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Hydrodynamics of Fischer-Tropsch Synthesis in Slurry Bubble Column Reactors

Quarterly Technical Progress Report

for the period 1 March 1985 - 31 May 1985

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I. Abstract

During this reporting period all metal parts and connections for the two glass columns (2" ID and 9" ID, 10 ft. tall) were fabricated, and the columns were installed. Instruments for temperature, flow rate and differential pressure measurements and/or control were installed, tested and calibrated. The shakedown of the 2"ID glass column was completed using kerosene and molten paraffin wax. Some preliminary tests with the 9"ID glass column were done using the kerosene as a liquid medium.

Fabrication of all parts for the 9.5"ID, 10 ft. tall and most of parts for the 2"ID, 10 ft. tall stainless steel columns has been completed.

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:

- Construction and installation of the two glass columns has been completed.
- Fabrication of all parts for the 9.5" ID stainless steel column has been completed.
- Instruments have been installed, tested and calibrated.
- Shakedown of the 2"ID glass bubble column is completed, and some preliminary tests with the 9"ID glass column have been made.

IV. Detailed Description of Technical Progress

All metal parts for the two glass bubble columns (BC1: 2"ID, 10ft tall and BC2: 9"ID, 10ft tall) have been fabricated, and the on-site installation is completed. The two glass columns and the steel frame support structure are shown in Figure 1. Both columns are wrapped with heating tapes, and the large column has a layer of insulation blanket at the bottom. The columns are completely covered with insulation to reduce heat losses. The columns are encased by aluminum sheets for safety reasons (Figure 2). Both the aluminum sheets and the insulation blankets are cut in sections of 1 or 2 ft in height, and will be removed at desired locations when liquid level measurements are performed or photographs of the flow field are taken.

Instrument panel with instruments for flow and temperature measurement and/or control is shown in Figure 3.

Metal parts and connections for the 9.5" ID stainless steel column have been fabricated, while the work on the 2" ID stainless steel column is in progress. These two columns will be used for measurements of the axial gas hold-up variation by differential pressure method, and the bubble size distribution by wax withdrawal followed by rapid freezing.

The shakedown of the bench scale unit for hydrodynamic measurements is in progress. The specific tasks carried out are listed below:

- Mass flow meters (Brooks-Model 5816 for the small bubble column, and Sierra Accu-Mass Series 730 for the large column) were calibrated with the wet test meter (Fischer Scientific) and/or the orifice type meter (Singer).

- DP-cell (Validyne - Model DP 15 TL) was calibrated in the range 0-5 psi with a mercury manometer.

- Temperature controllers and indicators were tested.

- Tested the transfer and drainage of liquid (kerosene and molten paraffin wax) between the storage tank and both columns.

- Checked all electrically heated lines and vessels for proper operation and achievment of desired temperatures.

The small bubble column was put in operation first. A shakedown run was carried out using kerosene as a liquid medium at temperatures 70 - 250°F (20 - 120°C) and the static liquid height of about 2m (6.5 ft). The superficial gas velocity was varied from 0 to 10 cm/s, and the gas distributor was an orifice plate with a 2mm diameter hole. Bubbles of various sizes were observed, and at higher flow rates slugging and foaming occurred.

This column was also filled up with the wax and heated up to 300°C. No leaks were detected over the period of 16 hrs on stream, with N_2 passing through at various flow rates. Teflon type gaskets were employed at glass-metal joints, and a silicon glass gasket (0.02" thick) was placed between metal flanges at the bottom of the column. Foaming was observed at superficial gas velocities greater than 2.5 cm/s.

The 9"ID glass column was tested with kerosene as the liquid medium at temperatures 20-120°C and the static liquid height of 2m. An orifice plate with 19 holes of 2mm in diameter placed in a triangular pitch was used. The column operated at superficial gas velocity of 5.7 cm/s for

several hours. A small leak at the distributor level between two metal flanges developed and the test was discontinued. A silicon glass gasket (0.02" thick) will be replaced with another type of gasket material (e.g. sheet asbestos or a thicker silicon) and the test will be repeated.

V. Future Work

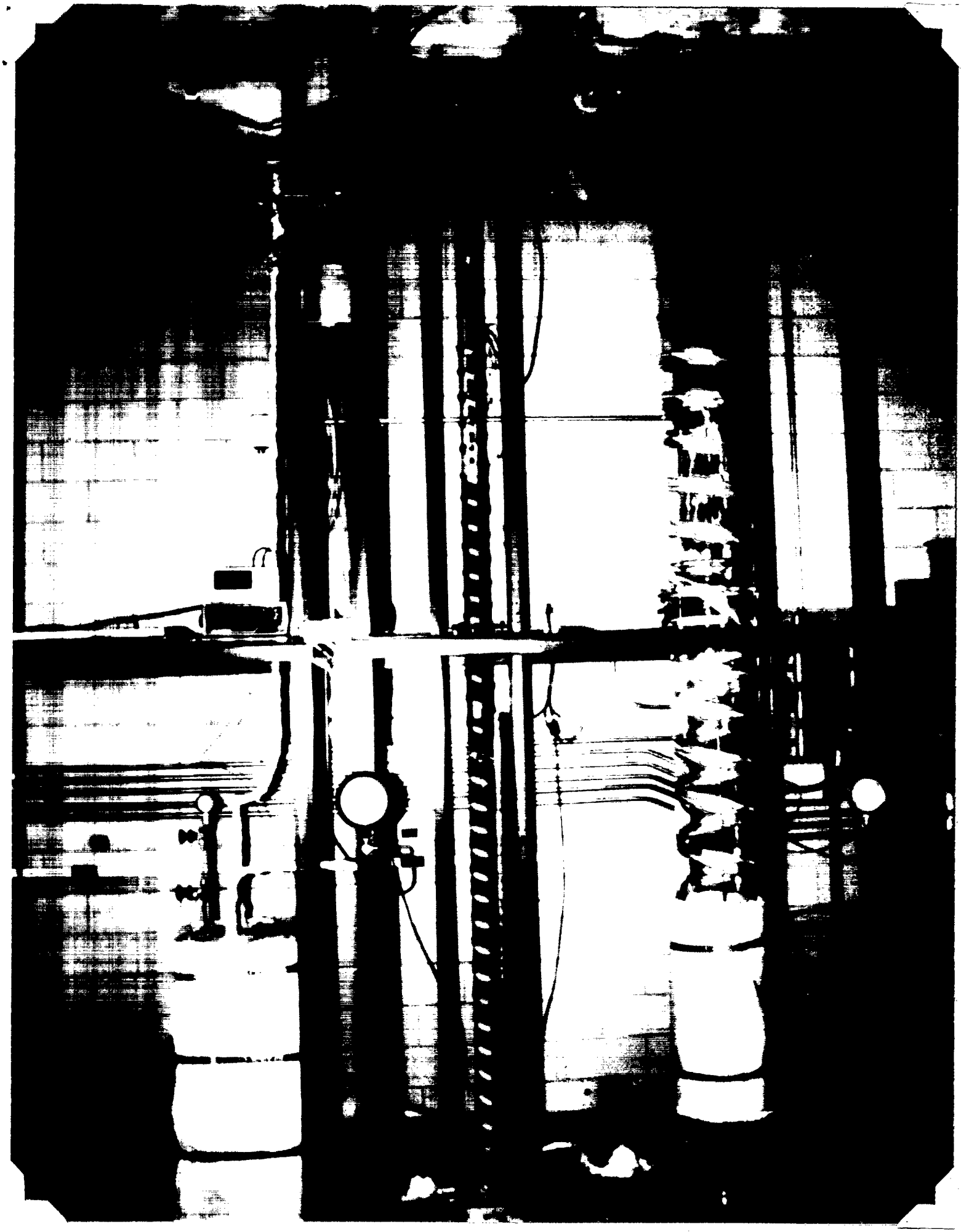
During the next quarter the following activities are planned:

- Testing of the large glass column with kerosene and wax will be completed.
- Fabrication of small stainless steel column will be completed, and both stainless steel columns will be installed.
- Studies on the effect of superficial gas velocity, temperature and distributor plate design (sintered metal plates and orifice plates) on the average gas hold-up and flow regimes in the 2"ID glass bubble column will be performed.
- Preliminary studies on the axial gas hold-up distribution and the wax withdrawal followed by rapid freezing will be conducted in the 2"ID stainless steel column.
- Preliminary studies on the effect of superficial gas velocity on flow regimes in the 9"ID glass column will be conducted.
- Work on photographic technique for bubble size distribution measurement will be initiated.

VI. Figures

Figure 1. Bubble column apparatus.
Details of heating tapes and insulation

(see the next page)



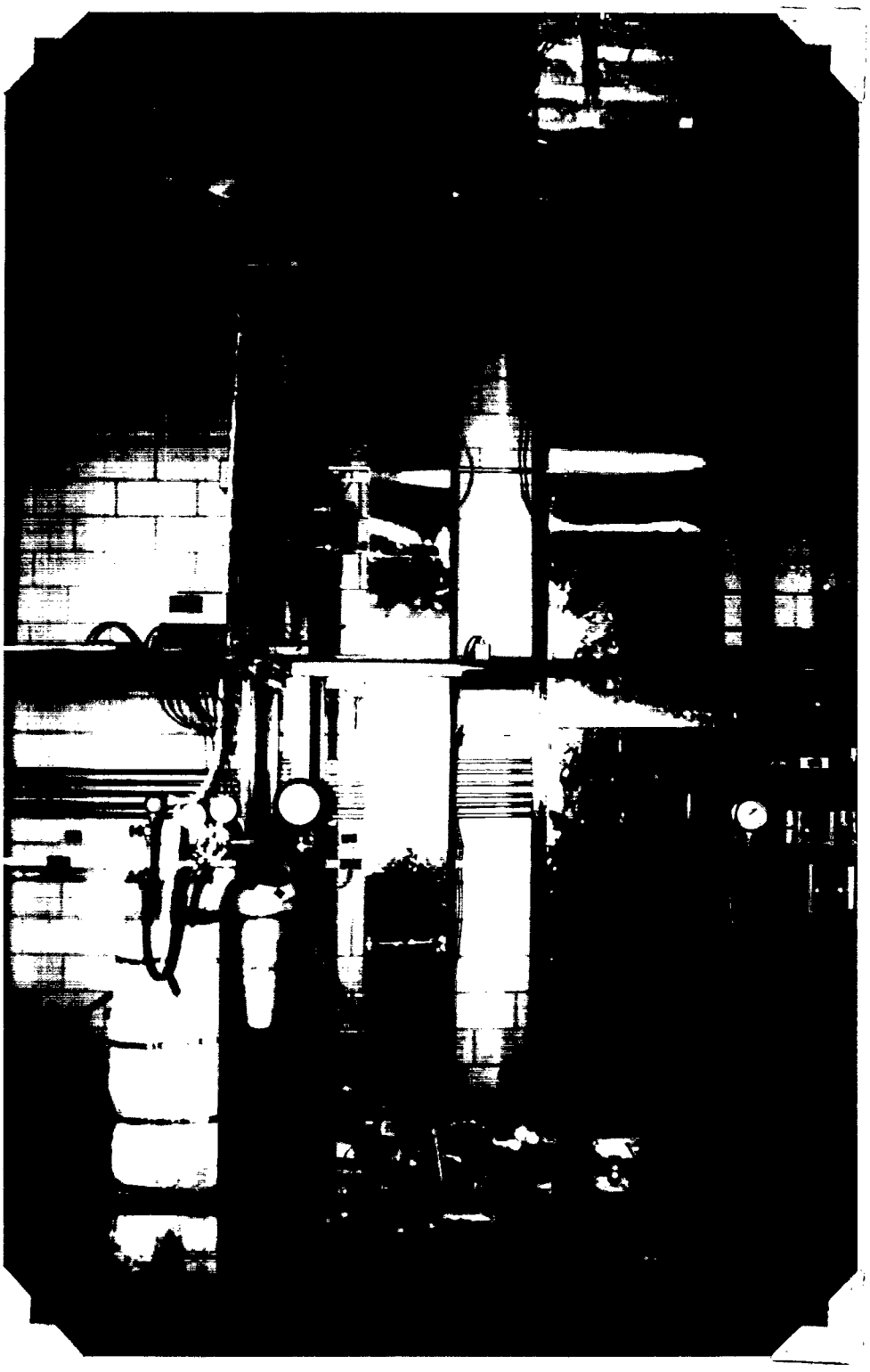


Figure 2. Bubble column with safety shields

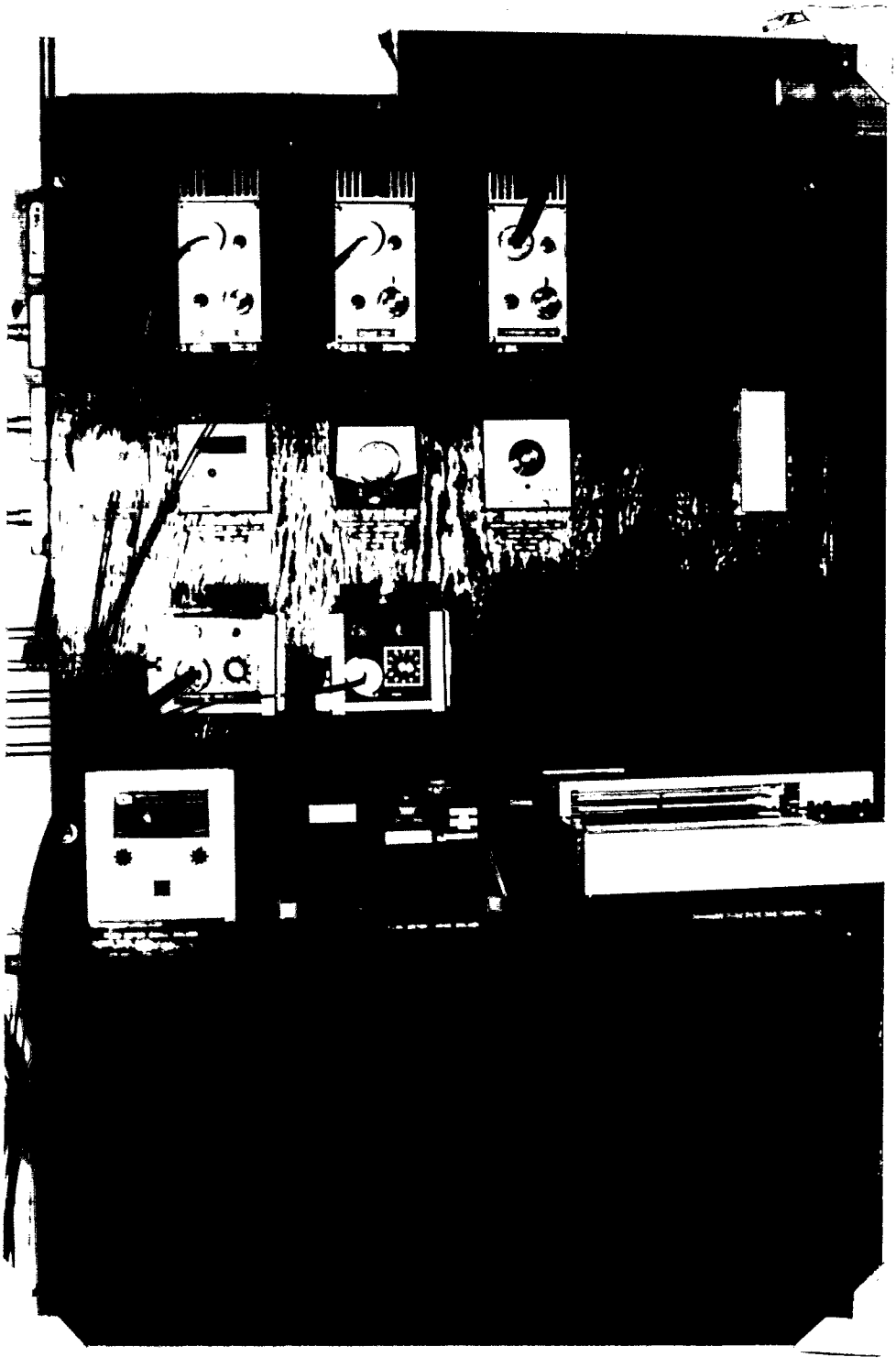


Figure 3. Instrument panel for the bubble column apparatus