HYDROGEN-OXYGEN ELECTROLYTIC REGENERATIVE FUEL CELLS

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1. INTRODUCTION

The completion of the design for the prototype fuel cell was accomplished during the past month. The tentative designs shown in the recent quarterly progress report were modified in certain respects as the result of a complete stress analysis. Fabrication of the fuel cell battery assembly will be started within a few days.

Single cell testing has been confined to characterizing total cell polarization while operating under conditions of charge and discharge corresponding to the 750 nautical mile orbit.

Instrumentation for the orbital simulation is being assembled. Discharge will be through a fixed resistance; charging will be accomplished with a constant current power supply. A charging rate slightly in excess of that necessary to replenish the reactant gases consumed during the discharge phase will be used. The charging current will be stopped by a pressure sensing switch at a preselected pressure when the cell stack has reached full charge.

2. FINAL FUEL CELL DESIGN

Some minor modifications have been made to the design shown in the first quarterly report. It will be noticed in Fig. 1 that a larger radius has been used for the end caps of the outer casing. A stress analysis showed this to be necessary, and in addition the thickness of the casing flange had to be increased. The materials indicated in the quarterly report have all been retained.

Three assumptions concerning operating conditions and characteristics were made for the purpose of the stress analysis. These are (1) maximum working pressure is 400 psia, (2) test pressure for the casing is 600 psia, and (3) the compression on the asbestos is 800 psi. The compressive forces on the asbestos are determined by the spacing between the electrodes and the original asbestos thickness. The pressure necessary to compress 70 mil asbestos containing 0.7 gm of electrolyte/gm of asbestos to 40 mils (the spacing used in the present model) is originally 3300 psi. However, if the asbestos is first saturated with water, compressed to 40 mils, and then dried, it will expand back to about 49 mils and the pressure required to return it to 40 mils, with electrolyte, is now only 1100 psi. If the pre-compression is taken to 35 mils, it has been found that on drying the asbestos expands to about 46 mils and now it can be returned to 40 mils with a pressure of only 625 psi.

Fig. 2 shows the present separator design. Fig. 3 shows the oxygen end plate assembly containing storage space for the stearic acid. This design remains unchanged.

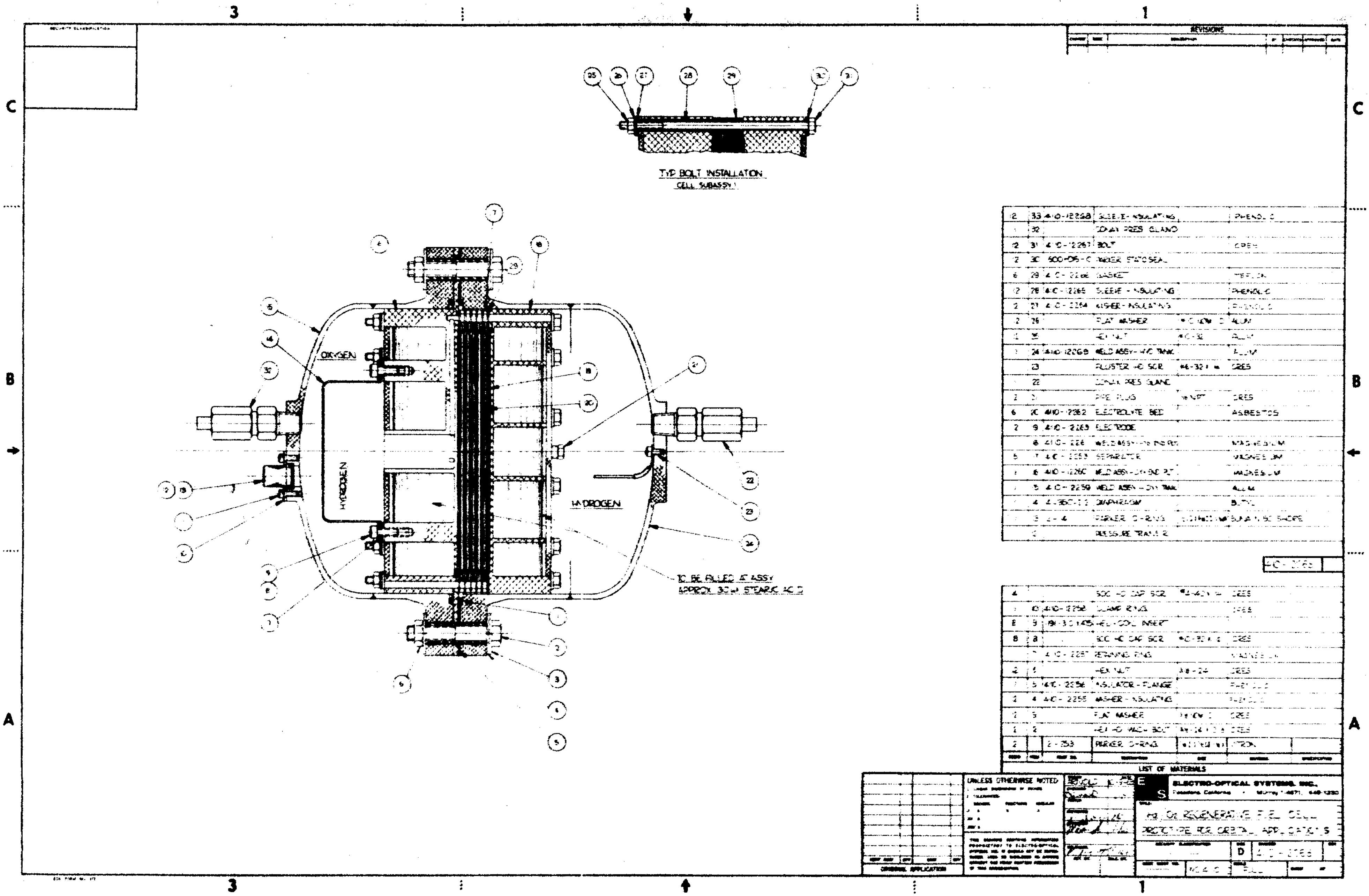

FIG. 1 FUEL CELL BATTERY, COMPLETE ASSEMBLY

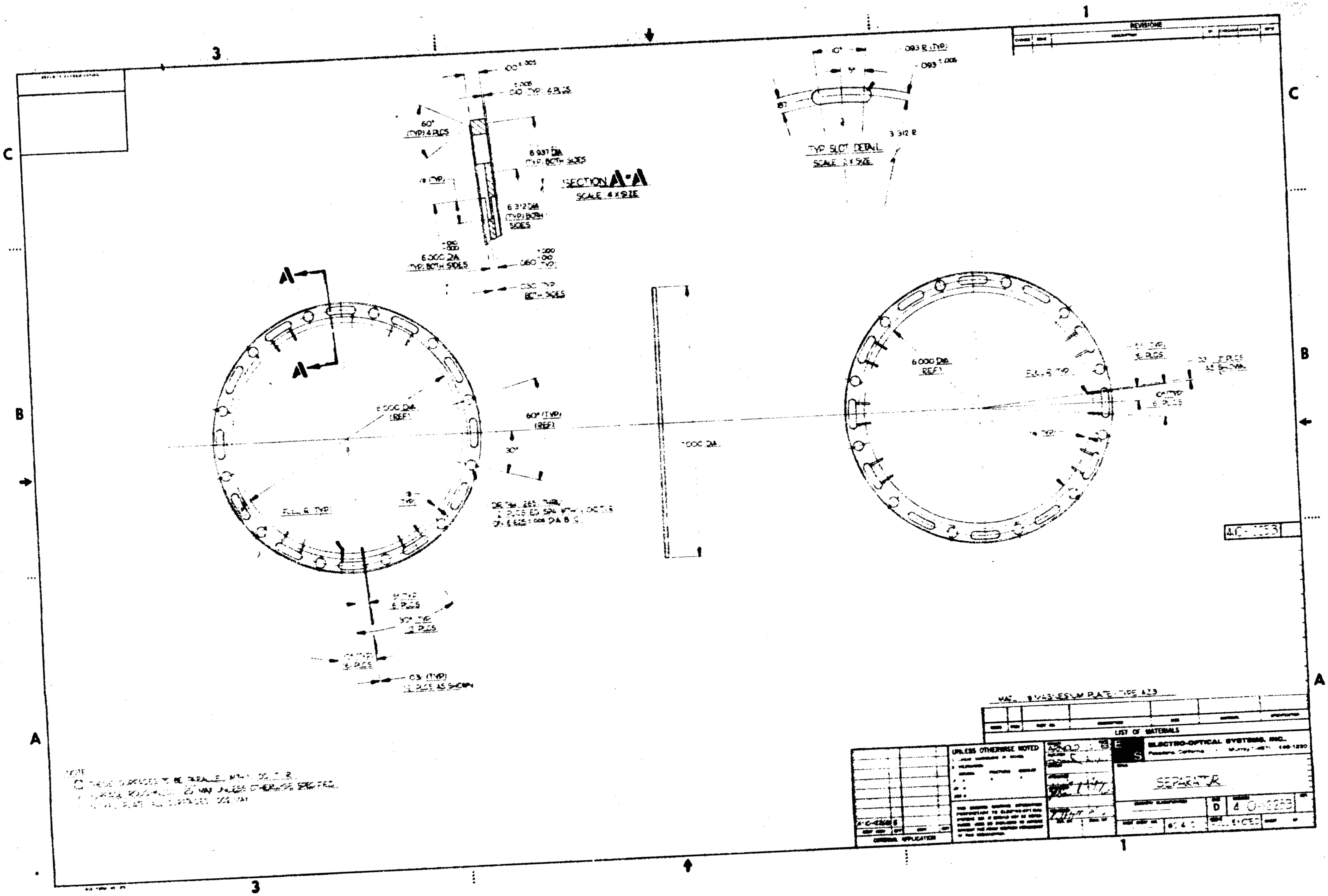

FIG. . SEPARATOR CONSTRUCTION

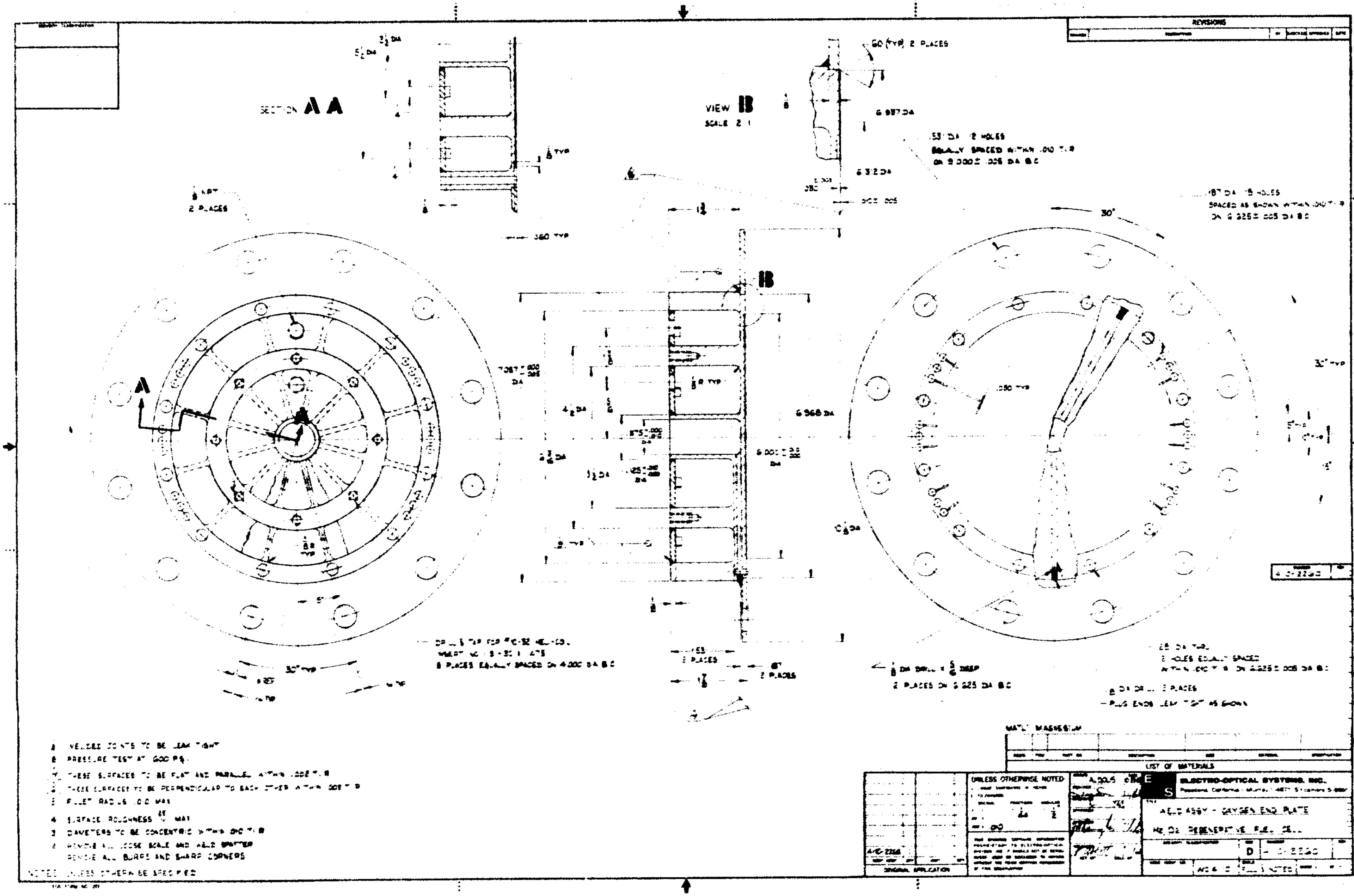

FIG. OXYGEN END PLATE

3. INSTRUMENTATION

A constant-current/constant voltage power supply will be used for the charging phase of each cycle. For a discharge at 19 amps, a charging current of 9.5 amps would be indicated if the fuel cell battery were running with 100 percent current efficiency. Because the current efficiency is less than 100 percent, and since the discharge current will very likely deviate from 19 amps, the charging rate will be about 10 amps. This means that the pressure will build up to the design pressure shortly before the end of the sunlight period in the 750 nautical mile orbit. A pressure sensing switch will stop the charging at the desired pressure level, i.e., 400 psia.

Discharge will be accomplished through a resistive load. Output current should remain relatively constant during most of the discharge period. Cycling will be accomplished by means of an Industrial Timing Corp. Model B continuous cycling timer.

Recording instrumentation is being assembled. It is presently assumed that a multi point strip chart recorder will be used to monitor the performance parameters.

4. SINGLE CELL PERFORMANCE STUDIES

Several performance studies were made during the month with a single cell having 2 1/4 inch diameter electrodes. The charging and discharging of the cell were done in a manner which corresponded in most respects to the way in which the complete fuel cell battery will be operated. The cell was charged and discharged at 70°C. The charging pressure was slightly above atmospheric, and the discharge pressure was 115 psia. After assembly the cell was charged for 76 minutes at 53 ma/cm^2, and then discharged 37.5 minutes at 104 ma/cm^2. These current densities correspond rather closely to the rates which will be used in the final unit.

The mid-point of the discharge curve was found to be about 0.75 volt. This is somewhat lower than the value (approximately 0.85 volt) which was indicated by previous polarization data, and assumed during the analytical phase. Subsequent experiments indicated partial flooding of the oxygen electrode to be the cause of poorer than anticipated performance. Improved polarization curves can be attained by providing a slight (approximately 0.5 psi) pressure differential across the cell with the oxygen on the high pressure side. The present single cell studies have been made with the pressures balanced.

The charge polarization characteristics are, however, slightly better than those assumed in the analysis. The assumed polarization curve indicated a charging voltage of 1.535 volts, whereas the midpoint of the charging curves in these recent experiments has been about 1.50 volts.

5. FUTURE PLANS

During the coming month the components for the final assembly will be built. Upon completion of these components the magnesium separators will be plated and initial testing will begin. These initial tests will be with a single cell in the system and finally the complete unit will be tested.

6. MANHOURS AND DOLLAR EXPENDITURES FOR PERIOD 28 SEP - 26 OCT 1963

Direct labor hours	585
Direct labor dollars	$2,701.25
Purchases and commitments	$ 223.26
Total expenditures	$6,780.29