | The ball bearing at the bottom of the cell is damaged.<br>The cell shaft bushing is worn so that the magnet follower on the shear shaft is hitting the inside cell wall.<br>The drive belt is too tight. |
| The total filtrate volume is much higher than expected. | The sample is unusual.<br>The core holder was insufficiently tightened or the gaskets are bad or omitted. |

| Problem | Causes |
|---|---|
| | The O-ring at the bottom of the cell clamp failed.<br>There was air in the filtrate system.<br>A lot of dissolved gas was in the filtrate.<br>The filtrate solenoid valve is leaking. |
| The Collector cannot be opened after a test. | Pressurized gas on the filtrate side of the collector Filtrate Piston is trapped. Open the Collector Bleed valve to relieve it. It will probably squirt vigorously. |
| When turned on, the instrument displays "PLEASE WAIT" and does nothing else. | RS-485 communications between the sensor modules and the computer have failed. Check the green and yellow pair of wires going to each module from the serial communications board. |
| The drive motor and/or heater will not start. | The door heater is too hot.<br>The door interlock switch K striker is not depressing the switch when the door is closed.<br>An internal fuse is blown |
| The life of the shear shaft ball bearing is too short. | Highly abrasive samples are being tested.<br>The bearing was insufficiently cleaned between tests.<br>Impact damage has occurred from rapid assembly.<br>Misalignment during cell closing jammed the bearing and Shear Shaft. |
| Test will not start because of an erroneous "out of position" message. | The interlock switch or its linkage is out of adjustment or damaged. |

## 7.2 General Maintenance

Little maintenance is required to keep the Model 90 in good operating condition. It must be cleaned carefully, and the O-rings must be replaced periodically. O-ring life depends on many factors. An O-ring may be near failure without obvious defects.

It is recommended that all the O-rings be replaced after 5000 degree hours of service. A cell O-ring failure would ruin a test and cause hot sample to spill inside the instrument around the heaters.

Most instrument servicing will require removing the left side/back, L-shaped panel. Some procedures require removing the cover as well. The right side panel rarely requires removal.

**Table 7-2 Preventative Maintenance Frequency**

| ITEM | INTERVAL |
|---|---|
| Cell O-rings | 5 kCHr |
| Collector O-rings | 100 hours |
| Drive Rotor & Bushing | 10 kCHr |
| Shear Shaft Top Bushing | 10 kCHr |
| Bushing | As Required |
| Shear Shaft Race | As Required |
| Drive Belt | As Required |
| Catch Pan | As Required |

### 7.2.1 Left Side/Back Panel Removal

Follow these steps to remove the left side/back panel:

1. Turn off the instrument power and unplug the power cord.
2. Remove all of the panel mounting screws.
3. Tilt the top left side of the panel slightly toward the back of the instrument. Then lift it upward to clear the pins at the bottom and remove.

### 7.2.2 Left Side/Back Panel Assembly

Follow these steps to assemble the left side/back panel:

1. Tilt the top of the panel slightly toward the back, and then guide the holes in the bottom edge of the panel over the two pins along the back edge of the base. Be careful not to pinch any wires between the panel and the base.
2. Tilt the top of the panel forward and guide the three holes along the left bottom edge over the pins.
3. Install and tighten the screws.

### 7.2.3 Top Cover Removal

Follow these steps to remove the top cover:

1. Remove left side/back panel as previously described.
2. Remove all of the mounting screws in the top cover.

3. Clear a space to the left of the instrument that is big enough to lay the cover in an upside-down position.
4. Locate the loose wires and ribbon cables going to the top cover, and running in the channel on the left side, front of the instrument. Carefully pull them out of the channel so that when the cover is lifted they will not inhibit its removal. Do not disconnect any of them.
5. Carefully lift the cover to clear the right side panel and yoke. Then roll it to the left side of the machine while guiding the electrical cables. Make sure the electrical cables are not cut or nicked against the edges of the sheet metal.
6. Lay the cover upside-down next to the left side of the instrument. It is not necessary to disconnect any of the cables.

### 7.2.4 Top Cover Assembly

Follow these steps to assemble the top cover assembly:

1. Make sure all of the cables between the cover and the instrument are connected.
2. Position the cover, right side up, over the top of the machine, and then lower it into position. Make sure no wires are pinched or strained. The front mounting brackets must be inside the cover. The top cover must be inside the top edge of the right side panel.
3. Position the cover to align it with the holes. Install and tighten the screws.
4. Position the wires and cables neatly into the channel.

### 7.2.5 Drive and Rotor Bushing

Refer to Figure 5-4 cell assembly.

Grease the drive rotor and bushing every 10 thousand $^{o}$C hours (kChr). This is done using a standard grease gun that fits zerk grease fittings. Pump 1 to 2 milliliters of grease into the bushing through the zerk fitting. This is a very small amount. Excessive grease will spill over into the interior of the instrument and cause excessive friction in the drive. A high-temperature grease should be used.

### 7.2.6 Shear Shaft Bushing

The shear shaft bushing should be removed and checked for wear every 10 kChr. Follow these steps to inspect and remove the shear shaft bushing:

1. Remove the bottom cell assembly and the shear shaft assembly. See Section 5.6.l Cleaning the Cell Assembly.
2. Insert a 1/4 inch (7 mm) diameter metal rod or Phillips screw driver through the two holes near the bottom of the drive housing and unscrew it.

3. Lift the plastic bushing and O-ring from the drive housing. Sometimes, the O-ring sticks to the bottom of the cell top. It can be removed with a screwdriver.
4. Measure the inside diameter of the bushing. Replace the bushing if it is more than 0.586 in (1.49 cm). It is normal for the plastic bushing to fit loosely in the drive housing.
5. Replace the O-ring whether or not the bushing is replaced.
6. Place the plastic bushing and the O-ring into the top of the drive housing.
7. Lubricate the O-ring and apply an anti-seize compound to the threads of the drive housing.
8. Screw the drive housing into the top cell assembly and tighten firmly using the rod.

### 7.2.7 Shear Shaft Race

The shear shaft race is assembled into the tapered end of the shear shaft. Refer to Figure 7-1.

1. Loosen the 8-32 hex socket set screw in the side of the shear shaft near the tapered end.
2. Pull the old race with its pin out of the shear shaft. If necessary, tap with a small chisel or screwdriver on the flange of the race.
3. Clean the hole in the end of the shear shaft, and then insert the new pin and race.
4. Tighten the 8-32 hex socket set screw.

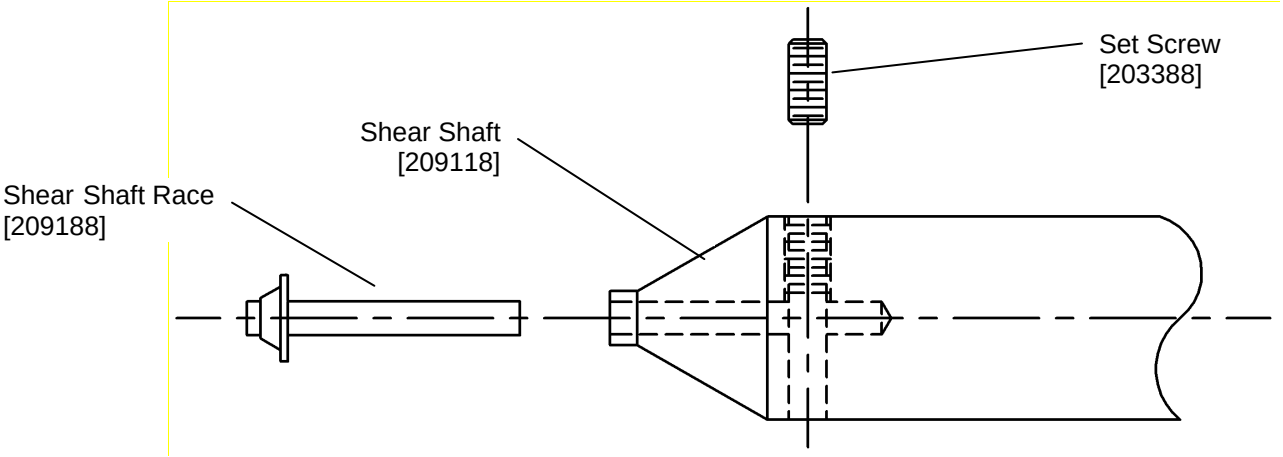



**Figure 7-1 Shear Shaft Race and Shear Shaft**

### 7.2.8 Bushing

The bushing is mounted in the bearing support. Refer to Figure 7-2. To replace the bushing, follow these instructions:

1. Set the bearing holder (bushing down) on a support. There must be enough clearance underneath the bushing so that it can drop under the bearing holder.
2. Push or tap the bearing removal tool to remove the old bushing.

If the bushing is corroded in place and cannot be removed, soak it in a strong solution of table salt and water.

3. Thoroughly clean the bushing cavity in the bearing holder.
4. Place the bearing holder on a work surface with the bearing cavity up.
5. Position the bushing on the bearing holder with the outside bevel in the bearing holder hole.
6. Use the round end of a plastic or wooden rod to push the bushing into the bearing holder. Do not hammer it.

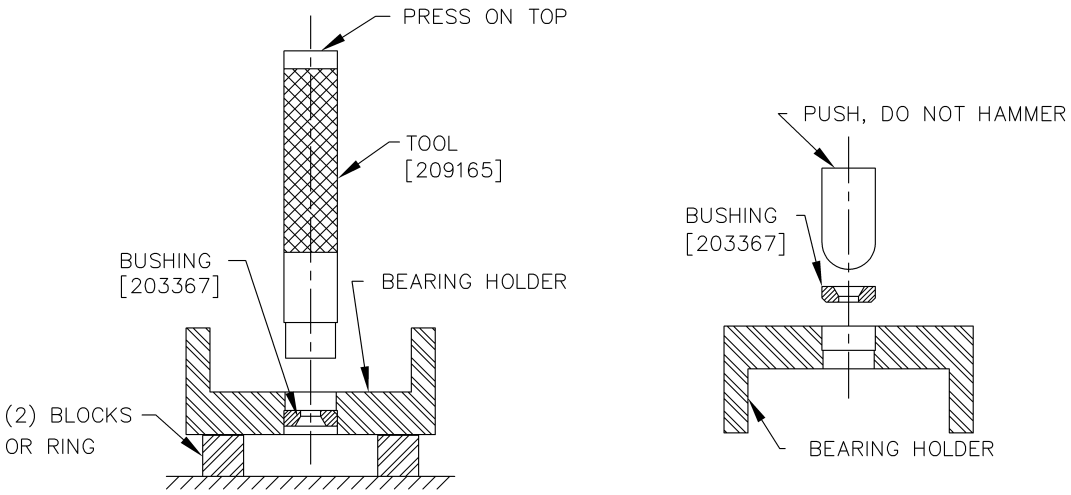



**Figure 7-2 Bushing Removal (left) and Installation (right)**

### 7.2.9 Drive Belt

To replace or adjust the drive belt, follow these instructions:

1. Turn off the instrument power and disconnect the power cord.
2. Remove the lower cell assembly and leave the cell head in the tilted position.
3. Loosen the two hex socket set screws on the bottom side of the rectangular aluminum cell mounting block. The cell mounting block is the part that the cell top mounts into. The set screws lock the round motor support rods that pass through the cell mounting block and hold the drive motor. The ends of the motor support rods can be seen from the front of the cell mounting block. The tubing fittings at the top of the cell head will be in the way of the set screw wrench. They can be removed for easier access.
4. Slide the motor support rods, moving the motor to tighten or loosen the belt. Slide the drive motor toward the cell to replace the belt.
5. Tension the belt to allow about 1/2 in. (1.27 cm) flex in the center of the drive belt span, and then tighten the set screws.
6. Replace the tubing fittings if they were removed, and tighten (one-sixth turn) them.

### 7.2.10 Catch Pan

The catch pan is located just behind the yoke near the bottom. It is used to catch any spills from the cell and to prevent it from flowing into the instrument. The catch pan also includes the cell-in-place switch linkage.

To remove the catch pan, perform the following steps:

1. Turn off the instrument power and disconnect the power cord.
2. Remove the lower cell assembly and leave the cell head in the tilted position.
3. Remove the left side/back panel as outlined in 7.2.2.
4. Remove the catch pan by lifting up to release its tabs from over the yoke and slide it out.

To replace the catch pan, perform the following steps:

1. When replacing the catch pan, make sure that the center bar of the switch linkage is pointed toward the back of the instrument. The linkage bar located on the end of the catch pan must be under the plunger of the switch.
2. After placing the catch pan over the yoke, press downward on the center switch bar, and listen for a click of the switch. This verifies proper switch operation.
3. Replace the left side/back panel as outlined in Section 7.2.2.

### 7.2.11 Main Power Fuse

Two fuses protect the instrument power. They are located in the power inlet module just above the power cord on the right side of the instrument. The fuses are 20 ampere for 115 volt operation and 10 ampere for 230 volt operation. To replace the main power fuses, do the following:

1. Turn off the instrument power and disconnect the power cord.
2. Lift the tab on the bottom of the fuse drawer located on the power inlet module, just above where the power cable plugs in, and remove the drawer.
3. Test the fuses and replace them if necessary.
4. Replace the fuse drawer.

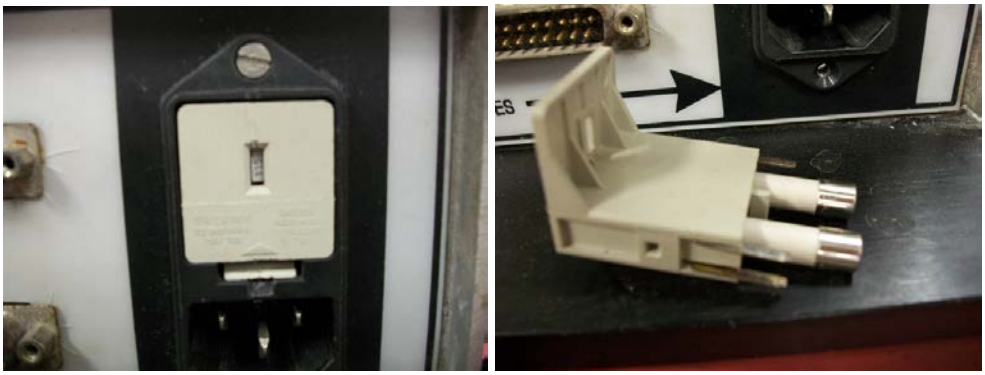


**Figure 7-3 Fuse Drawer in place (left) and removed (right)**

### 7.2.12 Internal Fuse

A blown fuse usually indicates a problem in the circuit. The problem should be solved before the fuse is replaced. Three fuses are located near the top left inside back panel. On the back panel, the fuses are shown in Figure 7-4 and arranged as follows:

| | | |
|---|---|---|
| Upper right | 6 ampere | Heater circuit |
| Lower right | 5 ampere | Motor circuit |
| Lower left | 2 ampere | Control Transformer circuits |

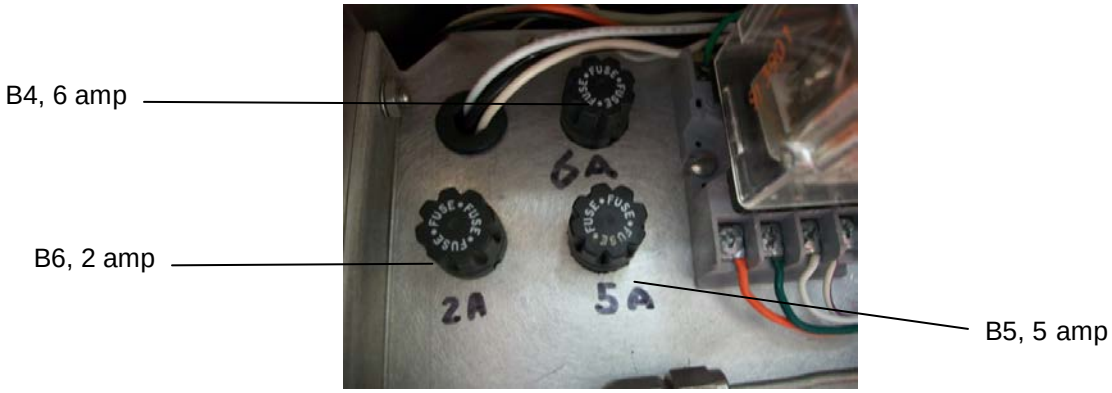



**Figure 7-4 Internal Fuses**

Follow these instructions to replace an internal fuse:

1. Turn off the instrument power and unplug the power cord.
2. Remove the left side/back panel.
3. Press and turn the fuse holder cap counterclockwise to access the fuse.
4. Check the fuse and replace it if necessary with the same type and amperage.
5. Press and turn the fuse holder cap clockwise to install the new fuse.
6. Replace the left side/back panel.

### 7.2.13 Collector Sensor

Refer to Figure 5-5 Collector Assembly.

The collector sensor cannot be repaired; it must be replaced if it fails.

To disassemble the collector sensor, follow these steps:

1. Lift and swing the filtrate tube and the inlet cap away from the yoke.

2. Slide the filtrate tube and inlet cap off the pivot cap and put these parts aside. The piston can remain in the filtrate tube.
3. Hold the upper nut with a wrench. Then unscrew and remove the connection magnet and the lower nut inside it.
4. Unscrew the sensor holder from the pivot cap. Slide the sensor holder off the sensor and remove it, leaving the sensor hanging by its wires.
5. Disconnect the connector inside the pivot cap by pulling on the wires, or pulling on the connector with needle nose pliers.
6. Clean the pivot cap, magnet, and the sensor holder. Clean the connector inside the pivot cap, using a cotton swab. If the collector sensor will be reused, clean its external surfaces only. Do not immerse the collector sensor in fluids.

Assemble the collector sensor into the pivot cap and the filtrate tube and inlet cap in the reverse order as follows:

It is very easy to pinch the leads of the sensor when installing it. Damaging these leads will destroy the sensor.

1. Use needle nose pliers or tweezers to plug the new sensor's connector into the pivot cap. The side of the connector with the two tabs goes on the same side as the wide tab on the connector in the pivot cap.
2. Push in and wrap around the connector as much of the sensor's lead wire as possible.
3. Push the corner of the sensor where the wires come out into the recess of the pivot cap at an angle so that the wires can be seen. Make sure that they are all below this recess in the pivot cap. The sensor end presses against the shoulder of this recess.
4. Keeping the wires away from the shoulder, pivot the sensor into its proper position on the shoulder. Hold it near the top, and close to the pivot cap.
5. With one hand, slide the sensor holder over the sensor until it touches the other hand that holds the sensor. Hold both pieces.
6. Push the sensor's rod, retracting it, until it can hold the sensor in place on the pivot cap's shoulder.
7. Holding the sensor in place with the rod, slide the sensor holder up, and hand screw it onto the pivot cap firmly. Do not expect the sensor holder to completely screw onto the pivot cap. Now, you can release the sensor's rod.
8. Screw the top nut, lock washer, and the magnet with its nut onto the sensor rod.

9. Adjust the nuts holding the magnet so that the nut in the notch of the magnet is flush with the end of the sensor's rod. Tighten the top nut firmly.

Figures 7-5, 7-6, and 7-8 are labeled with names and numbers. The following instructions refer to the parts in those figures with a number in brackets [X].

### 7.2.14 Solenoid Valves

Refer to Figure 7-5 Solenoid Valve.

The instrument uses nine solenoid valves. Seven solenoids have 1/32- inch orifices and two solenoids have 3/64-inch orifices. The 1/32–inch orifice valves are used in the gas pressurization system and the 3/64-inch orifice valve is used in the filtrate system. The filtrate valve is valve B12. Often debris gets between the pilot and seat of the valve. If that happens, cleaning is all that is required. However, if the valve seals are damaged, the complete valve must be replaced. If the pin/pilot is plastic, the valve may be repaired by replacing the pin/pilot.

To disassemble, follow these steps:

1. Turn the instrument power off and disconnect the power cord.
2. Remove the left side/back panel.
3. Remove the nut [1] on the top of the solenoid valve that holds the coil [2].
4. Remove the coil and let it hang by its leads.

Do not energize the coil when it is removed. This will overheat the coil and damage it.

5. Slide the solenoid valve wrench (P/N 209169) over the valve stem [3], and unscrew it. Do not lose the small parts inside it.
6. When the stem is removed, the pilot guide [8] may not come out with it. It may be necessary to remove the pilot guide using a small screwdriver or rod. Examine and clean the seat. Note that some valves do not use the pilot guide. The seat cannot be removed.

To assemble, follow these steps:

1. Clean all of the parts of the valve carefully.
2. If the pilot guide exists, put it back into the valve body.

3. Put the rubber gasket [7] into the valve body.
4. Assemble the small parts – the spring, pin/pilot and armature [4, 5, 6] into the stem.
5. Screw the stem into the body. Tighten using the solenoid valve wrench.
6. Replace the coil and secure with the nut.

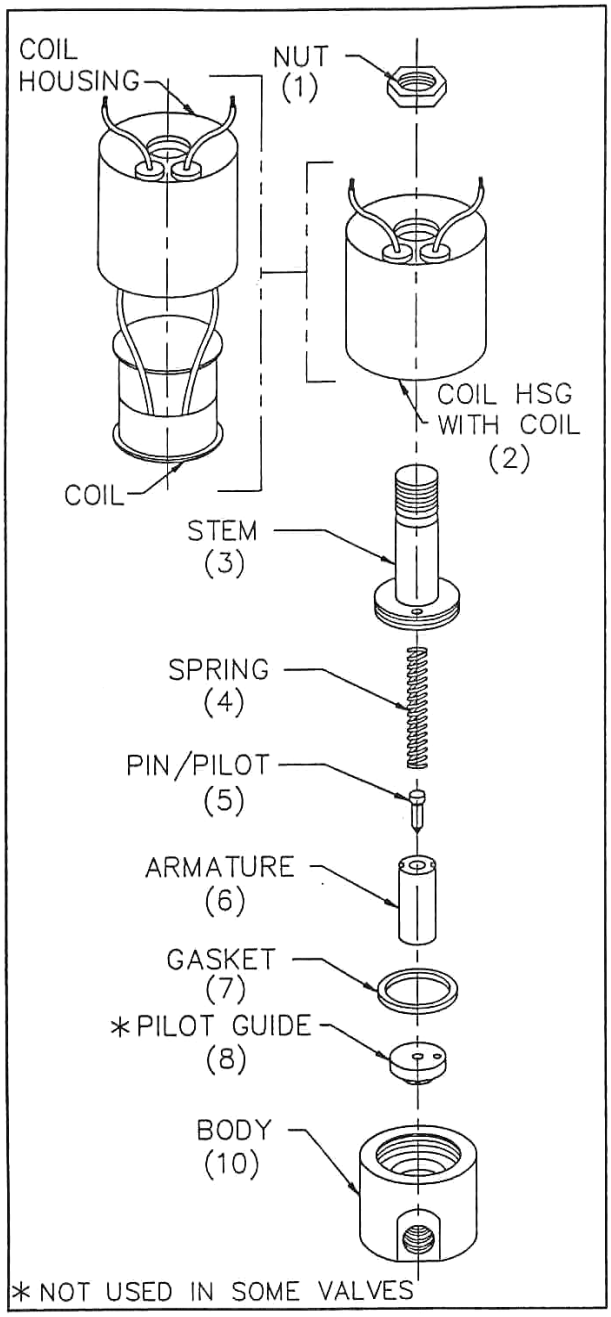



**Figure 7-5 Solenoid Valve**

### 7.2.15 Purge Pump

Refer to Figure 7-6.

The purge pump is a small volume gear pump that is magnetically coupled to its motor. If the pump becomes over pressured or jammed, the magnetic coupling will separate, allowing the motor to continue to turn. This prevents damage to the motor. Stopping the motor will restore the magnetic coupling.

If the pump is not working properly, the inlet or outlet tubes may be plugged, the gears may be jammed with debris, or gears and shoe may be worn. To service the pump, you must remove the pump head from the motor.

Follow these instructions to remove the pump head:

1. Remove the cell.
2. Turn off the instrument power and disconnect the power cord.
3. Remove the left side/back panel.
4. Remove the catch pan. (See section 7.2.10.)
5. Using a 7/16-inch end wrench, remove the suction and discharge tube connections to the pump.
6. Using a stubby screwdriver, remove the two screws holding the pump head to the motor, and then remove the pump head.

Follow these instructions to disassemble the pump head:

1. Mark the orientation of the drive housing [11] to the pump body [1] for reassembly later.
2. Remove the three screws [12] from the drive housing, and then separate the drive housing from the pump.
3. Remove the magnet cup [10] and magnet assembly [7] to see the gears [3 and 8] and the suction shoe [4].
4. For easier cleaning and inspection, disassemble the gears and suction shoe by removing the screw [6]. If any parts are damaged, replace them.

Follow these instructions to reassemble the pump head:

1. Make sure that the Teflon® seal [9] is clean and smooth, and then lubricate it with a thin film of grease.
2. Install the magnet assembly on the driving shaft [2], fit the spline pins into the holes of the gear.
3. Make sure that the pump gears are turning freely.

4. Align the orientation marks made during disassembly and install the magnet cup [10] and the drive housing [11] with the three screws [12]. Tighten the screws evenly to 10 ft-$lb_f$ (1.1N·m).

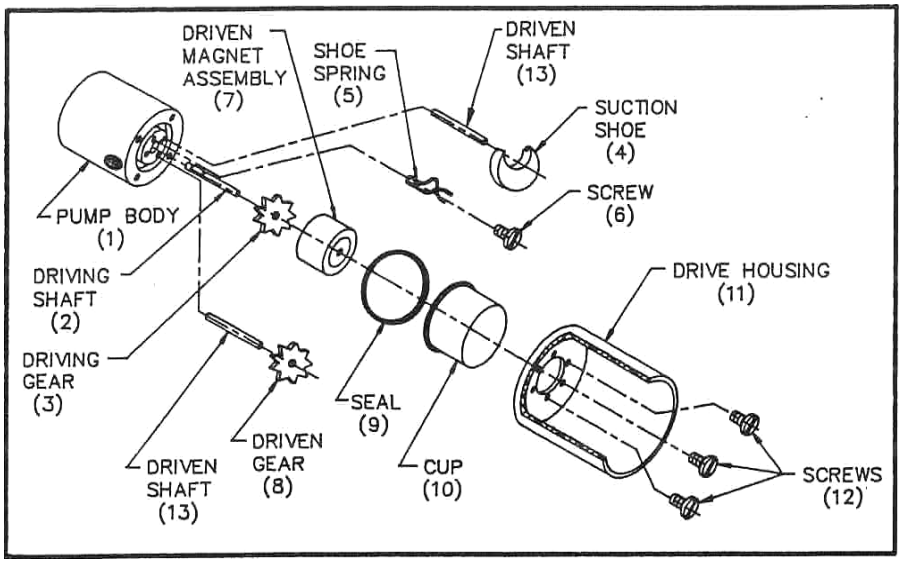



**Figure 7-6 Purge Pump**

### 7.2.16 Pump Head Installation

Follow these instructions to install the pump head:

1. Reassemble the pump head onto its motor. Observe that the tube fittings align properly with the tubes, and the flow arrow on the pump head is in the correct direction. Install and tighten the two mounting screws.
2. Connect the inlet and discharge tube connections. Tighten until snug, and then tighten again, an additional one-sixth (1/6) turn.

### 7.2.17 Filtrate Line Filter

Refer to Figure 7-7.

The filtrate line filter is in the hose that extends from the cell cap to the right side cell port. It prevents particles from plugging the filtrate solenoid valve.

Follow these steps to disassemble and reassemble the filtrate line filter:

1. Hold the filter with two 3/4- inch or adjustable wrenches on the hexes at opposite ends of the body. Unscrew the body, separating it at the gasket.
2. Remove and clean all internal parts.

3. Reassemble as shown in Figure 7-7 and tighten.

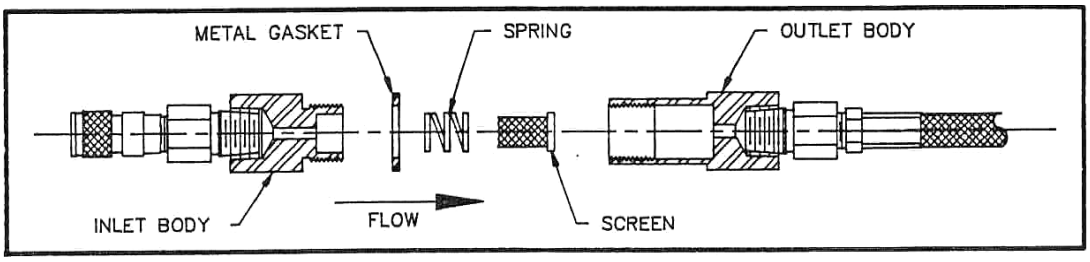



**Figure 7-7 Filtrate Line Screen**

### 7.2.18 Core Clamp O-ring

Refer to Figure 5-4 cell assembly.

1. Place the cell cap assembly on the locking pins on the base of the instrument.
2. Unscrew the filter core clamp from the cell cap using the handle of the filter core holder wrench (P/N 209171) in the slot of the core clamp.
3. Remove and replace the O-ring.
4. Clean and reassemble the parts.

### 7.2.19 Quick-Disconnect O-ring

The quick disconnect hose couplings are sealed with O-rings in the body of the coupler. One O-ring seals the space between the body and the stem, while the other seals the body from leaking when the coupler is disconnected. Before performing the following steps, remove the connector from the tubing or hose. Refer to Figure 7-8 Quick Disconnect.

1. While holding the body sleeve [2] back, remove the retainer ring [1].
2. Remove the body sleeve, body sleeve spring [3], and four balls [4].
3. Hold the connector by the hex in a vice or with a wrench, and place a 1/16- inch punch through the ball pocket holes. Unscrew the body [5] from the fitting adapter [11].

An alternate method of removing the body is to hold the connector by the hex, as in step 3 (above) and use the pliers to unscrew the body from the fitting adapter. If this technique is used, then steps 1 and 2 (above) do not apply.

4. Carefully remove the check valve spring [10], valve seat [9] with O-ring [8], and valve body insert [7].
5. Remove the stem O-ring [6] from the threaded end of the body.
6. Lubricate and then install a new stem O-ring into the body and a new check valve O-ring into the valve seat.
7. Reassemble following step 4 and then step 3 (reverse order). If disassembled, then follow step 2, and then step 1(reverse order).

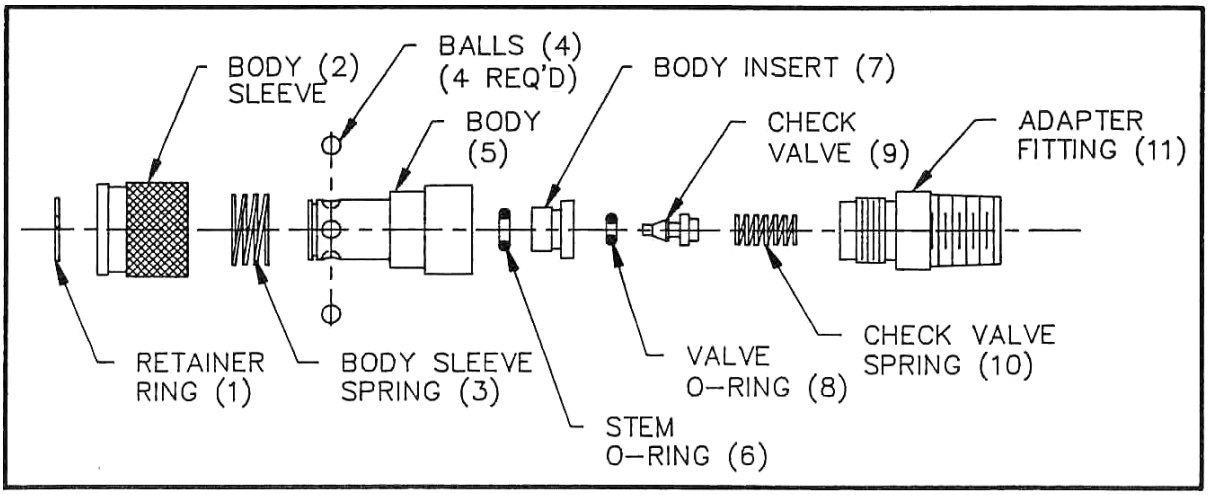



**Figure 7-8 Quick Disconnect**

### 7.2.20 Purge Pump Relief Valve

The purge pump relief valve is located inside the left side/back cover and next to the purge pump. It sits parallel to the pump and allows fluid to bypass when the pump outlet pressure exceeds about 40 psig (276 kPa). This relief pressure may be adjusted by loosening the pressure-adjust lock screw at the outlet end of the valve, and then turning the adjusting screw. Turning the screw clockwise increases pressure, and turning the screw counterclockwise decreases pressure. Use a hex socket wrench to make the adjustment. Re-tighten the lock screw.

Follow these steps to remove the purge pump relief valve:

1. Turn off the instrument and disconnect the power cord.
2. Remove the left side/back panel.
3. Remove the tubing nut at each end of the valve and remove the valve.

Follow these steps to disassemble, clean and reassemble the purge pump relief valve:

1. Using a hex socket wrench, remove the insert lock screw from the inlet end. This will allow the insert, poppet with O-ring, and spring to be removed. Do not move the screws at the outlet end unless a pressure adjustment is needed.
2. Clean all parts.
3. Inspect and replace the O-ring, if it is damaged.
4. Reassemble in the reverse order. Lubricate the O-ring and make sure it is not damaged while assembling it.

Follow these steps to install the purge pump relief valve:

1. Install the valve onto the tubing making sure the outlet of the valve is toward the suction of the purge pump.
2. Tighten all fittings and test for leaks.
3. Install left side/back panel.

# 8 Accessories

These accessories are optional items that can be ordered separately.

**Table 8-1 Accessories for the Model 90**

| Part No. | Quantity | Description |
|---|---|---|
| 203367 | 8 | BUSHING ANGULAR CONTACT |
| 203771 | 1 | CONNECTOR ADAPTER SERIAL DB25M |
| 204042 | 1 | BUSHING REDUCING 1/4 MNPT X 1/8 FNPT |
| 204127 | 2 | FUSE 5 AMP 125 V-FAST ACTING |
| 204233 | 1 | INSTRUCTION MANUAL |
| 204896 | 1 | PRESSURE REGULATOR, 6000 PSIG |
| 204616 | 5 | O-RING 1-3/8 X 3/32 NITRILE |
| 204617 | 10 | O-RING 1-3/8 X 1/16 VITON |
| 204618 | 5 | O-RING 2-1/2 X 3/32 VITON |
| 204619 | 3 | O-RING 2-1/16 X 3/32 NITRILE |
| 204620 | 5 | O-RING 7/8 ID X 3/32 NITRILE |
| 204621 | 5 | O-RING 0.734 X 1/8 NITRILE B-46 |
| 204622 | 4 | O-RING 1/16 X 1/16 VITON V-14 003 |
| 204623 | 4 | O-RING 5/32X1/16 VITON V-14 007 |
| 204816 | 1 | GREASE HIGH TEMP PERMATEX 82325 |
| 204897 | 1 | PRESSURE REGULATOR, 6000 PSIG in, 50-2500 PSIG out |
| 204929 | 1 | RETAINER INTERNAL 1.653 ID STAINLESS STEEL |
| 205625 | 1 | LUBRICANT GREASE STOPCOCK 75gm |
| 206112 | 1 | GUN GREASE CARTRIDGE or SUCTION |
| 206613 | 5 | O-RING 2-5/16 X 2-1/2 V-14 141-75 |
| 207313 | 5 | O-RING 13/16 X 1 VITON V14 117-75 |
| 209123 | 10 | CORE GASKET |
| 209169 | 1 | SOLENOID VALVE WRENCH |
| 209188 | 3 | SHEAR SHAFT RACE |
| 213483 | 1 | CERAMIC FILTER TUBE (CORE), MEAN PORE DIAMETER 35 MICRONS |

# 9 Parts List

The Model 90 parts list includes operating supplies and parts suggested for replacement in Section 7 Troubleshooting and Maintenance. Selected additional parts which could fail and require replacement are also listed. Installation of these parts will require a qualified technician.

**Table 9-1 Dynamic HPHT® Filtration System, Model 90, P/N 209113, Revision V**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203378 | 2 | 8-32 X 3/4 RHMS STAINLESS STEEL |
| 0002 | 203385 | 2 | 1/4-20 X 1/2 HHMS 304 STAINLESS STEEL |
| 0003 | 203416 | 2 | 8-32 X 1 RHMS STAINLESS STEEL |
| 0004 | 203427 | 4 | 1/4-20 X 1 1/2 HHCS STAINLESS STEEL |
| 0005 | 203438 | 3 | 1/4-20 X 1 HHCS STAINLESS STEEL |
| 0006 | 203465 | 4 | 6-32 X 1/2 THMS STAINLESS STEEL |
| 0007 | 203522 | 1 | CABLE POWER 115V 14 AWG M&F PLUG |
| 0008 | 203696 | 3 | PIN CONNECTOR MOLEX |
| 0009 | 203749 | 2 | CONNECTOR CRIMP TERMINAL HSG |
| 0010 | 204017 | 2 | CONNECTOR PORT 1/4 TUBE |
| 0011 | 204128 | 4 | FUSE US 20 AMP 1/4 X 1-1/4 LITTLE FUSE P/N 314020 20 AMP |
| 0012 | 204129 | 4 | FUSE 10 AMP EUROPEAN 5 mm X 20 mm MOD |
| 0013 | 204130 | 1 | FUSE 6 AMP MED-BLOW 3AG 1.25X.25 |
| 0015 | 204355 | 1 | FUSE HOLDER DRAWER EUROPEAN FU |
| 0017 | 204554 | 1 | TAG NITROGEN SUPPLY LINE MODEL |
| 0018 | 205075 | 1 | SPRING TENSION 7/16 OD X 2.0 |
| 0019 | 205082 | 1 | V-BELT |
| 0020 | 205303 | 5 | TAPE FOAM 3/8THK X 3/4WIDE 10F |
| 0021 | 205616 | 1 | INSERT MALE BARB 1/4 MNPT X 1/4 HOSE 316 SS 300 PSI MAX @ 72°F |
| 0022 | 205623 | 3 | TUBING TYGON 1/4 ID X 1/16 WALL TRANSLUCENT YELLOW |
| 0023 | 206111 | 1 | PLIERS TRUARC L-0300 SNAP RING |
| 0024 | 206145 | 1 | VALVE RELIEF 50-6000 PSI |
| 0025 | 206146 | 1 | SPRING I5021 RELIEF VALVE |
| 0026 | 207084 | 1 | FUSE 5 AMP SLOW-BLOW 3 AG |
| 0027 | 207336 | 2 | 8-32 X 3/8 BHMS STAINLESS STEEL |
| 0028 | 207488 | 2 | 6-32 X 3/8 BHMS STAINLESS STEEL |
| 0029 | 207512 | 4 | RETAINER EXTERNAL HC VISCOMETR |
| 0030 | 207607 | 6 | 10-32 X 3/8 BHMS STAINLESS STEEL |
| 0031 | 207626 | 4 | NUT 1/4-20 HEX REGULAR STAINLESS STEEL |
| 0032 | 207633 | 6 | NUT 10-32 HEX REGULAR STAINLESS STEEL |
| 0033 | 207635 | 6 | WASHER INTERNAL TOOTH 10 STAINLESS STEEL |
| 0034 | 207753 | 2 | WASHER SPLIT 1/4 STAINLESS STEEL |
| 0035 | 207842 | 32 | 6-32 X 1/4 THMS STAINLESS STELL |
| 0036 | 207921 | 4 | 8-32 X 3/4 BHMS STAINLESS STEEL |
| 0037 | 207995 | 1 | GROMMET 0.06-0.099, PANEL THICK,SLOTTED,ADHESIVE BACKED |
| 0038 | 209037 | 1 | CABLE NULL MODEM 10 FT DB25M X DB25F |

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0040 | 209115 | 1 | FILTRATE COLLECTION ASSEMBLY |
| 0041 | 209125 | 1 | CELL ASSEMBLY |
| 0042 | 209151 | 1 | CALIBRATION SLUG |
| 0043 | 209152 | 1 | FRAME ASSEMBLY |
| 0044 | 209153 | 1 | CHANNEL ASSEMBLY |
| 0045 | 209154 | 1 | HEATERS DOOR & FIXED ASSEMBLIES |
| 0046 | 209155 | 1 | MOTOR ASSEMBLY |
| 0047 | 209156 | 1 | COVER ASSEMBLY |
| 0048 | 209157 | 1 | DOOR ASSEMBLY |
| 0049 | 209158 | 1 | COMPUTER ASSEMBLY |
| 0051 | 209160 | 1 | NITROGEN SUPPLY ASSEMBLY |
| 0052 | 209165 | 1 | TOOL BEARING REMOVAL |
| 0053 | 209171 | 1 | TOOL FILTER HOLDER/INSTALLER |
| 0054 | 209183 | 1 | ACCESSORIES |
| 0055 | 209187 | 1 | GAUGE CELL SAMPLE FILL |
| 0056 | 210219 | 1 | FUSE 2 AMP SLOW-BLOW MDL-2 |
| 0057 | 209170 | 1 | TOOL CELL BEARING HOLDER/REMOVAL |
| 0058 | 209172 | 1 | TOOL RTD PROBE REMOVER/INSTALL |
| 0060 | 204618 | 1 | O-RING 2-1/2 X 3/32 VITON |
| 0070 | 206613 | 1 | O-RING 2-5/16 X 2-1/2 V-14 141-75 |
| 0080 | 204616 | 1 | O-RING 1-3/8 X 3/32 NITRILE |
| 0090 | 204617 | 1 | O-RING 1-3/8 X 1/16 VITON |

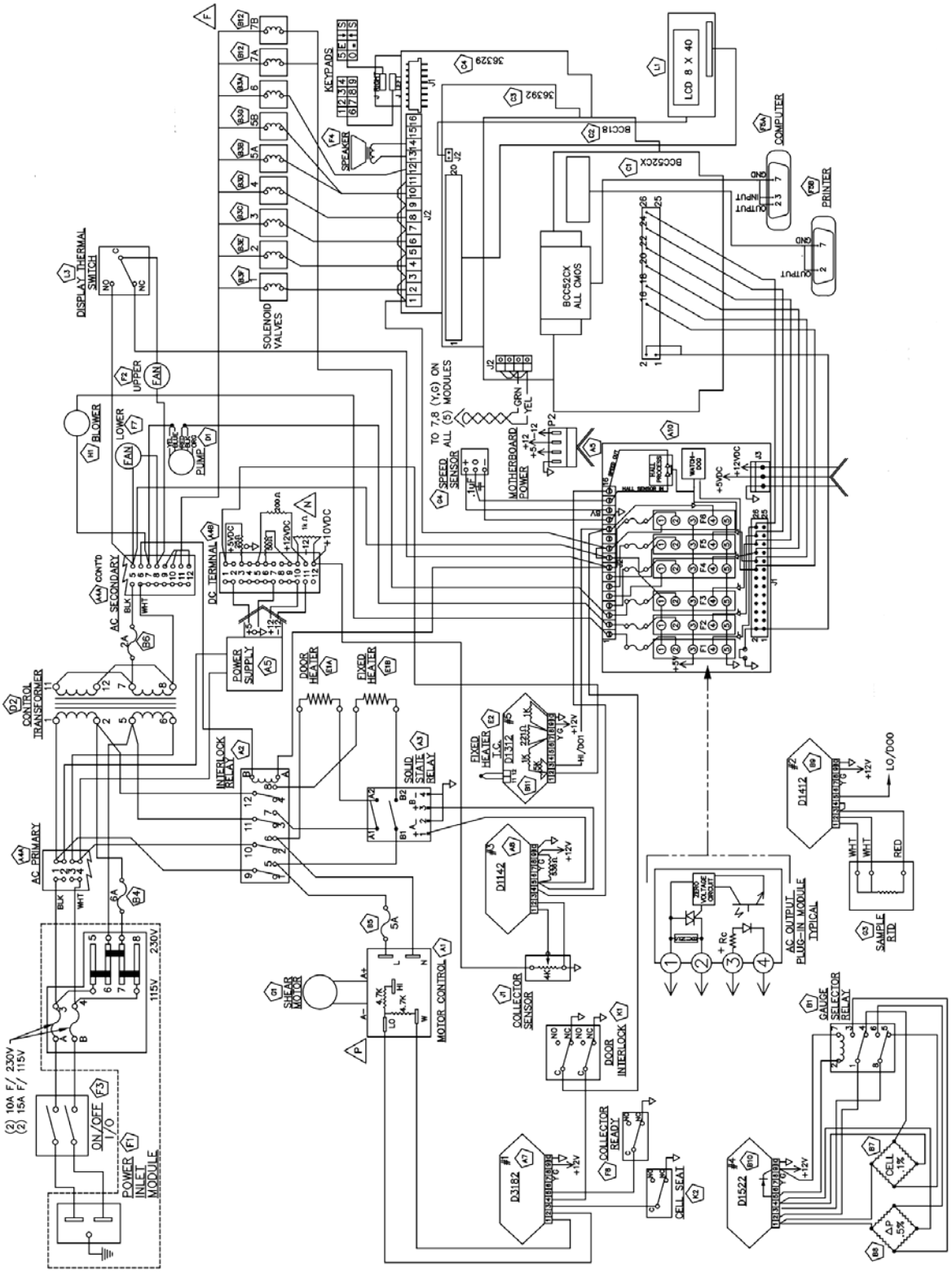



**Figure 9-1 Electrical Schematic, Model 90 and 90B, Rev P**

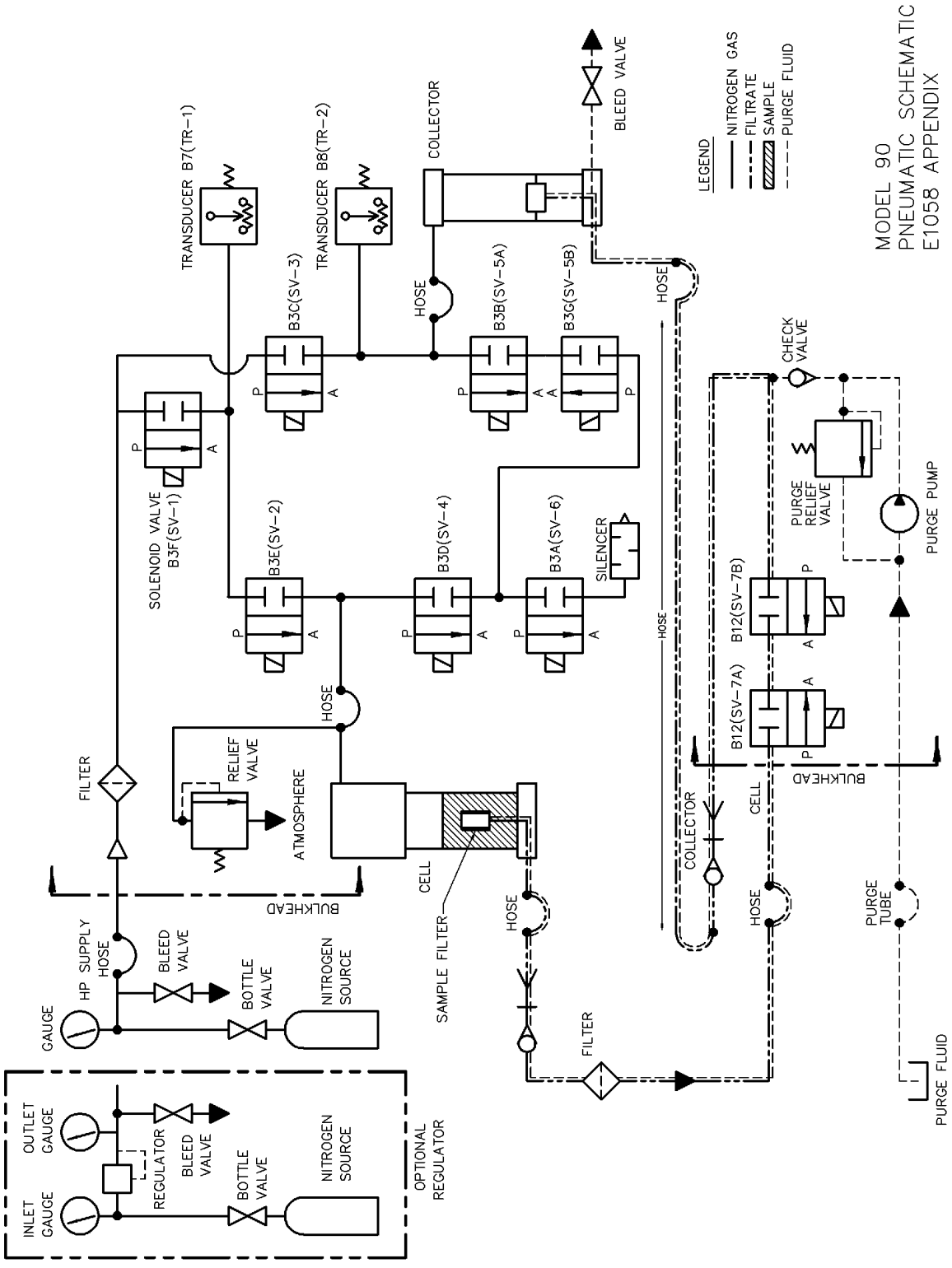



**Figure 9-2 Pneumatic Schematic**

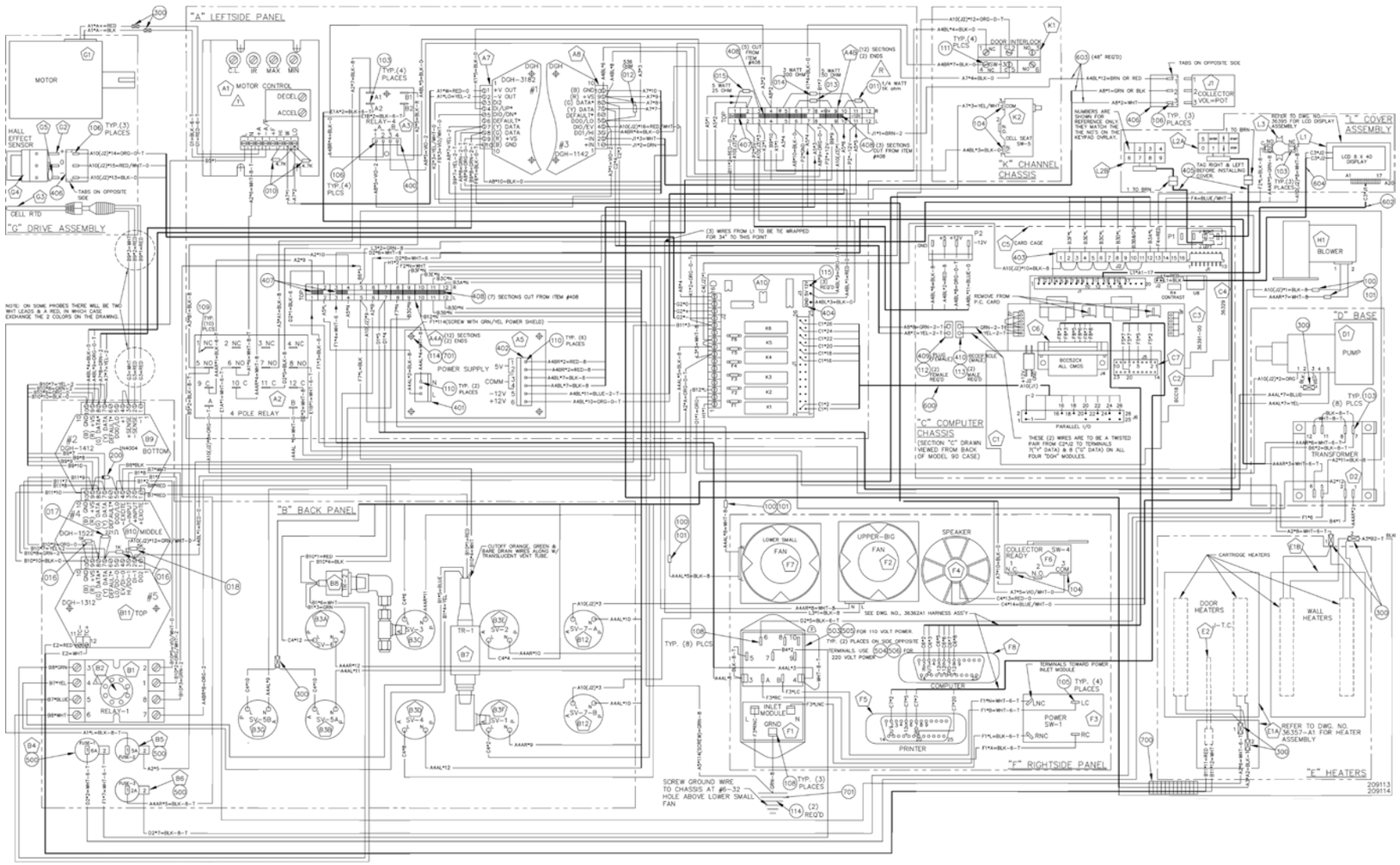



**Figure 9-3 Wire Diagram, page 1 of 2, Rev T**

BILL OF MATERIALS

| ITEM NO. | PART NO. | DESCRIPTION | QTY |
|---|---|---|---|
| A1 | E5010 | CONTROLLER, MOTOR | 1 |
| A2 | F8010 | RELAY, 4PDT | 1 |
| A3 | E3094 | SOLID STATE RELAY | 1 |
| A4 | H7020 | BLOCK, TERMINAL STRIP SINGLE | 24 |
| | H7021 | BLOCK, TERMINAL MOUNTING SECTION | 4 |
| A5 | E3093 | SUPPLY, POWER | 1 |
| A7 | E3086 | MODULE, INTERFACE | 1 |
| A8 | E3087 | MODULE, INTERFACE | 1 |
| A10 | 36430 | BOARD, I/O-WATCHDOG | 1 |
| B1 | F8002 | SOCKET, RELAY RECEPTICAL | 1 |
| B2 | 36351 | ASSEMBLY, RELAY F/M90 | 1 |
| B3 | P5019 | VALVE, SOLENOID | 7 |
| B4 | C7007 | FUSE, 6 AMP | 1 |
| B5 | 28623 | FUSE, 5 AMP | 1 |
| B6 | 70004 | FUSE, 2 AMP | 1 |
| B7 | P1005 | TRANSDUCER, PRESSURE 300 PSIG 0.1% | 1 |
| B8 | P1004 | TRANSDUCER, PRESSURE 300 PSIG 0.5% | 1 |
| B9 | E3088 | MODULE, INTERFACE | 1 |
| B10 | E3085 | MODULE, INTERFACE | 1 |
| B11 | E3101 | MODULE, INTERFACE | 1 |
| B12 | 36310 | VALVE, SOLENOID 3/64 SEAT | 2 |
| C1 | B3019 | CIRCUIT BOARD, COMPUTER/CONTROLLER | 1 |
| C2 | B3017 | CARD, DUAL SERIAL | 1 |
| C3 | 36392 | CIRCUIT BOARD ASS'Y F/ LCD DISPLAY | 1 |
| C4 | 36329 | CIRCUIT BOARD ASS'Y I/O | 1 |
| C5 | B3016 | MOTERBOARD, MINI W/ 6" CARD CAGE | 1 |
| C6 | B4081 | CONNECTOR D SHELL 25 CONDUCTOR | 1 |
| C7 | B4083 | CONNECTOR, 20 CONDUCTOR | 1 |
| D1 | J1005 | PUMP, GEAR MAGNETICALLY DRIVEN | 1 |
| D2 | P2006 | TRANSFORMER, CONTROL DUAL PRIMARY & SECONDARY | 1 |
| E1 | 36353 | MACHINE PARTS SET F/ HEATERS | 1 |
| E2 | H8018 | THERMOCOUPLE, TYPE J | 1 |
| F1 | E3092 | MODULE, RECEPTICLE | 1 |
| F2 | 31181 | FAN, CIRCULATING | 1 |
| F3 | H6042 | SWITCH, POWER | 1 |
| F4 | E3045 | SPEAKER | 1 |
| F5 | B4081 | CONNECTOR, D SHELL 25 CONDUCTOR | 1 |
| F6 | H6036 | SWITCH, STRAIGHT LEVER ACTUATED | 1 |
| F7 | E3033 | FAN, 43 CFM, 115 VOLT, 3.13 ø | 1 |
| F8 | B4094 | CONNECTOR D SHELL 25 CONDUCTOR | 1 |
| G1 | 36422 | MOTOR, 1/4 HP, 1725 RPM, 90 VDC | 1 |
| G2 | B4068 | HEADER, RIGHT ANGLE W/ .1 CENTERS | 1 |
| G3 | 36330 | PROBE, CELL TEMPERATURE | 1 |
| G4 | J7074 | SENSOR, POSITON ANALOG HALL EFFECT | 1 |
| G5 | A8033 | CAPACITOR, .1uF, 50V, 10% CERAMIC MONOLITHIC | 1 |
| H1 | E3091 | BLOWER, 54 CFM, 115 VOLT | 1 |
| J1 | K1018 | SENSOR, LINEAR MOTION POSITION | 1 |
| K1 | H6041 | SWITCH, LIMIT | 1 |
| K2 | H6043 | SWITCH, LIMIT 15 AMP, SPDT | 1 |
| L1 | 36395 | LCD DISPLAY ASSEMBLY | 1 |
| L2 | H6039 | KEYPAD, 2 X 4 MATRIX MEMBRANE | 2 |
| L3 | H8019 | THERMOSTAT, 115 DEG. F., SURFACE MOUNT | 1 |
| 010 | 32064 | RESISTOR, 4.7K OHM, 1/4 WATT, 5% | 2 |
| 011 | G5043 | RESISTOR, 825 OHM, 1/4 WATT, 1% | 1 |
| 012 | 32191 | RESISTOR, 536 OHM, 1/4 WATT, 1% | 1 |
| 013 | G3008 | RESISTOR, 50 OHM, 5 WATT, 5% | 1 |
| 014 | G3009 | RESISTOR, 200 OHM, 5 WATT, 5% | 1 |
| 015 | G3010 | RESISTOR, 25 OHM, 5 WATT, 5% | 1 |
| 016 | 32198 | RESISTOR, 1.00K OHM, 1/4 WATT, 1% | 2 |
| 017 | 32153 | RESISTOR, 221 OHM, 1/4 WATT, 1% | 1 |
| 018 | 32215 | RESISTOR, 4.99K OHM, 1/4 WATT, 1% | 1 |
| 100 | E3035 | TERMINAL, MALE TAB INSULATED | 4 |
| 101 | E3036 | TERMINAL, FEMALE DISCONNECT | 10 |
| 103 | E3001 | TERMINAL, FEMALE RIGHT ANGLE DISCONNECT | 15 |
| 104 | 33093 | TERMINAL, #6 FLANGE FORK | 14 |
| 105 | E3042 | TERMINAL, #6 FORK | 4 |
| 106 | B4007 | PIN, MOLEX CONNECTOR | 10 |
| 108 | E3099 | TERMINAL, FEMALE DISCONNECT, RIGHT ANGLE | 11 |
| 109 | E3100 | TERMINAL, STRAIGHT 3/28 FEMALE DISCONNECT | 10 |
| 110 | B4076 | CONNECTOR, CRIMP TERMINAL | 8 |
| 111 | E3055 | LUG, #4 STUD RING | 4 |
| 112 | B4042 | TERMINAL, FEMALE CRIMP .093 ø | 2 |
| 113 | B4043 | TERMINAL, MALE CRIMP .093 ø | 2 |
| 114 | 33095 | TERMINAL, #6 RING TONGUE | 3 |
| 115 | B4097 | CONNECTOR, PIN-TRIFURCON TERMINAL | 3 |
| 200 | B8001 | DIODE, SIGNAL IN4004 | 1 |
| 300 | E3071 | SPLICE, BUTT INSULATED | 6 |
| 400 | B4077 | CONNECTOR, HOUSING 4 CONDUCTOR .10 CENTERS | 1 |
| 401 | B4074 | CONNECTOR, 3 CONDUCTOR.156 CENTERS | 1 |
| 402 | B4075 | CONNECTOR, 6 CONDUCTOR .156 CENTERS | 1 |
| 403 | H7010 | CONNECTOR, 16 CONDUCTOR | 1 |
| 404 | B4096 | CONNECTOR, HOUSING 3 CONDUCTOR F/ TRIFURCON | 1 |
| 405 | B4073 | CONNECTOR, CABLE ASSEMBLY 6 CONDUCTOR | 2 |
| 406 | B4069 | CONNECTOR, CRIMP TERMINAL HOUSING, 3 CONDUCTOR | 2 |
| 407 | H7013 | JUMPER, TERMINAL STRIP 2 STATION | 3 |

BILL OF MATERIALS

| | | | |
|---|---|---|---|
| 408 | H7012 | JUMPER, TERMINAL STRIP 12 STATION | 1.50 |
| 409 | B4088 | PLUG, 2 CONDUCTOR POLARIZED | 1 |
| 410 | B4089 | RECEPTICLE, 2 CONDUCTOR POLARIZED | 1 |
| 500 | 32972 | HOLDER, FUSE | 3 |
| 503 | C7005 | FUSE, 15 AMP USA, 1/4 X 1-1/4 | 1 |
| 504 | C7006 | FUSE, 10 AMP EUROPEAN, 5MM X 20MM | 1 |
| 505 | E3098 | DRAWER, FUSE USA | 1 |
| 506 | E3095 | DRAWER, FUSE EUROPEAN | 1 |
| 600 | 36432 | CABLE, 26 CONDUCTOR RIBBON | 1 |
| 602 | 36396 | CABLE, HARNESS 34 CONDUCTOR | 1 |
| 603 | P9031-1FT | WIRE, 3 CONDUCTOR FLEXIBLE, SHIELDED | 6 |
| 604 | 33080-1IN | CABLE, CONTROL SINGLE PAIR 22 GAGE | 36 |
| 700 | H2001 | SPRING, EXTENSION .56 O.D. X 20.0 INCHES LONG | 50 |
| 701 | 35020 | WASHER, #6 INTERNAL TOOTH, SS | 1 |

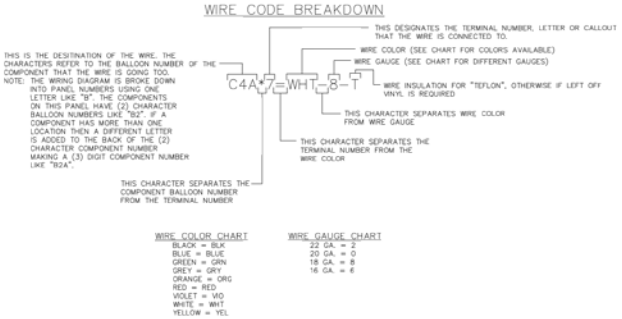



**Figure 9-4 Wire Code, page 2 of 2, RevT**

**Table 9-2 Filtrate Collector Assembly, Model 90, P/N 209115, Revision B**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 207313 | 2 | O-RING 13/16 X 1 VITON V14 117-75 |
| 0002 | 207633 | 2 | NUT 10-32 HEX REGULAR STAINLESS STEEL |
| 0003 | 208704 | 1 | WASHER SPLIT 10 STAINLESS STEEL |
| 0004 | 209116 | 1 | MACHINE SET COLLECTOR |
| 0004a | 209197 | 1 | PIVOT PIN |
| 0004b | 209195 | 1 | SENSOR HOLDER |
| 0004b | 209196 | 1 | FILTRATE COLLECTION TUBE |
| 0004c | 345670 | 1 | END CAP, SENSOR |
| 0004d | 209199 | 1 | FILTRATE INLET CAP |
| 0004d | 209200 | 1 | FILTRATE PISTON CAP |
| 0004e | 209198 | 1 | FILTRATE PISTON |
| 0005 | 209117 | 1 | VALVE BLEED OFF |
| 0006 | 209124 | 1 | PIVOT CAP ASSEMBLY |
| 0007 | 209126 | 1 | SENSOR FILTRATE ASSEMBLY |
| 0008 | 203366 | 1 | BALL 3/16 in. DIAMETER STAINLESS STEEL |
| 0009 | 203411 | 1 | 10-32 X 1/2 FHMS STAINLESS STEEL |
| 0010 | 204015 | 1 | QUICK CONNECT STEM TYPE QM |
| 0011 | 204621 | 1 | O-RING 0.734 X 1/8 NITRILE B-46 |
| 0012 | 205057 | 1 | MAGNET, UPPER, CELL ASSEMBLY |
| 0013 | 205402 | 1 | HOSE 3000PSI 1/8 NPT X 16.5 TFE w/SS BRD |

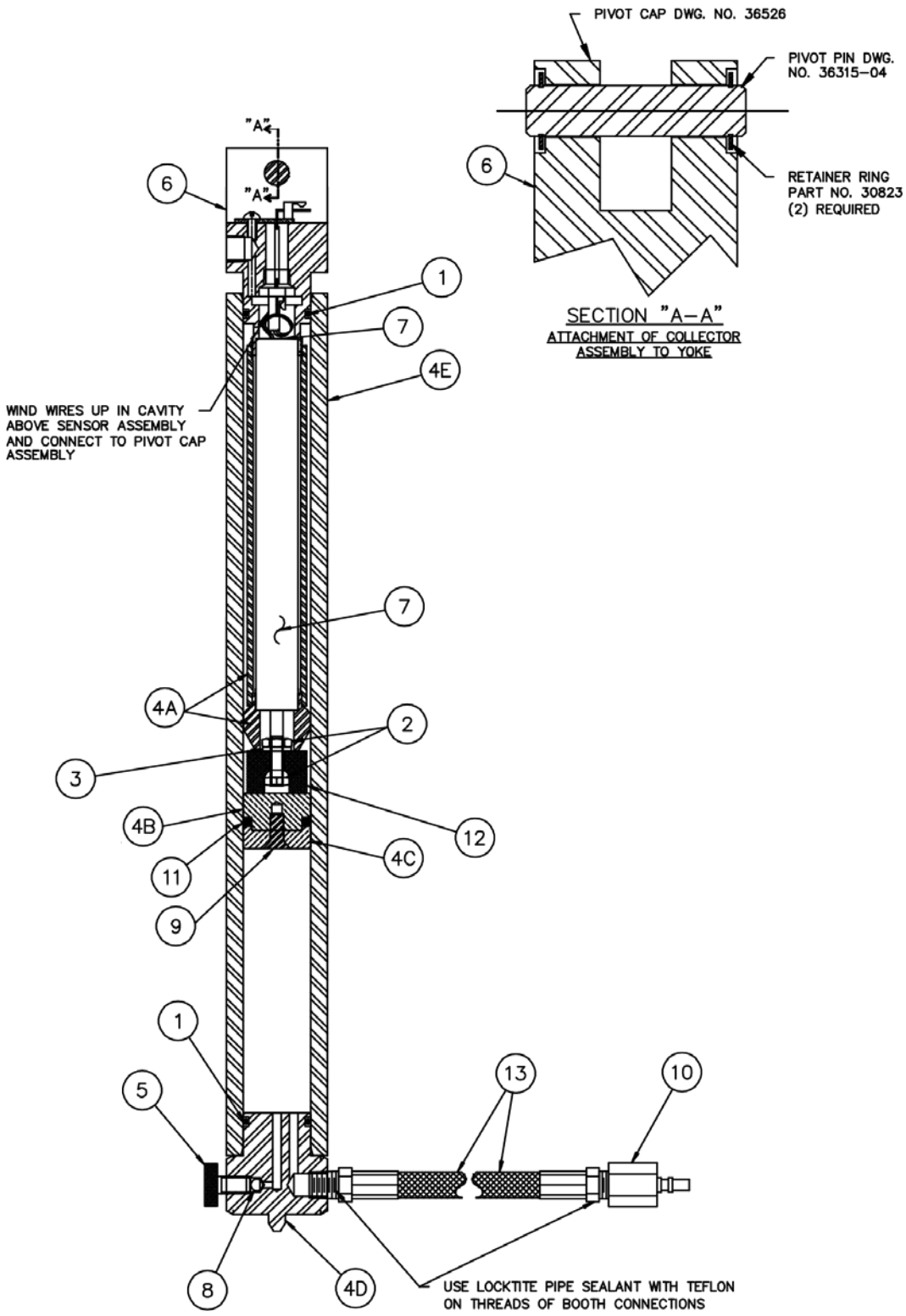



**Figure 9-5 Filtrate Collector Assembly, Rev D**

**Table 9-3 Cell Assembly, Model 90, P/N 209125, Revision J**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203388 | 1 | 8-32 X 1/4 LG-SHSS-STAINLESS |
| 0002 | 203441 | 1 | 10-32 X 3/16 SHSS STAINLESS |
| 0003 | 203463 | 3 | 10-24 X 1 FHMS STAINLESS |
| 0004 | 223264 | 1 | SPEED SENSOR ASSEMBLY |
| 0005 | 209120 | 1 | CELL MACHINE SET |
| 0005a | 209201 | 1 | CASING CELL CAP |
| 0005b | 209202 | 1 | CELL CASING |
| 0005c | 209203 | 1 | CORE CELL CLAMP |
| 0005d | 209204 | 1 | DRIVE HOUSING |
| 0005e | 209205 | 1 | CELL TOP |
| 0005 | 209206 | 1 | BEARING HOLDER |
| 0005j | 209207 | 1 | FILTER HOLDER |
| 0005h | 209208 | 1 | VAPOR CAP |
| 0005n | 209209 | 1 | MAGNETIC FOLLOWER |
| 0005p | 209210 | 1 | LOWER BEARING SUPPORT |
| 0005r | 209211 | 1 | FILTER CAP |
| 0005g | 209213 | 1 | STOP RING |
| 0005k | 209214 | 1 | DRIVE ROTOR & BUSHING ASSEMBLY |
| 0005 | 209215 | 1 | CASING CAP HANDLE |
| 0005m | 209216 | 1 | RETAINER VAPOR CAP CELL |
| 0006 | 204015 | 1 | QUICK CONNECT STEM TYPE QM |
| 0007 | 204018 | 1 | TEE MALE BRANCH 1/4T & 1/8 MP |
| 0008 | 204616 | 1 | O-RING 1-3/8 X 3/32 NITRILE |
| 0009 | 204617 | 2 | O-RING 1-3/8 X 1/16 VITON |
| 0010 | 204618 | 1 | O-RING 2-1/2 X 3/32 VITON |
| 0011 | 204619 | 1 | O-RING 2-1/16 X 3/32 NITRILE |
| 0012 | 204620 | 1 | O-RING 7/8 ID X 3/32 NITRILE |
| 0013 | 204928 | 1 | RETAINER EXTERNAL 3 IN SHAFT |
| 0014 | 204929 | 1 | RETAINER INTERNAL 1.653 ID STAINLESS STEEL |
| 0015 | 205325 | 1 | FITTING GREASE 1/4-28TPI X STR |
| 0016 | 205404 | 1 | HOSE 3000 PSI 1/8 NPT X 6 IN TFE w/SS BRAID |
| 0018 | 206613 | 1 | O-RING 2-5/16 X 2-1/2 V-14 141-75 |
| 0019 | 207307 | 2 | 6-32 X 3/8 FHMS STAINLESS STEEL |
| 0020 | 207609 | 1 | 6-32 X 1/8 HSSS STAINLESS STEEL |
| 0021 | 209118 | 1 | SHAFT SHEAR MODEL 90 DFS CELL |
| 0022 | 209119 | 1 | BUSHING SHAFT MODEL 90 CELL |
| 0024 | 209121 | 2 | MAGNET BLOCK |
| 0025 | 209122 | 4 | MAGNET SQUARE BAR 1/8 SQ. X 3/4 |
| 0026 | 209128 | 1 | CELL TEMPERATURE PROBE |
| 0027 | 209123 | 2 | CORE GASKET |
| 0028 | 209185 | 1 | SENSOR SHAFT |
| 0029 | 209188 | 1 | SHEAR SHAFT RACE |
| 0030 | 203367 | 1 | BUSHING ANGULAR CONTACT |

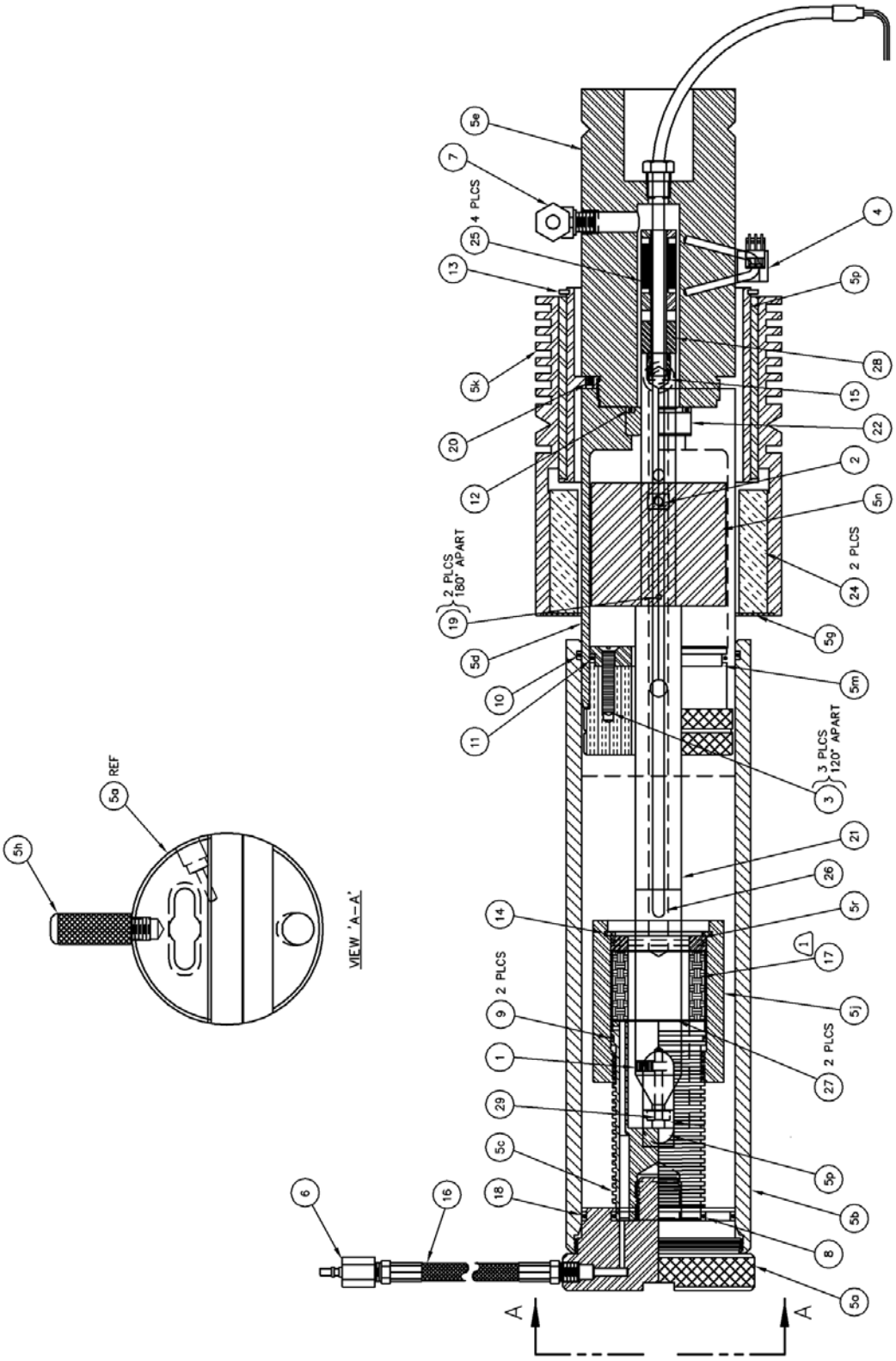


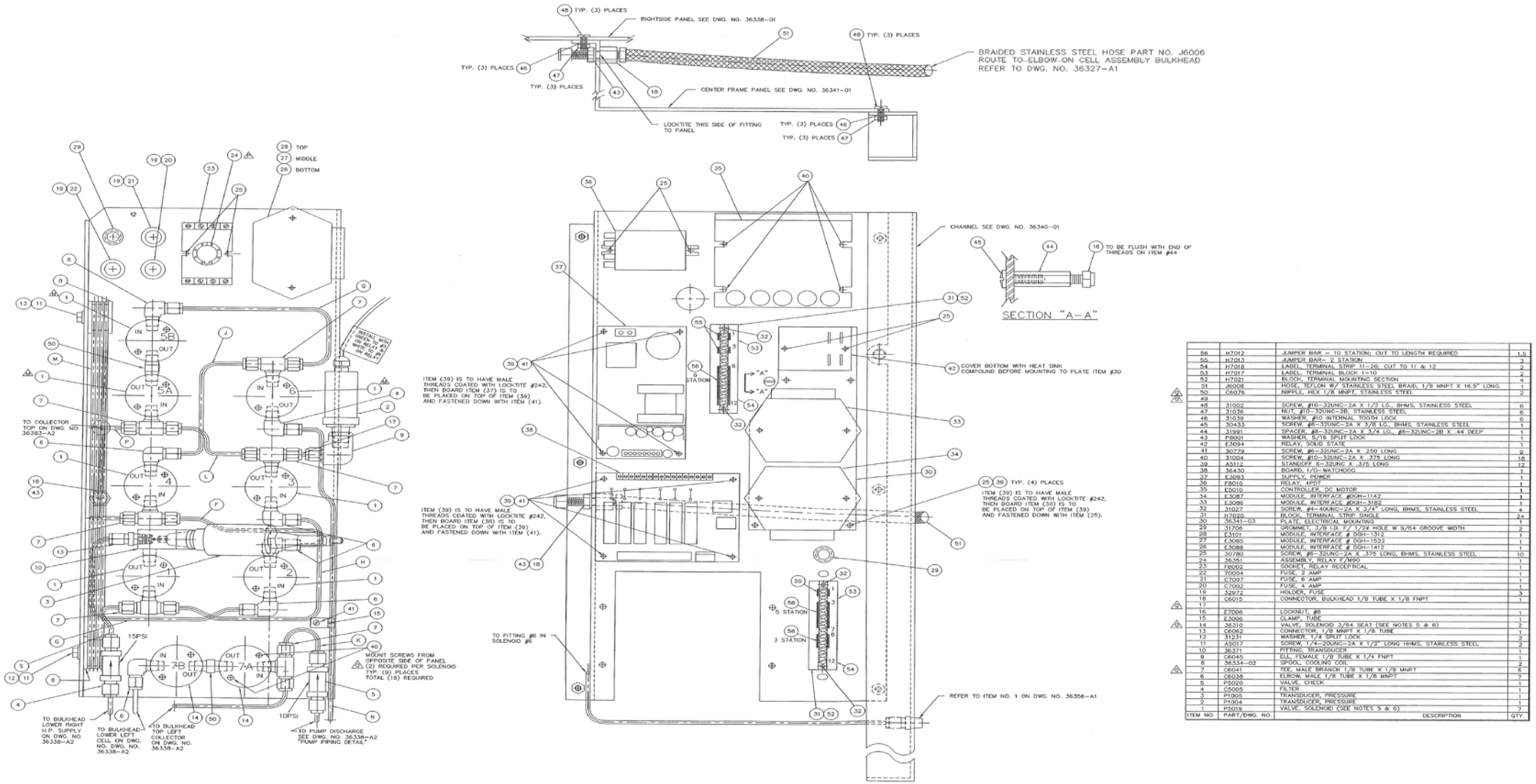

**Figure 9-6 Cell Assembly**

**Table 9-4 Frame Assembly, Model 90, P/N 209152, Revision I**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203485 | 12 | SPACER 6-32 M-F 1/4 HEX X 1/2 |
| 0002 | 203462 | 1 | NUT 5/16-18 UNC-2B-STAINLESS STEEL |
| 0003 | 203696 | 7 | PIN CONNECTOR |
| 0004 | 203751 | 1 | CONNECTOR 3 COND 0.156 CNT. W |
| 0005 | 203752 | 1 | CONNECTOR 6 COND 0.156 CNT. W |
| 0006 | 203753 | 8 | CONNECTOR CRIMP TERM 0.156 CN |
| 0007 | 203754 | 1 | CONNECTOR HOUSING 4 COND 0.1 |
| 0008 | 203769 | 1 | CONNECTOR HOUSING 3 COND TRIFU |
| 0009 | 203770 | 3 | CONNECTOR PIN-TRIFURCON TERMINAL |
| 0010 | 203904 | 1 | DIODE SIGNAL 1N4004 |
| 0011 | 203956 | 1 | FILTER 15 MICRON INLINE |
| 0012 | 203988 | 1 | CONNECTOR BULKHEAD 1/8TUBE X 1/8FNPT |
| 0013 | 101443952 | 7 | ELBOW 1/8 TUBE X 1/8 MNPT SS |
| 0014 | 204011 | 2 | CONNECTOR PORT 1/8 TUBE |
| 0015 | 204012 | 6 | TEE MALE BRANCH 1/8 T & 1/8 MP |
| 0016 | 204013 | 1 | ADAPTER TUBE 1/8 T & 1/8 MPT |
| 0017 | 204016 | 1 | ELL FEMALE 1/8 T & 1/4 FPT |
| 0018 | 204026 | 25 | TUBING 316 SS 0.125 IN. OD X 0.055 IN. ID 15 KSI |
| 0019 | 204027 | 1 | ELBOW 1/8 FNPT X 1/4 TUBE |
| 0020 | 204028 | 1 | CONNECTOR 1/8 MNPT X 1/8 F TUBE |
| 0022 | 204040 | 2 | NIPPLE 1/8 NPT HEX STAINLESS |
| 0024 | 204275 | 1 | CLAMP CABLE METAL 1/8 ARC |
| 0025 | 204294 | 100 | TIE WRAP 1/16  IN. TO 2 IN. DIAMETER |
| 0026 | 204299 | 6 | TERMINAL FEMALE Q.C .25X.032 1 |
| 0027 | 204345 | 1 | MODULE INTERFACE 30 MV BRIDGE DGH D1522 |
| 0028 | 204346 | 1 | MODULE INTERFACE 0 TO 10 VDC DGH D3182 |
| 0029 | 204347 | 1 | MODULE INTERFACE +/-10 VDC DGH D1142 |
| 0030 | 204348 | 1 | MODULE INTERFACE RTD 100 OHM DGH D1412 |
| 0031 | 204353 | 1 | POWER SUPPLY 85-264V UNIV-30W |
| 0032 | 204354 | 1 | RELAY SOLID STATE-2 SPST-NO |
| 0033 | 204359 | 10 | DISCONNECT-FEMALE-STRAIGHT-INS |
| 0034 | 204360 | 1 | MODULE INTERFACE TCPLE DGH D1312 |
| 0035 | 204470 | 1 | CONTROLLER MOTOR SPEED |
| 0036 | 204596 | 1 | NUT 8-32 ELASTIC LOCK |
| 0037 | 204900 | 1 | SOCKET RELAY 8 PIN P&B 27E122 |
| 0038 | 204906 | 1 | RELAY 4PDT 10A CONTACTS 115VAC |
| 0039 | 204948 | 1 | RESISTOR 50 OHM-5 WATT |
| 0040 | 204949 | 1 | RESISTOR 200 OHM-3 WATT |
| 0041 | 204950 | 1 | RESISTOR 25 OHM-5 WATT |
| 0042 | 208078 | 1 | RESISTOR 10K OHM 1/4W 1% MF |
| 0043 | 205155 | 2 | JUMPER BAR 10 STATION TERMINAL |
| 0044 | 205156 | 3 | JUMPER BAR 2 STATION TERMINAL |
| 0045 | 205160 | 2 | LABEL TERMINALS 1-10 H7011 SEC |
| 0046 | 205161 | 4 | LABEL TERMINALS 11-20 H7021 SE |
| 0047 | 205163 | 4 | END TERMINAL BLOK MODULAR w/MT |
| 0048 | 205164 | 24 | SECTION TERMINAL BLOCK MODULAR |
| 0049 | 205401 | 1 | HOSE 3000PSI 1/8 NPT X 10 TFE w/SS BRAID |
| 0050 | 205402 | 1 | HOSE 3000PSI 1/8 NPT X 16.5 TFE w/STAINLESS STEEL BRAID |

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0051 | 206067 | 1 | PRESSURE TRANSDUCER |
| 0052 | 206068 | 1 | SPUTTER DEPOSITED GAGE, 3MV /VOLT UNAMPLIFIED WITH 8-15 VOLT SUPPLY |
| 0053 | 206143 | 7 | VALVE SOLENOID 2-WAY NC HIGH PRESSURE 1/8 NPT, 3000 PSI, 0.022 CV 120V, 60 HZ COIL |
| 0054 | 206144 | 1 | VALVE CHECK O-RING SEAT |
| 0055 | 206202 | 2 | WASHER LOCK SPLIT 5/16 IN. |
| 0056 | 206215 | 13 | WIRE 18 AWG TEFLON STRANDED WHITE |
| 0057 | 208530 | 15 | WIRE 16 AWG TEFLON STRANDED BLACK |
| 0058 | 206217 | 60 | WIRE 20 AWG PVC STRANDED RED |
| 0059 | 206218 | 12 | WIRE 20 AWG PVC STRANDED WHITE |
| 0060 | 206219 | 120 | WIRE 20 AWG PVC STRANDED BLACK |
| 0061 | 206220 | 18 | WIRE 20 AWG PVC STRANDED BLUE |
| 0062 | 206221 | 60 | WIRE 20 AWG PVC STRANDED RED/WH |
| 0064 | 206223 | 12 | WIRE 22 AWG TEFLON STRANDED ORANGE |
| 0065 | 208531 | 15 | WIRE 16 AWG TEFLON STRANDED WHITE |
| 0066 | 206225 | 30 | WIRE 20 AWG PVC STRANDED YELLOW W/ WHITE |
| 0067 | 206226 | 60 | WIRE 20 AWG PVC STRANDED VIOLET WHITE |
| 0068 | 206227 | 18 | WIRE 20 AWG PVC STRANDED GREEN |
| 0069 | 206229 | 6 | WIRE 22 AWG PVC STRANDED GREEN |
| 0071 | 206239 | 6 | WIRE 28 AWG FLEX-SHIELDED 3 CON |
| 0073 | 206241 | 12 | WIRE 20 AWG TEFLON STRANDED ORANGE |
| 0074 | 206242 | 15 | WIRE 22 AWG TEFLON STRANDED BLUE |
| 0075 | 207336 | 1 | 8-32 X 3/8 BHMS STAINLESS STEEL |
| 0076 | 207487 | 12 | 6-32 X 1/4 BHMS STAINLESS STEEL |
| 0077 | 207488 | 6 | 6-32 X 3/8 BHMS STAINLESS STEEL |
| 0078 | 207607 | 14 | 10-32 X 3/8 BHMS STAINLESS STEEL |
| 0080 | 207871 | 4 | WASHER FLAT 10 STAINLESS STEEL |
| 0081 | 207932 | 2 | GROMMET RUBBER 3/8 IN. ID X 13/16 IN. |
| 0083 | 208026 | 1 | SPACER 8-32 M-F X 1/4 HEX X 7 |
| 0084 | 208043 | 2 | RESISTOR 4.7K OHM 1/4W 5% RHEM |
| 0085 | 208069 | 1 | RESISTOR 221 OHM 1/4W 1% MF 88 |
| 0086 | 208077 | 1 | RESISTOR 536 OHM 1/4W 1% MF 50 |
| 0087 | 208078 | 2 | RESISTOR 10K OHM 1/4W 1% MF |
| 0088 | 208085 | 1 | RESISTOR 4.99K OHM 1/4W 1% MF |
| 0089 | 208402 | 3 | HOLDER FUSE RHEOMETER & CONSISTOMETER |
| 0091 | 208455 | 3 | TERMINAL RING 6 22-16 AWG RED |
| 0092 | 208478 | 10 | TUBE HEAT SHRINK 1/8 DIA CLR |
| 0094 | 208518 | 3 | WIRE 22 AWG PVC STRANDED ORANGE |
| 0095 | 371966 | 5 | WIRE 22 AWG TEFLON STRANDED YELLOW |
| 0096 | 208520 | 4 | WIRE 22 AWG PVC STRANDED VIOLET |
| 0097 | 208543 | 13 | WIRE 18 AWG TEFLON STRANDED BLACK |
| 0098 | 208523 | 3 | WIRE 18 AWG PVC STRANDED RED |
| 0099 | 208526 | 7 | WIRE 18 AWG PVC STRANDED GREEN |
| 0100 | 208659 | 2 | WASHER INTERNAL TOOTH 6 STAINLESS STEEL |
| 0101 | 209112 | 2 | VALVE SOLENOID ASSEMBLY 3/64 ORIFICE |
| 0102 | 209139 | 1 | SHEET METAL SET FRAME |
| 0103 | 209149 | 1 | RELAY ASSEMBLY |
| 0104 | 209166 | 1 | FITTING TRANSDUCER |
| 0105 | 209167 | 1 | PLUG TRANSDUCER STEM 36371 FIT |

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0106 | 209192 | 1 | PCB ASSEMBLY I/O-WATCHDOG |
| 0107 | 209194 | 1 | CABLE ASSEMBLY 26 CONDUCTOR RI |
| 0108 | 206153 | 1 | PIN SOLENOID VALVES P5019-363 USED ON SOLENOID VALVE 206143 |
| 0109 | 204670 | 1 | POTENTIOMETER |
| 0110 | 102101327 | 11 | NYLON INSUL RIGHT ANGLE FEMALE 0.205/0.187 x 0.020 16-14 AWG |
| 0111 | 102101349 | 19 | NYLON INSUL RIGHT ANGLE FEMALE 0.0250 x 0.032 16-14 AWG |
| 0112 | 101260754 | 4 | SCREW, MACHINE, PAN HEAD, PHILLIPS, 4-40 UNC x 0.50, SS, 18-8 |




| ITEM NO. | PART/DWG. NO. | DESCRIPTION | QTY. |
|---|---|---|---|
| 58 | H7012 | JUMPER BAR – 10 STATION; CUT TO LENGTH REQUIRED | 1-5 |
| 55 | H7013 | JUMPER BAR– 2 STATION | 3 |
| 54 | H7018 | LABEL, TERMINAL STRIP 11–20; CUT TO 11 & 12 | 2 |
| 53 | H7017 | LABEL, TERMINAL BLOCK 1–10 | 2 |
| 52 | H7021 | BLOCK, TERMINAL MOUNTING SECTION | 4 |
| 51 | J6006 | HOSE, TEFLON W/ STAINLESS STEEL BRAID, 1/8 MNPT X 16.5" LONG. | 1 |
| 50 | C6076 | NIPPLE, HEX 1/8 MNPT, STAINLESS STEEL | 2 |
| 49 | | | |
| 48 | 31002 | SCREW, #10–32UNC–2A X 1/2 LG., BHMS, STAINLESS STEEL | 6 |
| 47 | 31030 | NUT, #10–32UNC–2B, STAINLESS STEEL | 6 |
| 46 | 31039 | WASHER, #10 INTERNAL TOOTH LOCK | 6 |
| 45 | 30433 | SCREW, #8–32UNC–2A X 3/8 LG., BHMS, STAINLESS STEEL | 1 |
| 44 | 31991 | SPACER, #8–32UNC–2A X 3/4 LG., #8–32UNC–2B X .44 DEEP | 1 |
| 43 | P0801 | WASHER, 5/16 SPLIT LOCK | 1 |
| 42 | E3094 | RELAY, SOLID STATE | 1 |
| 41 | 30779 | SCREW, #6–32UNC–2A X .250 LONG | 9 |
| 40 | 31004 | SCREW, #10–32UNC–2A X .375 LONG | 18 |
| 39 | A3112 | STANDOFF, 6–32UNC X .375 LONG | 12 |
| 38 | 36430 | BOARD, I/O–WATCHDOG | 1 |
| 37 | E3093 | SUPPLY, POWER | 1 |
| 36 | F8012 | RELAY, 4PDT | 1 |
| 35 | E5010 | CONTROLLER, DC MOTOR | 1 |
| 34 | E3087 | MODULE, INTERFACE, #DGH–1142 | 1 |
| 33 | E3086 | MODULE, INTERFACE, #DGH–3182 | 1 |
| 32 | 31027 | SCREW, #4–40UNC–2A X 3/4" LONG, BHMS, STAINLESS STEEL | 4 |
| 31 | H7020 | BLOCK, TERMINAL STRIP SINGLE | 24 |
| 30 | 36341–03 | PLATE, ELECTRICAL MOUNTING | 1 |
| 29 | 31706 | GROMMET, 3/8 I.D. 7/16 HOLE W 9/64 GROOVE WIDTH | 2 |
| 28 | E3101 | MODULE, INTERFACE # DGH–1312 | 1 |
| 27 | E3085 | MODULE, INTERFACE # DGH–1522 | 1 |
| 26 | E3088 | MODULE, INTERFACE # DGH–1412 | 1 |
| 25 | 30780 | SCREW, #6–32UNC–2A X .375 LONG, BHMS, STAINLESS STEEL | 10 |
| 24 | 36351 | ASSEMBLY, RELAY F/M90 | 1 |
| 23 | F8002 | SOCKET, RELAY RECEPTICAL | 1 |
| 22 | 70004 | FUSE, 2 AMP | 1 |
| 21 | C7007 | FUSE, 6 AMP | 1 |
| 20 | C7002 | FUSE, 4 AMP | 1 |
| 19 | 32972 | HOLDER, FUSE | 3 |
| 18 | C6015 | CONNECTOR, BULKHEAD 1/8 TUBE X 1/8 FNPT | 1 |
| 17 | | | |
| 16 | E7006 | LOCKNUT, #8 | 1 |
| 15 | E3006 | CLAMP, TUBE | 1 |
| 14 | 36310 | VALVE, SOLENOID 3/64 SEAT (SEE NOTES 5 & 6) | 2 |
| 13 | C6062 | CONNECTOR, 1/8 MNPT X 1/8 TUBE | 1 |
| 12 | 31231 | WASHER, 1/4 SPLIT LOCK | 2 |
| 11 | A5017 | SCREW, 1/4–20UNC–2A X 1/2" LONG HHMS, STAINLESS STEEL | 2 |
| 10 | 36371 | FITTING, TRANSDUCER | 1 |
| 9 | C6045 | ELL, FEMALE 1/8 TUBE X 1/4 FNPT | 1 |
| 8 | 36334–02 | SPOOL, COOLING COIL | 2 |
| 7 | C6041 | TEE, MALE BRANCH 1/8 TUBE X 1/8 MNPT | 6 |
| 6 | C6038 | ELBOW, MALE 1/8 TUBE X 1/8 MNPT | 7 |
| 5 | P5020 | VALVE, CHECK | 1 |
| 4 | C5005 | FILTER | 1 |
| 3 | P1005 | TRANSDUCER, PRESSURE | 1 |
| 2 | P1004 | TRANSDUCER, PRESSURE | 1 |
| 1 | P5018 | VALVE, SOLENOID (SEE NOTES 5 & 6) | 7 |

**Figure 9-7 Frame Assembly**

**Table 9-5 Channel Assembly, Model 90, P/N 209153, Revision C**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 204028 | 1 | CONNECTOR 1/8 MNPT X 1/8 F TUBE |
| 0002 | 205129 | 1 | LIMIT SWITCH SPDT 15A PLUNGER |
| 0003 | 203461 | 4 | 6-32 X 1 LG RHMS STAINLESS STEEL |
| 0004 | 209138 | 1 | SHEET METAL SET CHANNEL |
| 0005 | 207605 | 3 | 10-32 X 1/2 BHMS STAINLESS STEEL |
| 0006 | 207635 | 3 | WASHER INTERNAL TOOTH 10 STAINLESS STEEL |
| 0007 | 207633 | 4 | NUT 10-32 HEX REGULAR STAINLESS STEEL |
| 0009 | 209164 | 1 | MANIFOLD SILENCER |
| 0010 | 207816 | 4 | TUBING TYGON 1/2 X 3/4 X 0.125W |
| 0012 | 207871 | 1 | WASHER FLAT 10 STAINLESS STEEL |
| 0013 | 209161 | 1 | PIVOT TILT ACTUATOR |
| 0014 | 203462 | 1 | NUT 5/16-18 UNC-2B-STAINLESS STEEL |
| 0015 | 206202 | 1 | WASHER LOCK SPLIT 5/16 IN. |
| 0016 | 207835 | 1 | 10-32 X 2 BHMS STAINLESS STEEL |
| 0018 | 205127 | 1 | SWITCH LIMIT |
| 0019 | 207566 | 3 | PIN ROLL 1/16 X 5/16 STAINLESS STEEL |
| 0020 | 208454 | 2 | TERMINAL FORK 6 22-16 AWG |
| 0021 | 204315 | 4 | RING LUG 4 STUD 16-22 AWG.18 |
| 0022 | 208659 | 4 | WASHER INTERNAL TOOTH 6 STAINLESS STEEL |
| 0024 | 100021528 | 1 | MUFFLER, 1/8 NPT, SINTERED |

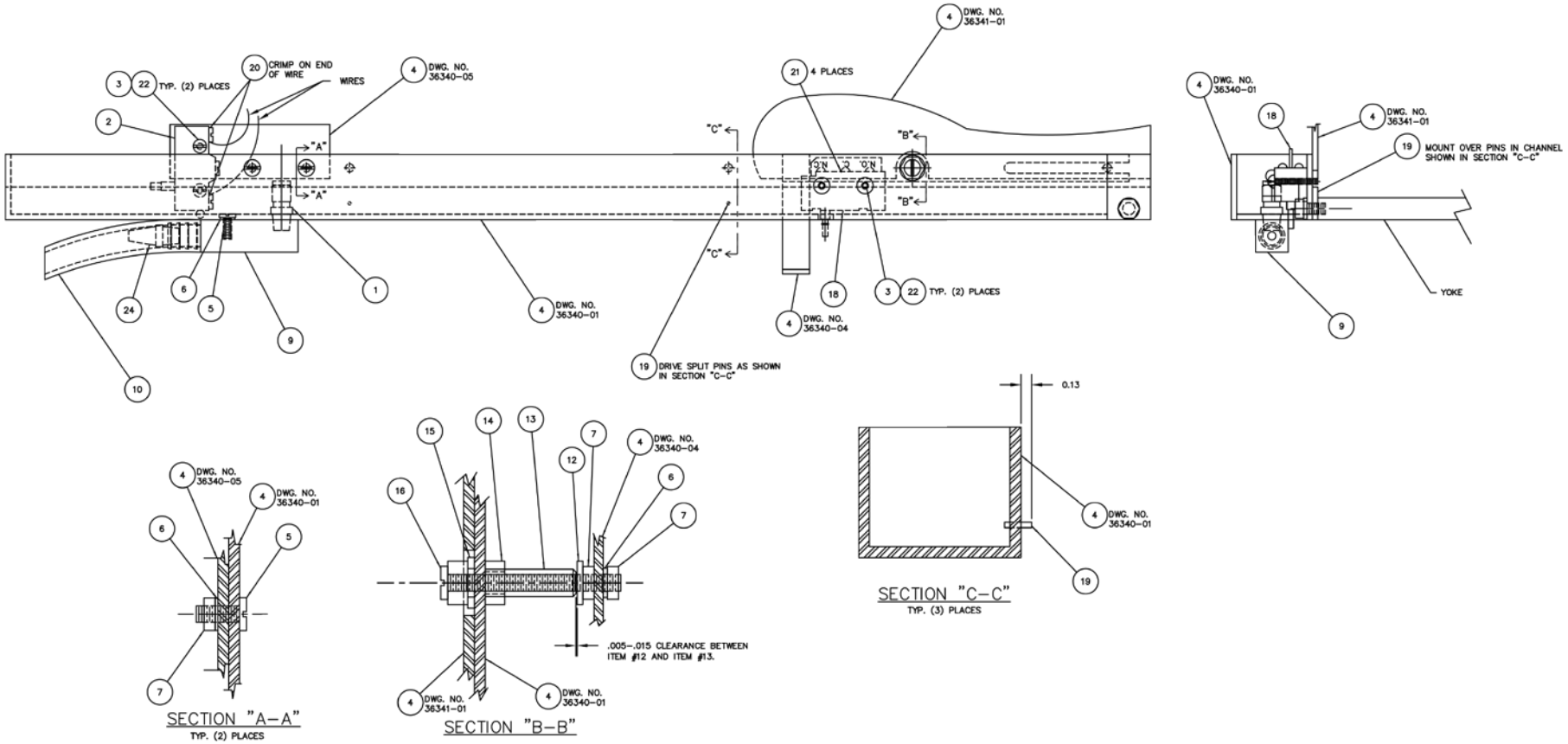



**Figure 9-8 Channel Assembly, Rev C**

**Table 9-6 Heater Door & Fixed Assembly, Model 90, P/N 209154, Revision D**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 207487 | 9 | 6-32 X 1/4 BHMS STAINLESS STEEL |
| 0002 | 207759 | 3 | 8-32 X 1/4 BHMS STAINLESS STEEL |
| 0003 | 207855 | 4 | 10-32 X 7/8 SHCS BOPL |
| 0004 | 209130 | 1 | MACHINE SET INSULATION |
| 0005 | 209131 | 1 | HEATER HOUSING SHEET METAL SET |
| 0006 | 209150 | 1 | MACHINE PARTS SET HEATER |
| 0007 | 209182 | 2 | SHUTTER AIR OUTLET |
| 0008 | 203400 | 12 | 6-32 X 1-1/4 RHMS STAINLESS STEEL |
| 0009 | 203450 | 4 | 6-32 X 1-1/4 FHMS STAINLESS STEEL |
| 0010 | 203461 | 4 | 6-32 X 1 LG RHMS STAINLESS STEEL |
| 0011 | 204292 | 6 | SLEEVING SIZE 3/8 CLASS R GR C |
| 0012 | 204331 | 4 | BUTT SPLICE 16-14 AWG INSULATED |
| 0013 | 204351 | 1 | BLOWER 54 CFM 115V 50/60 HZ, MAX INLET TEMP 104°F |
| 0014 | 205066 | 1 | GASKET SILICONE RUBBER 1/4 IN. THICK |
| 0015 | 205067 | 4 | SILICONE SPONGE RUBBER 1/4 IN. THICK X 1 IN. WIDE X 3 FT. LONG |
| 0016 | 205074 | 10 | SPRING EXTENSION 9/16 OD X 20 |
| 0017 | 205179 | 1 | THERMOCOUPLE TYPE J 1/8 X 6 3 |
| 0018 | 205323 | 1 | ADHESIVE SILICONE HIGH-TEMP, RED |
| 0019 | 205391 | 4 | HEATER ROD MODEL 90 & MULTI-RETORT |
| 0020 | 205713 | 2 | CONNECTOR ANGLE EP&LUB TESTER |
| 0021 | 208530 | 6 | WIRE 16 AWG TEFLON STRANDED BLACK |
| 0022 | 208531 | 6 | WIRE 16 AWG TEFLON STRANDED WHITE |
| 0030 | 204298 | 2 | TERMINAL MALE .25X.032 14-16 AWG |
| 0040 | 204299 | 2 | TERMINAL FEMALE Q.C 0.25X 0.032 1 |

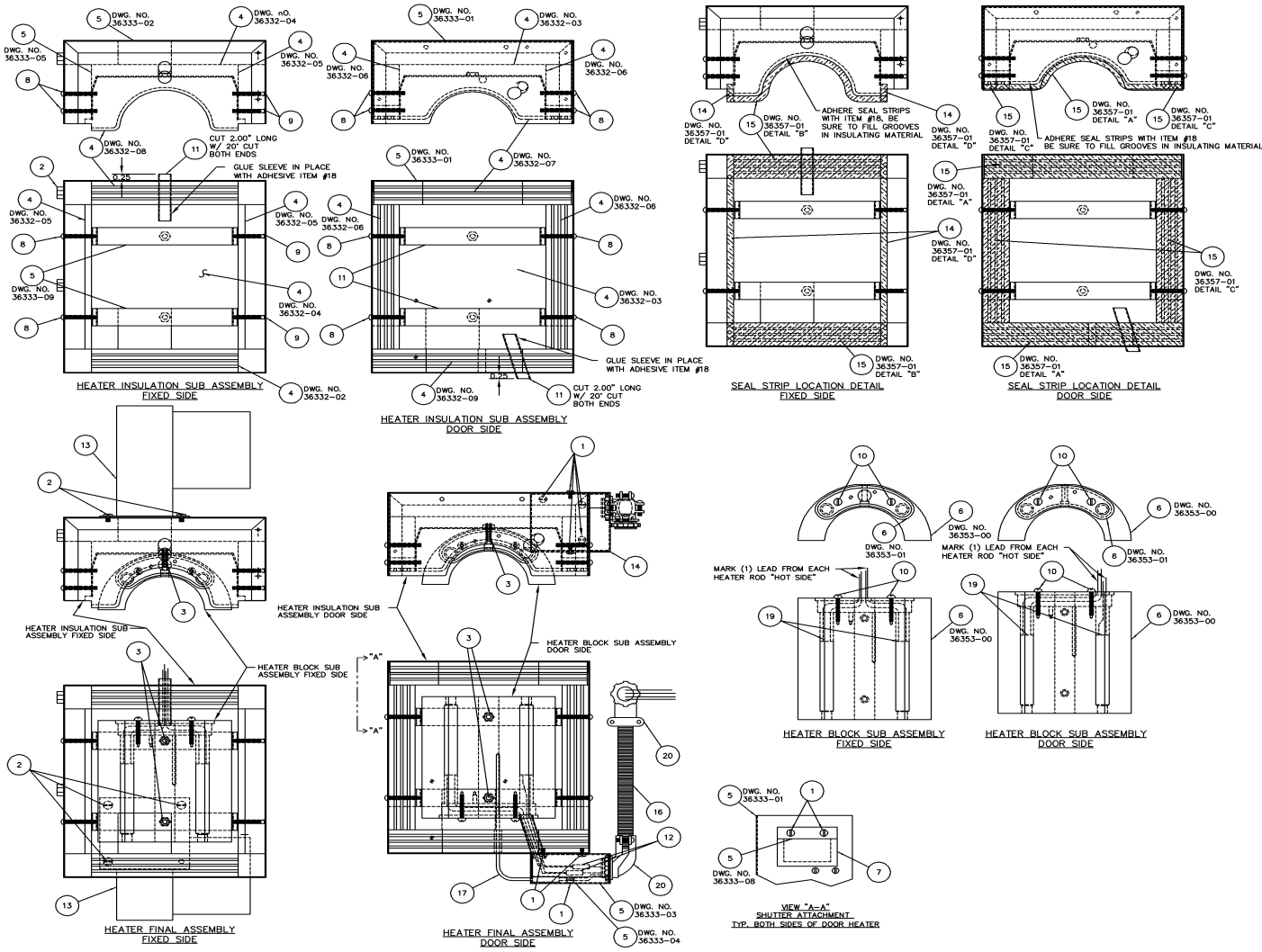



**Figure 9-9 Heater Door & Fixed Assembly, Rev B**

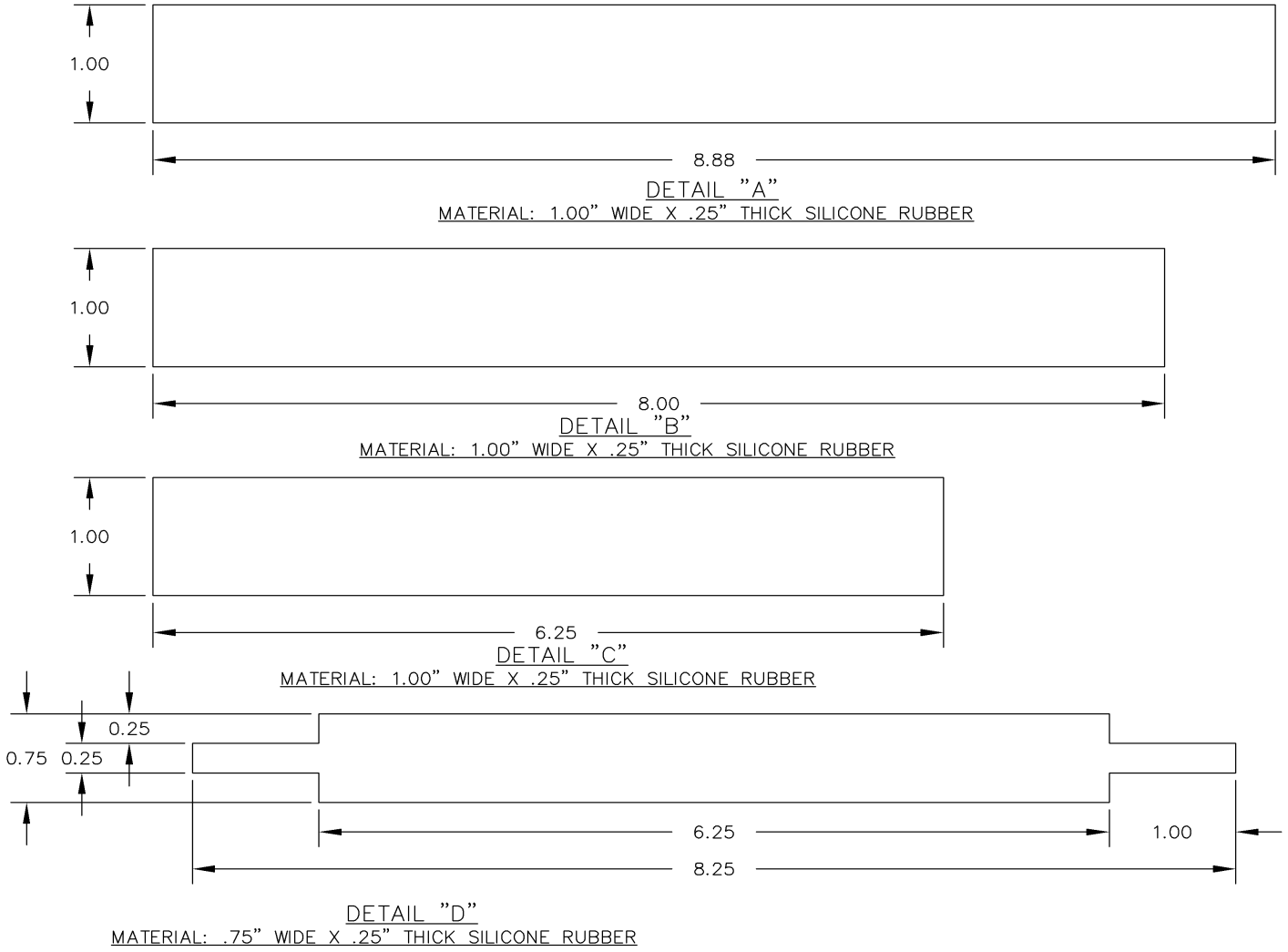



**Figure 9-10 Seal Strips for Heater**

**Table 9-7 Motor Assembly, Model 90 DFS, P/N 209155, Revision C**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203373 | 2 | 1/4-20 X 5/8 HHCS STAINLESS STEEL |
| 0002 | 203375 | 2 | 6-32 X 3/8 RHMS STAINLESS STEEL |
| 0003 | 203438 | 2 | 1/4-20 X 1 HHCS STAINLESS STEEL |
| 0004 | 203441 | 1 | 10-32 X 3/16 SHSS STAINLESS STEEL |
| 0005 | 204331 | 2 | BUTT SPLICE 16-14 AWG INSULATED |
| 0006 | 204363 | 1 | REDUCER-THREADED ½ FNPT X 3/4 |
| 0007 | 204639 | 1 | PIN ROLL 3/32 X 11/16 STAINLESS STEEL |
| 0008 | 205074 | 10 | SPRING EXTENSION 9/16 OD X 20 |
| 0009 | 205713 | 2 | CONNECTOR ANGLE EP&LUB TESTER |
| 0010 | 371965 | 36 | WIRE 16AWG TEFLON STRANDED RED TYPE E EXTRUDED |
| 0011 | 208530 | 3 | WIRE 16 AWG TEFLON STRANDED BLACK |
| 0012 | 207607 | 7 | 10-32 X 3/8 BHMS STAINLESS STEEL |
| 0013 | 207621 | 2 | 1/4-20 X 3/8 HSSS STAINLESS STEEL |
| 0014 | 207633 | 2 | NUT 10-32 HEX REGULAR STAINLESS STEEL |
| 0015 | 207635 | 7 | WASHER INTERNAL TOOTH 10 STAINLESS STEEL |
| 0016 | 207753 | 2 | WASHER SPLIT 1/4 STAINLESS STEEL |
| 0017 | 207764 | 1 | 10-32 X 3/8 HSSS BOPL HEX SOCKET SET SCREW CUP POINT |
| 0018 | 207819 | 2 | WASHER SPLIT 6 STAINLESS STEEL |
| 0019 | 207871 | 1 | WASHER FLAT 10 STAINLESS STEEL |
| 0020 | 209133 | 1 | MACHINE SET MOUNT MOTOR |
| 0021 | 209134 | 1 | MOUNT MOTOR SHEET METAL SET |
| 0022 | 209186 | 1 | MOTOR 1/4 HP |
| 0023 | 209501 | 4 | SCREW CAP LOCKING 5/16-18 X 1/2 |

**Table 9-8 Cover Assembly, Model 90, P/N 209156, Revision A**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203391 | 4 | 4-40 X 1/2 RHMS STAINLESS STEEL |
| 0002 | 203433 | 4 | 6-32 X 1/4 LONG SHCS STAINLESS STEEL |
| 0003 | 203448 | 4 | SPACER 4-40 X 1/4 HEX X 7/16 A |
| 0004 | 203750 | 2 | CONNECTOR CABLE ASSEMBLY 6 CON |
| 0005 | 204285 | 1 | TIE WRAP 6 IN. LONG WITH 8 MTG |
| 0006 | 204294 | 6 | TIE WRAP 1/16 IN. TO 2 IN. DIAMETER |
| 0007 | 205126 | 2 | KEYPAD 2 X 4 MATRIX MEMBRANE |
| 0008 | 205180 | 1 | THERMOSTAT 115 $^{o}$F SURFACE |
| 0009 | 205296 | 2 | TIE WRAP ADHESIVE PAD |
| 0010 | 207487 | 3 | 6-32 X 1/4 BHMS STAINLESS STEEL |
| 0011 | 207664 | 4 | 4-40 X 1/4 BHMS STAINLESS STEEL |
| 0012 | 207856 | 19 | EDGING TRIM PLASTIC PANEL 0.040 |
| 0013 | 208658 | 4 | WASHER FLAT 6 STAINLESS CC-BLUE |
| 0014 | 209141 | 1 | SHEET METAL SET COVER |
| 0015 | 209144 | 1 | OVERLAY KEYBOARD |
| 0016 | 209179 | 1 | PLATE LCD DISPLAY MOUNT |
| 0017 | 209180 | 1 | LCD DISPLAY ASSEMBLY |
| 0018 | 209181 | 1 | CABLE HARNESS 34 IN. LONG w/2 (2X17) |

**Table 9-9 Door Assembly, Model 90, P/N 209157, Revision C**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203395 | 7 | 6-32 X 1/4 FHMS |
| 0002 | 205320 | 1 | LATCH FLUSH-LIFT AND TURN |
| 0003 | 207158 | 1 | PIN ROLL 1/16 X 3/8 STAINLESS STEEL |
| 0004 | 207487 | 4 | 6-32 X 1/4 BHMS STAINLESS STEEL |
| 0005 | 207607 | 4 | 10-32 X 3/8 BHMS STAINLESS STEEL |
| 0006 | 207763 | 4 | WASHER FLAT 1/4 STAINLESS STEEL |
| 0007 | 207842 | 5 | 6-32 X 1/4 THMS STAINLESS STEEL |
| 0008 | 101629481 | 1 | SCREW, SHCS, M 8 x 1.25, 20 MM LONG 316 STAINLESS |
| 0009 | 209142 | 1 | DOOR SHEET METAL PARTS |
| 0010 | 101420574 | 1 | OVERLAY, BOTTOM FRONT |
| 0011 | 209162 | 1 | EXTENSION DOOR LATCH |
| 0012 | 209178 | 1 | INLET AIR DOOR |

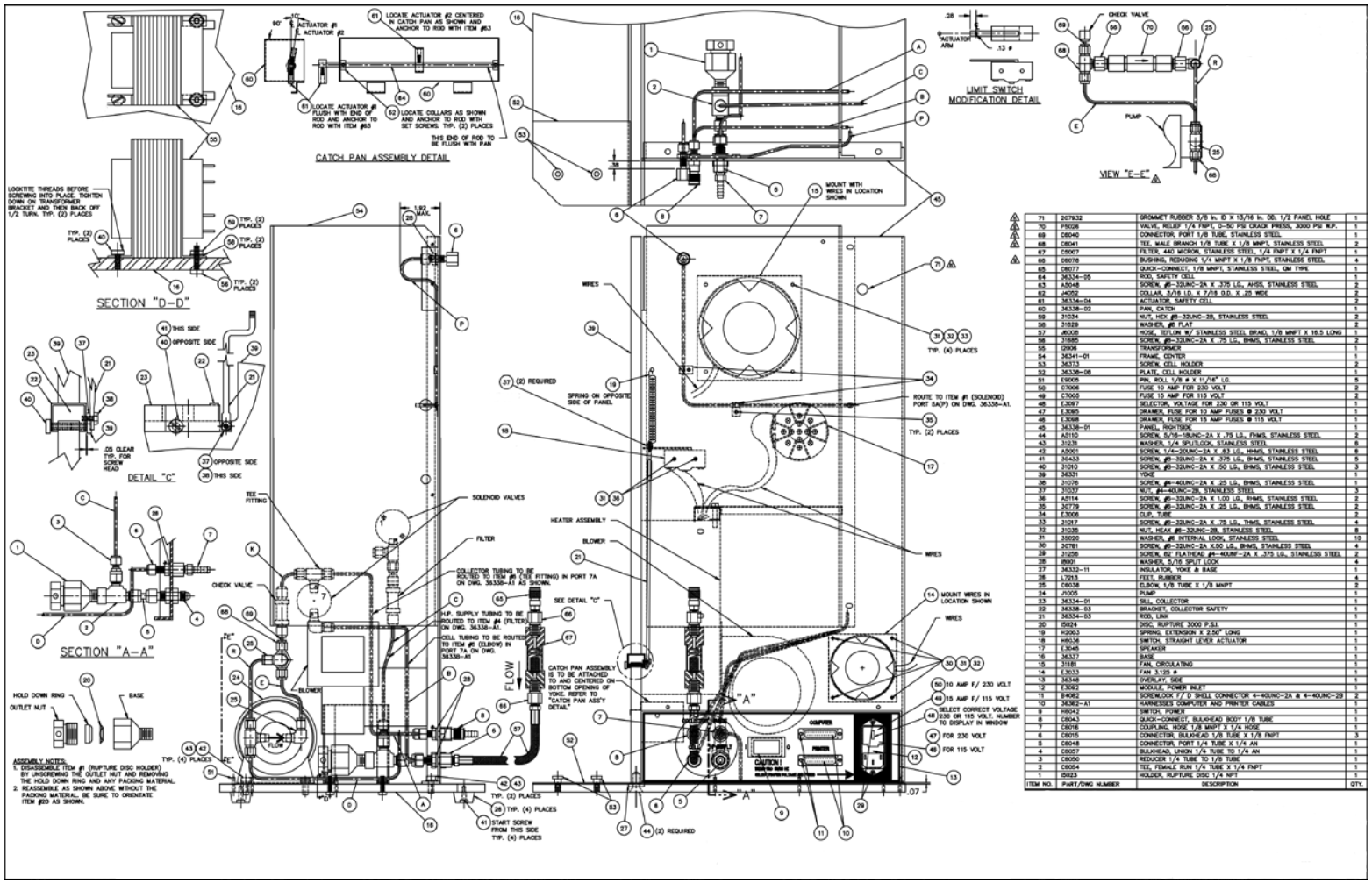
**Table 9-10 Computer Assembly, Model 90, P/N 209158, Revision A**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203664 | 1 | MOTHERBOARD-MINI W/6 IN. CARD C |
| 0002 | 203665 | 1 | SERIAL CARD DUAL BCC18U-1 DUAL RS-232/485 SERIAL PORT BOARD FOR USE WITH BCC52C COMPUTER |
| 0003 | 203667 | 1 | COMPUTER/CONTROLLER EXPANDED |
| 0004 | 203723 | 2 | TERMINAL FEMALE CRIMP 14-20 AWG |
| 0005 | 203724 | 2 | TERMINAL MALE CRIMP 14-20 AWG |
| 0006 | 203764 | 1 | PLUG 2 CIRCUIT POLARIZED |
| 0007 | 203765 | 1 | RECEPTACLE 2 CIRCUIT POLARIZED |
| 0008 | 204362 | 1 | RAM SMART WATCH 64/256K |
| 0009 | 205472 | 1 | RAM-STATIC CMOS 32X8 70-100NS |
| 0010 | 205473 | 2 | TRANSCEIVER LTC485CN8 |
| 0011 | 207607 | 4 | 10-32 X 3/8 BHMS STAINLESS STEEL |
| 0012 | 207871 | 4 | WASHER FLAT 10 STAINLESS STEEL |
| 0013 | 209127 | 1 | CIRCUIT BOARD ASSEMBLY (I/O) |
| 0014 | 209177 | 1 | PCB ASSEMBLY LCD |
| 0015 | 209280 | 1 | ROMS 1 & 2 PROGRAMMED MODEL 90, VERSION 3 |

**Table 9-11 Base & Right Side Panel Assembly, Model 90, P/N 209159, Revision I**

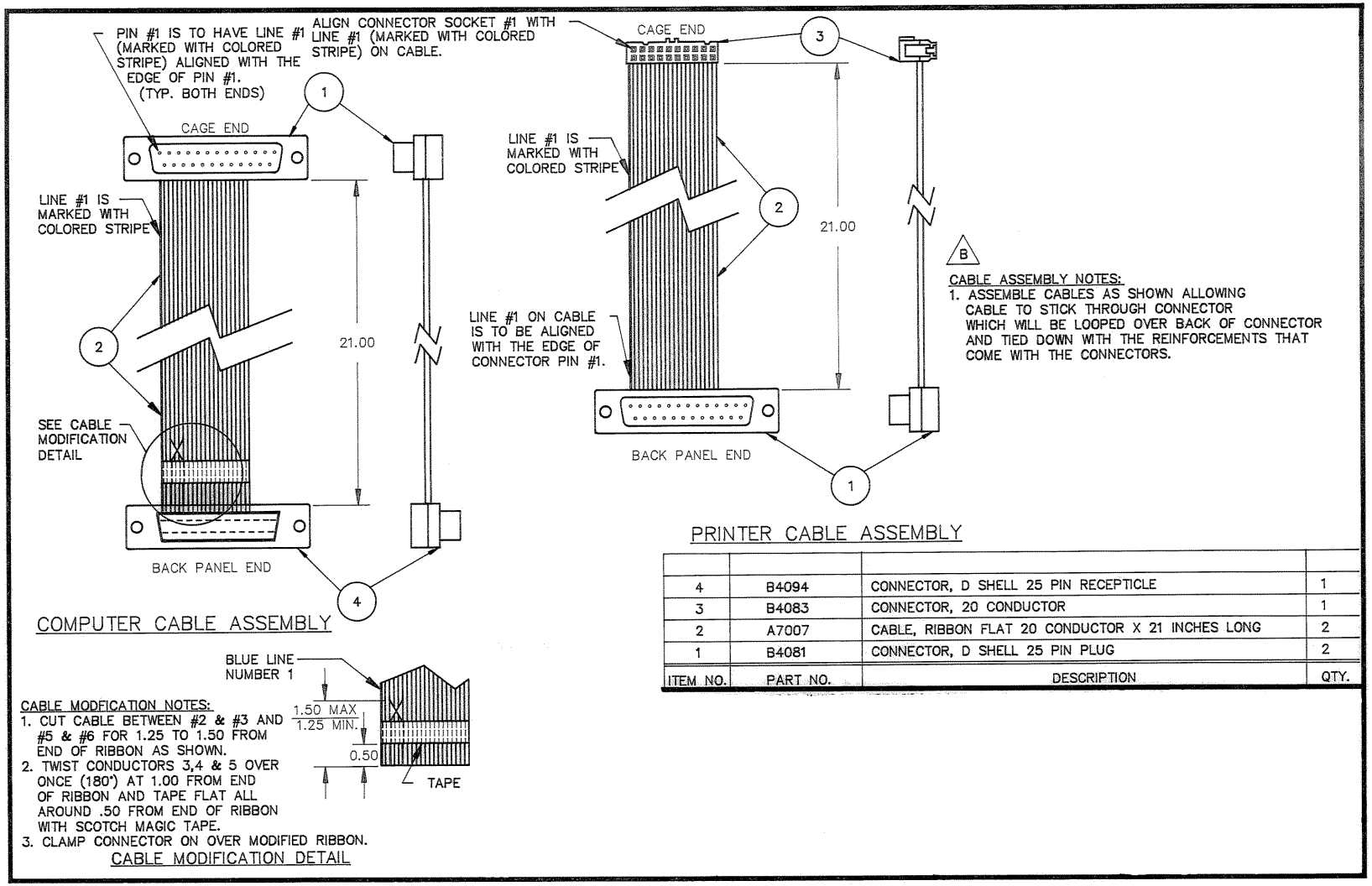
| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0701 | 208659 | 10 | WASHER INTERNAL TOOTH 6 STAINLESS STEEL |
| 0710 | 203373 | 6 | 1/4-20 X 5/8 HHCS STAINLESS STEEL |
| 0720 | 203413 | 2 | 6-32 X 3/8 AHSS STAINLESS STEEL |
| 0730 | 203458 | 2 | 5/16-18 X 3/4 LG SOCKET FLAT |
| 0740 | 203461 | 2 | 6-32 X 1 LG RHMS STAINLESS STEEL |
| 0750 | 203516 | 42 | CABLE FLAT (RIBBON) 20 COND. 28GA 100 FT ROLL STD |
| 0760 | 203758 | 2 | CONNECTOR D SHELL 25 COND PLUG |
| 0770 | 203759 | 4 | SCREWLOCK D SHELL CONN 4-40 SC |
| 0780 | 203760 | 1 | CONNECTR 2 X 10, 0.1 IN. FEMALE-RIBBON |
| 0790 | 203767 | 1 | CONNECTOR D SHELL 25 COND R |
| 0800 | 203958 | 1 | FILTER 440 MICRON INLINE f/MOD 90 3K PSI |
| 0810 | 203988 | 3 | CONNECTOR BULKHEAD 1/8TUBE X 1/8FNPT |
| 0820 | 203989 | 1 | COUPLING HOSE 1/8MNPT X 1/4 HO |
| 0830 | 101443952 | 2 | ELBOW 1/8 TUBE X 1/8 MNPT SS-2 |
| 0840 | 204011 | 1 | CONNECTOR PORT 1/8 TUBE |
| 0850 | 204012 | 2 | TEE MALE BRANCH 1/8 T & 1/8 MP |
| 0860 | 204014 | 1 | QUICK CONNECT BULKHEAD BODY TY |
| 0870 | 204017 | 1 | CONNECTOR PORT 1/4 TUBE |
| 0880 | 204019 | 1 | REDUCER 1/4 TO 1/8 TUBE |
| 0890 | 204023 | 1 | TEE FEMALE RUN 1/4 T & 1/4 FNP |
| 0900 | 204025 | 1 | UNION BULKHEAD 1/4 T TO 1/4 AN |
| 0910 | 204026 | 13 | TUBING 316 SS 0.125 IN. OD IN X .055 IN. ID 15 KSI |
| 0920 | 204041 | 1 | QUICK CONNECT 1/8 MNPT STAINLESS QM |
| 0930 | 204042 | 4 | BUSHING REDUCING 1/4 MNPT X 1/8 FNPT |
| 0940 | 204270 | 8 | DISCONNECT FEMALE 90DEG FLAG 1 |
| 0950 | 204275 | 2 | CLAMP CABLE METAL 1/8 ARC |
| 0960 | 204296 | 1 | FAN 3.125in. SQ X 1.5in. THK 115V 43CFM |
| 0970 | 204298 | 2 | TERMINAL MALE .25X.032 14-16 AWG |
| 0980 | 204299 | 2 | TERMINAL FEMALE Q.C .25X.032 1 |
| 0990 | 204304 | 4 | TERMINAL FORK 6 16-14AWG BLUE |
| 1000 | 204307 | 1 | SPEAKER 45 OHM 2.75 DIAMETER |
| 1010 | 204331 | 1 | BUTT SPLICE 16-14 AWG INSULATED |
| 1020 | 204338 | 10 | TUBE HEAT SHRINK 3/8 DIA BLK |
| 1030 | 204350 | 6 | TUBE HEAT SHRINK 1/8 DIA BLK |
| 1040 | 204352 | 1 | MODULE POWER INLET RECEPT-VOLTSEL-F |
| 1050 | 204356 | 1 | INSERT VOLTAGE SELECTOR E3092 |
| 1060 | 204357 | 1 | FUSE DRAWER E3092 |
| 1070 | 204358 | 11 | DISCONNECT FEMALE 90 DEG.187 1 |
| 1080 | 204641 | 5 | PIN ROLL 1/8 X 11/16 |
| 1090 | 205076 | 1 | SPRING TENSION 3/8 OD X 2-1 |
| 1100 | 205123 | 1 | SWITCH STRAIGHT LEVER ACTUATOR |
| 1110 | 205128 | 1 | SWITCH POWER 15 AMP LIGHTED |
| 1120 | 205205 | 1 | PUMP GEAR MAGNETICALLY DRIVEN |
| 1130 | 205296 | 16 | TIE WRAP ADHESIVE PAD |
| 1140 | 205321 | 2 | COLLAR SHAFT 3/16 IN. |
| 1150 | 205402 | 1 | HOSE 3000PSI 1/8 NPT X 16.5 TFE w/SS BRD |
| 1160 | 205779 | 4 | RUBBER FEET 3/4 IN. |
| 1170 | 206081 | 1 | TRANSFORMER CONTROL DUAL PRIMARY 115/230V |

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 1180 | 206147 | 1 | HOLDER RUPTURE DISC |
| 1190 | 206148 | 1 | DISC RUPTURE 3,000 PSI |
| 1200 | 206149 | 1 | VALVE RELIEF 1/4 FNPT 3000 PSI |
| 1210 | 206202 | 4 | WASHER LOCK SPLIT 5/16 IN. |
| 1220 | 206203 | 4 | WASHER FLAT 4 STAINLESS STEEL |
| 1230 | 207336 | 5 | 8-32 X 3/8 BHMS STAINLESS STEEL |
| 1240 | 207487 | 4 | 6-32 X 1/4 BHMS STAINLESS STEEL |
| 1250 | 207489 | 4 | 6-32 X 1/2 BHMS STAINLESS STEEL |
| 1260 | 207609 | 2 | 6-32 X 1/8 HSSS STAINLESS STEEL |
| 1270 | 207610 | 3 | 8-32 X 1/2 BHMS STAINLESS STEEL |
| 1280 | 207617 | 4 | 6-32 X 3/4 THMS STAINLESS STEEL |
| 1290 | 207631 | 2 | NUT 8-32 HEX REGULAR STAINLESS STEEL |
| 1300 | 207632 | 8 | NUT 6-32 HEX REGULAR STAINLESS STEEL |
| 1310 | 207634 | 3 | NUT 4-40 HEX REGULAR STAINLESS STEEL |
| 1320 | 207664 | 1 | 4-40 X 1/4 BHMS STAINLESS STEEL |
| 1330 | 207728 | 1 | FAN 4.687 IN. SQ X 1.5 IN. THK 115V 120 CFM |
| 1340 | 207753 | 6 | WASHER SPLIT 1/4 STAINLESS STEEL |
| 1350 | 207768 | 2 | 4-40 X 3/8 FHMS STAINLESS STEEL |
| 1360 | 207895 | 2 | WASHER FLAT 8 |
| 1370 | 207921 | 1 | 8-32 X 3/4 BHMS STAINLESS STEEL |
| 1380 | 208454 | 2 | TERMINAL FORK 6 22-16 AWG |
| 1390 | 209129 | 1 | YOKE |
| 1400 | 209132 | 1 | MACHINE SET BASE |
| 1410 | 209135 | 1 | BASE |
| 1420 | 209136 | 1 | BASE INTERNAL SHEET METAL |
| 1430 | 209146 | 1 | OVERLAY SIDE |
| 1440 | 209168 | 2 | SCREW CELL HOLDER |
| 1450 | 207932 | 1 | GROMMET RUBBER, 3/8 IN. ID X 13/16 IN. OD, 1/2 PANEL HOLE, 3/32 PANEL THICKNESS, 55 DURO |




| ITEM NO. | PART/DWG NUMBER | DESCRIPTION | QTY. |
|---|---|---|---|
| 71 | 207932 | GROMMET RUBBER 3/8 in. ID X 13/16 in. OD, 1/2 PANEL HOLE | 1 |
| 70 | P5026 | VALVE, RELIEF 1/4 FNPT, 0-50 PSI CRACK PRESS, 3000 PSI W.P. | 1 |
| 69 | C6040 | CONNECTOR, PORT 1/8 TUBE, STAINLESS STEEL | 1 |
| 68 | C6041 | TEE, MALE BRANCH 1/8 TUBE X 1/8 MNPT, STAINLESS STEEL | 2 |
| 67 | C5007 | FILTER, 440 MICRON, STAINLESS STEEL, 1/4 FNPT X 1/4 FNPT | 1 |
| 66 | C6078 | BUSHING, REDUCING 1/4 MNPT X 1/8 FNPT, STAINLESS STEEL | 4 |
| 65 | C6077 | QUICK-CONNECT, 1/8 MNPT, STAINLESS STEEL, OM TYPE | 1 |
| 64 | 36334-05 | ROD, SAFETY CELL | 1 |
| 63 | A5048 | SCREW, #8-32UNC-2A X .375 LG, AHSS, STAINLESS STEEL | 2 |
| 62 | J4052 | COLLAR, 5/16 I.D. X 7/16 O.D. X .25 WIDE | 2 |
| 61 | 36334-04 | ACTUATOR, SAFETY CELL | 2 |
| 60 | 36338-02 | PAN, CATCH | 1 |
| 59 | 31034 | NUT, HEX #8-32UNC-2B, STAINLESS STEEL | 2 |
| 58 | 31629 | WASHER, #8 FLAT | 2 |
| 57 | J6008 | HOSE, TEFLON W/ STAINLESS STEEL BRAID, 1/8 MNPT X 16.5 LONG | 1 |
| 56 | 31685 | SCREW, #8-32UNC-2A X .75 LG, BHMS, STAINLESS STEEL | 2 |
| 55 | 12006 | TRANSFORMER | 1 |
| 54 | 36341-01 | FRAME, CENTER | 1 |
| 53 | 36373 | SCREW, CELL HOLDER | 2 |
| 52 | 36336-08 | PLATE, CELL HOLDER | 1 |
| 51 | E9005 | PIN, ROLL 1/8 # X 11/16" LG. | 5 |
| 50 | C7006 | FUSE 10 AMP FOR 230 VOLT | 2 |
| 49 | C7005 | FUSE 15 AMP FOR 115 VOLT | 2 |
| 48 | E3097 | SELECTOR, VOLTAGE FOR 230 OR 115 VOLT | 1 |
| 47 | E3095 | DRAWER, FUSE FOR 10 AMP FUSES @ 230 VOLT | 1 |
| 46 | E3096 | DRAWER, FUSE FOR 15 AMP FUSES @ 115 VOLT | 1 |
| 45 | 36336-01 | PANEL, RIGHTSIDE | 1 |
| 44 | A5110 | SCREW, 5/16-18UNC-2A X .75 LG, FHMS, STAINLESS STEEL | 2 |
| 43 | J7139 | WASHER, 1/4 SPLITLOCK, STAINLESS STEEL | 6 |
| 42 | A5001 | SCREW, 1/4-20UNC-2A X .63 LG, RHMS, STAINLESS STEEL | 6 |
| 41 | 30433 | SCREW, #8-32UNC-2A X .375 LG, BHMS, STAINLESS STEEL | 5 |
| 40 | 31010 | SCREW, #8-32UNC-2A X .50 LG, BHMS, STAINLESS STEEL | 1 |
| 39 | 36331 | YOKE | 1 |
| 38 | 31076 | SCREW, #4-40UNC-2A X .25 LG, BHMS, STAINLESS STEEL | 1 |
| 37 | 31037 | NUT, #4-40UNC-2B, STAINLESS STEEL | 3 |
| 36 | A5114 | SCREW, #8-32UNC-2A X 1.00 LG, RHMS, STAINLESS STEEL | 2 |
| 35 | 30779 | SCREW, #8-32UNC-2A X .25 LG, BHMS, STAINLESS STEEL | 2 |
| 34 | E3006 | CLIP, TUBE | 2 |
| 33 | 31017 | SCREW, #8-32UNC-2A X .75 LG, THMS, STAINLESS STEEL | 4 |
| 32 | 31035 | NUT, HEAX #8-32UNC-2B, STAINLESS STEEL | 8 |
| 31 | 35020 | WASHER, #8 INTERNAL LOCK, STAINLESS STEEL | 10 |
| 30 | 30781 | SCREW, #8-32UNC-2A X.50 LG, BHMS, STAINLESS STEEL | 4 |
| 29 | 31256 | SCREW, 82° FLATHEAD #4-40UNF-2A X .375 LG, STAINLESS STEEL | 2 |
| 28 | 18001 | WASHER, 5/16 SPLIT LOCK | 4 |
| 27 | 36332-11 | INSULATOR, YOKE @ BASE | 1 |
| 26 | L7213 | FEET, RUBBER | 4 |
| 25 | C6038 | ELBOW, 1/8 TUBE X 1/8 MNPT | 2 |
| 24 | J1005 | PUMP | 1 |
| 23 | 36334-01 | SILL, COLLECTOR | 1 |
| 22 | 36338-03 | BRACKET, COLLECTOR SAFETY | 1 |
| 21 | 36334-03 | ROD, LINK | 1 |
| 20 | 15023 | DISC, RUPTURE 3000 P.SI. | 1 |
| 19 | H2003 | SPRING, EXTENSION X 2.50" LONG | 1 |
| 18 | H6036 | SWITCH, STRAIGHT LEVER ACTUATOR | 1 |
| 17 | E3048 | SPLASH | 1 |
| 16 | 36327 | BASE | 1 |
| 15 | 31181 | FAN, CIRCULATING | 1 |
| 14 | E3033 | FAN 3125 # | 1 |
| 13 | 36348 | OVERLAY, SIDE | 1 |
| 12 | E3092 | MODULE, POWER INLET | 1 |
| 11 | E4082 | SCREWLOCK F/ D SHELL CONNECTOR 4-40UNC-2A & 4-40UNC-2B | 2 |
| 10 | 36362-A1 | HARNESSES COMPUTER AND PRINTER CABLES | 1 |
| 9 | H9042 | SWITCH, POWER | 1 |
| 8 | C6043 | QUICK-CONNECT, BULKHEAD BODY 1/8 TUBE | 1 |
| 7 | C6016 | COUPLING, HOSE 1/8 MNPT X 1/4 HOSE | 1 |
| 6 | C6015 | CONNECTOR, BULKHEAD 1/8 TUBE X 1/8 FNPT | 3 |
| 5 | C6048 | CONNECTOR, PORT 1/4 TUBE X 1/4 AN | 1 |
| 4 | C6057 | BULKHEAD, UNION 1/4 TUBE TO 1/4 AN | 1 |
| 3 | C6050 | REDUCER 1/4 TUBE TO 1/8 TUBE | 1 |
| 2 | C6054 | TEE, FEMALE RUN 1/4 TUBE X 1/4 FNPT | 1 |
| 1 | 15023 | HOLDER, RUPTURE DISC 1/4 NPT | 1 |

**Figure 9-11 Base & Right Side Panel Assembly, Rev H**

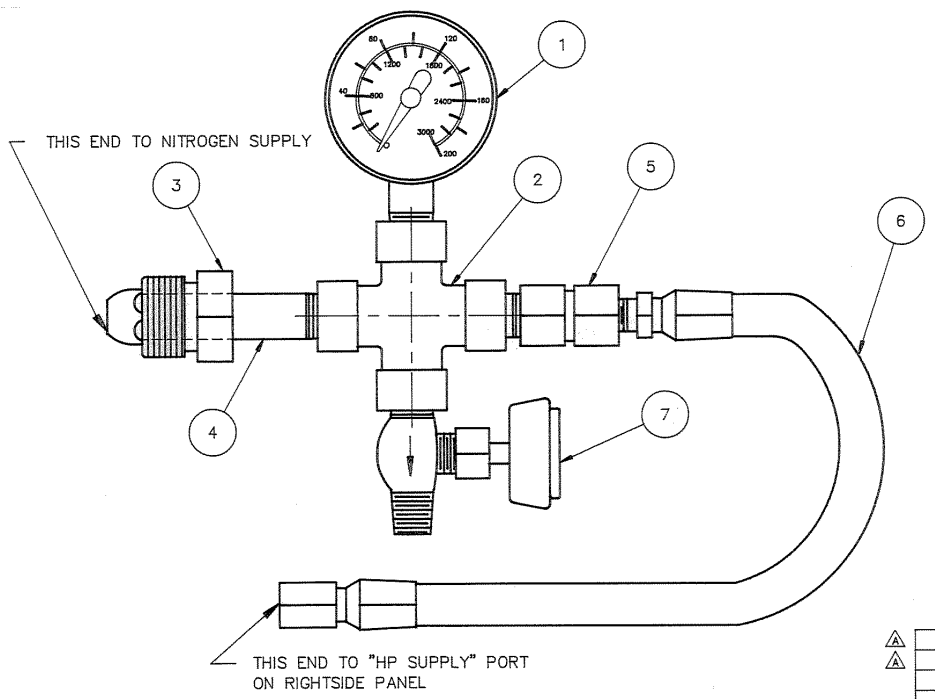



| ITEM NO. | PART NO. | DESCRIPTION | QTY. |
|---|---|---|---|
| 4 | B4094 | CONNECTOR, D SHELL 25 PIN RECEPTICLE | 1 |
| 3 | B4083 | CONNECTOR, 20 CONDUCTOR | 1 |
| 2 | A7007 | CABLE, RIBBON FLAT 20 CONDUCTOR X 21 INCHES LONG | 2 |
| 1 | B4081 | CONNECTOR, D SHELL 25 PIN PLUG | 2 |

**Figure 9-12 Printer & Computer Cable Harness, Rev B**

**Table 9-12 Nitrogen Supply Assembly, Model 90, P/N 209160, Revision A**

| Item No. | Part No. | Quantity | Description |
|---|---|---|---|
| 0001 | 203950 | 1 | NUT GLAND RIGHT HAND WATER PUMPED NITROGEN |
| 0002 | 203951 | 1 | GLAND WATER PUMPED NITROGEN CYLINDER |
| 0003 | 204042 | 1 | BUSHING REDUCING 1/4 MNPT X 1/8 FNPT |
| 0004 | 204043 | 1 | CROSS 1/4 FNPT 316 STAINLESS STEEL |
| 0005 | 204554 | 1 | TAG NITROGEN SUPPLY LINE |
| 0006 | 205403 | 1 | HOSE 3000 PSI 6 FT X 3/16 IN. |
| 0007 | 208655 | 1 | VALVE NEEDLE 1/4 X 1/4 CHROME |
| 0008 | 209467 | 1 | GAUGE 3000 PSI 2 IN. DIAL 1/4 BOTTOM CONN |




| | ITEM NO. | PART/DWG. NO. | DESCRIPTION | QTY |
|---|---|---|---|---|
| | 8 | E6087 | LABEL, WARNING NITROGEN SUPPLY (SEE NOTE #2) | 1 |
| A | 7 | 34900 | VALVE, NEEDLE | 1 |
| | 6 | J6009 | HOSE, H.P.(3000 PSI) 6 FT. LG. W 3/16 I.D. | 1 |
| | 5 | C6078 | COUPLING, REDUCING 1/4MNPT X 1/8FNPT | 1 |
| | 4 | C4009 | GLAND, WATER PUMPED NITROGEN CYLINDER | 1 |
| | 3 | C4008 | NUT, WATER PUMPED NITROGEN CYLINDER 1/4 MNPT | 1 |
| A | 2 | C6080 | CROSS 1/4 FNPT, SS | 1 |
| | 1 | 38407 | GAUGE, 3000 PSI, 2" DIAL, 1/4 BOTTOM CONNECTION | 1 |

BILL OF MATERIALS

**Figure 9-13 Nitrogen Supply Assembly, Rev A**

# 10 Warranty and Returns

## 10.1 Warranty

Fann Instrument Company warrants its products to be free from defects in material and workmanship for a period of 12 months from the time of shipment. If repair or adjustment is necessary, and has not been the result of abuse or misuse within the twelve-month period, please return, freight prepaid, and correction of the defect will be made without charge.

Out of warranty products will be repaired for a nominal charge.

Please refer to the accompanying warranty statement enclosed with the product

## 10.2 Returns

For your protection, items being returned must be carefully packed to prevent damage in shipment and insured against possible damage or loss. Fann will not be responsible for damage resulting from careless or insufficient packing.

Before returning items for any reason, authorization must be obtained from Fann Instrument Company. When applying for authorization, please include information regarding the reason the items are to be returned.

Our correspondence address is:

**Fann Instrument Company**
P.O. Box 4350
Houston, Texas USA 77210

Telephone: 281-871-4482
Toll Free: 800-347-0450
FAX: 281-871-4446

Email fannmail@fann.com

Our shipping address is:

**Fann Instrument Company**
14851 Milner Road, Gate 5
Houston, Texas USA 77032