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CHEMISTRY DIVISION

Section C-IV

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Waldo E. Cohn, Section Chief

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A HYDRODYNAMIC STUDY OF RESIN COLUMNS

(Problem Assignment CX1-9)

* * *

M. B. Hawkins and R. E. Garber

* * *

December 14, 1945

This report covers work between periods
November 1 and November 15, 1945

Received: 12/20/45 Issued: 12/21/45

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INTRODUCTION

During the actual design and construction work for the Volume Reduction Columns (see Report MonC-34), it became apparent that in order to convert the Flow Sheet and Schematic Diagram (See MonC-34, Figures I and II) to a practical engineering set-up, certain information concerning the hydrodynamics of resin columns would have to be obtained. For instance, the efficiency of elution increases with an increase in the length to area (L/A) ratio. However, the pressure head required to force solution through a column increases with the L/A ratios at any given flow rate. Consequently, while it might seem advantageous to use a very high L/A ratio, the head required to give a satisfactory flow rate might be prohibitive in a gravity flow system, due to the dimensions of the cell housing the column. Therefore, a satisfactory design for a column must be, at best, a compromise involving available pressure head efficient L/A ratio, and practical flow rate. Since the only data available concerned the chemical aspects, a limited study of the hydraulics of resin columns was necessary.

EQUIPMENT

To provide a sufficient range of length to diameter ratios (L/D)* four columns of diameters 1.2 cm., 2.5 cm., 4.4 cm., and 7.95 cm. were selected. The apparatus is shown in Figure I. The flow rates were measured by three Fischer-Porter Rotameters covering a range from about 2 ml/min. to about 650 ml/min. A storage bottle, employing a constant head vent, was used as a supply vessel. Vented glass tubes inserted in the column and in the column discharge line indicated the pressures at those points.

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*Length to diameter ratios were found to be more satisfactory in these tests than the L/A ratios used in previous chemical experiments.

PROCEDURE

The test procedure was very simple. A measured quantity of resin (IR-1) was added to a column. Tap water was allowed to flow through the column. When equilibrium was reached, the flow rate and the pressures were recorded. Then, the head was decreased by throttling the inlet tube and more readings taken. After checking the flow rates throughout the available pressure head range, more resin was added and the procedure repeated. The columns of various diameters were each tested by this method.

RESULTS

From the data collected, a number of graphs of flow rate (ml/min.) vs. across-column pressure drop (cm. of H_2O) at various resin bed depths were plotted. These graphs were all combined into a single graph (Figure II), plotting L/D ratios vs. flow rate for the four columns at various across-column pressure drops. Figure II represents the actual data collected since no attempt was made to derive any formulae or to correct the values for assumed inaccuracies.

Figure III is a calculated graph showing the relationship between L/D ratios and resin bed volumes for various diameter resin columns of cylindrical shape. The purpose of this chart is to facilitate the use of Figure II in column design.

An example of the use of the graphs in column design is as follows: Previous experiments on the elution characteristics determine that the resin bed volume for a column should be about 100 ml. and the L/D ratio as high as possible. The available head is about 40 cm. of H_2O. For practicability, the flow rate should not be less than 30 ml. per minute. From Figure II, at a flow rate of 30 ml/min. and a 40 cm. head, a L/D ratio of 12 on a 1.2 cm. diameter column and a L/D ratio of 20 on a 2.5 cm. diameter column are given. From Figure III, at a volume of 100 ml., diameters of approximately 2.1 cm. and 1.9 cm. are given, respectively, for L/D ratios of 12 and 20. Assuming a practical value of 2 cm. for the diameter, an L/D ratio of 16 is indicated. Returning to Figure II, an L/D ratio of 16 and a diameter of 2 cm. (interpolating between 1.2 diameter and 2.5 diameter, both at 40 cm. of H_2O pressure) indicate approximately 30 ml. per minute flow rate.

Consequently, the design factors for the column set-up are as follows: Resin bed volume - 100 ml. (given); across-column pressure head - 40 cm. of H_2O (given); flow rate - 30 ml. per min. (given); L/D ratio - 16 (determined); column dimensions - 2 cm. in diameter by 32 cm. high (determined).

CONCLUSIONS

The data collected has proved satisfactory for rough estimations, but much more comprehensive tests should be made in the future. Various factors, such as resin quantity and particle size, should be regulated much more closely than was done on these tests; also, flow rate, column volume and pressure head should be studied over a wider range. Other factors, such as resin packing, effect of other solutions (HCl, ammonium citrate, H_2SO_4, etc.) should also be considered.

Figure I
Schematic Diagram of
Test Equipment

Drawing No. 1831
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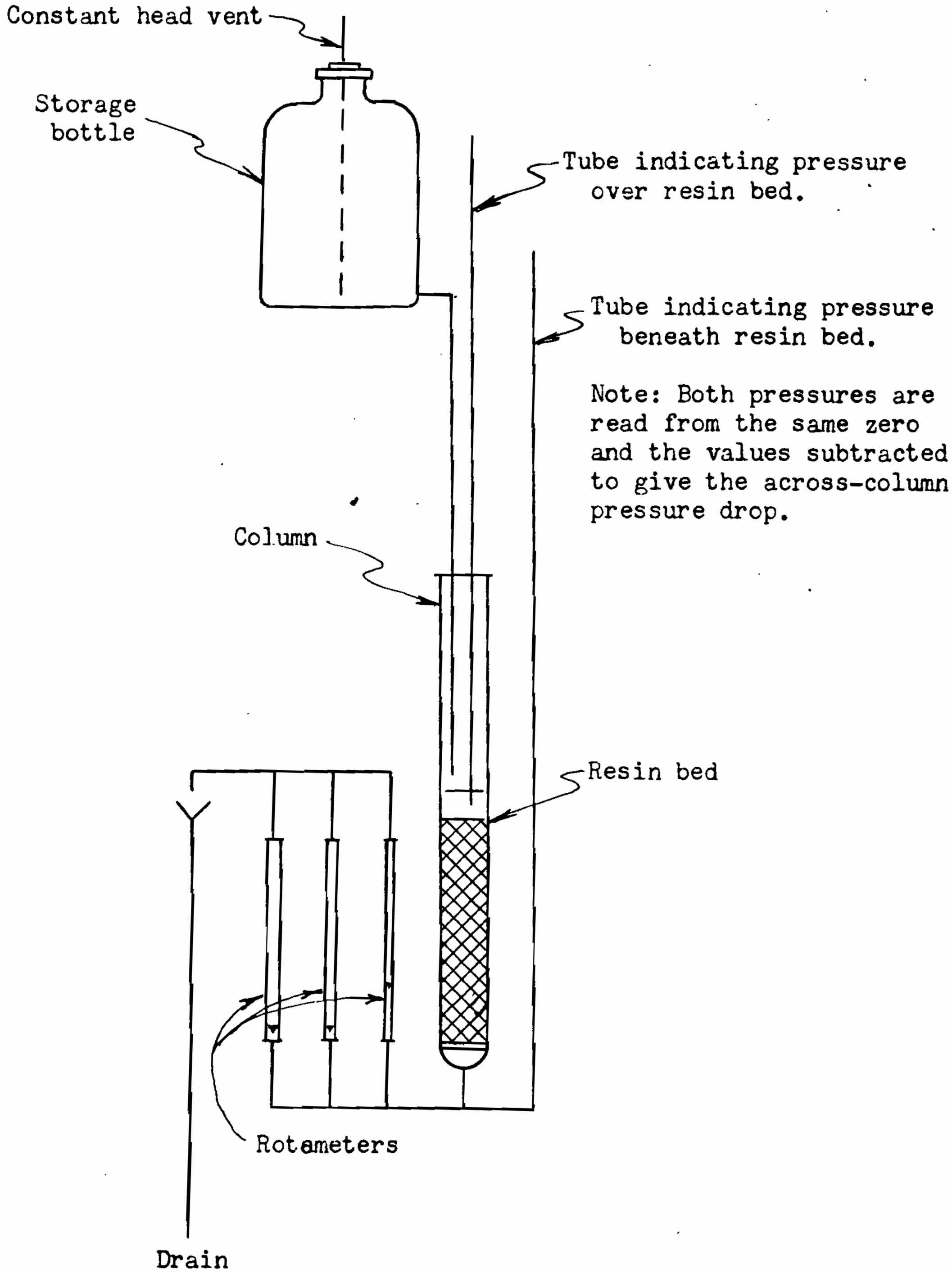

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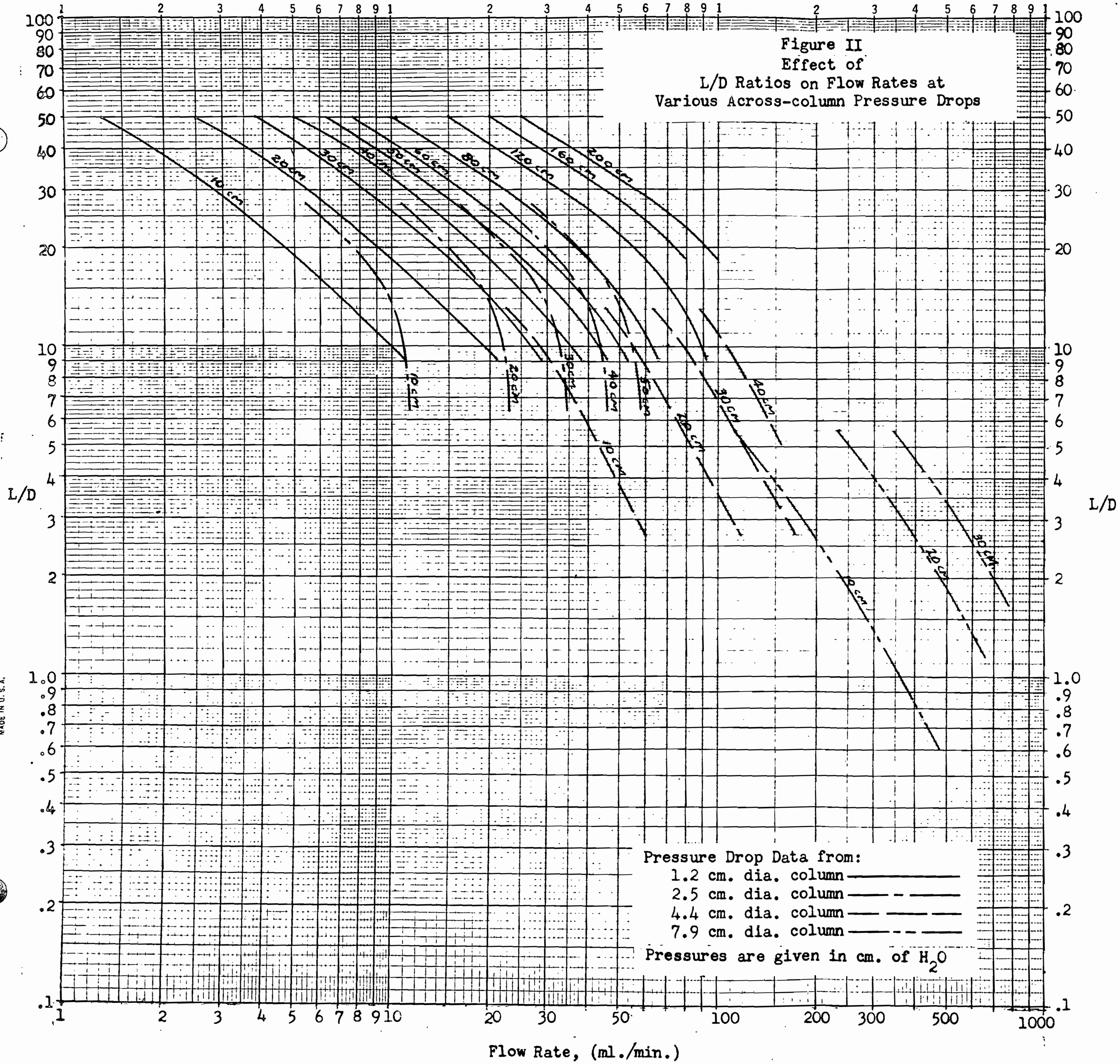

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