NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

TELESCOPE OPERATIONS DIVISION REPORT NO. 9

# OPERATION OF CRYOGENIC SYSTEMS

DAVID P. WILLIAMS

AUGUST 1972

50 COPIES

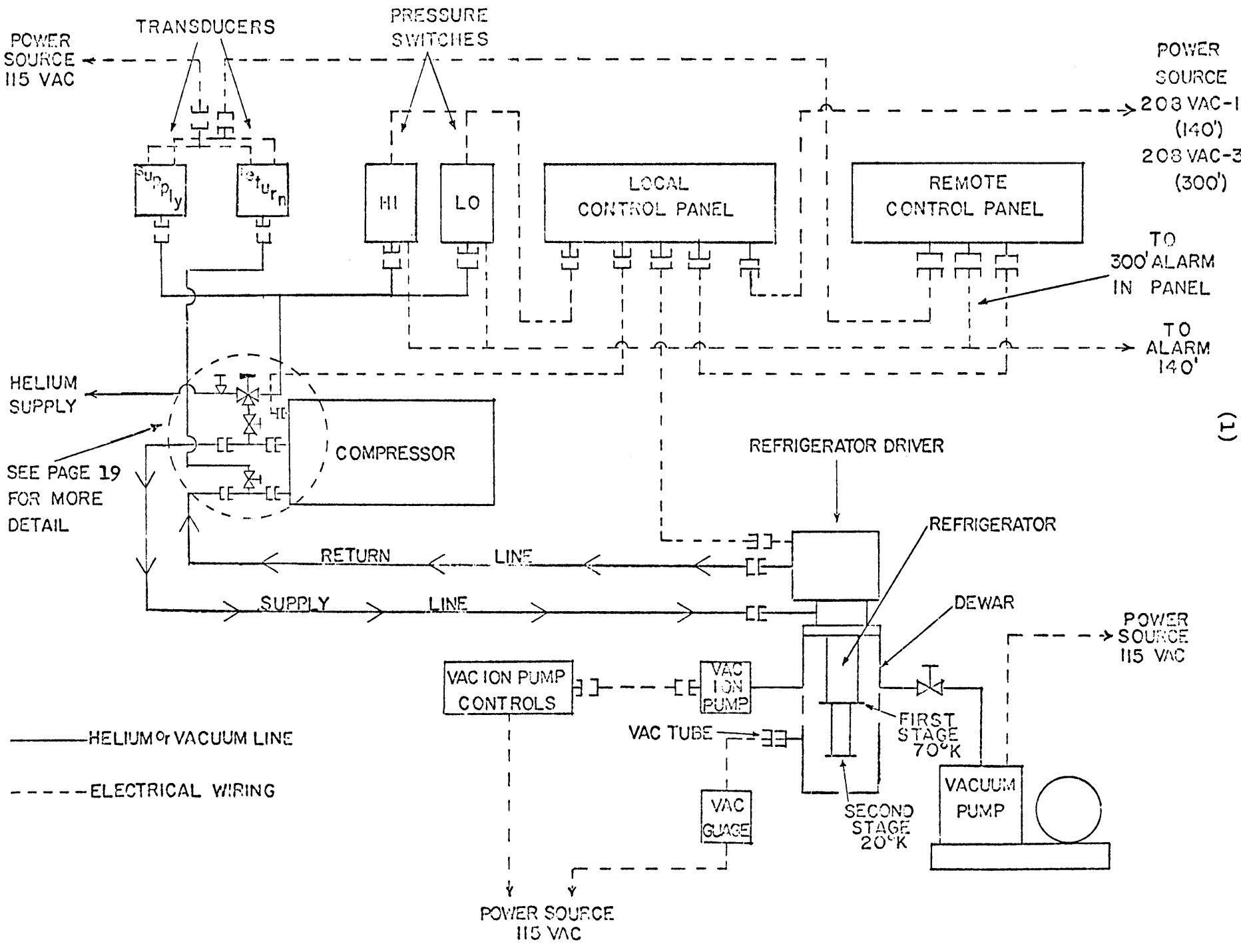
INDEX

INDEX (continued)



PHOTOGRAPHS

# HELIUM REFRIGERATOR SYSTEM SCHEMATICS (140' & 300')




(1)

I. THEORY OF OPERATION

A. The helium refrigerator is based on a principle similar to that used in a household refrigerator, namely, that most gases cool when they are expanded. The low temperatures that are obtainable with these refrigerators results from the use of:

1. an effecient thermodynamic cycle
2. special heat exchangers
3. two stages of refrigeration
4. the refrigerant - helium - that remains fluid even at temperatures approaching absolute zero (-273°C, -459.4°F, 0°K)

II. PRE-START

A. Vacuum Integrity of Dewar

With the roughing pump (Fig. 1), evacuate to 30 microns of Hg before starting the refrigerator. At 10 microns or less bring on the vac ion pump (Fig. 2) if there is one installed on the system. Be sure to remove the rough pump at the 5-10 micron level of vacuum. Upon cooldown the dewar should reach an evacuation pressure of $10^{-6}$ to $10^{-8}$ Torr. (1 micron equals $10^{-3}$ Torr.)

B. Compressor Pressures

Start up pressure on all compressors should be 135 psi on both the supply and return lines. Additionally, on the Model 1020 compressor (Fig. 3) at the 300' the oil pressure should also indicate 135 psi.

(See page 19 for charging instructions)

C. Compressor Oil Level

On all compressors oil should be visible in the oil sight glass (Fig. 4). If oil is not visible do not start the compressor.

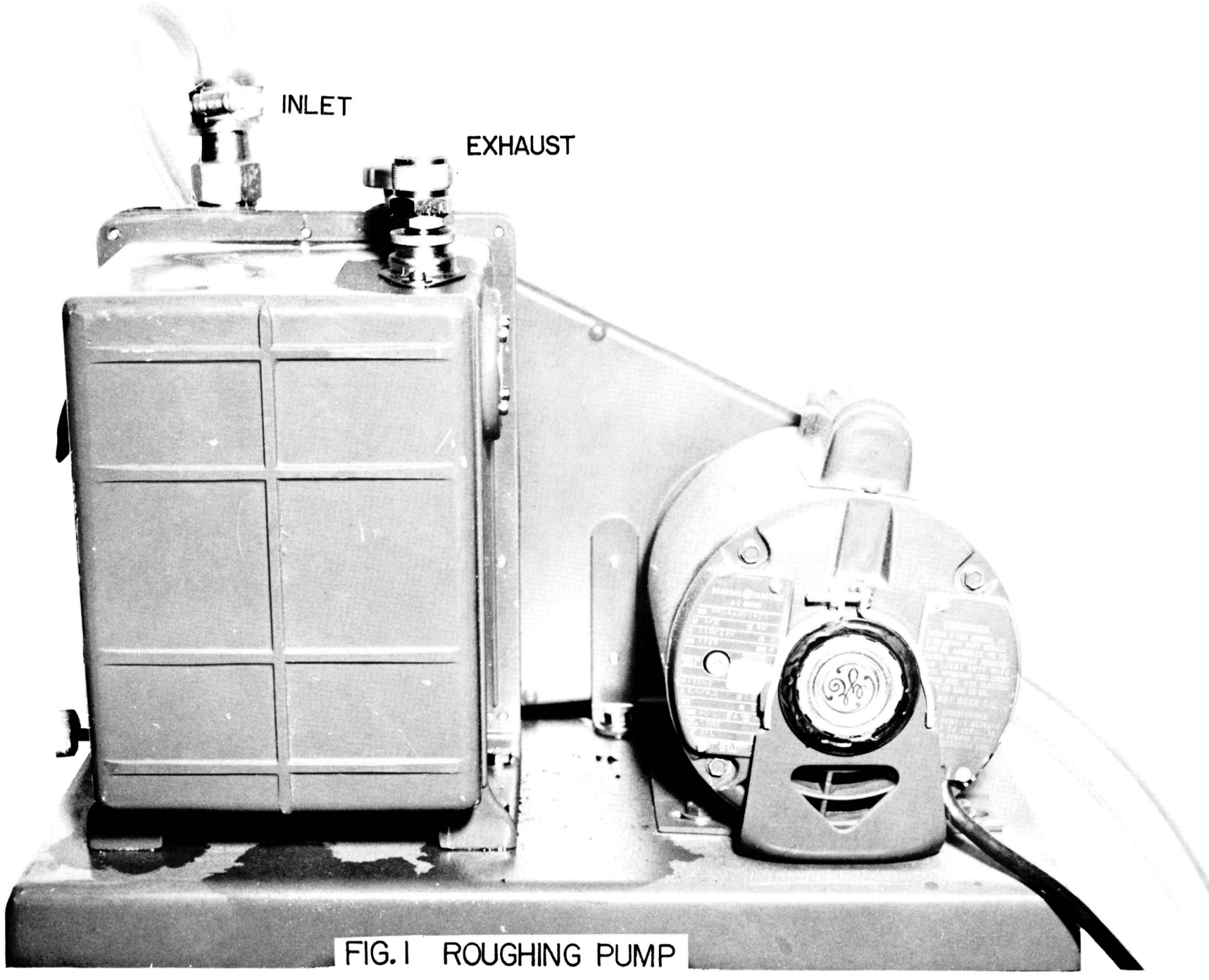



FIG. 1 ROUGHING PUMP

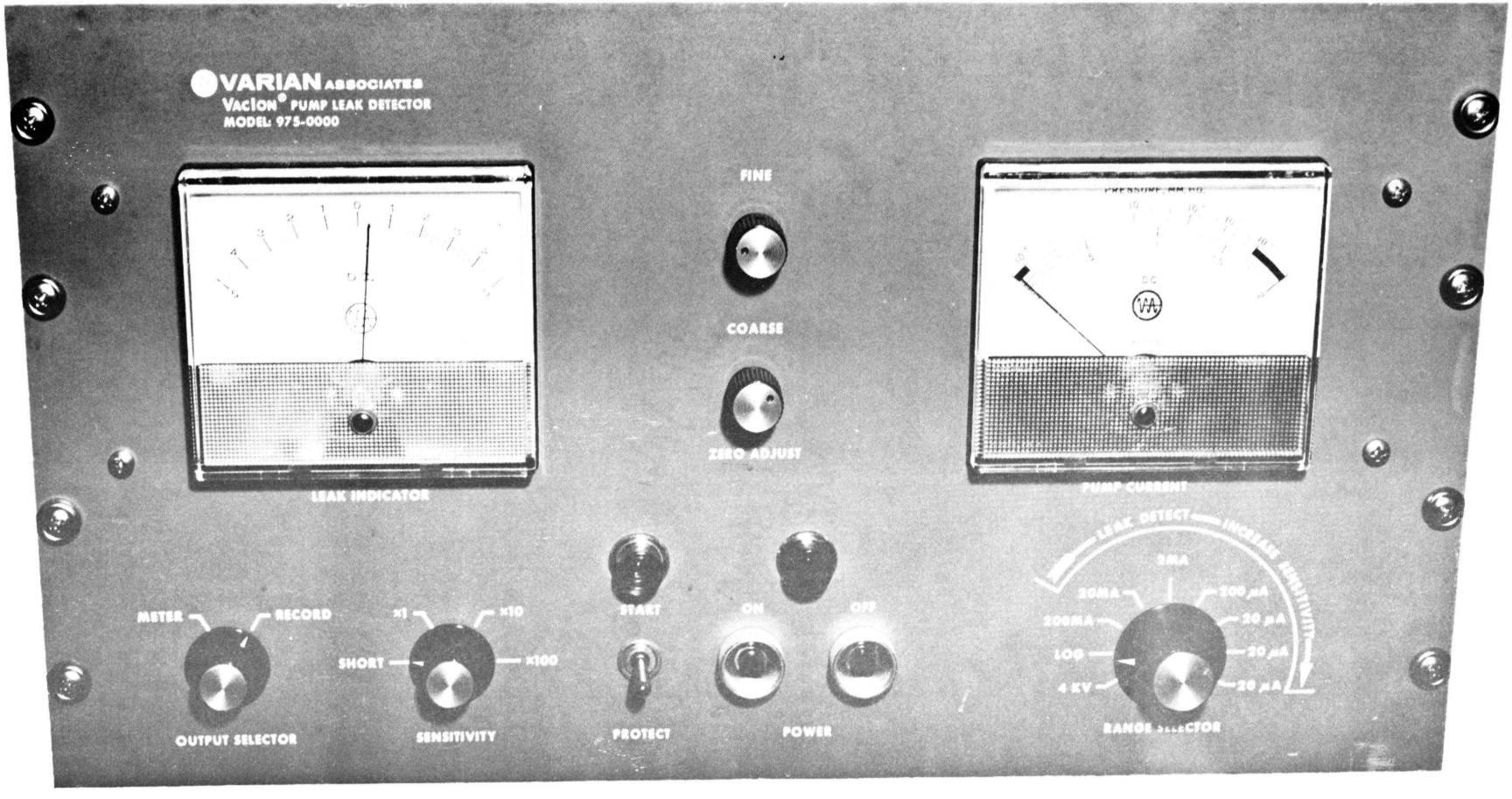



FIG.2 VAC ION PUMP CONTROL

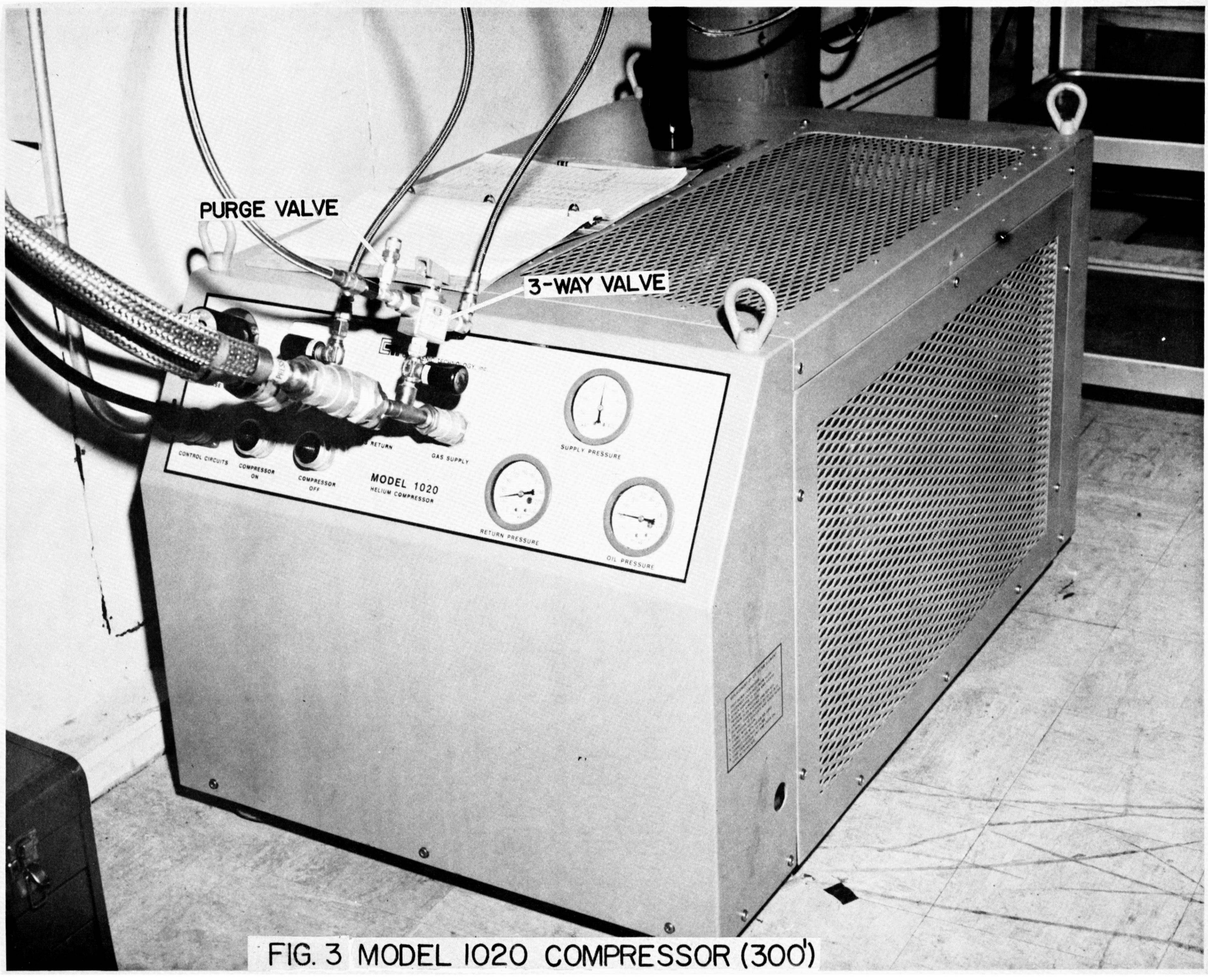



FIG. 3 MODEL 1020 COMPRESSOR (300')

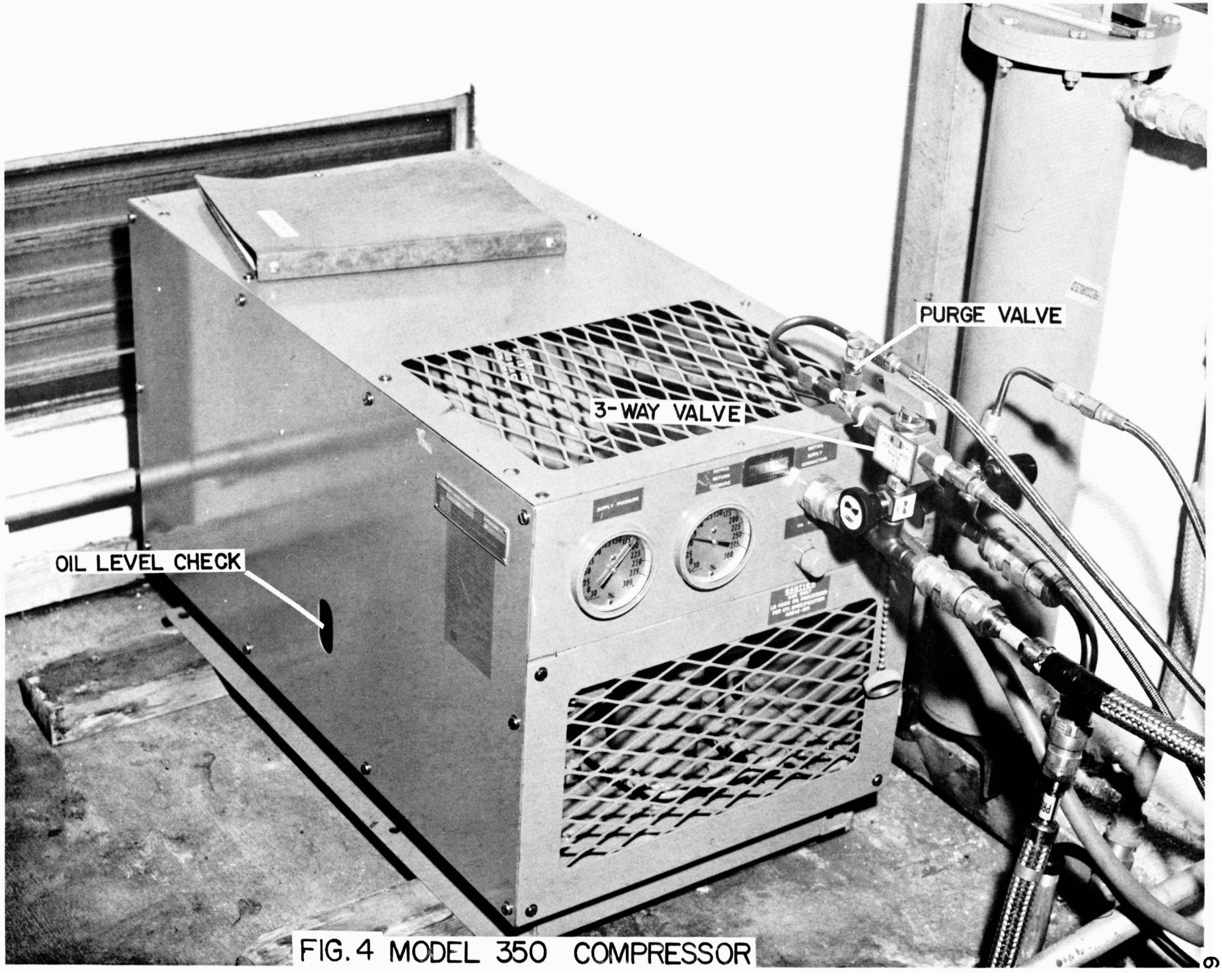



FIG. 4 MODEL 350 COMPRESSOR

III. START UP.

A. Refrigerator

Depress the on-off switch to start the refrigerator and note the current reading on the remote panel (Fig. 5). This only indicates that the refrigerator driver is getting power. Somebody should check to be certain that the driver is rotating in the proper direction (CW). The driver is quite capable of run-in the wrong direction with no different indication on the ammeter.

B. Compressor

Depress the compressor on - off switch to start compressor and carefully watch the pressure gauges. On the Model 350 (Fig. 4) or 340 (Fig. 6) compressors, the supply pressure should advance to approximately 220 - 230 psi. The return gauge should indicate approx. 30 - 45 psi. On the Model 1020 (Fig. 3) at the 300' the supply should be approx. 240 - 250 psi, the return 10 - 20 psi, and the oil pressure gauge approx. 45 - 60 psi. The above pressures are for compressors without the manifold bypasses installed. The compressors at the lab are equipped with manifolds and the pressures differ from those at the telescopes. The supply pressure will be approx. 195 - 205 psi and the return 50 - 60 psi. These pressures will not change greatly because of the manifold which keeps the differential pressure at nearly the same from start up to cooldown.

C. Vac Ion Pump

The vac ion pump should not be started until the rough pump has achieved a vacuum of 5 microns or less. To start, set the breaker on the control panel (Fig. 2) to start & then turn power on. With the meter on the 200 ma scale the current should read approx. 150 ma, and the voltage should increase steadily toward max. voltage. Once the pump has warmed up and max. voltage output has been obtained the current should start decreasing.

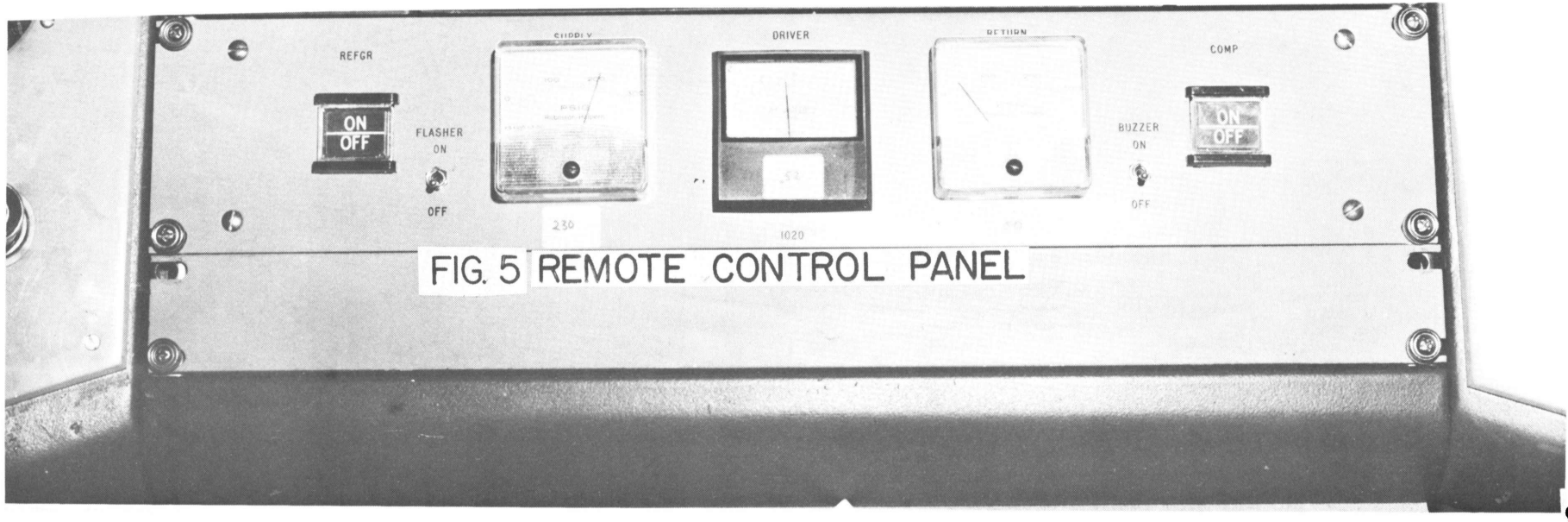



FIG. 5 REMOTE CONTROL PANEL

As soon as the current has dropped to 20 ma set the toggle switch to run or protect, in which position the pump is protected by the breaker. From this time on the vacuum scale (Torr) should be monitered with an occasional look at the current and voltage readings. If everything is working properly the dewar should reach a vacuum level of $10^{-7}$ Torr or better. Should the breaker ever kick the system should be carefully inspected before trying to restart the pump. In case of power failure this unit will not restart itself.

IV. RUNNING

A. Refrigerator (Fig. 7)

The ammeter on the remote control panel is the only indication that the refrigerator driver has power, other than the performance of the cooling cycle itself. The ammeter will read .5 to .6 amps, but this only indicates that power is being supplied to the drive motor. The drive motor will continue to draw the same current at a dead stall, so therefore the ammeter is not all that important as a monitering device, and should not be depended upon in case of refrigerator troubles.

B. Compressor

Upon cooldown the pressure differential will decrease. On the 340 (Fig. 6), 350 (Fig. 4), model compressors the supply pressure will be 175 - 190 psi and the return pressure will read approx. 60 - 70 psi. The 1020 (Fig. 3) compressor at the 300' will have slightly higher pressures. The supply will be approx. 195 - 205 psi, the return pressure will be 25 - 40 psi, and the oil pressure 50 - 65 psi. The above pressures are without manifolds. For pressures with manifolds installed see Section III, B in this paper.

C. Operating Log

The operator on duty or some other person at the telescope should check the compressor and log the following information once a shift.

1. Date

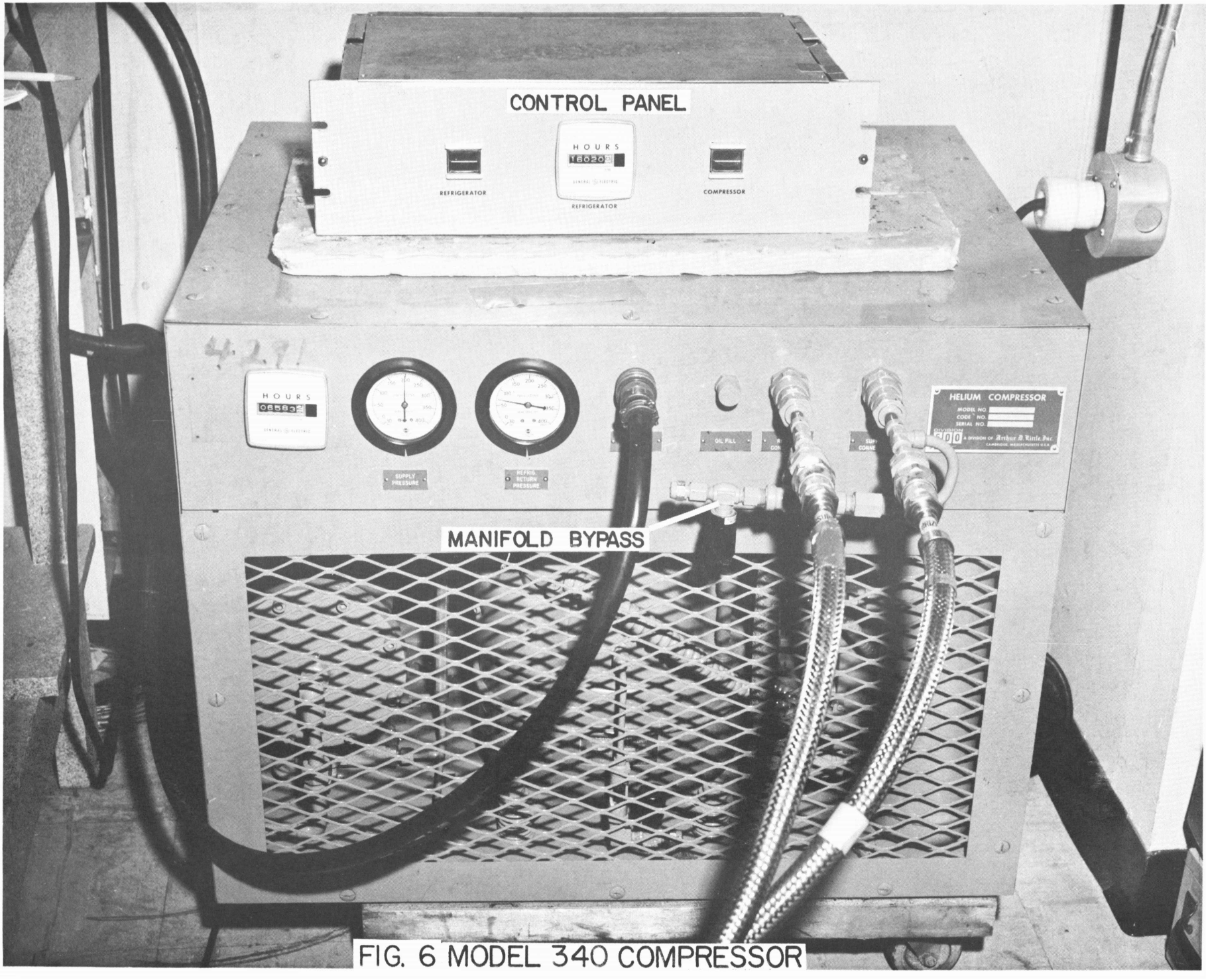



FIG. 6 MODEL 340 COMPRESSOR

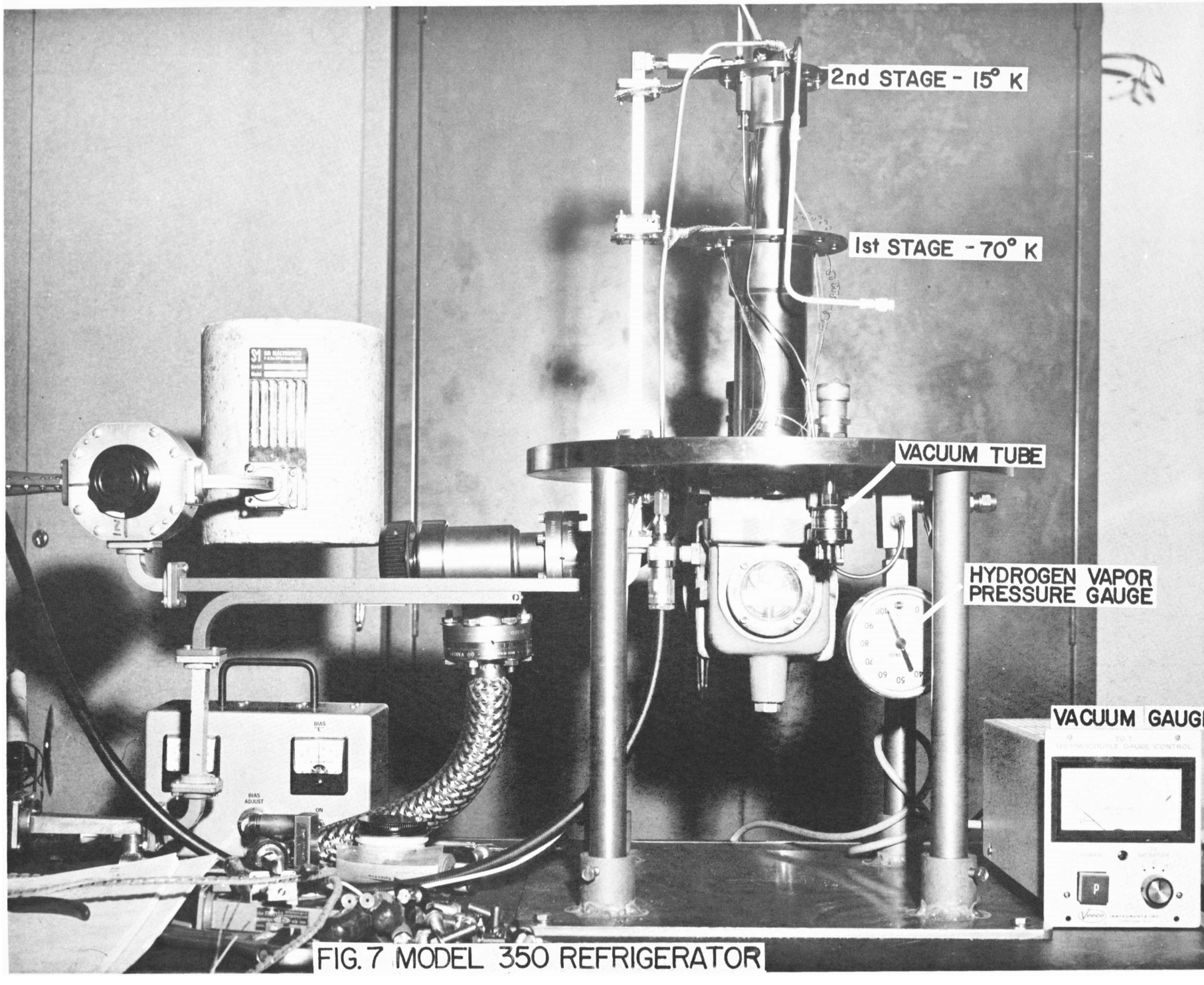



FIG. 7 MODEL 350 REFRIGERATOR

2. Time (EST or EDT)
3. ETM (Elapsed Time Meter) Reading - Time meter on the control panels (Fig. 8 & 9). On the 340, 350 model systems their is only one meter, which is the refrigerator elapsed time (log this). On the 1020 system at the 300' their are two meters, one on the compressor (Fig. 3) and one on the control panel (log this one).
4. Supply pressure
5. Return pressure
6. Oil pressure (300' system only)
7. Outside temperature
8. Remarks - such as:
    a. recharging the system with helium
    b. oil level reading
    c. temperature extremes in building
    d. any other information that may be important to the running of the system

V. PROBLEMS

A. Pressure Drops

A slow pressure drop indicates there is a very small leak somewhere in the system (compressor, refrigerator/driver, or the interconnecting piping). This is no real problem in only that the system will need recharging occasionally. (See page 19 on procedure for recharging)

A fast pressure drop indicates a bad leak such as a broken line, ruptured seal or some other malfunction. In such a case as this the system must be shutdown until the problem has been cleared. Should this problem occur at either the 300' or 140' the compressor will automatically stop due to pressure switches (Fig. 8 & 9) in the system. (See page 16, Section VI, A)

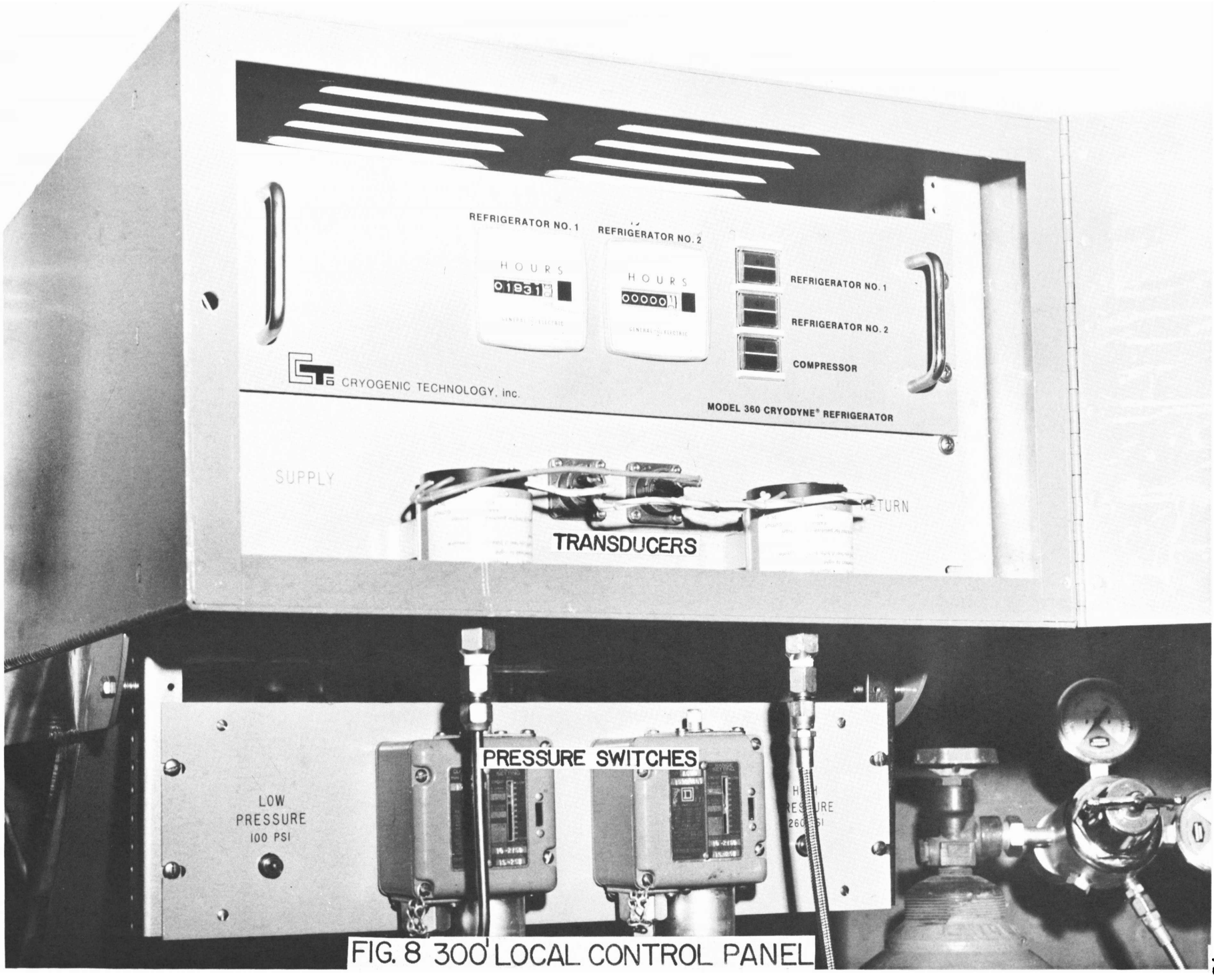



FIG. 8 300 LOCAL CONTROL PANEL


FIG. 9 140' LOCAL CONTROL PANEL

B. Pressure Rises

A slow pressure rise above the normal operating pressures may be associated with a rise in refrigeration temperature due to lose of vacuum, thermal problems, contamination of refrigerator, or possibly paramp overheating. Should this condition continue the compressor differential pressure will eventually increase to pressures near that of start up, which will necessitate shutting the system down.

A fast pressure rise would indicate a restriction of gas flow which could be caused by refrigerator failure or compressor problems. In such an instance the compressor will automatically stop because of the pressure switch. (See page 16, Section VI, A)

C. Vacuum Problems

If the vacuum gauge in the back end rack indicates a decaying vacuum or a rapid changing vacuum, this will probably be associated with a rise or cycling of the refrigerator temperature. Do not shut the system down until both the electronics and cryogenics people have been notified. Some systems do not have vacuum gauges installed that can be read from the control room. In this case the above can be ignored.

D. Compressor Failure

Several things may cause a compressor to fail, of which some have already been discussed. In Section II, B it was stated that start pressure should be 135 psi. Should the pressure be below 110 psi the compressor will not start. Also if the pressure becomes too high, the pressure switch will stop the compressor. If the temperature of the room in which the compressor is located becomes too high the compressor may stop because of thermal switches on the compressor housing. Failure of some component in the control panel may cause a compressor to stop.

E. Power Failure

1. 140'

A power failure at the 140' should not cause any problems, once power has been restored, although a certain amount of precaution should be taken. The refrigerator and compressor should restart as soon as power has been restored, but should be checked to be certain. If the power should be off for any length of time (this should not be the case because of emergency power), time should be allowed for the refrigerator to cool back to normal operating temperature.

2. 300'

The system at the 300' is somewhat different. The compressor will not restart if there has been a power failure. The compressor is controlled by a starter relay behind a switch with a momentary contact. If the power fails the relay falls out and will not start automatically because of the momentary contacts on the start switch. Therefore the compressor must be restarted manually by pressing the on - off switch twice. The refrigerator should restart as soon as the power has been restored.

3. Laboratory

All compressors at the Laboratory in both Green Bank and CV should follow the same pattern as the compressor at the 140'.

VI. SAFETY FEATURES

A. Pressure Switches (Fig. 8 & 9)

The compressors at the 140' and 300' are protected by pressure switches which automatically shut the compressor off if the pressure becomes abnormally high or low. The switches at the 300' are set to open at 225 psi (high), and 125

(low). At the 300' only, these switches are bypassed at start-up due to high differential pressures. The switches at the 140' are set at 250 (high), and 125 (low).

The compressors at the labs in Green Bank and Charlottesville are not protected by pressure switches and therefore should be monitered more closely.

B. Thermal Switches

All compressors have thermal switch attached to the housing. These switches, controlled by a thermocouple, will open up if the compressor overheats, and will not reclose until it has cooled to a safe level again.

C. Circuit Breakers

The compressor and refrigerator power (208 V 1Ø) at the 140' is on circuit breaker #19 on the 2nd floor in the pump room.

The compressor power (208 V 3Ø) at the 300' is on circuit breakers #18-19-20 in the generator room and the refrigerator and control panel power (110 V) at this telescope is circuit breaker #4 on the south wall of the relay shack opposite the compressor.

The circuit breaker for the compressor in George Behrens laboratory is #26 and 28 in the small breaker box located on the north wall in the instrument repair laboratory.

The breaker for the compressor in the other front end laboratory is #4 located in the first office on the north wall of the laboratory.

D. Alarms

The compressor at the 140' has an audio and visual alarm at the console alerting the operator of problems with the system. This alarm is part of the

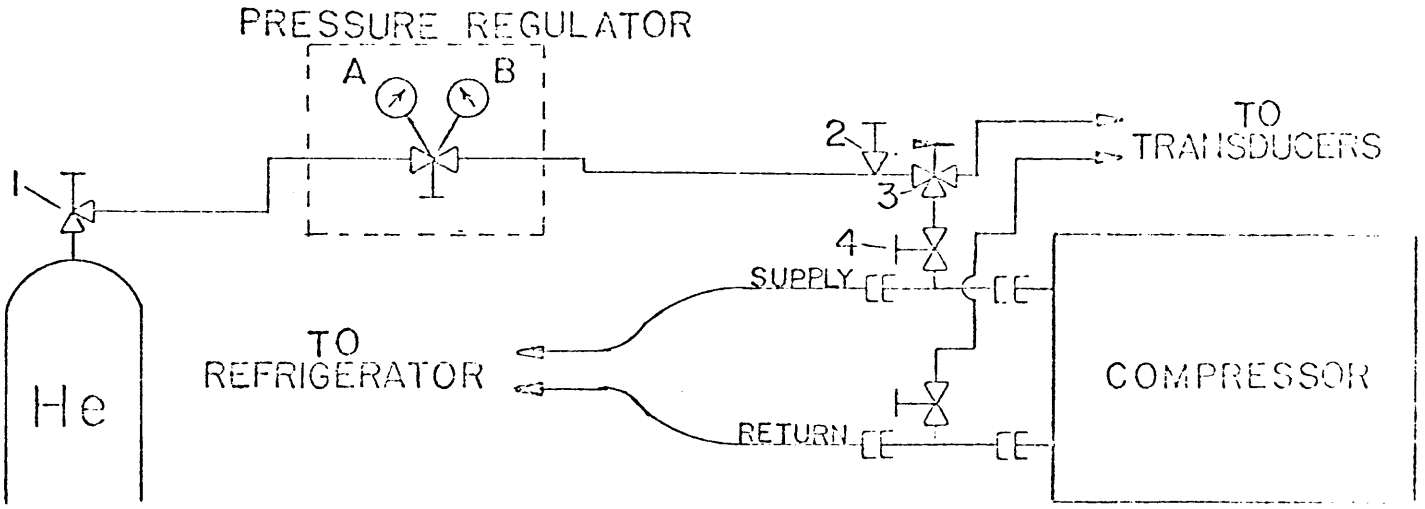
telescope alarm system and is labeled He System Lo Pressure.

The compressor alarm at the 300' will sound a buzzer and turn on all lights on the remote control panel.

Both of these alarms, which are controlled by the pressure switches, indicate that the compressor has shutdown due to abnormal pressures.

The alarm system at the 300' is bypassed at start-up. (See Section VI, A)

# COMPRESSOR RECHARGING PROCEDURE




To recharge or add helium to the system follow these directions:

A. Open valve (1) on top of He tank Gauge (A) on the pressure regulator should indicate 200 psi or more, or the system cannot be charged.

B. Assuming gauge (A) indicates 200 psi or more turn the handle of the regulator clockwise until gauge (B) indicates charging pressure desired. See page 2 for appropriate pressure.

C. Next open valve (2), which is a purge valve, and let it blow for approximately 5 seconds to remove all air from the charging line, then close snugly. Do not over tighten or the valve may be damaged.

D. Turn valve (3)-which is a three-way valve-, to the position necessary to receive gas from the supply tank. When this valve is so arranged, the supply pressure gauge on the compressor will gradually assume the same pressure as set on the pressure regulator gauge (B). Do not reset this valve until the return pressure has had time to advance an equal amount. When the desired pressures have been obtained, rotate valve (3) back to the position which

passes the He onto the transducers and pressure switches.

E. Close valve (1) on top of He tank and open valve (2) until all He has been removed from regulator and line. Then back off regulator control to approximately its original position.

# ELECTRICAL SCHEMATICS 300' SYSTEM

A1-Alarm(Buzzer)
A2-Alarm(Flashing Light Module)
C1 & C2 - Capacitor 6.5μf, 360V 60Hz
C3 & C4- " 1.75μf, " 50Hz
E-Elapsed Time Meter
CR-Control Relay
G-Green Light
M1-Starter Relay
OL-Overload
R-Red Light
R-Return
R1-R10-Resistors 2500 OHMS 8W.
R11 & R12- " 150 "
P1-Pressure Switch-High 250psi
P2- " " -Low 125psi
S-Supply
SW1-Comp. Switch
SW2 & SW4-Ref. Switch
SW3-Local/Remote Switch
TR-Transducers