

®

**Dynamic Filtration System  
Model 90  
Instruction Manual**

For more information, please contact us:

[ExpotechUSA](#)  
[10700 Rockley Road](#)  
[Houston, Texas 77099](#)  
[USA](#)

[281-496-0900 \[voice\]](#)

[281-496-0400 \[fax\]](#)

E-mail: [sales@expotechusa.com](mailto:sales@expotechusa.com)

Website: [www.ExpotechUSA.com](http://www.ExpotechUSA.com)

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Flow Schematic

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## **SECTION 1 INTRODUCTION**

The FANN® Model 90 Dynamic Filtration System is a computerized instrument for conducting filter cake formation, fluid loss, and permeability analysis. Utilizing a selection of available Filter Core mediums and selecting one that closely resembles the formation of interest, the Model 90 simulates the down hole conditions of pressure, temperature and shear rate. Test parameters input into the Model 90 will optimize the test simulation.

The Filter Core medium is a thick walled cylinder with formation-like characteristics to simulate the depositing and build up of cake on the formation. The porosity and permeability simulates the fluid loss to the formation. The fluid loss rate can be tracked as well as the fluid loss volume measured.

Results of the test are shown on the screen while the test is in progress and may be read on the screen after the test is complete. A summary of the test results is also available on the screen. This data may be permanently saved by printing it out, or down loading it to a computer file.



## SECTION 2 SPECIFICATIONS

<b>SIZE:</b>	Width 12.50 in. (31.75 cm.) Depth 17.75 in. (45.10 cm.) Height 28.00 in. (71.12 cm.)
<b>WEIGHT:</b>	170 lbs. (77.3 kg.)
<b>POWER:</b>	Voltage - 115/230 Volts AC, 50/60 Hz. Current - 13 amperes at 115 Volt 8 amperes at 230 Volt
<b>TEMPERATURE:</b>	Maximum - 500 °F. (260 °C) Minimum - Ambient
<b>HEATING RATE:</b>	Maximum - 10 °F/minute (5.6 °C/minute)
<b>COOLING RATE:</b>	Typical - 2.8 °F/minute (1.5 °C/minute) from 300 °F (149 °C) Maximum - 5.0 °F/minute (2.8 °C/minute) from 500 °F (260 °C)
<b>STATIC PRESSURE:</b>	Maximum - 2500 psi. (7238 kPa)
<b>DIFFERENTIAL PRESSURE:</b>	Limited by the strength of the filter. Up to Static Test Pressure.
<b>SUPPLY PRESSURE:</b>	Maximum - 2700 psi (18600 kPa) Minimum - 200 psi (1400 kPa) higher than maximum programmed target static pressure. The target static pressure is automatically elevated to prevent boiling if insufficient pressure was programmed in accordance with the following formula: $\text{Static Pressure (kPa)} = \text{Sample Temperature (°C)} \times 26$ The minimum supply pressure must be at least 200 psi greater than the larger of the programmed static or the calculated pressures.
<b>SHEAR RATE:</b>	Initial shear rate with Newtonian fluid, standard geometry, and no filter cake. Maximum - 269 1/S (1000 rpm) Minimum - 8.1 1/S (30 rpm)
<b>FILTRATE VOLUME:</b>	Maximum - 50 ml
<b>SAMPLE VOLUME:</b>	275 ml
<b>COMPUTER PORT:</b>	RS-232, 9600 Baud, 8 Data Bits, 1 Stop Bit, No Parity, Full Duplex
<b>PRINTER PORT:</b>	One way, no hand-shaking, RS-232, 9600 Baud, 8 Data Bits, 1 Stop Bit, No Parity
<b>DATA RATE:</b>	1 data point per 0.3 ml of filtrate volume



## SECTION 3 OPERATIONAL OVERVIEW

The Model 90 is built around a full-yoke pressure vessel (cell). This type of pressure vessel requires no threaded or bolted closures on the ends of the cell. This makes it relatively easy to open and close, almost impossible to open when pressurized. The yoke is actually part of the pressure vessel. The threads on the bottom of the Cell serve only to prevent the bottom from falling off when carrying the Cell around. "O" rings are used for reliable seal performance.

All of the systems of the Model 90 are controlled by an internal 8 bit computer. Part of its ram memory is sustained by an internal battery. The battery life is about 7 years. The actual programs that run the instrument are contained in read-only-memory (ROM). Most of the program is written in a form of BASIC. The following is a description of the major systems of the instrument:

**PRESSURE CONTROL** - Pressure is maintained using an external pressure source, usually bottled nitrogen, and a group of solenoid valves. The valves typically work in pairs to increase the pressure by allowing supply pressure in, or decrease it by venting to the atmosphere. The atmospheric vent is located just inside the heater door, at the bottom left. It is external so that if a sample fluid is vented due to overfilling or boiling, it will be in an area easily seen and that is easy to clean. "*Refer to Appendix for 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 is used to select 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 in kPa is  $26 * \text{Sample Temperature } (^\circ\text{C})$ , when the temperature is above 50  $^\circ\text{C}$ . This is sufficient to prevent boiling for typical sample fluids.

**HEATING & COOLING** - Heating is accomplished with a split cylindrical block type heater. Each half has two cartridge heaters, for a total capacity of 1200 watts. Intimate contact of the heater halves with the cell wall is used to transfer heat. One half of the heater is attached to the door. That heater has a thermocouple embedded in it. The temperature of that thermocouple is monitored continuously by a microprocessor based module. If it senses an over-temperature condition, it opens a safety interlock relay that mechanically disconnects the power from the heaters. This is an independent safety that will prevent damaging temperatures if the computer fails. That same module also transmits the heater temperature to the computer on demand.

The heater is surrounded by an insulated case. A gap between the case and the heater allows space for air to be blown around the heater block for cooling. 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, the higher the cooling rate.

The sample temperature is measured by means of a resistance-temperature-device (RTD) that 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.

**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. The rotating magnets couple to a magnetic piece on the Shear Shaft inside of the Cell. The shear shaft is supported by a plastic bushing at the top and a small angular contact ball bearing at the bottom.

Shear Shaft speed is sensed by means of magnets at the top of the Shear Shaft, and a magnetic field sensor that 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.

**FILTRATE** - The differential pressure is between the sample in the Cell and the backside of the Filter Core (the outside diameter). The differential is induced by reducing the pressure above the Filtrate Piston in the Collector, to a pressure less than the Cell pressure. The volume below the Filtrate Piston experiences approximately the same pressure as long as the piston is free to move. This is why the bore of the Filtrate Tube is lubricated on assembly.

The volume below the piston is connected, through the Filtrate Valve, to the volume behind the Filter Core. When the Filtrate Valve is opened, fluid flows from the sample, through the Filter Core wall, through passages to the hose at the bottom of the Cell. *"Refer to Appendix for Flow Schematic"*. The filtrate then flows through a coarse filter in the hose. This filter stops particles big enough to plug the Filtrate Valve (0.047 inch - 1.19 mm, diameter). The nominal size of the filter is 440 microns. It is mounted in the hose where it is accessible for cleaning. This filter is probably most useful when a Filter Core cracks, letting the sample through without filtering.

From the in-line filter, the filtrate flows into the instrument and through the Filtrate Valve. From the valve, it flows to the bottom of the Collector, where it pushes the Filtrate Piston upwards. The motion of the piston is converted to a voltage by the Collector Sensor, which is magnetically attached to the Filtrate piston. The voltage is digitized by a microprocessor based module and sent to the computer when commanded.

Any air or leaks in the Filtrate system are very detrimental to the instrument's performance. Air, or any gas, would cause exaggerated and jerky movement of the piston. The measured filtrate volume will probably be too large. Leaks cause reduced volume measurements. The likely leaks would be past the Filtrate Piston, or out of the Collector Bleed Valve. It is also possible to have leaks in the quick-disconnects and other fittings in the system. The Filtrate System must be kept in good repair.

**PURGE** - The purge system is used to remove air from the filtrate system and to flush out 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 location of the connection to the filtrate system was selected so that the flow of the purge fluid is opposite the filtrate flow direction. 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 of the purge fluid flows directly to the bottom of the Filtrate Collector, below the Filtrate Piston. This fluid is released by opening the Collector Bleed Valve, venting any 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.

## **SECTION 4 SAFETY CONSIDERATIONS**

- ✍ The system utilizes elevated pressures; therefore, temperatures, and appropriate precautions should always be exercised. High pressure gas, normally Nitrogen, is usually supplied in high pressure cylinders. The cylinder should be secured so that it can not be tipped over.
- ✍ The instrument cannot be pressurized unless the Collector and the Cell are both in place.
- ✍ The heaters will not turn on unless there is sufficient pressure for the test, the Collector, and Cell are in place, and the door is closed. If the door is opened during a test an intermittent beeping sound will indicate that the door should be closed. If the door is not closed within several minutes, the test will be aborted and the cool down mode will be initiated.

The above features insure the safety of the instrument when heat and pressure are applied. Seals are maintained by "O" rings and must be replaced when they become cut, have taken a set, or become hard due to high temperature testing. This is especially important if the sample being tested is flammable.

### **CAUTION**

NEVER SUBSTITUTE FITTINGS OR HOSES ON THE HIGH PRESSURE CONNECTION WITHOUT BEING SURE THE PART IS RATED FOR AT LEAST 3000 psi (20685 kPa) WORKING PRESSURE.

The connection to the Model 90 is made with a hose assembly capable of 3000 psi (20,685 kPa). A rupture disc internally connected to the pressure connection port provides safety from over-pressure of the gas source. A relief valve at the top of the cell is used to provide safety from cell over-pressure. All safety precautions normally practiced when using high pressure gas should be followed when connecting or disconnecting the high pressure gas source.

### **CAUTION**

SERIOUS BURNS COULD EASILY OCCUR.

The heaters and parts of the cell get very hot when high temperature tests are run. Even with the built in safety feature of disconnecting 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.

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.



## SECTION 5 KEYPAD FUNCTIONS

Some generalizations can be made about the function of the keypads on the front of the instrument. They require a firm push in the center to operate reliably. Because of the slight delay in computer response, the tendency is to push much harder and longer than required. After the push of a key, the computer takes a short time to react and the display may not change immediately. A short sharp push will give the most satisfactory operation. The non-number keys have the following functions:

**ENTER** - Activates items from a menu that have been selected by putting the "?" pointer next to the item. It also completes the entry of numeric values.

**ARROW KEYS (Up and Down)** - Are used to move the "?" pointer from one item to another on a menu and on the Test Sequence Edit display. They are also used during a test to skip to the next step or back to the previous step. On the Data Access displays, they are used to move to the next set of data or data summary.

**START** - Starts some operations. It is also used in the Test Sequence Edit Screen to turn the filtrate valve to the "On" (Open) position.

**STOP** - Stops many operations. It is also used in the Test Sequence Edit Screen to turn the filtrate valve to the "Off" (Closed) position. It is also used in the top line of the Test Sequence Edit screen to exit from the Editor. The message "**STOP** - Exits" is used as a reminder of that function. In some cases, stop will also clear a value to zero.

**. (DECIMAL POINT)** - In addition to its normal function in a number, which is not always allowed, the decimal point is also used to send a Form Feed to an attached printer while in the Test Menu and the Data Access Menu.



Fig. 1 - KEYPAD

## SECTION 6 SCREEN FUNCTIONS

The software of the Model 90 presents a series of menus to allow operator choices. When the instrument is turned on, "PLEASE WAIT" is displayed while the instrument initializes itself. After a few seconds, it is followed by the copyright notice. In the upper left corner of the copyright display, the total testing time of the instrument is displayed in hours. In the upper right corner of the same display, the total testing thousand degree hours is displayed. A test for one hour at 200° C would add 0.2 kChr to the total. This information is useful for maintenance purposes.

After a few seconds, the MAIN MENU is presented. In addition to the date and time, the MAIN MENU screen lists three items that may be selected:

1. **CALIBRATE** - This is the designation for procedures to set up infrequently changed operating parameters:
  - a. The units of measure, either English Engineering or International (SI)
  - b. The current date and time
  - c. The filter core and shear shaft dimensions, and also mean pore size.

### NOTE

Once these parameters are set, these steps do not need to be repeated unless a parameter being used changes.

Also included under the CALIBRATE MENU is the calibration procedure for the filtrate collector.

Unlike the procedures above, the filtrate collector calibration should be done once every five to ten tests to insure the collector volume is read accurately. As a quick check that the calibration is probably good is to observe that the collector volume is close to zero at the start of the test. Another check that the calibration is good is that the displayed total volume of filtrate is approximately the same as the volume measured by pouring the filtrate into a graduate at the end of a test. Refer to Section 9 "PROCEDURE FOR CALIBRATION" for more detail.

2. **TEST** - This is the designation for setting the conditions of the test and running it. Selecting this option will display the TEST MENU. The RUN TEST screen is one option from the TEST MENU screen. 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 as edited. The date of the last edit is shown to help identify the test sequence. Refer to Section 7 "TEST SEQUENCE OPTIONS" for more details on test sequences. The RUN TEST SCREEN shows the target values and the real time conditions of the test as it progresses.

STEP 3	HP (psi)	dP (psi)	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

**Fig. 2 RUN TEST SCREEN**

Other options from the TEST MENU screen are:

- a. **SETUP TEST SEQUENCE** - Which allows programming of the steps and conditions of each step. Note that if the "STANDARD TEST" is selected from the TEST SEQUENCE MENU, it is considered edited whether any of the values in the test are changed or not. It is now the latest test sequence.
- b. **PRINT TEST SEQUENCE** - May be used to print the current test sequence either before a test is run to check for accuracy of the program or after the test is run for verification of the sequence and target values used. Refer to Section 15 "PRINTER INSTALLATION" for details of the connection of the printer.
- c. **COOL AND VENT** - Allows the machine to be brought to near ambient conditions after a test has been stopped in a heated and pressurized condition.

#### NOTE

The High Pressure (H P) SUPPLY must be connected and pressurized before the "COOL AND VENT" or "PURGE" function can operate.

- d. **PURGE SYSTEM** - Is used to initiate the purge sequence. The filtrate system must be purged of gases before each test is run. Purge expels all air from the flow path between the outside of the filter core in the cell to the bottom side of the floating piston in the collector. This floating piston is connected to the transducer which measures the filtrate volume. It is very important that this flow path be full of purge fluid with no air bubbles at the start of each test. Refer to Section 9 "RUNNING A TEST" for purge procedure.
3. **DATA ACCESS** - This is the designation for the procedures to collect and store test data. The data can either be printed with a summary of the data for each step, or transferred to a computer. Refer to Section 12 "TRANSFERRING DATA TO A COMPUTER" or Section 13 "PRINTER INSTALLATION" for details.

In general, an "EXIT" from any menu will return to the parent menu.

## SECTION 7 TEST SEQUENCE OPTIONS

A Test Sequence consists of a sequence of steps made up of the desired (target) conditions and the time intended to attain or maintain them. The system is capable of slow ramping of the controlled variables. For example, this allows a steady increase of the temperature. Ramping is limited by the systems ability to respond. If too high a ramp rate is programmed, the system will respond with the best it can do. The instrument is limited to 20 steps.

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 may not be attainable. In this case the instrument will stay on the erroneous step until the test is terminated by the operator or the operator forces the transition to the another step. Transition to another step can be forced by pressing one of the arrow keys.

In general it is desirable to standardize on Test Sequences as much as possible to allow for the easy comparison of tests. For this reason a suggested standard test has been programmed into the instrument. This standard test can be changed only with the use of an external computer. Refer to Section 16 "CHANGING THE STANDARD TEST" for details.

The following procedure will describe in detail the target conditions that can be programmed. This information is entered into the instrument. The instrument will retain this information as the LAST TEST until edited. Generally a test consists of the following five steps:

### *➤STEP 1 - Establishes the static conditions*

This is normally the step where the static pressure is applied and where the sample is heated to the desired temperature. The step time is usually set to "0" to obtain test conditions in the minimum time. During this step the sample is usually agitated by having the shear shaft turning at velocity so that a shear rate of 100 reciprocal seconds (1/s) is obtained. Since step conditions have not stabilized, filtrate should not be collected during this step. The differential pressure should be set at "0" and the filtrate flow should be "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 achieved. Only a few seconds are usually required to adjust the collector pressure. Zero time is programmed for this step. The target static pressure, shear rate, and filtrate flow are usually set 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 "2" minute step time is usually adequate. The target static pressure, shear rate, and filtrate flow are usually set the same as in steps 1 and 2.

### *➤STEP 4 - Collects dynamic filtration data*

This is the step where all of the conditions of the test are held constant while filtrate is collected. The duration of this step is usually from 45 to 90 minutes. The conditions of this step are usually the same as step 3, except that the filtrate flow is "ON".

## **STEP 5 - Cools down and vents the pressure**

During this step the cell will be cooled to a temperature where it can be handled safely and the pressure will be vented. The step time should be set to "0" for minimum cooling time. The target static pressure should also be set to "0". The instrument will maintain sufficient pressure on the cell during cool down to prevent boiling of the sample. The pressure maintained will be 6.79 psi/°F (26 kPa/°C) above 122°F (50°C). The instrument reduces the pressure as the cell temperature drops and the cell will be completely vented by the time the target temperature is reached. This is usually a temperature of 115°F (46°C). The target shear rate for this step is usually set at 100 1/s to aid in cooling. Since no filtrate is collected during cool down, the filtrate flow is set "OFF".

Six parameters must be established for **each** of the steps making up the Test Sequence.

1. **STEP TIME** - The time the designated conditions of the step are to be reached in, or held. For steps where minimum time to conditions is desired, the time of the step is set at "0". The instrument will advance to the desired conditions at its best rate. When all of the conditions are within acceptable tolerances, the instrument will proceed to the next step.
2. **STATIC PRESS (PRESSURE)** - The pressure on the sample in the cell. It is the pressure applied to inside diameter of the filter.
3. **DIFFERENTIAL** - 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** - The sample temperature inside of the cell desired on completion of the step.
5. **SHEAR RATE** - The rate at which the sample is sheared in the annulus between the inside diameter surface 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. Refer to Section 11 "PROCEDURE FOR CALIBRATION" for the details of entering these values. The shear rate is proportional to the speed of rotation of the shear shaft. The instrument calculates the correct rotational speed from the target shear rate using the Filter Core and Shear Shaft geometry.
6. **FILTRATE** - The position of the filtrate valve at the beginning of the step is programmed. It controls whether or not filtration can occur. "OFF" means that during the step no filtration occurs. Conversely, "ON" means that during the step filtration can occur.

Up to twenty steps may be programmed for variations of the above test procedure. For instance, the sample could be heated to an intermediate temperature, held there for a period of time, then raised to another higher temperature, and then filtered. Or, the shear rate could be changed from one step to another, or a step added for a different shear rate. These are only examples of the tailoring possible.

## SECTION 8 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 either "STANDARD", "NEW TEST", or "LAST/EDIT". The selection depends on which of the three is the most convenient. Pick the one that is most like the test required:

- a. **STANDARD TEST** - The standard test is a short test sequence that has been pre-programmed into the instrument. It allows selection of 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 prompt for the test temperature. The default temperature is 300°F (149°C). One temperature entry on this screen is all that is required to revise the programmed temperature in the appropriate steps of the standard test. The temperature entry will bring up the "EDIT" screen so that additional changes could be made.

- b. **NEW TEST** - This clears all times and target values to "0" for all steps (sample temperatures will be 32°F in English units). The "FILTRATE" valve position will default to "OFF". This is used when a radically different Test Sequence is required. Entering "NEW TEST" will bring up the "EDIT" screen where the new test sequence can be entered.
- c. **LAST/EDIT** - This allows modification of the most recently edited (last) test sequence. Entering "LAST/EDIT" will bring up the "EDIT" screen where the modifications can be made.

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

**FIG. 3 - EDIT SCREEN**

4. The "EDIT SCREEN" will display the first step of the current test sequence. If no changes are desired, press the "STOP" key to exit. A "?" pointer must be next to the step number to exit the editor.

The "?" will be displayed after the "STEP" in the top line. This pointer must be positioned with the arrow keys to the left of the value to be changed. When the "ENTER" key is pressed after a new value has been keyed, the pointer will be positioned at the next value. This process will be described as if every value is to be changed in a step. The following steps assume that, for example, step 3 needs to be modified:

5. Position the pointer next to the step number.

6. Key in "3" followed by the "ENTER" key. The screen will be updated to show the current conditions of step 3. Under "Current", towards the center of the screen, will be listed the target step conditions of the previous step (2). These are the conditions that must be attained before step 3 is started. The current conditions would be "INITIAL" if the step was 1. The pointer will have been positioned to the right of the "STEP TIME (M)" label.
7. Enter the planned step time. The pointer will be re-positioned next to the value of the target "STATIC PRESSURE".

#### **NOTE**

In place of pressing the "ENTER" key to enter a value, an arrow key can be used to move the pointer to the next condition or the previous condition. This has the effect of entering the value that was keyed in. The arrow key can also be used to bypass any value that does not need to be altered.

8. Enter the planned step "STATIC PRESSURE". The pointer will be re-positioned next to the value of the target "DIFFERENTIAL" pressure. If more than 2500 psi is entered it will be reduced to 2500 psi (17237 kPa).

#### **CAUTION**

IT IS POSSIBLE TO ACHIEVE DIFFERENTIAL PRESSURES THAT WOULD CRACK THE FILTER CORE. MANY TYPES OF FILTER CORES ARE LIMITED TO ABOUT 500 PSI (3500 kPa) DIFFERENTIAL PRESSURE.

9. Enter the planned step "DIFFERENTIAL" pressure. The pointer will be re-positioned next to the value of the target sample "TEMPERATURE". If more than 2500 psi is entered it will be reduced to 2500 psi (17237 kPa).
10. Enter the planned step sample "TEMPERATURE". The pointer will be re-positioned next to the value of the target "SHEAR RATE". If more than 500°F is entered it will be reduced to 500°F (260°C). The lowest temperature should be at least 10°F (6°C) above ambient conditions.
11. Enter the planned step "SHEAR RATE". The pointer will be re-positioned next to the value of the target "FILTRATE" valve position. The shear rate will be limited to the equivalent of 1000 revolutions per minute (rpm). The shear rate limit depends on the geometry of the Shear Shaft and Filter Core. The dimensions last entered in "CALIBRATION" are used to determine the limit. For the standard configuration, the limit is 286 reciprocal seconds (1/S).
12. Enter the "FILTRATE" valve position by pressing "START" for "ON" (open), or "STOP" for "OFF" (closed). This is the desired position of the valve at the start of the test step. The pointer will be repositioned next to the "STEP" number on the top line of the display.
13. Repeat steps 4 through 12 as required until **all** of the 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.

#### **NOTE**

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

## SECTION 9 RUNNING A TEST

This procedure assumes that the instrument previously has been installed and is ready to operate, and that the Cell and Collector have been disassembled and cleaned from the previous run. It also assumes that the Collector has already been calibrated. If not, refer to Section 11 "PROCEDURE FOR CALIBRATION" for the procedure.

**(Ref. to Fig. 4 & 7)**

1. Turn on the instrument by moving the power switch on the lower right to the "I" position. After a delay, the "MAIN MENU" will be displayed.
2. If necessary, disassemble the Cell by following steps 7 through 21 in Section 10 "CLEANING AFTER A TEST".
3. Confirm the Cell and Collector "O" rings are in good condition. Refer to Section 10 "CLEANING AFTER A TEST", steps 35 and 36.

### INSTALLATION OF THE FILTER CORE

4. Filter Core installation is best accomplished with the Cell End Cap [1] and Filter Core Holder assembly [3,7] 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 ball Bearing [19] in the Bearing Support [11] is in good condition. It should not be missing any balls and the balls should be free to rotate. Clean if necessary. If must be replaced, refer to Section 19.
6. Place the Bearing Support into the slot in the Filter Core Clamp [3] with the ears of the Bearing Support point downward.
7. Screw the Filter Core Holder upward on the Filter Core Clamp as far as possible.
8. Wipe a coating of grease (P/N L4026) on the "O" Ring [29] in the Filter Core Cap [12].
9. Place into the Filter Core Holder the following, in the order listed:
  - a. Filter Core Gasket [25]
  - b. Filter Core [23]
  - c. Filter Core Gasket [25]
  - d. Filter Core Cap with "O" ring installed
10. Use the supplied Retainer Ring Pliers (P/N P4004) to place the Retainer Ring [18] in the groove above the Filter Core Cap.
11. Screw the Filter Core Holder downward until filter core is clamped in place. Use the special wrench (P/N 36378) to tighten the Filter Core Clamp (30 to 35 ft. lbs - 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 [31] near the base of the Cell Cap Assembly with the supplied 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 [2], just above the threads, on the inside where the "O" ring will seat.
14. Screw the Cell Casing onto the Cell Cap Assembly.
15. Lubricate the area of the "O" Ring [26] at the top of the Cell Casing with the supplied grease. A thin film of lubricant should be applied from the inside top edge to about  $\frac{3}{4}$  inch (2 cm) below the "O" ring.

## **PURGING THE SYSTEM OF AIR**

*(Refer to Fig. 5)*

16. Make sure the parts of the Collector Assembly are clean.
17. Wipe a heavy film of the supplied grease into each end of the Filtrate Collection Tube [3], to about 1.5 inches (4 cm) inside.
18. Lubricate the Filtrate Piston [5] and its "O" Ring [14] and push it completely into one end of the Filtrate Collection Tube.
19. Remove the Cell Assembly from the holder and place it on the bench.
20. Connect the Cell Assembly Hose into the quick disconnect on the end of the Hose coming from the port labeled "CELL".
21. Connect the hose from the Filtrate Inlet Cap of the Collector [6] into the quick disconnect labeled "COLLECTOR" on the right side panel.
22. Place the Filter Inlet Cap of the Collector into the Collector Tube end nearest to the Filtrate Piston.
23. Slide the open end of the Filtrate Collection Tube over the Collector Sensor [2] and its Connection Magnet [8]. Push it all the way up past the "O" ring [13] on the Pivot Cap [15].
24. Hold the Filtrate Inlet Cap up against the Filtrate Collection Tube and swing it in and then down to engage the hole in the Collector Sill.
25. 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.
26. From the "MAIN MENU" select "TEST".
27. From the "TEST" menu select "PURGE SYSTEM".

### **NOTE**

"HP SUPPLY" gas must be connected and pressurized before the system can be purged.

28. Enter the time desired to purge the system. The default value is 5 minutes.

29. 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 the "STOP" key. It may be necessary to pour off some of the fluid to prevent overflowing.

#### **CAUTION**

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.

30. Place a small beaker or other suitable container below the Collector Bleed Valve [16] and open the valve about 2 turns.
31. When no more air bubbles are observed coming from the Collector Bleed Valve, close the valve tightly.

#### **CAUTION**

FAILURE TO PROPERLY CLOSE THE COLLECTOR BLEEDER VALVE COULD CAUSE INACCURATE FILTRATE MEASUREMENTS.

32. 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 in line filter.
33. 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.
34. When the purge time has expired and the purge pump has stopped, empty all the purge fluid from the cell.
35. Be sure that the Bearing Holder is still properly positioned, flat on the Core Clamp.

#### **LOADING THE SAMPLE**

*(Refer to Fig. 4 & 7)*

36. Hang the Fill Gauge (P/N 36424) over the top lip of the Cell Casing with the long end inside the cell.
37. Fill the Cell Assembly with the sample to be tested to the bottom of the fill gauge. Remove the fill gauge.

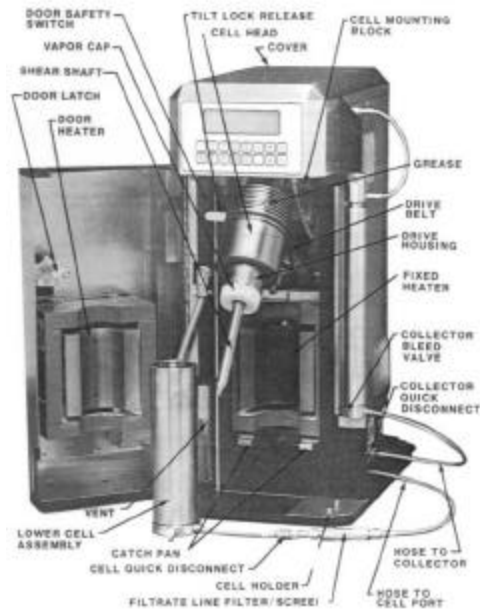
## CLOSING THE CELL

38. Open the Door by pulling the bottom of the door latch outward and then rotating it about 90 degrees in either direction.
39. 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.
40. Make sure that the Cell Head is clean and properly assembled. Refer to Section 10 "CLEANING AFTER A TEST" for cleaning and inspection details.
41. Inspect the Shear Shaft Race on Figure 10 on the pointed end of the Shear Shaft [21] to make sure it is in good condition. Refer to Section 10 "CLEANING AFTER A TEST" for cleaning and inspection details.
42. Fill the hole in the center of the Shear Shaft with purge fluid. The purge fluid thermal couples the shear shaft to the RTD type temperature sensor. It also lubricates the spots where the temperature sensor rubs on the inside of the shaft.
43. Insert the square end of the Shear Shaft into the Cell Head, until it is held by the drive magnets.
44. Install the Vapor Cap [9,27] over the shear shaft into the upper part of the cell. Do not lubricate its "O" Ring [27] or the inside of the Cell Head. The friction of the "O" ring holds the Vapor Cap in place.

### CAUTION

PROPER LUBRICATION OF THE JOINT BETWEEN THE CELL HEAD AND THE CELL ASSEMBLY IS VERY IMPORTANT. BOTH OF THE SURFACES THAT MATE MUST BE LUBRICATED TO EASE THE ASSEMBLY AND DISASSEMBLY. LUBRICATION OF JUST THE "O" RING [26] IS INSUFFICIENT. IF THE SURFACES ARE NOT CLEAN AND LUBRICATED, IT WILL BE DIFFICULT TO CLOSE THE CELL AND LOCK IT INTO THE YOKE.

45. With the grease supplied, apply a film of grease on the outside lower end of the Drive Housing [4] 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).
46. 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 [8]. Make sure the Cell Assembly is in line with the Cell Head. If the Cell Assembly can not be pushed all the way up, the Shear Shaft has not engaged the bearing at the bottom. Engagement may be attained by sliding the Cell Assembly down a little and re-trying. Another possible cause is that the Bearing Holder has shifted out of position. See the second caution on step 28.
47. Hold the Cell Assembly up and rotate it until the knurled Handle [16] points outward, away from the instrument. This roughly aligns the slot in the bottom of the Cell Cap.
48. 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 the slot in the Cell Cap slides all the way down over the bottom of the Yoke.



**Fig. 6 MODEL 90 ASSEMBLY**

## CAUTION

IF THE CELL ASSEMBLY IS NOT ALL THE WAY DOWN ON THE YOKE,  
A SAFETY SWITCH WILL PREVENT THE STARTING OF A TEST.

49. Close and latch the door.
50. Select the "TEST MENU" from the "MAIN MENU" with the keypad. Refer to Fig. 1.
51. Select "RUN TEST" if this test is to be the same as the last test or if the test has already been edited as desired. If it is desired to make any changes in the Test Sequence, Refer to section 8 "PROGRAMMING A TEST SEQUENCE". After the appropriate revisions have been made on the Edit screen, then select "RUN TEST".
52. A message will warn that starting this test will destroy the results of the last test. If the data from the last test is to be retained, it must be printed out or transferred to a computer before continuing. Refer to Section 12 "TRANSFERRING DATA TO A COMPUTER".
53. When ready to start the test, press "START" as directed on the warning screen.

## NOTE

THE TEST CAN BE STOPPED AT ANY TIME BY PRESSING THE "STOP" KEY.

54. 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.

On completion of the test, the data can be transferred to a computer or printed. Then the instrument should be cleaned in accordance with Section 10 "CLEANING AFTER A TEST". Shut off the high pressure gas supply and turn off the instrument if it is not going to be used again immediately.

## FILTRATE VOLUME CHECK

*(Refer to Fig. 5)*

It is good practice to compare the instrument's total filtrate volume to the amount of fluid actually found in the collector.

1. Lift the Filtrate Tube [3] and Filtrate Inlet Cap [6] upward to release the Cap from the Collector Sill, then swing them outward.
2. Slide the Inlet Cap and Filtrate Tube downward off of the Pivot Cap [15].
3. Invert the Inlet Cap and Filtrate Tube so that the Inlet Cap is up.
4. Loosen the Bleed Valve [16] on the Inlet Cap, then pull the Inlet Cap off while holding the Filtrate Tube vertical.
5. Pour the filtrate out of the Filtrate Tube into a suitable graduated cylinder. The volume of filtrate 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.

## **SECTION 10 CLEANING AFTER A TEST**

The following procedure should be used to clean the Cell and Filtrate Collector after each use.

### **CELL DISASSEMBLY**

*(Refer to Fig. 4 & 7)*

1. Open the door.
2. Lift upward on the Cell Handle [16] on the bottom of the Cell Cap [1], while bumping the top of the Cell Casing [2] 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. (Figure 6)
4. Swing the bottom of the cell outward into the tilted position and release the Cell Position Latch.

### **CAUTION**

SOME SAMPLE FLUID WILL DRIP FROM THE SHEAR SHAFT [21]  
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 [9] out of the Cell Head and set aside for cleaning.

### **CAUTION**

THE SHEAR SHAFT MAY BE FILLED WITH A FLUID THAT WILL  
SPILL OUT IF TIPPED OF LAID DOWN.

9. Pull the Shear Shaft [21] from the Cell Head and set it aside for cleaning.
10. Unscrew the Casing [2] from the Cell Cap [1] and set aside for cleaning.
11. Using the Filter Core Holder Wrench (P/N 36378) loosen the Filter Core Clamp [3].
12. Remove the Retainer Ring [18] using Retainer Ring Pliers (P/N I4004).
13. Screw the Filter Core Holder downward (clockwise), using the filter core holder wrench if necessary, until the Filter Core Cap [12] is pushed out. Remove the Filter Core Gaskets [25] and Filter Core [23].

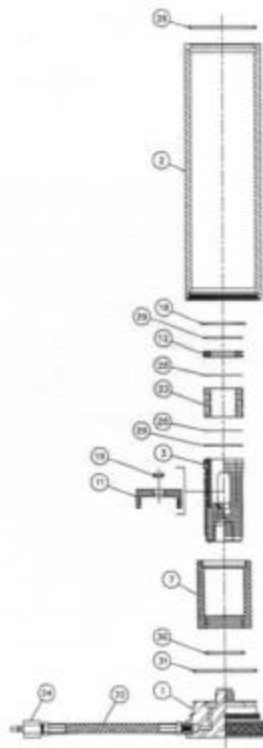


FIGURE 7 - LOWER CELL



## NOTE

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 [6] and set it aside for cleaning.

### PURGING THE TEST FILTRATE

16. Remove the Cell Cap Assembly from the Cell Holder and place it in a shallow tray.
17. From the "TEST MENU" select "PURGE" and conduct a purge. Refer to Section 9 "RUNNING A TEST", steps 16 through 25. Flow enough purge fluid through the Filtrate lines to flush filtrate from the system. If no flow is obtained, the Filter in the hose from the Instrument to the Cell Cap may be plugged. Refer to Section 19 "REPAIR" for disassembly of the filter.

### CELL CLEANING AND INSPECTION

18. Disconnect the hose from the instrument to the Cell Cap at the quick-disconnect.
19. Empty the tray and set it aside.
20. Remove all of the "O" rings. The "O" Rings should be inspected for evidence of taking a set (no longer a round cross section), cuts, nicks, swelling, and hardness. Replace any defective "O" rings.
21. 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 [19] in the Bearing Holder. They must be free to roll. Dry the bearing thoroughly to prevent rusting.
22. 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 19 "REPAIR".
23. Inspect the ball bearing [19] in the Bearing Holder for condition of the balls. If any of the balls are rusted, stuck, or are missing, the bearing should be replaced. Refer to Section 18 "MAINTENANCE".
24. Inspect the Bearing Race [33] on the tapered end of the Shear Shaft. Replace if broken or damaged. Refer to Section 18 "MAINTENANCE".

This completes the cell cleaning procedure. Reassemble as described in Section 9 "RUNNING A TEST".

### FILTRATE COLLECTOR CLEANING AND INSPECTION

*(Refer to Fig. 5)*

25. Lift the Filtrate Tube [3] and Filtrate Inlet Cap [6] upward to release the Cap from the Collector Sill, then swing them outward.
26. Slide the Inlet Cap and Filtrate Tube downward off of the Pivot Cap [15].
27. Use a wooden or plastic rod to push the Filtrate Piston [5] 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 this passages. If the Bleed Valve is separated from the Inlet Cap the Ball [12] can fall out.

29. Inspect the Sensor Holder [2] for evidence of contamination by the sample fluid. Should this be found, disassemble and clean. Refer to Section 19 "REPAIR", for disassembly and assembly details.
30. Inspect "O" ring [13] on the Inlet Cap and Pivot Cap and "O" ring [14] on the floating piston for cuts, flatness, or hardening.
31. Should the "O" ring in the floating piston need replacing, the screw [11] should be removed, then the Piston [5] and Piston Cap [7] separated.

This completes the Collector cleaning procedures. Leave the Filtrate Tube off of the instrument so that the Collector Sensor can dry between test.

### **INTERNAL FILTRATE SYSTEM CLEANING**

The Filter Core occasionally will crack or break during a filtration test. When this happens, the UN-filtered sample is forced into the filtrate flow system. This could also happen if the Core Holder was not properly tightened or a gasket was left out. A filtrate line filter (screen) near the cell hose quick-disconnect is used to help prevent plugging down stream. Sample debris getting past 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. Follow steps 7 through 23 above.
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 19 "REPAIR, CLEANING THE FILTRATE LINE FILTER", for instructions.
4. Follow steps 31 through 36 above to remove and clean the Filtrate Collector.
5. Remove the Left Side/Back panel. Refer to Section 19 "REPAIR", for details.
6. Disassemble filtrate solenoid valve B-12 (SV-7). This valve is on the lower right when looking at the back panel. Refer to Section 19, 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 can not 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 can not 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. Refer to Section 19 "REPAIR."
11. Perform a purge, without the Filter Core, to check for proper operation of the system. Refer to Section 9 "RUNNING A TEST", Steps 16-35.

## SECTION 11 PROCEDURE FOR CALIBRATION

The items on the "CALIBRATION MENU" allow changes in parameters that do not change vary often. The most frequently used option will be the calibration of the Filtrate Collector Sensor. This procedure should be done every five to ten tests. If the instrument has been in operation 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 be displayed. The following is a brief description of the use of each of the displayed options:

1. **SELECT UNITS** - From the "CALIBRATE MENU" select "SELECT UNITS". Select either "EXIT", "INTERNATIONAL (SI)", or "ENGLISH ENGINEERING". The "INTERNATIONAL (SI)" shows the temperature in degrees Centigrade (°C), the pressures in kilo Pascals (kPa), and lengths 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<sup>2</sup>).

The English Engineering system shows the temperature in degrees Fahrenheit (°F), the pressure in pounds per square inch (psi), and lengths in inches (in). However the units for the filtrate volume and filtering rate are the same as "INTERNATIONAL (SI)" units.

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, year format, two digits each. The time is entered in 24 hour format (hour, minute, second) with two digits each.
3. **SET GEOMETRY** - From the "CALIBRATE MENU" select "SET GEOMETRY". From the "SET GEOMETRY MENU" select the dimension 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 first three dimensions are used by the instrument to calculate the shaft speed required to attain the target shear rate. The "MEAN PORE SIZE" is only used for record purposes. It is printed with the test results.
4. **CALIBRATE COLLECTOR SENSOR** - From the "CALIBRATE MENU" select "CALIBRATE COLLECTOR SENSOR". The sensor is calibrated at two points on its span, empty and at 45.05 ml. This is simulated by using a metal Volume Calibration Slug (P/N 36354). Gas pressure must be available to the instrument for this procedure. Numbers in brackets in the following steps refer to Figure 5. Filtrate Collector must be assembled in its normal position.
  - a. Open the Bleed Valve [16] about 2 turns.
  - b. Lift and swing the Collector Tube [2] and the Inlet Cap out, away from the Yoke.
  - c. Holding the Collector Tube up onto the Pivot Cap [15], remove the collector Inlet Cap.
  - d. Make sure the Filtrate Piston [5] is in the Collector Tube.
  - e. Insert the Volume Calibration Slug into bottom of the Collector Tube. It must be placed below the piston so that it holds the piston up from the Collector Cap.
  - f. Replace the collector Inlet Cap on the Bottom of the Collector Tube and swing it back in place. Push it down so that it fully engages the hole in the Sill.

- g. 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.
- h. After the Collector has stopped venting, follow the prompt and remove the slug from the Collector Tube. Leave the Piston in place and re-assemble the Collector as before.
- i. 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.

## SECTION 12 TRANSFERRING DATA TO A COMPUTER

Data is transferred from the Model 90 by means of serial RS-232C communication through the connector labeled "COMPUTER". The data is transmitted in a format that can be imported into popular spread sheet programs. All of the numbers are delineated by commas.

A suitable cable (P/N 35677) 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 the steps below to accomplish a transfer.

### NOTE

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 both off (0) 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 Model 90's "DATA ACCESS MENU" select "DOWNLOAD - RS232:9600,N,8 1".
6. A message will prompt for a press of the Model 90's "START" key or a "Ctrl Q" from the computer.
7. On the computer, prepare for downloading ASCII data. With Procomm, this is done 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's keyboard or press "START" on the Model 90's keypad. The data will be displayed on the computers screen as it is transferred. This take less than a minute.
9. Close the file that was opened for the data on the Model 90. With Procomm, this is done by pressing the "Esc" (Escape) key.

This completes the transfer. The original data will remain in the Model 90 until another test is run, or until the "COOL DOWN AND VENT" procedure is run.



## SECTION 13 DATA ANALYSIS

Currently there are no standard methods for the interpretation of Dynamic Filtration Data. Some parameters that can be determined from the data obtained using the Model 90 are:

1. *Spurt loss volume* - Usually considered to be the volume of filtrate obtained initially when filtration begins. This could be considered as the difference in the volume from the start of filtration volume at the end of the first 10 seconds. It is desirable to have a low spurt loss volume.
2. *Particle plugging of pores* - 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* - Can be evaluated over any interval during the filtration process. This is accomplished by calculating the rate of change in the filter volume versus time (ml/min). It is desirable to have a low filtration rate. The rate should be less than 0.2 ml/min for most oil well drilling fluid systems.
4. *Cake Deposition Index (CDI)* - May be determined by calculating 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 oil well drilling fluid systems a CDI of 10 ml/hr<sup>2</sup> or less is desired.

## SECTION 14 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. Pick the location for the instrument using the following considerations:

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 this space when disassembling the cell or collector. Some of this space is also required for a container of purge fluid. This will be a 1/2 to 2 gallon container (2 to 8 liters).

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. Should the laboratory be equipped with high pressure nitrogen outlets the gas cylinder will not be required. A 6 foot (1.8 m) long high pressure hose is provided for this connection. The gas cylinder or the gas outlet should be within reach of this hose.

A 7 foot power cable is provided for power connection. Preferably the electrical outlet should be within reach of this cable.

### CAUTION

THE INSTRUMENT WEIGHS APPROXIMATELY 170 POUNDS (77 kg).  
USE THE PROPER TECHNIQUES WHEN LIFTING AND MOVING THE  
INSTRUMENT TO AVOID BACK INJURIES.

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

### CAUTION

THE HIGH PRESSURE GAS SUPPLY MUST NOT BE IN EXCESS OF  
2500 psi (17238 kPa) WITHOUT THE USE OF A PRESSURE INLET  
REGULATOR.

3. Connect the high pressure hose and gauge assembly to the high pressure gas cylinder. Make sure the cylinder pressure is not in excess of 2500 psi (17238 kPa). The cylinder connector (CGA 580) provided will screw into the cylinder valve. Tighten the nut to 40-50 ft. lbs. (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.lbs (14-20 N ? m). *Refer to Appendix for Flow Schematic.* Should the laboratory be equipped with high pressure nitrogen outlets, make sure the pressure at these outlets is not in excess of 2500 psi (17238 kPa). Connect the high pressure hose and gauge assembly into this outlet.
4. If the high pressure supply is in excess of the 2500 psi rating for the instrument, a pressure regulator will be required to reduce the pressure to the instrument. A regulator suitable for this purpose, rated at 6000 psi (41369 kPa), maximum inlet pressure is available as an option. Use of this regulator also requires the use of a higher pressure inlet gland. The (CGA 580) normally supplied is not to be used in excess of 3000 psi (20685) kPa). Hose and fittings supplied are suitable for use after the regulator.

5. Set the instrument's operating voltage if required. 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. Pull the voltage selector out of the module, rotate it to the desired voltage setting, and place it back in the module. Select the black fuse drawer and the short 10 amp 5 X 20 mm European fuses for 230 volt operation. The tan fuse drawer that holds the long 15 amp 1/4 X 1 1/4 in fuses is used for 115 volt operation. Replace the fuse drawer with its fuses.

6. Put the power switch in the off (O) position.
7. 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 15 amperes, connect the power cable to it.

If the power source is 230 volt, an appropriate 230 volt power cable must be obtained. It should be rated for 10 amperes.

8. Provide a clean purge fluid container. It should have an opening large enough for the 1/4 plastic tubing provided and inlet weight. The opening should not be so large that debris can fall in and contaminate the fluid.
9. Connect the tubing from the container to the PURGE port. The purge fluid is used to purge air from the filtrate system.
10. Remove the shipping retainer from the top of the Collector Tube on the right side of the instrument.
11. Open the door by pulling the bottom of the door latch outward and then rotating it about 90 degrees.
12. Remove the shipping retainer from near the top of the cell assembly.
13. 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.
14. Holding the cell up, pull the Tilt Lock Release (Refer to Fig. 6) 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.
15. 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.***

16. Place the main power switch on the lower right side to the "I" or ON position. The screen will display "PLEASE WAIT" for several seconds. This will be followed by the copyright screen for several seconds. The "MAIN MENU" screen will be displayed next. This screen will remain until one of the options of the menu is selected and entered. Refer to Section 5 "KEYPAD FUNCTIONS" and Section 6 "SCREEN FUNCTIONS" for details on use of the instruments controls.
17. Follow the procedures of Section 11 "PROCEDURE FOR CALIBRATION" before attempting to run a test.

## **SECTION 15 PRINTER INSTALLATION**

The Model 90 requires a serial printer capable of operating at 9600 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, P/N 35677, is suitable for connecting a standard serial printer to the "PRINTER" port on the right side of the instrument. No additional steps are required to enable the printing feature of the instrument.

### **CAUTION**

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 it is not on line or is out of paper, no warnings will be given. However, if the data is not printed during the test it can be printed at the completion of the test from the "DATA ACCESS MENU".

If the printer is on line and connected to the Model 90, it will print. A form feed can be sent to the printer to put it at the top of a page from the "TEST MENU" or the "DATA ACCESS MENU" by pressing the decimal key (.). When a test is started, the printer will print a header. 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 printing the header, a data point will be printed at the beginning of each step, and every 5 minutes after the start of the test. In addition, a data point is also printed after every 0.3 milliliters of total filtrate collected.

This method minimizes the number of data points saved. Since the filtrate Collector has a nominal capacity of 50 ml, the number of data points will normally be in the range of 175. Each data point printed will list all of the current conditions of the test.



## SECTION 16 CHANGING THE STANDARD TEST

The Standard Test sequence is loaded into battery backed memory when the instrument is manufactured. Most operators will find it satisfactory for running the more common fluids. It is important that a standard testing procedure be adopted so that dynamic filtration data from different operators can be compared.

The following procedure will enable an operator 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. This is done in the same manner as in Section 12 "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, stop bits at 1, with no parity check.
3. Turn on the Model 90.
4. Program the desired test sequence. Refer to Section 8 "PROGRAMMING A TEST SEQUENCE".
5. On any steps where it is desirable to allow the operator to choose the target temperature, use a target temperature of 41 °F (5 °C). An operator who selects the "STANDARD TEST" is given an opportunity to select a temperature (default = 300 °F, 149 °C). The operator's selected temperature is inserted by the Model 90 into the test sequence wherever the 5 °C temperature is found.
6. Use the "STOP" key to exit to the "TEST MENU".
7. When the "TEST MENU" is displayed, hold down the computer's Control (Ctrl) key and press the "C" key. This breaks the Model 90's normal operating program. The Model 90 will display the message "STOP in line.... ", followed by ">READY".
8. On the computer keyboard, type "CALL 6015H" followed by the "ENTER" key. This transfers the screen output to the external computer. A ">" prompt will appear on the screen of the computer.
9. On the computer keyboard, type "RROM2" and follow it with a press of the "Enter" key. The characters will be echoed on the computer's screen. The Model 90 will store the test that was just edited as the Standard Test in protected memory. It will then restart the normal operating program. The Model 90's screen will go through the same sequence of displays as if it had just been turned on. This completes the process.



## SECTION 17 TROUBLESHOOTING

PROBLEM	CAUSES
1. <i>Purge flow is low or stopped.</i>	<ul style="list-style-type: none"><li>A. No purge fluid in the reservoir.</li><li>B. Purge valve (B12) is plugged or damaged.</li><li>C. Purge valve (B12) is not being energized.</li><li>D. Purge fluid inlet is plugged.</li><li>E. The in-line filter in the hose from the Cell to the "CELL" port is plugged.</li><li>F. The purge pump is damaged or not running.</li></ul>
2. <i>The Cell is difficult to engage or disengage with the yoke.</i>	<ul style="list-style-type: none"><li>A. The joint between the Cell Head and the Cell Assembly is dirty or not properly lubricated.</li></ul>
3. <i>The displayed filtrate volume is much less than the volume of filtrate found in the collector.</i>	<ul style="list-style-type: none"><li>A. The Bleed Valve on the bottom of the collector is leaking.</li><li>B. The check valve located in the discharge tubing of the purge pump is leaking.</li><li>C. The collector Filtrate Piston "O" ring is leaking.</li><li>D. The collector has not been properly calibrated.</li><li>E. The collector sensor has been damaged. Look for pinched wires.</li><li>F. The "O" rings in the cell or collector hose quick-disconnects are leaking.</li></ul>
4. <i>The collector will not calibrate.</i>	<ul style="list-style-type: none"><li>G. The Filtrate Filter is plugged.</li><li>A. The collector sensor is damaged.</li><li>B. The connector at the top of the Collector Pivot Cap is disconnected or damaged.</li><li>C. The Volume Calibration Slug was not removed after the first step.</li></ul>
5. <i>The filtrate rate is very erratic.</i>	<ul style="list-style-type: none"><li>D. The Filtrate Piston is stuck.</li><li>A. All the air has not been purged from the filtrate system. Repeat purge.</li><li>B. The Collector Tube bore has not been properly lubricated, and the Filtrate Piston has a jerky motion.</li><li>C. The Collector Sensor has been damaged.</li></ul>
6. <i>A test is automatically</i>	

*terminated and the "MAIN MENU" is displayed.*

7. *A test is automatically terminated and the "TEST MENU" is displayed.*

8. *Step 99, automatic Cool & Vent was initiated.*

9. *The sample temperature is vary erratic, usually going high.*

10. *The instrument is slow in reaching sample temperature or fails to do so.*

11. *The instrument fails to reach target HP pressure.*

12. *The instrument fails to reach or has trouble maintaining the differential pressure.*

13. *The HP supply cylinder pressure drops when the instrument is not running a test.*

- A. The power failed.
  - B. The internal DC power supply has erratic output.
  - C. An intermittent short or overload is occurring in the internal DC power circuit.
  - D. An intermittent open circuit is occurring in the power supply circuit to the internal computer.
- A. The drive motor exceeded the rpm limit. The number "1" will be the last thing printed on the printer.
  - B. The temperature limit has been exceeded in the sample. The number "2" will be the last thing printed on the printer.
  - C. The temperature limit has been exceeded on the heater. The number "4" will be the last thing printed on the printer.
  - D. The target shear rate was not achieved. The instrument executed an automatic step 99 cool and vent.
- A. The target shear rate was not achieved. The instrument will beep intermittently before cooling.
  - A. The RTD temperature device is failing.
  - B. The sample temperature module is defective (B9).
- A. The door heater is miss-adjusted, so that it does not have full contact with the cell when the door is closed.
  - B. The door heater thermocouple has failed.
  - C. The door heater temperature module is defective (B11).
- A. The HP supply pressure is too low.
  - B. There is a leak in the system.
  - C. The relief valve on the head of the cell is leaking.
- A. One or more of the valves B3C, B3B, B3G, B3D or B3A are leaking.
  - B. The electrical feed through at the top of the collector Pivot Cap is leaking.
- A. There is a leak in the hose connection to the instrument or the cylinder.
  - B. There is a leak in the internal tubing up to solenoid valves B3F and B3C.
  - C. One or both of the solenoid valves B3F and B3C are leaking.

14. *The instrument fails to reach target shear rate, but the drive motor can be heard turning.*
- A. The Shear Shaft was not put in the instrument before starting the test.
  - B. The Shear Shaft is binding due to damaged bearings.
  - C. The Shear Shaft has been locked by a filter cake build up on the surface of the Filter Core.
  - D. The speed sensor on the back of the head of the cell has failed or is disconnected.
  - E. The wiring from the speed sensor has been damaged.
  - F. The speed sense module (A8) has failed.
  - G. The drive belt is too loose, oily, or has come off.
  - H. The magnets on the blunt end of the Shear Shaft have been damaged.
15. *Excessive noise is heard from the cell while testing.*
- A. The ball bearing at the bottom of the cell is damaged.
  - B. The cell Shaft Bushing is worn so that the Magnet Follower (10) on the Shear Shaft is hitting the inside cell wall.
  - C. The drive belt is too tight.
16. *The total filtrate volume is much higher than expected.*
- A. The sample is unusual.
  - B. The Core Holder was insufficiently tightened or the gaskets are bad or omitted.
  - C. The "O" ring (30) at the bottom of the Cell Clamp (3) failed.
  - D. There was air in the filtrate system.
  - E. A lot of dissolved gas was in the filtrate.
  - F. The filtrate solenoid valve is leaking (B12).
17. *The Collector can not be opened after a test.*
- A. 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.
18. *When turned on, the instrument displays "PLEASE WAIT" and does nothing else.*
- A. 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 (C2).
19. *The drive motor and/or heater will not start.*
- A. The door heater is too hot.
  - B. The Door Interlock Switch (K1) striker is not depressing the switch when the door is closed.
  - C. An internal fuse is blown.

20. *The life of the Shear Shaft ball bearing is too short.*

- A. Highly abrasive samples are being tested.
- B. The bearing was insufficient cleaned between test.
- C. Impact damage has occurred from rapid assembly.
- D. Misalignment during cell closing jammed the bearing and Shear Shaft.

21. *Test will not start because of an erroneous "out of position" message.*

- A. The interlock switch or its linkage is out of adjustment or damaged.

## SECTION 18 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 routinely all the "O" Rings be replaced after 5000 degree hours of service. A cell "O" Ring failure would ruin a test and could release hot sample inside the instrument around the heaters.

### 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
Cell Ball Bearing	As Required
Shear Shaft Race	As Required
Drive Belt	As Required
Catch Pan	As Required

#### DRIVE ROTOR AND BUSHING LUBRICATION

*(Refer to Fig. 4)*

Grease the drive rotor and busing [8] every 10 thousand °C hours (kChr). This is done using a standard grease gun that fits zerk grease fittings. Pump 1 to 2 milliliters grease into the bushing through the zerk fitting [43]. This is a very small amount. Excessive grease will be slung all over the interior of the instrument and cause excessive friction in the drive. A high temperature grease such as Dow Corning #1292 should be used.

#### SHEAR SHAFT BUSHING INSPECTION

The Shear Shaft Bushing [22] should be removed and checked for wear every 10 kChr. It is removed by:

1. Remove the bottom cell assembly and the shear shaft assembly. Refer to Section 10 "CLEANING AFTER A TEST".
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 [4] and unscrew it.
3. Lift the plastic bushing and "O" Ring [28] out of the top of the Drive Housing when it has been removed. Sometimes the "O" ring sticks to the bottom of the Cell Top [5]. It can be knocked off with a screwdriver.
4. Measure the inside diameter of the bushing and replace if it is over 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 [28] (P/N E8018) 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.

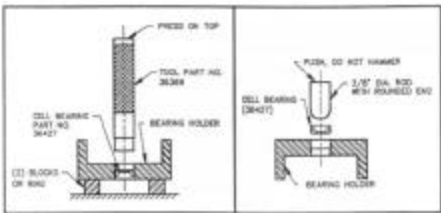
**CELL BALL BEARING REPLACEMENT**

The outer race [19] of the bearing is mounted in the bearing support [11]. Refer to Figure 8 and 9.

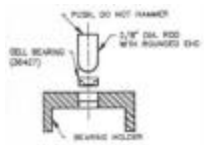
1. Set the Bearing Holder, with the Bearing down, on a support. There must be enough clearance underneath the Bearing so that it can drop out under the bearing holder.
2. Push or tap tool (P/N 36369) to remove the old bearing.

Note: If the bearing is corroded in place and can not be removed, it can be corroded out in a few days by soaking it in a strong solution of table salt and water.

3. Thoroughly clean the bearing cavity in the Bearing Holder.
4. Place the Bearing Holder on a work surface with the bearing cavity up.
5. Position the Bearing on the Bearing Holder with the balls up.
6. Use the rounded end of a plastic or wooden rod to push the Bearing into the Bearing Holder. Do not hammer on it.



**Fig. 8 - BEARING REMOVAL**

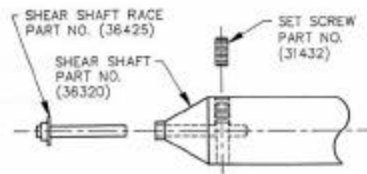


**Fig. 9 - BEARING INSTALLATION**

## SHEAR SHAFT RACE REPLACEMENT

The Shear Shaft Race [33] is assembled into the tapered end of the Shear Shaft. Refer to Figure 10.

1. Loosen the 8-32 hex socket set screw [42] in the side of the shear shaft [21] 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.



**Fig. 10 - SHEAR SHAFT RACE REPLACEMENT**

## DRIVE BELT REPLACEMENT OR ADJUSTMENT

*(Refer to Fig. 6)*

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 [5] 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. The drive motor can be slid all the way in, 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, then tighten the set screws.
6. Replace the tubing fittings if they were removed. Tighten 1/6 turn after they are snug.

## **CLEANING THE CATCH PAN**

The Catch Pan is located just behind the Yoke near the bottom. It is used to catch any spillage from around the cell and prevent it from getting into the bottom of the instrument. The Catch Pan also incorporates the "Cell-In-Place" switch linkage.

### **REMOVAL:**

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. Refer to Section 19 "REPAIR".
4. Remove the Catch Pan by lifting up to release its tabs from over the Yoke and slide it out.

### **REPLACEMENT:**

1. When replacing the Catch Pan, make sure the center bar of the switch linkage is pointed toward the back of the instrument. The linkage bar on the end of the Catch Pan must be positioned under the plunger of the switch.
2. After the catch pan has been replaced 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.

## SECTION 19

### REPAIR

Most servicing of the instrument will require the removal of the Left Side/Back, ell shaped panel. In addition some procedures require removal of the Cover. The right side panel rarely requires removal.

#### MAIN POWER FUSE REPLACEMENT

Two fuses protect all of the instrument power. They are located in the Power Inlet Module just above the power cord on the right side of the instrument. These are 15 ampere for 115 Volt operation or 10 ampere for 230 Volt operation.

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 if necessary.
4. Replace the fuse drawer.

#### INTERNAL FUSE REPLACEMENT

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 side in the inner back panel. Looking at the back panel, these fuses are:

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

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.

#### REPLACING THE COLLECTOR SENSOR (Refer to Fig. 5)

The collector Sensor [1] cannot be repaired, it must be replaced if it fails.

##### DISASSEMBLY:

1. Lift and swing the Filtrate Tube [2] and the Inlet Cap [6] out away from the yoke.
2. Slide the Filtrate Tube and Inlet Cap downward off the Pivot Cap [15] and put these parts aside. The Piston [5] can remain in the Filtrate Tube.
3. Hold the upper nut [10] with a wrench, then unscrew and remove the Magnet [8] and the lower nut [10] inside the magnet.

4. Unscrew the Sensor Holder [2] from the Pivot Cap. Slide the Sensor Holder off the Sensor [1] 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 is to be reused, clean its external surfaces only. Do not immerse the Collector Sensor in fluids.

**ASSEMBLY:**

Assemble the Sensor into the Pivot Cap, and the Filtrate Tube and Inlet Cap in the reverse order observing the following:

**CAUTION**

IT IS VERY EASY TO PINCH THE LEADS OF THE  
SENSOR WHEN INSTALLING IT. DAMAGING THE  
LEADS OF THE SENSOR WILL DESTROY IT.

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 that the wires come out of 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, close to the Pivot Cap.
5. With the free hand, slide the Sensor Holder over the Sensor until it touches the hand holding the Sensor. Hold both pieces with the top hand.
6. Push up on 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 screw it onto the Pivot Cap firmly by hand. Do not expect the Sensor Holder to screw all the way onto the Pivot Cap. The Sensor's rod can be released at this time.
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.

**LEFT SIDE/BACK PANEL REMOVAL:**

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 of panel slightly toward the back of the instrument then lift it upward to clear the pins at the bottom and remove.

## **LEFT SIDE/BACK PANEL ASSEMBLY**

1. Tilt the top of the panel slightly toward the back 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. Tilt the top of the panel forward and guide the three holes along the left bottom edge over the pins.
2. Install and tighten the screws.

## **TOP COVER REMOVAL**

1. Remove Left Side/Back panel as above.
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 (3) 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 cover upward enough 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 up-side-down next to the left side of the instrument. It is not necessary to disconnect any of the cables.

## **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 and install and tighten the screws.
4. Position the wires and cables neatly into the channel.

## SOLENOID VALVES REPAIR (Refer to Fig. 11)

The instrument uses eight solenoid valves, seven of which have 1/32 inch orifice and one which has 3/64 orifice. The 1/32 orifice valves are used in the gas pressurization system and the 3/64 orifice valve is used in the filtrate system. The filtrate valve is valve (B12). Problems associated with the solenoid valves usually result from debris getting between the pilot and seat of the valve. In this case the valve usually can be repaired by cleaning. Problems can also occur if the seals of the valve are damaged. In this case the complete valve must be replaced. In the case where the pin/pilot is plastic, it may be repairable by replacing the pin/pilot with P/N P5034.

### SOLENOID VALVE DISASSEMBLY:

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.

#### CAUTION

DO NOT ENERGIZE THE COIL WHEN IT IS OFF. THIS WILL OVERHEAT THE COIL AND DAMAGE IT.

5. Slide the tool (P/N 36376) over the valve Stem [3], and unscrew it. Do not lose the small parts inside it.
6. With the stem is removed, the pilot guide may not come with it. It may be necessary to remove the Pilot Guide [8] using a small screwdriver or rod. The seat can now be examined and cleaned as necessary. Note that in some valves the Pilot Guide is not used. The seat can not be removed.

### SOLENOID VALVE ASSEMBLY:

1. Clean all of the parts of the valve carefully.
2. If used, replace the Pilot Guide into the valve Body.
3. Put the rubber Gasket [7] into the valve Body.
4. Assemble the small parts [4, 5, 6] into the Stem.
5. Screw the Stem into the Body. Tighten using the same special tool.
6. Replace coil and secure with the nut.

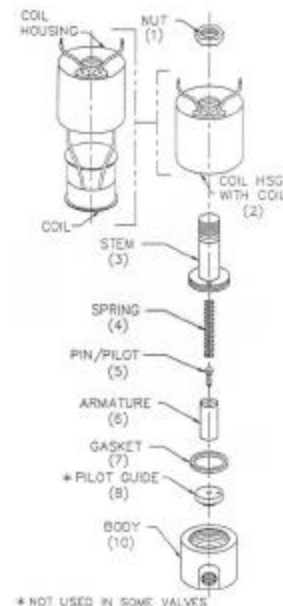


Fig. 11 - SOLENOID VALVE REPAIR

## PURGE PUMP REPAIR

(Refer to Fig. 12)

The Purge Pump is a small volume gear pump magnetically coupled to its motor. Should the pump be over pressured or jammed, the magnetic coupling will disengage allowing the motor to continue to turn. This prevents damage to the motor. Stopping the motor will re-establish 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 it is necessary to remove the pump head from the motor.

### **PUMP HEAD REMOVAL:**

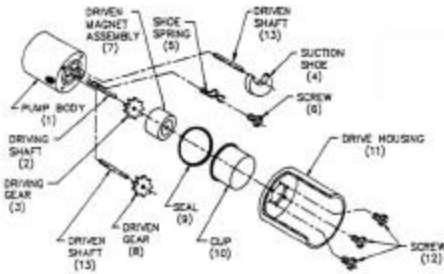
1. Remove the Cell.
2. Turn off the instrument power and disconnect the power cord.
3. Remove the Left Side/Back Panel.
4. Remove the Catch Pan (See above).
5. Using a 7/16 end wrench, remove the suction and discharge tube connections to the pump.
6. Using a stubby screwdriver remove the two screws holding the Pump Head to the motor then remove the Pump Head.

### **PUMP HEAD DISASSEMBLY:**

1. Mark the orientation of the Drive Housing [11] to the Pump Body [1] for identification at re-assembly.
2. Remove the three screws [12] from inside the Drive Housing and separate the drive housing from the rest of the pump.
3. Remove the Magnet Cup [10] and Magnet Assembly [7]. This will expose the Gears [3 and 8] and the Suction Shoe [4].
4. For ease of cleaning and inspection, the Gears and Suction Shoe can be disassembled by removing screw [6]. If any of these parts are found to be damaged, they should be replaced.

### **PUMP HEAD REASSEMBLY:**

1. Make sure 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], engaging the Spline Pins into the holes of the Gear.
3. Verify 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 in-lbs (1.1 N ? m).



**Fig. 12 - PURGE PUMP**

**PUMP HEAD INSTALLATION:**

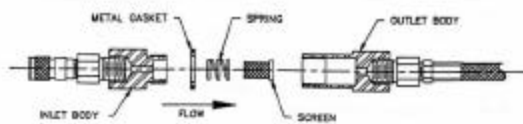
1. Reassemble the pump head onto its motor. Observe that the tube fittings align properly with the tubes, and the flow arrow on the pump head is pointed in the correct direction. Install and tighten the two mounting screws.
2. Connect the inlet and discharge tube connections. Tighten until snug, then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

**CLEANING THE FILTRATE LINE FILTER**

*(Refer to Fig. 13)*

The Filtrate Line Filter is located in the hose from the Cell Cap to the right side "CELL" port of the instrument. It stops particles big enough to plug the filtrate solenoid valve.

1. Disassemble the filter by holding it 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. Re-assemble in the order shown and tighten.



**Fig. 13 - FILTRATE LINE SCREEN**



## REPLACING THE CORE CLAMP "O" RING [30] Figure 4 and 7.

1. Place the Cell Cap Assembly on the locking pins on the base of the instrument.
2. Unscrew the Filter Core Clamp [3] from the Cell Cap [1] using the handle of the Filter Core Holder Wrench (P/N 36378) in the slot of the Core Clamp.
3. Remove and replace the "O" Ring [30].
4. Clean and reassemble the parts.

## QUICK-DISCONNECT "O" RING REPLACEMENT

The Quick disconnect hose couplings are sealed with "O" rings in the body of the coupler. One "O" ring seals between the body and the stem, while the other seals the body from leaking when the coupler is disconnected. The following steps assume the connector has been removed from the tubing or hose.

1. 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. Holding the connector by the hex, either in a vice or with a wrench, and placing a 1/16 in. punch through the ball pocket holes unscrew the body [5] from the fitting adapter [11].

### NOTE

An alternate method of removing the body is to hold the connector by the hex, as in step 3, the using pliers unscrew the body from the fitting adapter. If this method is used, steps 1, and 2 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 body from the threaded end.
6. Lubricate then install a new stem "O" ring into the body and a new check valve "O" ring into the valve seat.
7. Reassemble in the reverse order of steps 4 and 3, and if disassembled, steps 2, and 1.

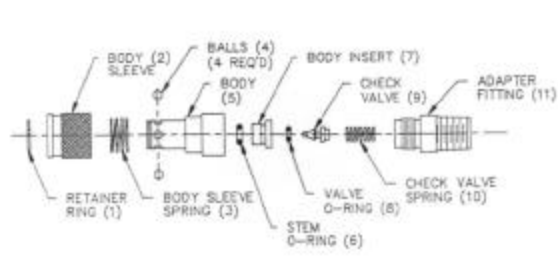


Fig. 14 - QUICK DISCONNECT

## **PURGE PUMP RELIEF VALVE**

The purge pump relief valve is located inside the Left Side/Back cover along the side of the purge pump. It is connected in parallel with the pump and allows the pump to bypass whenever the pump outlet pressure exceeds about 40 psi (276 kPa). This relief pressure may be adjusted by loosening the pressure adjust lock screw at the outlet end of the valve, then turning the adjusting screw. Screwing clockwise increases pressure, counterclockwise decreases pressure. Use a hex socket wrench to make the adjustment. Retighten the lock screw.

### **REMOVAL**

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.

### **DIS-ASSEMBLY, CLEANING, AND ASSEMBLY**

1. Disassemble by removing the insert lock screw using a hex socket wrench 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 to be made.
2. Clean all parts.
3. Inspect and replace "O" ring if damaged.
4. Re-assemble in the reverse order. Lubricate the "O" ring and make sure it is not damaged while assembling it.

### **INSTALLATION**

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.

## SECTION 20 PARTS LIST

The MODEL 90 parts list includes operating supplies, and parts suggested for replacement in Section 18, "MAINTENANCE". Selected additional parts which could fail and require replacement are also listed. Installation of these parts will require a qualified technician.

PART NO.	DESCRIPTION
10798	O RING - 2- 5/16 X 2 1/2 X 3/32
28623	FUSE 5 AMP (5 BOX)
30352	O RING 13/16 X 1 X 3/32
36310	SOLENOID VALVE (FILTRATE)
36319	BLEED VALVE
36325	CORE GASKET
36328	FILTRATE SENSOR
36330	TEMPERATURE PROBE (RTD)
36354	CALIBRATION SLUG
36369	BEARING REMOVAL TOOL
36376	SOLENOID VALVE WRENCH
36378	FILTER HOLDER WRENCH
36425	CELL BALL BEARING
36427	SHEAR SHAFT INNER RACE
38407	GAUGE 3000#
70004	FUSE 2 AMP (5 BOX)
89005	FILTER TUBE 5 MICRON
89010	FILTER TUBE 10 MICRON
89020	FILTER TUBE 20 MICRON
89035	FILTER TUBE 35 MICRON
89060	FILTER TUBE 60 MICRON
89090	FILTER TUBE 90 MICRON
89150	FILTER TUBE 150 MICRON
89190	FILTER TUBE 190 MICRON
A4003	BALL, BLEED VALVE
A7014	POWER CORD
C4008	GLAND NUT
C4009	GLAND

(cont.)

**PARTS LIST (cont.)**

PART NO.	DESCRIPTION
C5005	FILTER 15 MICRON N <sub>2</sub> LINE
C5007	FILTER (SCREEN) FILTRATE
C6077	QUICK DISCONNECT BODY
C7005	FUSE 15 AMP
C7006	EUROPEAN FUSE 10 AMP
E8014	O RING 1-3/8 X 1-9/16 x 3/32
E8015	O RING 1-3/8 x 1-1/2 x 1/16
E8016	O RING 2-1/2 x 2-11/16 x 3/32
E8017	O RING 2-1/16 X 2-1/4 X 3/32
E8018	O RING 7/8 X 1-1/16 X 3/32
E8020	O RING 1/16 X 3/16 X 1/16
E8021	O RING 5/32 X 9/32 X 1/16
E8019	O RING 3/4 X 1 X 1/8
F7006	** PRESSURE REGULATOR, 6000 PSI
F9010	SNAP RING
H3001	* V BELT
H8018	* THERMOCOUPLE (DOOR HEATER)
J1005	* PURGE PUMP
J5004	* CARTRIDGE HEATER
J6009	HOSE 6 FT.
L3979	TYGON TUBING 1/4 ID (FT)
L7213	RUBBER FEET
P1004	* PRESSURE TRANSDUCER
P1005	* PRESSURE TRANSDUCER
P4004	SNAP RING PLIERS
P5019	* SOLENOID VALVE
P5020	CHECK VALVE
P5024	* RUPTURE DISC
P5034	PIN, FOR SOLENOID VALVES P5019, 36310

*\* These parts require a qualified technician for installation*

*\*\* Optional*

## SECTION 21 ACCESSORIES LIST

This is a list of accessories that are shipped with the model 90.

PART NO.	DESCRIPTION	QTY.
10798	O RING 2-5/16 x 2-1/2 #141-75	5
30352	O RING 13/16 x 1 #117-75	5
35677	CABLE, SERIAL	1
36325	GASKET, CORE	10
36354	SLUG, CALIBRATION	1
36363	NITROGEN SUPPLY ASSEMBLY	1
36369	TOOL, BEARING REMOVAL	1
36376	WRENCH, SOLENOID VALVE	1
36378	TOOL, FILTER HOLDER INSTALLER	1
36424	GAUGE, CELL SAMPLE FILL	1
36425	RACE, SHEAR SHAFT	3
36427	BEARING, OUTER RACE	8
89035	TUBE , CERAMIC FILTER 35 MICRON (10 PER BOX)	1 BOX
A7014	POWER CABLE 115 VOLT	1
A4098	CONNECTOR, SERIAL ADAPTER 25 PIN TO 9 PIN	1
C7004	FUSE 5 AMP 125 VOLT	2
C7006	FUSE, EUROPEAN 10 AMP, 5 X 20 MM	4
E1058	INSTRUCTION MANUAL	1
E3095	FUSE HOLDER, EUROPEAN	1
E8014	O RING 1-3/8 X 3/32	5
E8015	O RING 1-3/8 X 1/16	10
E8016	O RING 2-1/2 X 3/32	5
E8017	O RING 2-1/16 X 3/32	3
E8018	O RING 7/8 X 3/32	5
E8019	O RING 0.734 X 1/8	5
E8020	O RING 1/16 X 1/16	4
E8021	O RING 5/32 X 1/16	4
F4160	GREASE, HIGH TEMPERATURE	1
F9010	RETAINER, INTERNAL 1.653 I.D., SS	1
L3904	INSERT, BARBED 1/4	1
L3979	TUBING, TYGON 1/4 X 1/16 (PER FOOT)	3 FT.
L4026	LUBRICANT, GREASE	1
P4004	PLIERS, TRUARC SNAP RING	1
P4005	GUN, GREASE CARTRIDGE OR SUCTION LOAD	1

## **APPENDIX**

FLOW SCHEMATIC

WIRING SCHEMATIC

FIGURE 4 - CELL ASSEMBLY

FIGURE 5 - COLLECTOR ASSEMBLY

For more information, please contact us:

ExpotechUSA  
10700 Rockley Road  
Houston, Texas 77099  
USA

281-496-0900 [voice]

281-496-0400 [fax]

E-mail: sales@expotechusa.com

Website: www.ExpotechUSA.com