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Hydrodynamics of Fischer-Tropsch Synthesis in Slurry Bubble Column Reactors

Quarterly Technical Progress Report

for the period 1 December 1984 - 28 February 1985

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I. Abstract

The design of the experimental apparatus for studies of hydrodynamic properties of a high molecular weight paraffin wax has been completed, and the final detailed drawings of the auxilliary metal vessels have been prepared. Shop fabrication of some of the metal vessels has been completed and for the remaining ones is in progress. All major purchase orders for equipment and instrumentation have been made, and most of the major items have been delivered. The on-site installation of equipment has been initiated.

II. Objective and Scope of Work

The overall objective of this contract is to determine effects of reactor geometry, distributor design, operating conditions (i.e., temperature and gas flow rate), and oxygenated compounds on hydrodynamics of slurry bubble column reactors for Fischer-Tropsch synthesis, using a hard paraffin wax as the liquid medium. To accomplish these objectives, the following specific tasks will be undertaken.

Task 1 - Project Work Plan

The objective of this task is to establish a detailed project work plan covering the entire period of performance of the contract, including estimated costs and manhours expended by month for each task.

Task 2 - Bubble Column Reactor Design/Construction

Two bubble columns made of borosilicate glass of approximately 2" ID and 9" ID, and 10 ft tall will be designed and assembled for measurement of the gas hold-up and the bubble size distribution. After the design, procurement of equipment and instrumentation, and construction of the unit is completed, a shakedown of test facilities will be made to verify achievement of planned operating conditions. During this period instruments will be calibrated.

Task 3 - Process Variable Studies

The objective of this task is to determine the effect of various system variables (e.g. gas flow rate, temperature, and addition of minor amounts of oxygenated compounds) on hydrodynamic properties using the two bubble columns (2" and 9" ID) and different types of distributors. All

experiments will be conducted using nitrogen at atmospheric pressure. It is planned to determine the following hydrodynamic characteristics: gas hold-up, flow regime characterization, bubble size distribution, and the gas-liquid interfacial area.

Task 4 - Correlation Development and Data Reduction

Correlations based on our experimental data for prediction of average gas hold-up and the gas-liquid interfacial area will be developed.

III. Summary of Progress

During the reporting period the following accomplishments have been made

- Design of all major vessels has been completed.
- Final detailed drawings for fabrication of metal containers and parts have been prepared.
- The wax storage tank, the gas-liquid separator, the expansion unit and the plenum chamber for the 2" ID bubble column have been fabricated.
- Most of the instruments have been received.
- The on-site installation of the bench scale unit for hydrodynamic studies has been initiated.

IV. Detailed Description of Technical Progress

The flow diagram of the unit for hydrodynamic studies was included in the previous Quarterly Report, but it is reproduced here again (Fig. 1) in order to facilitate the understanding of the progress made to date.

The instruments for measurement and control of gas flow rate (FC1 and FC2) for both bubble columns have been installed, as well as all the tubing up to the bubble columns inlet sections. The preheater is an electrically heated U-shaped tube (1/2" for the BC1, 1/4" for the BC2). The plenum chamber, the expansion unit for the 2" ID bubble column (BC2), and all required flanges have been fabricated. The flanges for the large diameter bubble column (BC1) have been fabricated, but we are still waiting for delivery of the 10" OD stainless steel tubing which is required for fabrication of the plenum chamber and the expansion unit for this column.

A storage tank for wax (1), and the gas-liquid separator (2) have been fabricated and installed. All instruments for temperature measurement, pressure measurement, and control have been delivered.

The revised detailed drawings of the expansion units and plenum chambers for both bubble columns are shown in Figures 2-5, and the final drawings of the gas-liquid separator (2), and the wax storage tank (1) are shown in Figs. 6 and 7.

Two stainless steel columns having similar dimensions as the glass bubble columns (i.e. both are 10 ft tall, one has a 9.5" ID, and the other 2" ID) have been designed and will be used to determine the axial gas hold-up variation by differential pressure method, and the bubble size distribution by wax withdrawal followed by rapid freezing. The use of glass columns for this purpose is not suitable, due to a large number of

glass/metal connections required which can cause frequent leakages of wax, and/or the breakage of glass at the glass/metal joints. A tentative position of liquid sampling ports, connections for differential pressure measurements, and the thermocouples (the small diameter column only) are shown in Fig. 8. For the 9.5" ID column a thermocouple well will be installed along the center and temperature measurement will be possible at any desired location along the column. A schematic arrangement of DP cell for axial pressure drop measurement is shown in Fig. 9. This arrangement enables one to measure the pressure drop across the distributor, and/or between any two locations along the column. Each of the four locations along the column can be connected to either the low (L) or the high (H) side of the DP cell. The differential pressure transducer with digital indicator (Validyne Model DP 15 TL) has been received.

V. Future Work

Fabrication of all metal parts and/or connections for the glass and stainless bubble columns will be completed, and all components of the apparatus will be installed. The instruments will be calibrated and shake-down of test facilities will be made to verify achievement of planned operating conditions.

VI. Figures

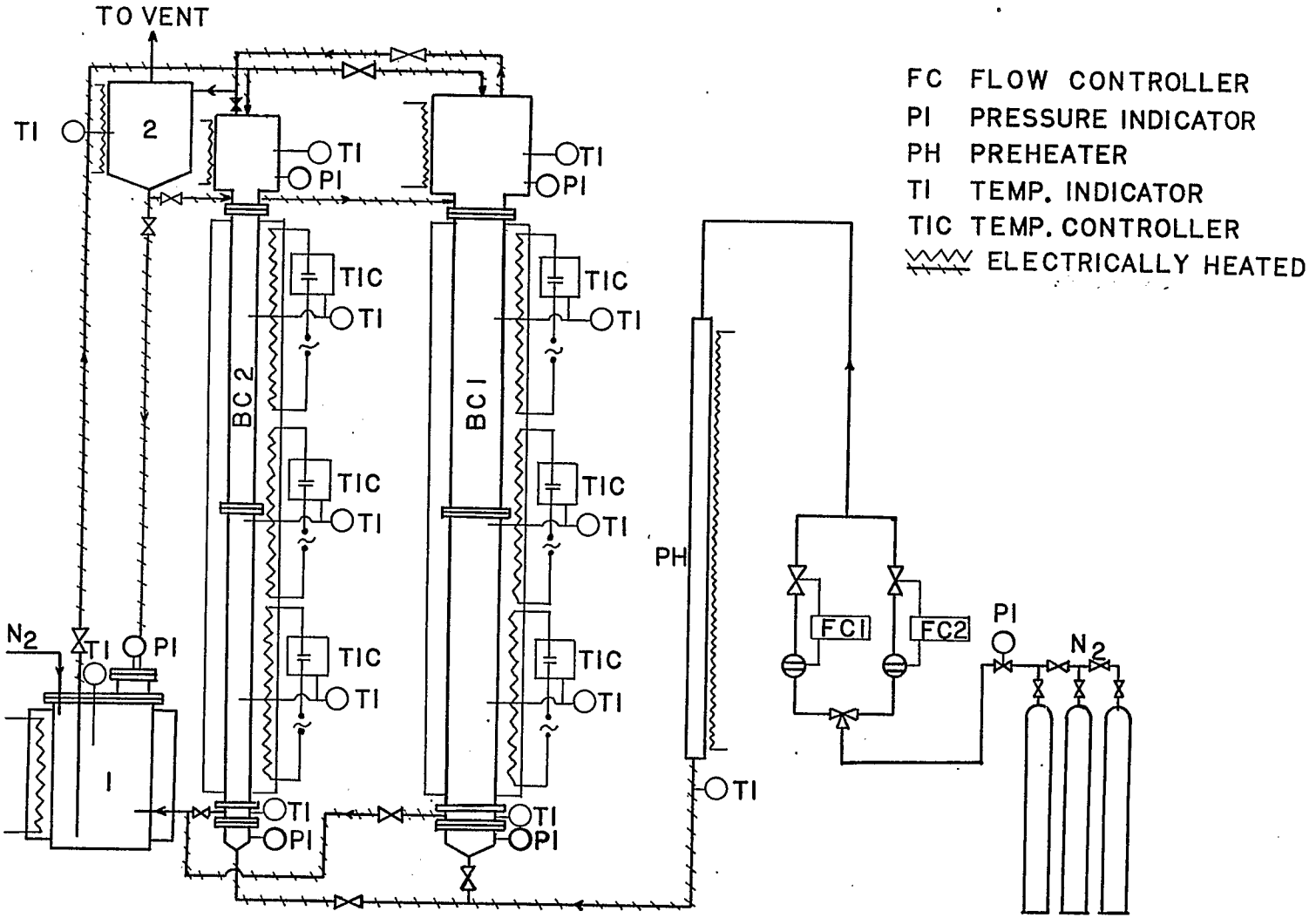

Figure 1. Flow diagram of experimental apparatus

Legend: 1- Storage tank; 2 - Gas-liquid separator; BC1 - Bubble column (I.D. = 22.9 cm); BC2 - Bubble column (ID = 5.1 cm).

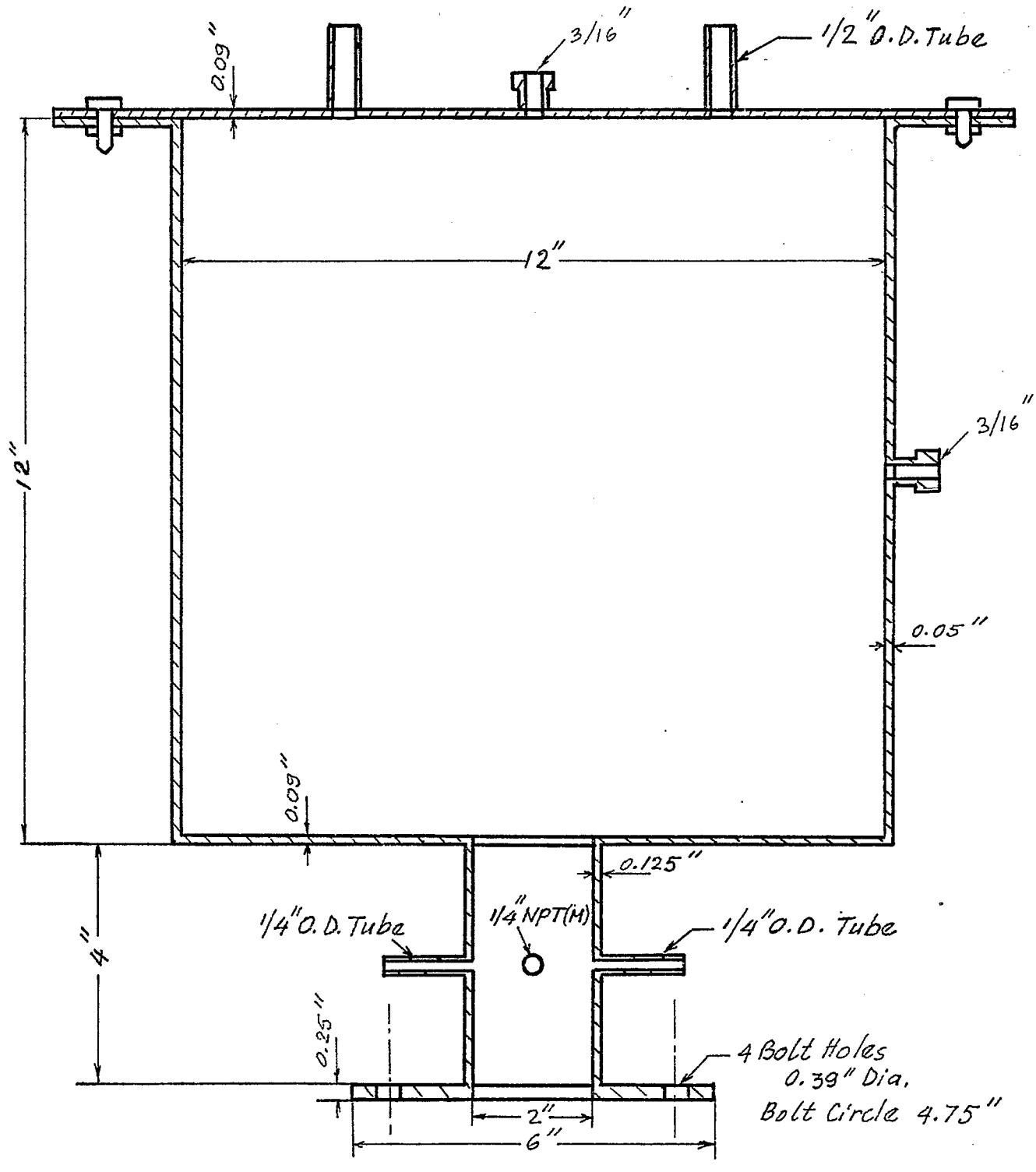

Figure 2. Expansion unit for the 2" ID bubble column (BC2)

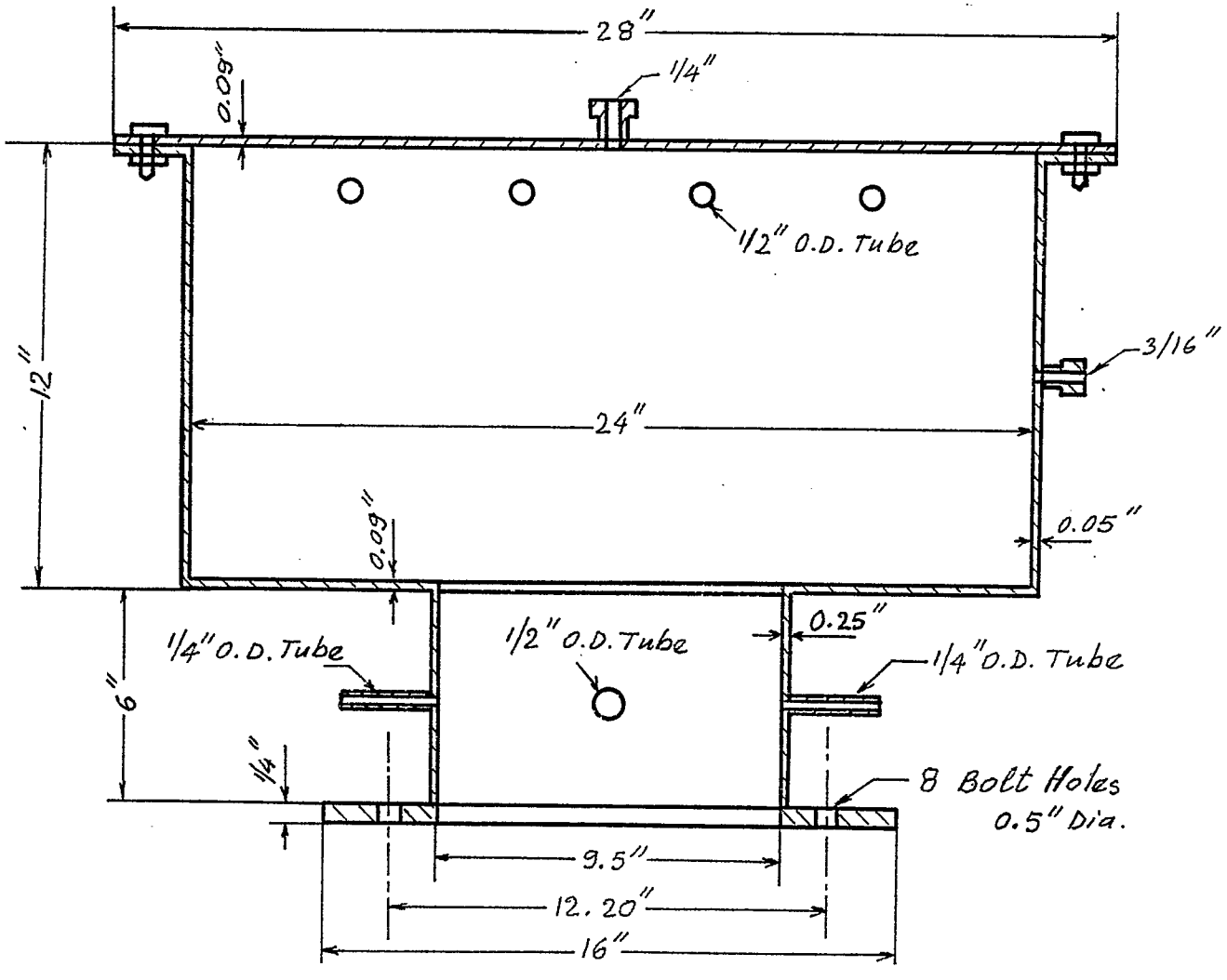

Figure 3. Expansion unit for the 9" ID bubble column (BC1)

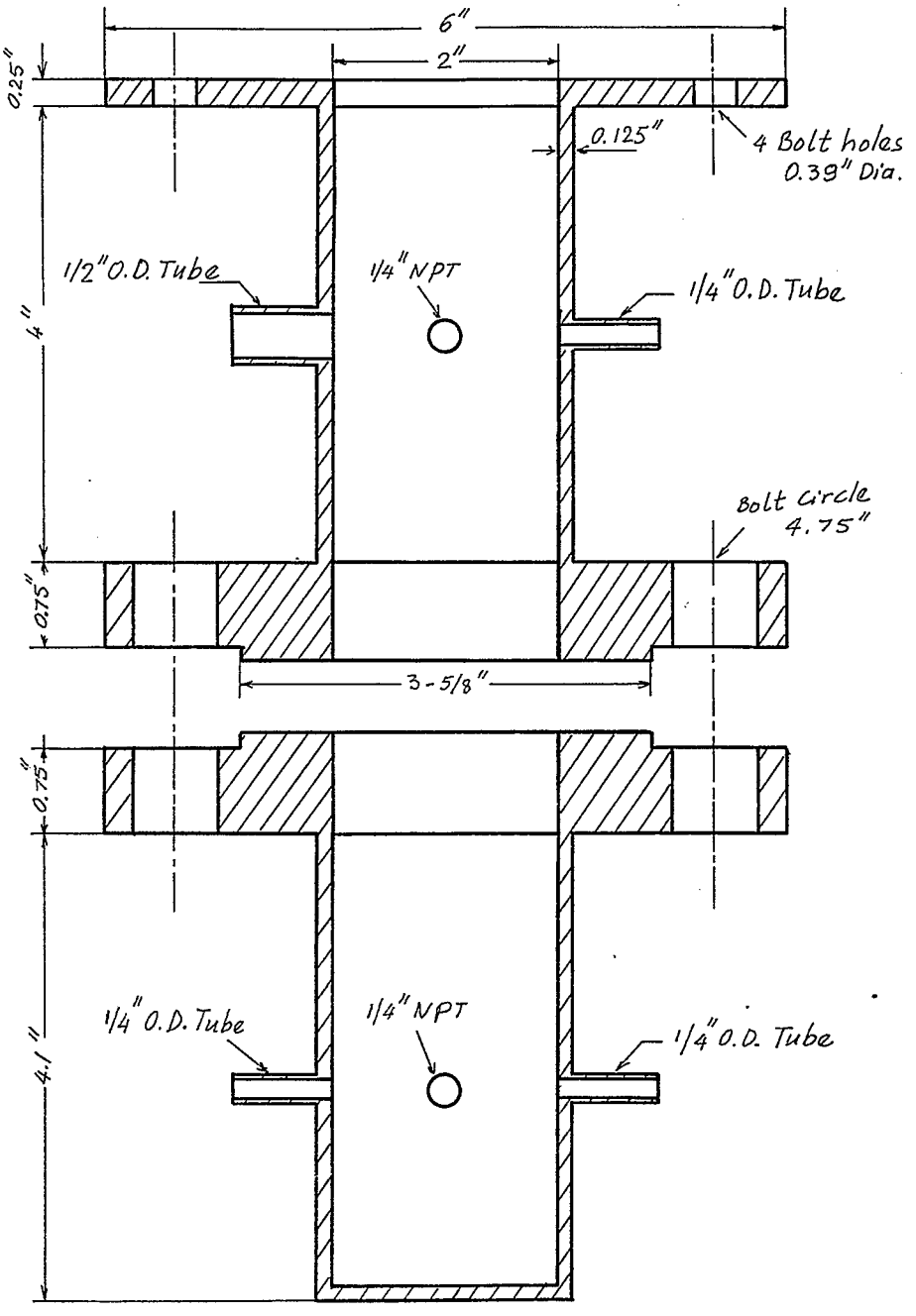

Figure 4. Support and distributor for the 2" ID bubble column (BC2)

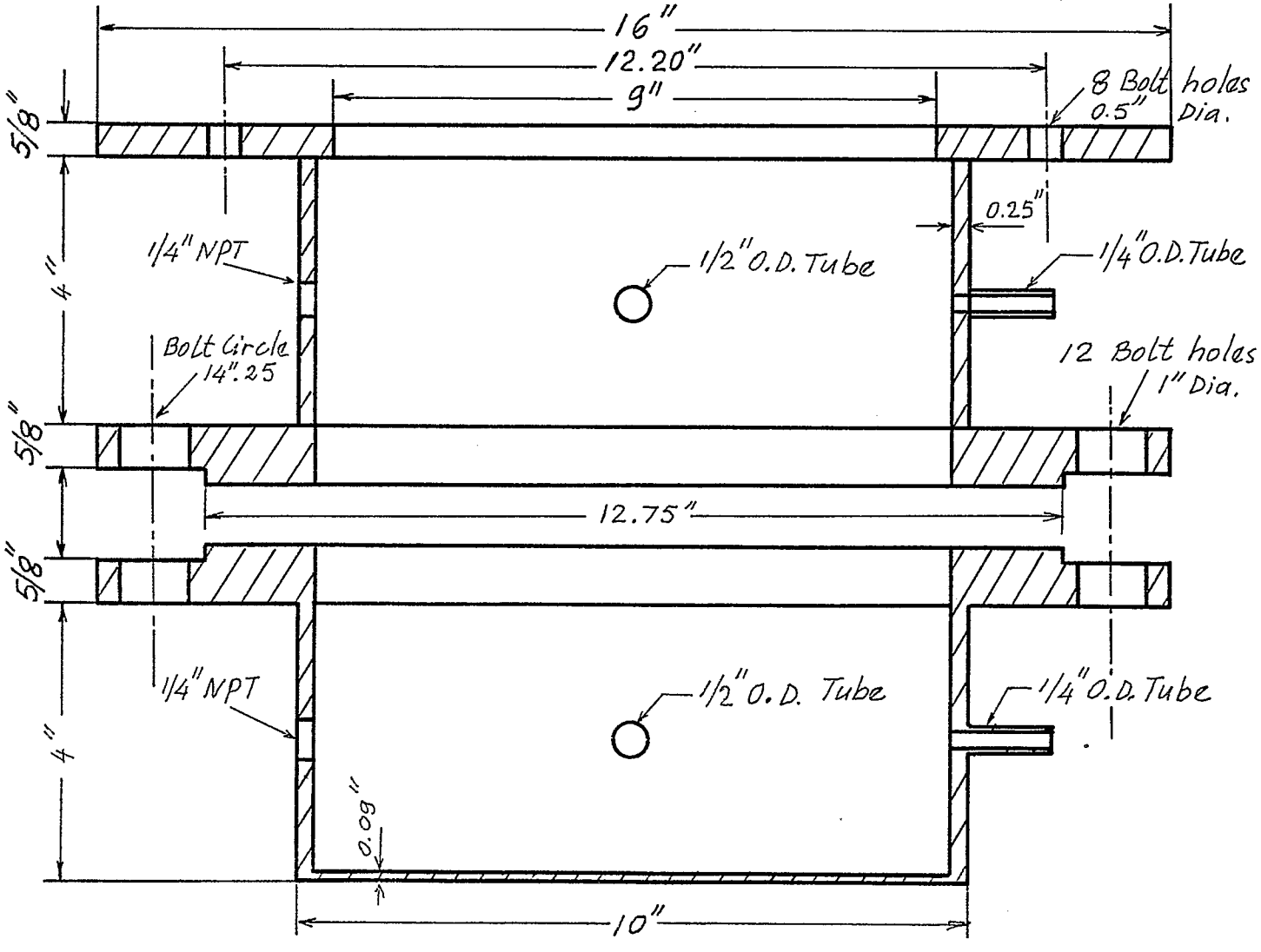

Figure 5. Support and distributor for the 9" ID bubble column (BC1)

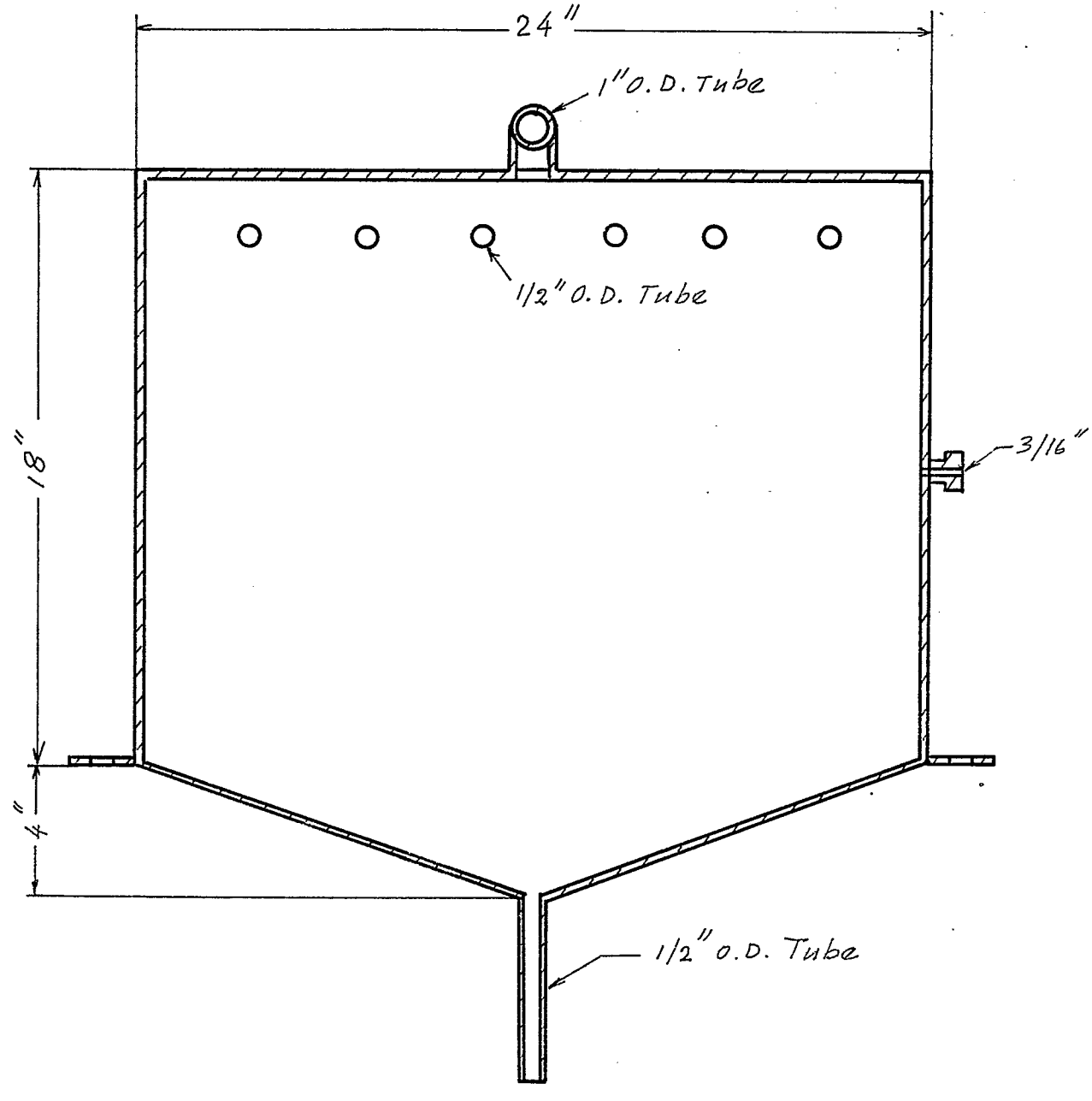

Figure 6. Gas-liquid separator

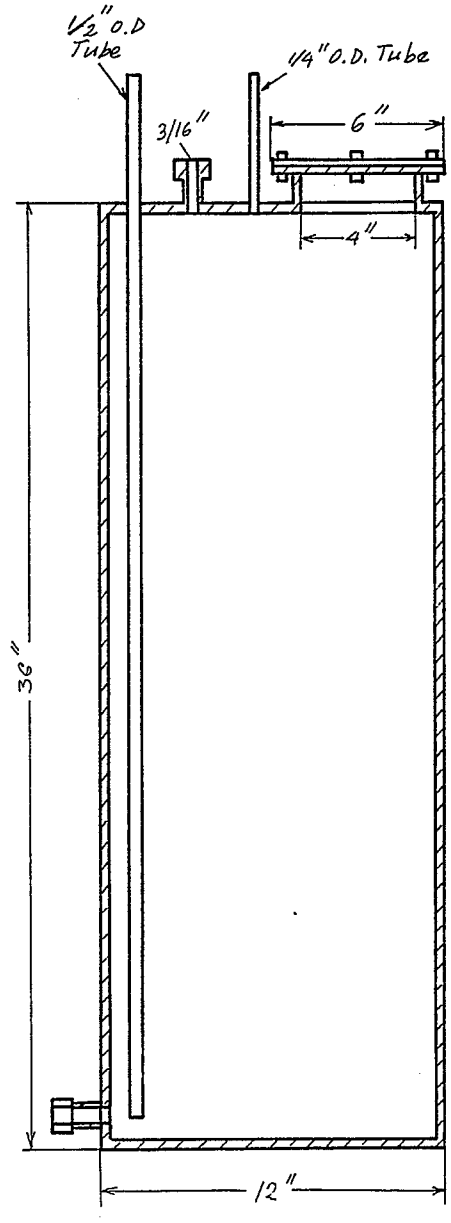

Figure 7. Storage tank for wax

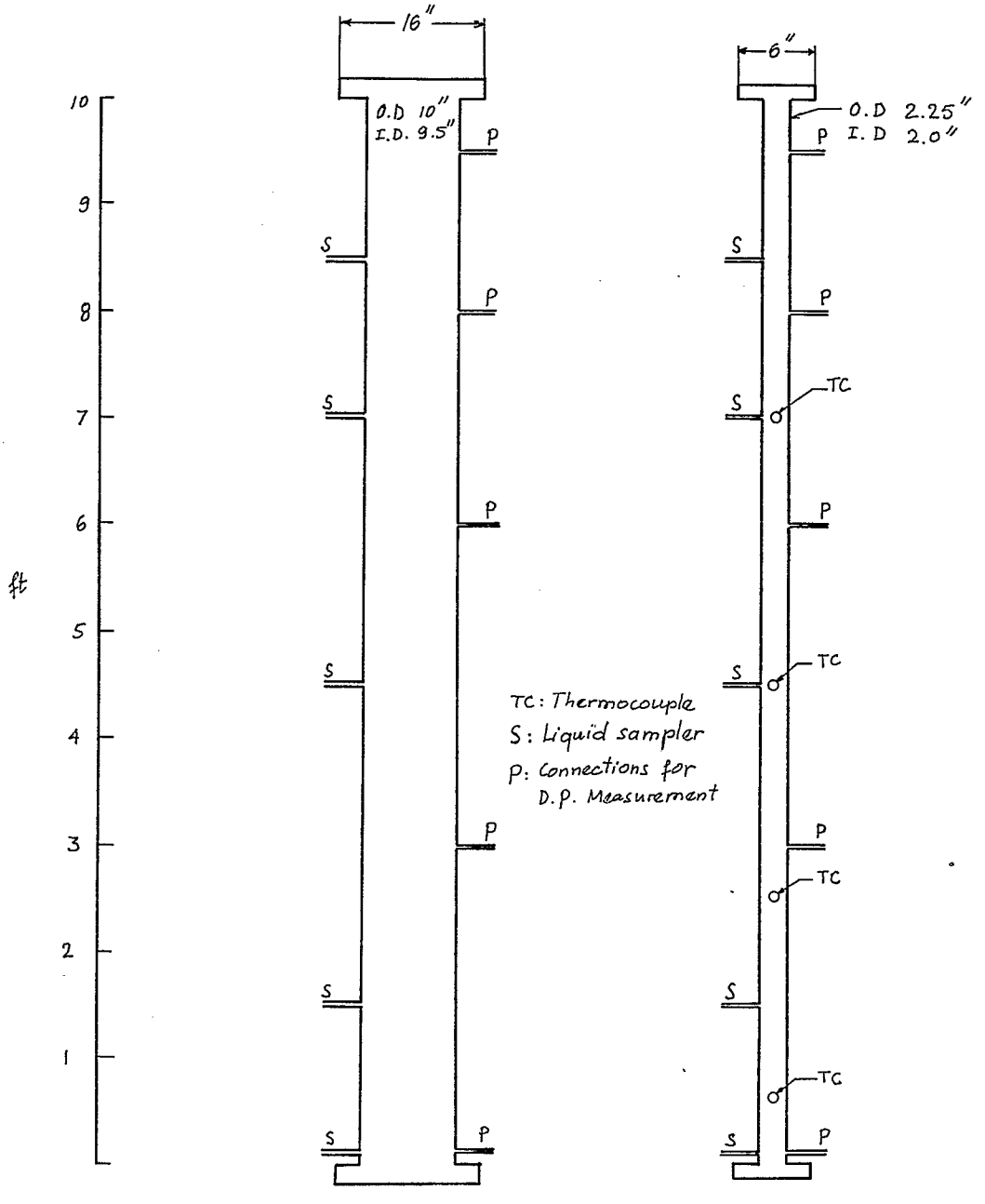

Figure 8. Schematic diagram of liquid sampling ports, pressure taps and thermocouple locations for stainless steel bubble columns.

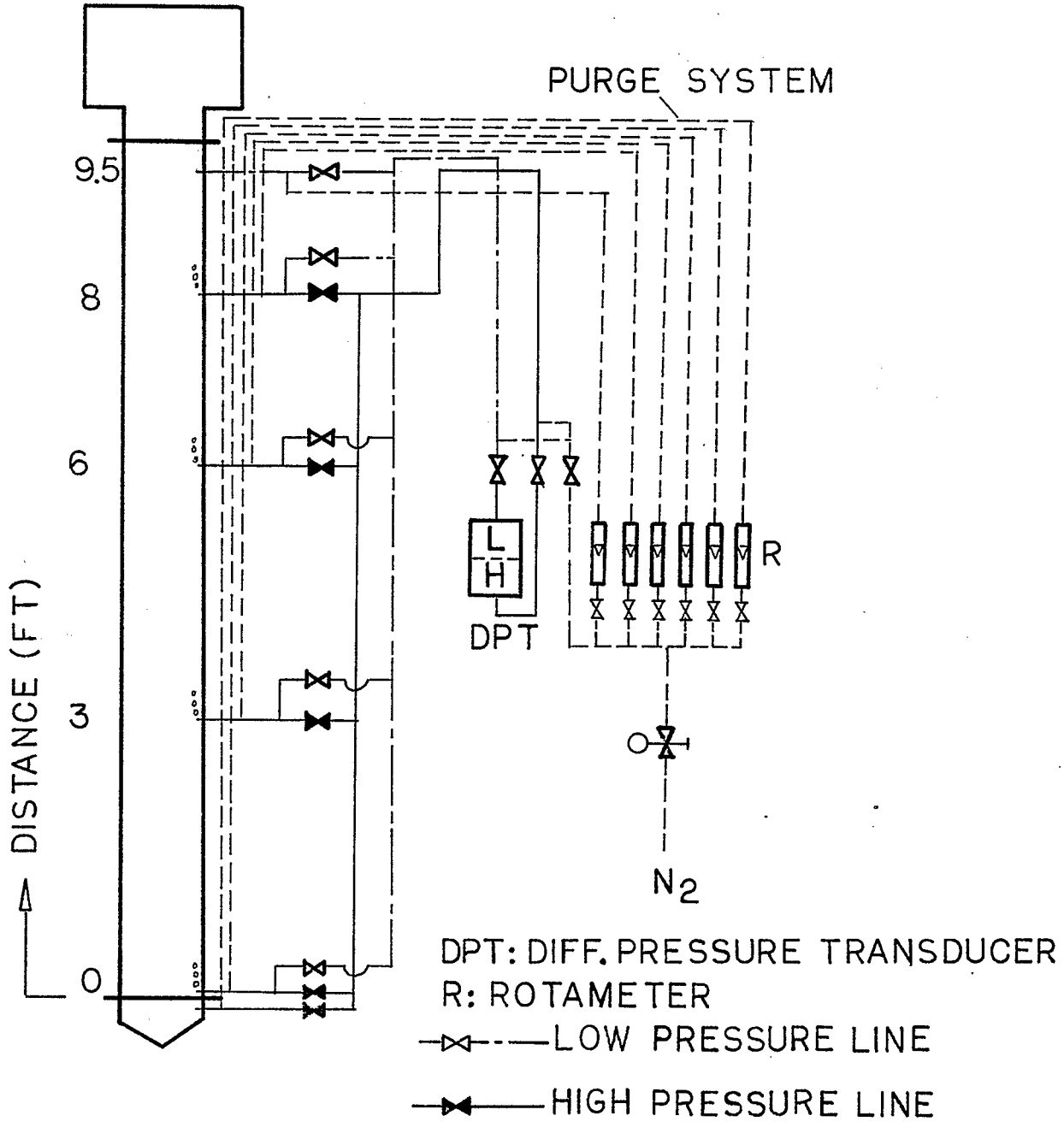

Figure 9. Schematic arrangement of DP-cell for differential pressure measurement