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Edward E. Hood, Jr. Professor of Engineering

Dr. Edwin P. Rood
Office of Naval Research
Scientific Office Code: 1132F
800 North Quincy Street
Arlington, VA 22217-5000

Dear Dr. Rood:

The purpose of this letter is to transmit a quarterly progress report on ONR grant N00014-91-J-1271 ("An Experimental Study of Plunging Liquid Jet Induced Air Carryunder and Dispersion", Lahey & Drew - CoPI).

The first report period was devoted to designing the plunging test facility and to assuring that it would have the capability to cover at least the same range of parameters that have been previously tested by others. This is important since our test facility will be significantly different from those of all previous investigators, and thus benchmarking is considered to be essential if comparisons between our detailed 3-D data and previous global observations are to be meaningful.

Significantly, all previous investigations have been performed using axisymmetric nozzles. Thus using well developed design practices employed in wind tunnels [Dryden & Schubauen, 1947; Loehrke & Nagib, 1976; Rae & Pope, 1984; and, Scheiman & Brooks, 1981], we have designed the axisymmetric nozzle shown in Figures-1. It can be seen in Figure-1a that the cylindrical inlet section employs a removable honeycomb and various removable screens (both coarse and fine) to help assure uniformity of the velocity profile (U) and reduce (and homogenize) the turbulence level. Screens redistribute the flow to keep the pressure drop across them equal, as a consequence they flatten the mean velocity profile of the fluid exiting the screens. However, screens reduce the axial turbulence level more than the lateral turbulence level. In contrast, honeycomb does just the opposite. Thus both devices were used to achieve our objectives.

The honeycomb to be used will have a length which is 10 times the cell size of the honeycomb. This exceeds the recommended minimum of 6 to 8 times the cell size [Rae & Pope, 1984].

Figure-1b shows that an axisymmetric nozzle with a significant contraction ratio will be used. This was done to assure uniformity in the velocity profile at the exit of the nozzle. That is, in accordance with Helmholt's theorem, any nonuniformities ($\Delta U_{in}/U_{in}$) at the inlet to the nozzle will be suppressed in accordance with:

$$\Delta U_{out}/U_{out} = (D_{out}/D_{in})^4 \, \Delta U_{in}/U_{in}$$

where, D_k is the nozzle diameter at location-k, and, $D_{out} << D_{in}$.

The axisymmetric nozzle is being designed so that the screens and honeycomb can be easily changed. In this way the residual turbulence level in the exiting jet can be parametrically varied.

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Subsequent to benchmarking our new data against similar data from previous studies, a 2-D planar nozzle will be used to investigate the effect of liquid jet shape on the air carryunder process. Indeed, a planar jet is more like a ship's bow wave than an axisymmetric jet.

Figures-2 shows the planar nozzle which we have designed. The water enters from the left and exits through the 2-D (75 mm x 4 mm) nozzle on the right (see Fig.-2b). The cylindrical section between the inlet and outlet contains the same type screen and honeycomb arrangement as was employed in the axisymmetric nozzle. This unique nozzle design is currently under review by wind tunnel design experts at RPI to make sure that it is the optimum design for our needs. In any event, subsequent to this review, it is intended to fabricate both the final axisymmetric and planar nozzle designs.

The overall test loop was also designed during this report period. The closed-loop design under consideration is shown schematically in Figure-3. It is intended that the nozzle be coupled to the piping with a braided hose such that its angle of attack (as the jet impinges on the pool's surface) can be easily changed. Moreover, it is intended to use a special screw pump to mitigate any flow noise which may otherwise be induced by a centrifugal pump. In this way it is hoped to avoid the need for an accumulator or a large holding tank (such as those used by previous investigators to control flow fluctuations to the nozzle's inlet).

It is anticipated that the test loop design will be finalized during the next quarter and a design modification of the 3-D LDA/PDA measurement system's traversing mechanism will take place.

Sincerely yours,

R. T. Lahey

Dr. R.T. Lahey, Jr.
The Edward E. Hood, Jr. Professor of Engineering

RTL/ev
Attachments

cc:
- Administrative Grants Officer,
  Office of Naval Research
- Director, Naval Research Laboratory
- Defense Technical Information Center ✓
- D.A. Drew (RPI)
- F. Bonetto (RPI)

REFERENCES

Dryden, H.L. & Schubauen, G., "The Use of Damping Screens for the Reduction of Wind Tunnel Turbulence," IAS, 14, pp. 221-228, April 1947.

Loehrke, R.I. and Nagib, "Control of Free-Stream Turbulence by Means of Honeycombs: A Balance Between Suppression and Generation," J. Fluids Engineering, 342-353, September 1976.

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Scheiman, J. & Brooks, J.D., "Comparison of Experimental and Theoretical Turbulence Reduction from Screens, Honeycombs, and Honeycomb-Screen Combinations," IAS, 18, 638-643, August 1981.

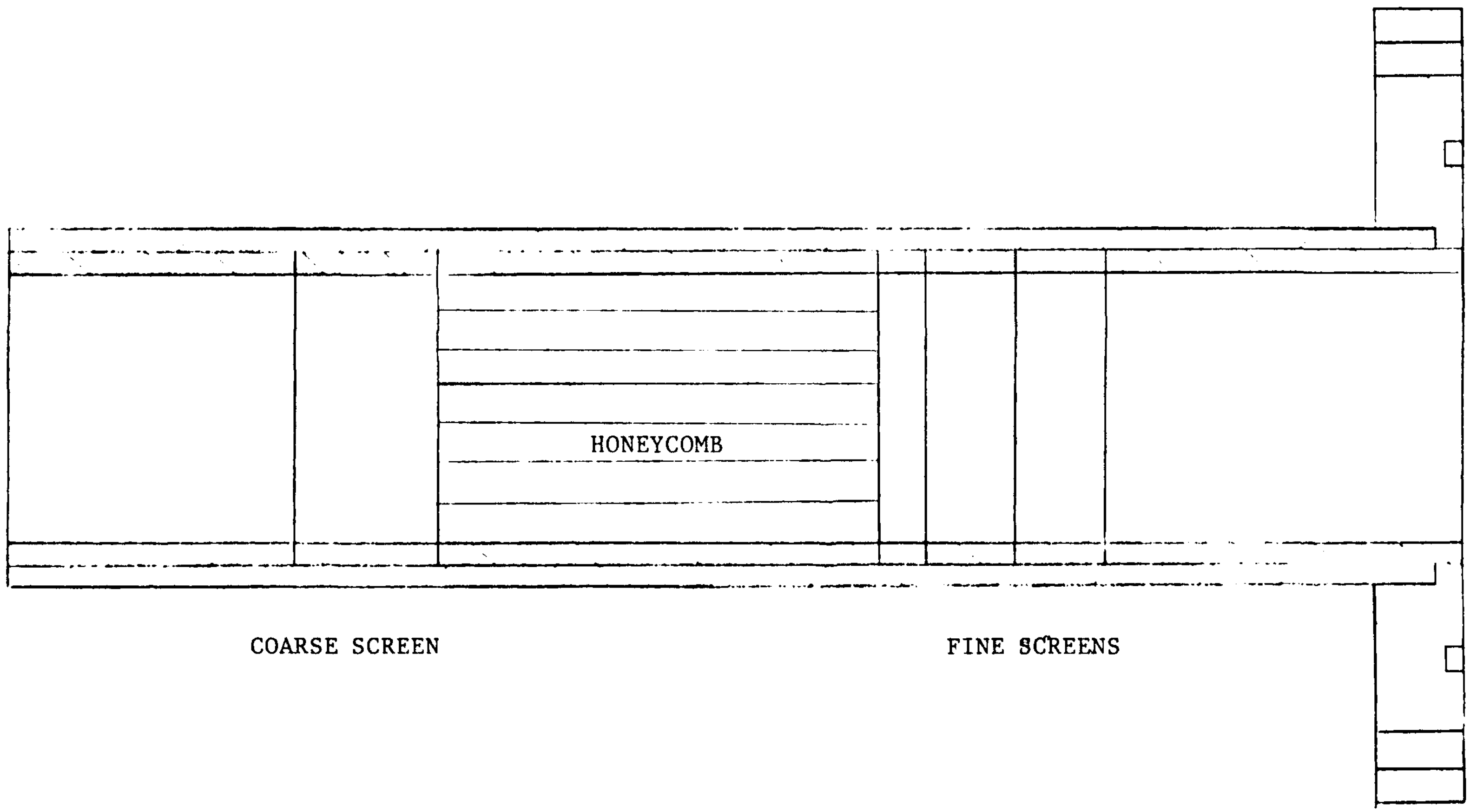

Figure-1a Symmetrical Nozzle's Inlet Section

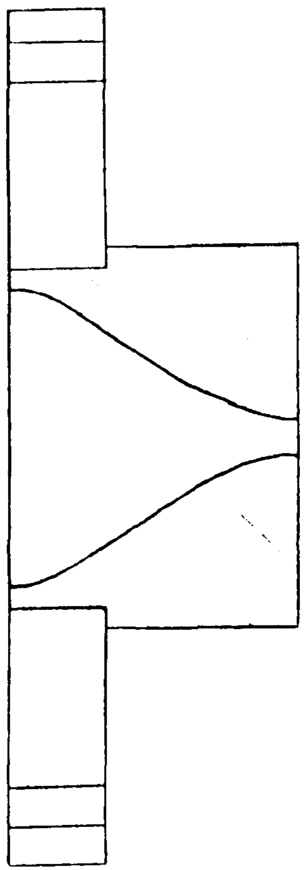

Figure-1b Symmetrical Nozzle

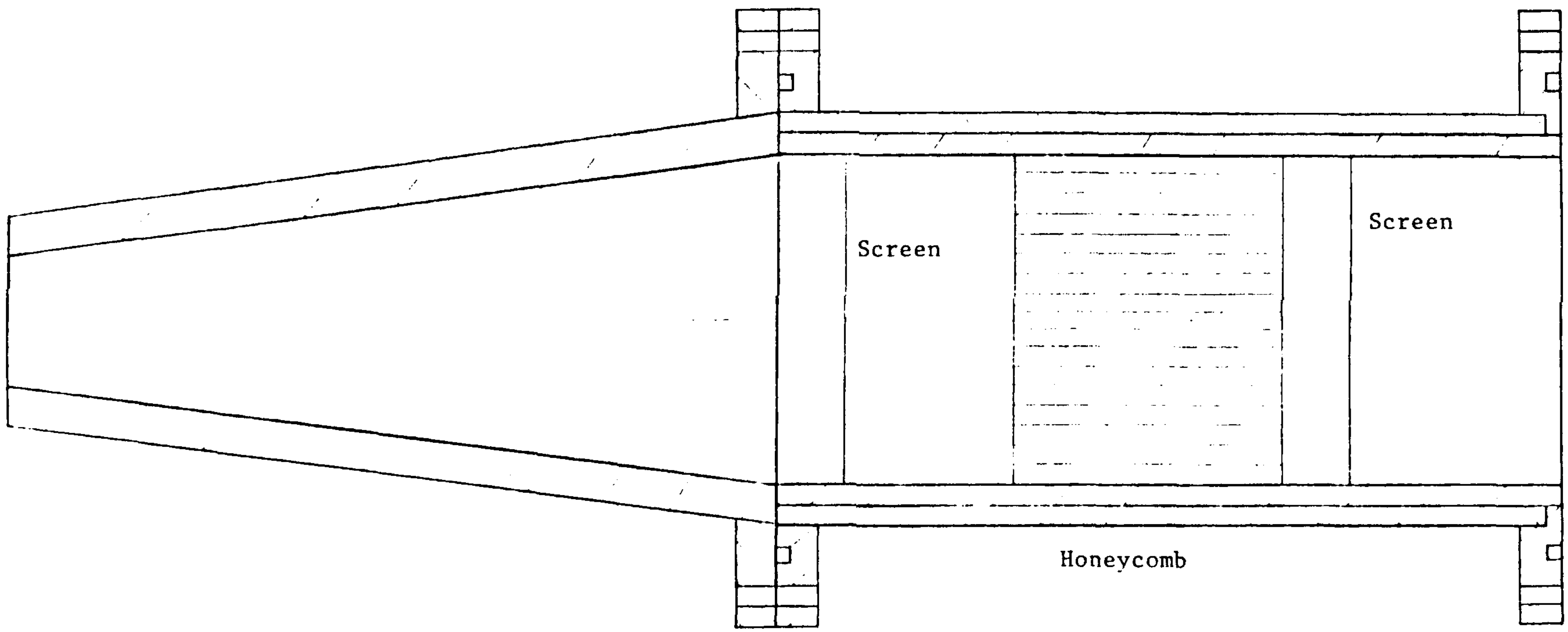

Figure-2a Planar Nozzle's Inlet Section

Figure-2b   Planar Nozzle

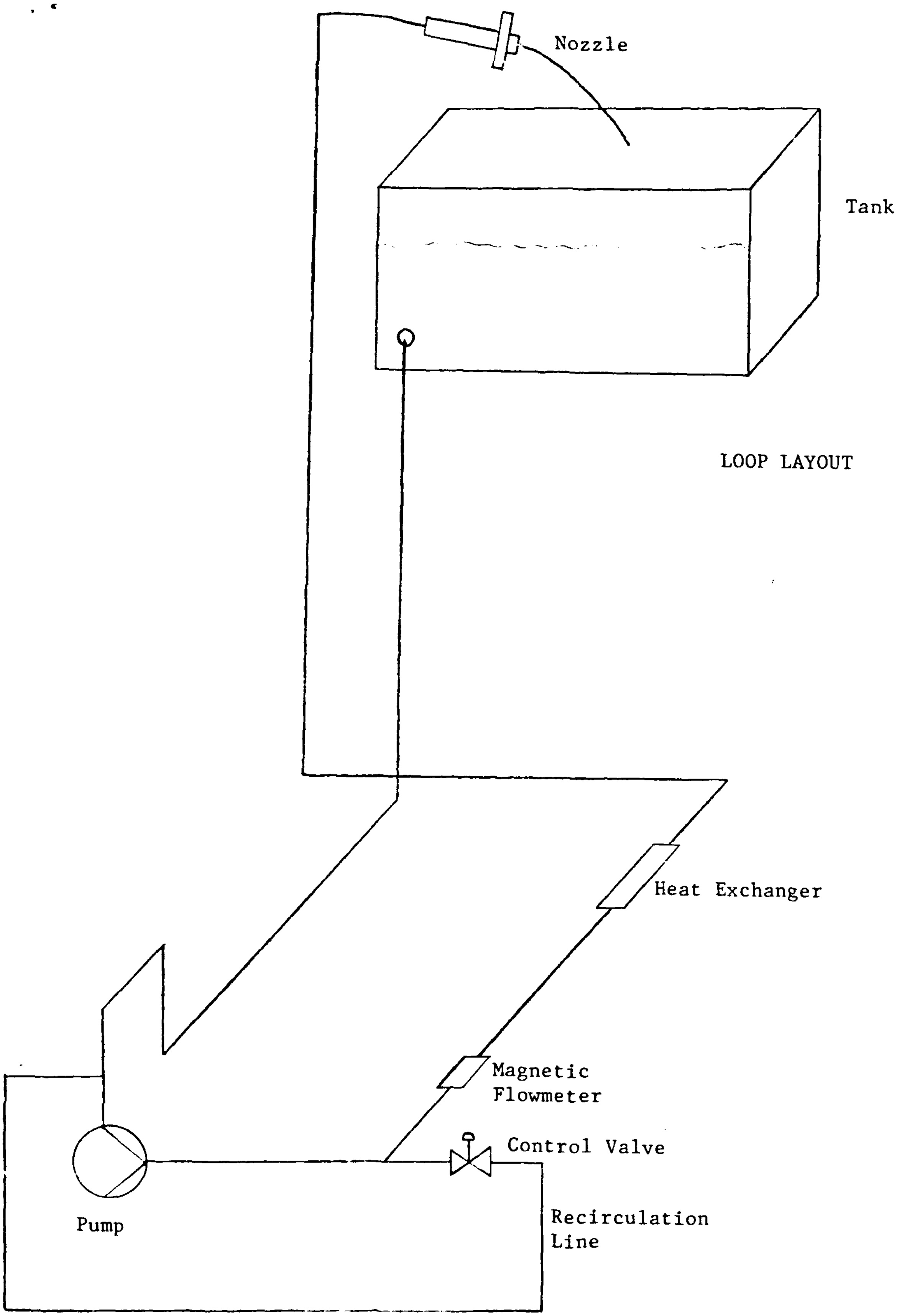

Figure-3 Primary Liquid Test Loop