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# ENERGY LOSSES IN BULB TURBINE INTAKES
(SEMINAR 2)

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# ENERGY LOSSES IN BULB TURBINE INTAKES

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by

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## Introduction

Intakes for bulb and rim generator turbines are very large in relation to the runner diameter. Since the velocity is small in the intake section, the losses are also small. Research in the Hydraulics Branch of the Water and Power Resources Service is investigating the effect on energy losses of simplifying intake shapes. Using straight surfaces in place of curved bellmouth entrances could reduce construction costs. Reducing the size of the intake would reduce the size and cost of trashracks, bulkheads, and the cranes required to lift them. In a conventional hydropower example, reducing the size of the traditional bellmouth entrance design saved $13 million in construction costs at the Third Powerplant at Grand Coulee Dam with little effect on energy losses. Savings may also be possible for bulb turbine intakes.

## Testing Apparatus

Air is used as the testing fluid. The measurements made are scaled to the prototype using the Euler number, $E = \rho V^2/p$; where $\rho$ is the fluid density, V is the velocity, and p is the pressure drop. The model runner diameter (D1) was approximately 155 mm. This size was chosen to maintain air velocity in the incompressible range. Discharge was computed from differential pressure across a calibrated orifice in the upstream supply pipe. Figure 1 is a schematic diagram of the testing apparatus.

Discharge is varied from 0 to approximately 0.52 $m^3/s$ with a motor driven cone valve. The intake section is made from sheet metal and the turbine flow passages from transparent plexiglass. The bulb and wicket gates are formed from wood. The bulb supporting piers and intake pier are polyurethane. Runner blades are not included. The wicket gates are adjustable from full open to 90 percent closed. Figure 2 is a photograph of an intake with a pier installed in the center.

Pressures were measured in the stilling chamber and along the sides, top, and bottom of the intake section with a 0 to 34.5 kPa differential pressure transducer. The data were recorded on cassette tape with a desk-top computer, for later analysis and plotting.

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A model of a typical intake and bulb turbine was built as a basis for comparison with other intakes. The model dimensions basically corresponded to standard flow passage dimensions used by a major manufacturer (figure 3). The flow passage dimensions are given in terms of the runner diameter (D1).

After testing the original intake, another intake with a simplified top (figure 4) was installed and tested, and the results compared. Testing was done on the original intake with and without a bulkhead slot; with various intake channel configurations; and with and without a pier installed in the center of the intake.

## Results

Table 1 compares losses for a typical prototype installation. The head for this example is 13.52 m at a rated discharge of 128 $m^3/s$. Pressure profiles were plotted through the intake for various configurations to show the effect of geometry changes on pressure drops. Velocity distributions will be measured at the bulkhead slot for various intakes to determine the effect of geometry changes on flow distribution.

Table 1 - Comparison of intake losses

| INTAKE COMPARISON* | DIFFERENCE IN HEAD LOSS (m) | DIFFERENCE IN HEAD LOSS percent of total head |
|---|---|---|
| INTAKE 1 vs. INTAKE 2 | 0.10 | 0.8 |
| INTAKE 1 without center pier vs. INTAKE 1 with pier | 0.15 | 1.1 |
| INTAKE 1 without Bulkhead Slot vs. INTAKE 1 with Bulkhead Slot | 0.002 | 0.02 |
| INTAKE 1 without Intake Channel vs. INTAKE 1 with a Trapezoidal Intake Channel | 0.04 | 0.3 |

*The first configuration listed has lower loss than the second. Wicket gates were full open.

## Conclusions

1. Studies are continuing to compare losses in a variety of intake shapes.

2. The head-loss data obtained in this study can be used to evaluate the cost effectiveness of making design changes in the intake section of bulb turbines.

3. Losses due to the bulkhead slot are negligible, and losses due to the intake channel are small.

4. Further study on shortening draft tubes is planned which may lead to less costly draft tubes.

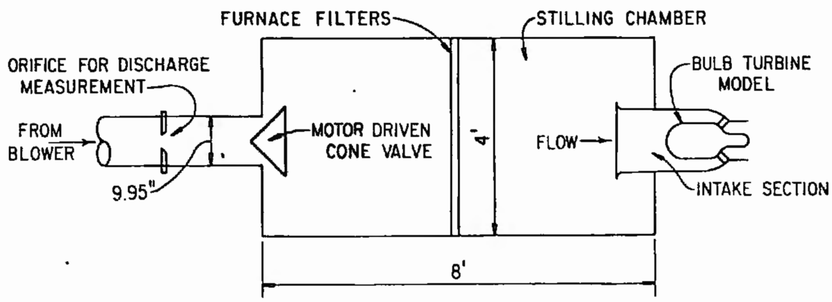



FIGURE 1 - SCHEMATIC DIAGRAM OF APPARATUS
(1' = 0.3048 m, 1" = 25.4 mm)

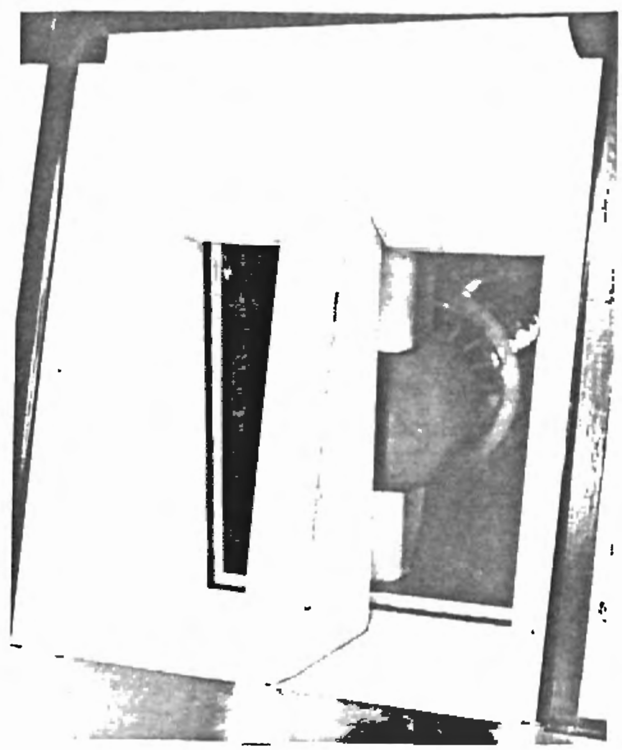
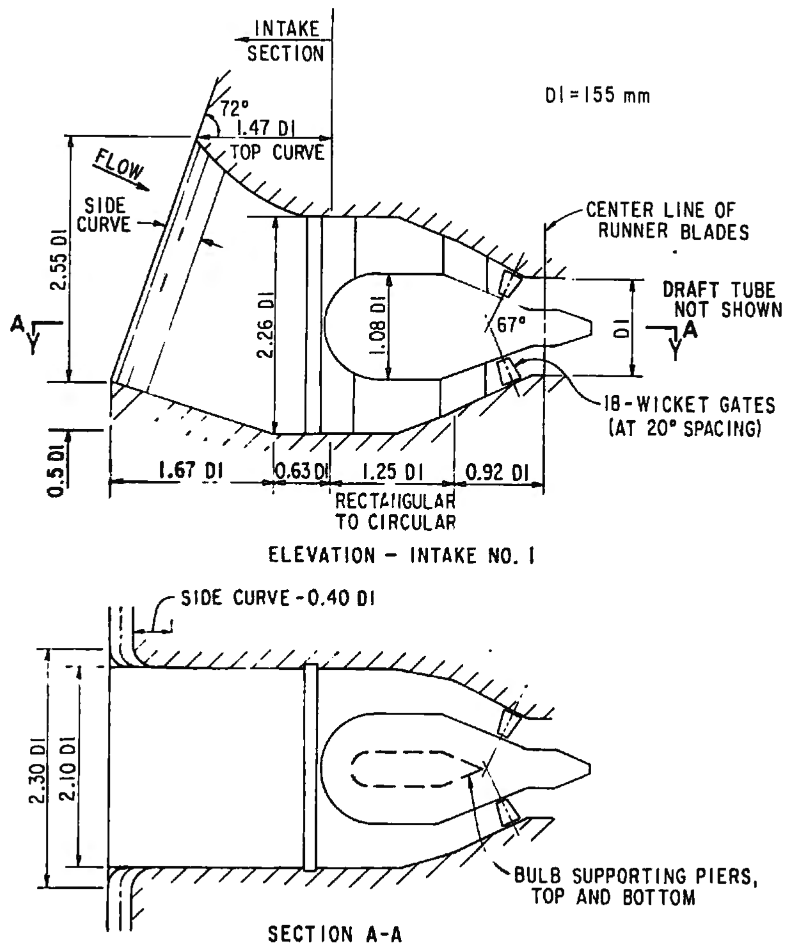
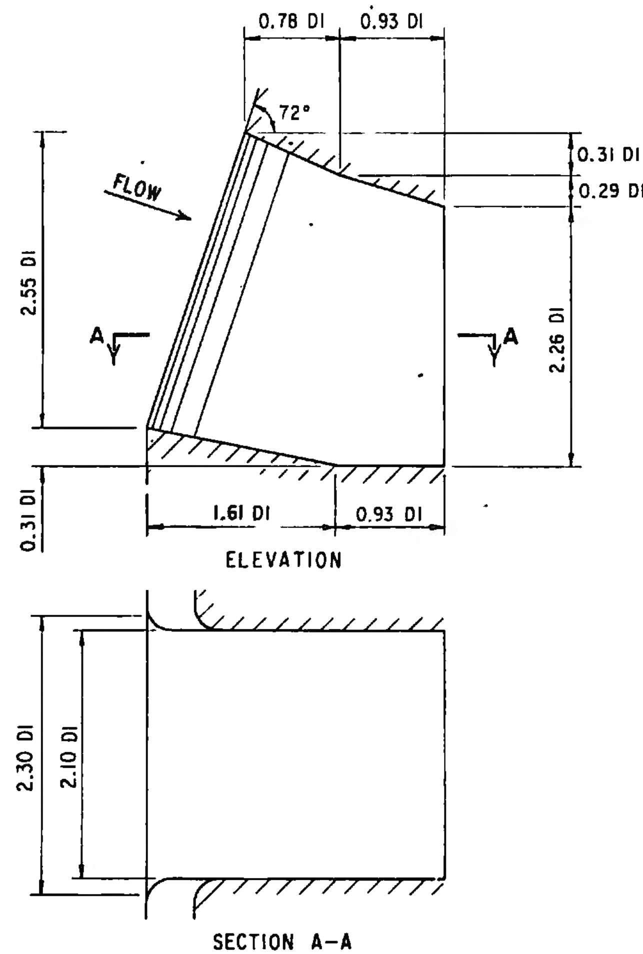


FIGURE 2 - PHOTOGRAPH OF INTAKE NO. 1,
WITH CENTER PIER




BULB TURBINE AIR MODEL
INTAKE NO. 1

FIGURE 3




INTAKE NO. 2

FIGURE 4