PAP-490

FEDERAL HIGHWAY

PORTABLE FLUME DEMONSTRATION PROJECT

BY

CASSIE C. KLUMPP

PAP-490

Form DFC-11
(12-81)
Bureau of Reclamation

INFORMATIONAL ROUTING

D-1531
PAP file
No. 490

D-1532

FEB 21 1986

Mr. Douglas Bernard
Chief, Demonstration Projects Division
Federal Highway Administration
400 Seventh Street, SW.
Washington DC 20590

Subject: Final Report for Federal Highway Portable Flume Demonstration Project, Agreement No. DTFH71-A00006

Dear Mr. Bernard:

GPO 852320

In September 1985, the work was completed on the Portable Flume Demonstration Project under the subject agreement. Five copies of the report summarizing our work are enclosed.

The final cost report for this project indicates charges of $49,252. Since $48,210 was authorized for the project under the original agreement and the two subsequent amendments, the Federal Highway Administration will be billed for the additional $1,042. The account will be closed when the final adjustment is made.

Sincerely yours,

H. Walter Anderson

FOR Francis G. McLean
Chief, Division of Research
and Laboratory Services

Enclosures

Copy to: Mr. Dennis Richards
Federal Highway Administration
1000 North Glebe Road
Arlington VA 22201

Mr. Gary Klinedinst
Division Engineer and Contracting Officer
U. S. Department of Transportation
Federal Highway Administration
1000 North Glebe Road
Arlington VA 22201

Blind copies to codes on attached sheet.

Blind to: D-320
D-360
D-361 (Anderson)
D-1500B
D-1531 (PAP file)
(with copy of enclosure)
D-1530
(with copy of enclosure)
D-1532
(with copy of enclosure)
D-1532 (Klumpp)
(with two copies of enclosure)
D-1532 (Fitzwater)

CCKlumpp:flh

FEDERAL HIGHWAY
PORTABLE FLUME DEMONSTRATION PROJECT

by

Cassie C. Klumpp

ACKNOWLEDGMENTS

The Federal Highway Portable Flume Demonstration was conducted in the hydraulic laboratory of the Engineering and Research Center of the U. S. Bureau of Reclamation. Mr. Clifford A. Pugh provided technical review of the work. Mr. Jerry R. Fitzwater worked in conjunction with me, and provided the invaluable conceptualization and design of the roadway and weir box models. Mr. Kenneth W. Doering built all of the plastic models at the hydraulic laboratory. Mr. Leo Callewyn of Interstate Pattern Manufacturing Company built the brass grates for the highway inlet models.

INTRODUCTION

The Federal Highway Administration has used a portable flume to demonstrate hydraulic design concepts for the past 9 years in over 200 flume demonstrations. The flume has been used for demonstrating energy dissipators, head loss in culverts of different roughnesses, measuring velocities at inlets and outlets of culverts and energy dissipators, and highway inlets. In 1984, the Federal Highway Administration contracted with the U. S. Bureau of Reclamation to design and construct grate and curb-opening inlet models for the portable flume and to provide new instrumentation. During the 9 years of use, the portable flume received damage and deterioration of its outward appearance from its extensive use. The contract also provided for the renovation of the flume and packing cartons. Three energy dissipators were to be replaced: (1) roughness ring energy dissipator, (2) rock riprap energy dissipator, and (3) hook energy dissipator. The repair of various other model parts was also needed.

APPROACH

The main task of the project was the design and construction of eight highway grate models, a curb-opening inlet and a slotted drain inlet. Also, two or three different roadway sections had to be designed to contain the grates. Two design requirements were needed for these models:

1. The first requirement was to select a model scale that would visually show the efficiency of different highway inlet models and adequately scale the discharge according to the Froude law.

2. The second requirement was to design and construct the roadway sections to specific cross slopes and longitudinal slopes. The roadway sections needed to be compact, and designed so that they could be easily interchanged during a demonstration.

The model scale selected for the grate and highway inlet models was 1:6. This scale provided adequate visualization of the size of the grate in the portable flume. The model was scaled based on the Froude law for typical prototype discharges intercepted on roadways by different inlet models, and through consideration of the maximum flume pump capacity of approximately 80 gallons per minute.

The roadway and inlet models were designed to be compact and easily interchangeable through the use of a weir box that was placed in the portable flume, figure 1. Two types of roadway sections can be placed on top of the weir box. A roadway with uniform cross-slopes of 0, 2 or 10 percent can be placed on the weir box, and any combination of grate, curb opening or slotted drain inlet can be demonstrated in the portable flume. A roadway section with composite cross slopes of 2 percent and 10 percent was also designed to be placed on the weir box to demonstrate any combination of curb opening, grate and slotted drain inlet. The weir box used to hold the roadways was designed to capture flow that falls through the inlet models. The discharge through the weir box is measured with a v-notch weir. A visual scale placed on the side of the weir box was designed to read flow in gallons per minute. In this way the efficiency of any inlet grate model can be demonstrated by comparing the total flow rate coming into the flume and the flow rate that is being captured by the inlet model.

The slotted drain and curb opening inlet models were constructed of plexiglass. They were designed to fit into the uniform and composite roadways by simple removal and placement of new pieces in a grooved section at the edge of the roadway. Figure 1 is a photograph of the roadway section showing the slotted drain inlet model, and the general layout of the weir box, roadway section, and inlet model.

Seven grates (4 inches by 8 inches) and one grate (4 inches by 4 inches) were constructed under the original contract, and four additional grates (4 inches by 4 inches) were made in the second work amendment. The Federal Highway Administration requested that the grates be constructed out of brass or some other type of metal because plastic had not worked well in previous applications. The grates were fabricated by Interstate Pattern Manufacturing Company of Denver, Colorado. Four typical grates are shown in figures 2 through 5.

Photographs of the flume with different highway inlet models are presented in figures 6 through 8. In figure 6, the flume is demonstrated with the composite roadway, the transverse grate and a curb opening representing 4 inches. Part of the water is intercepted and discharged through the v-notch weir. The balance of the flow discharges from the roadway into the portable flume. The uniform roadway with the curved vane grate inlet model is shown in figure 7. No curb opening is demonstrated in figure 7. The P-1 7/8-4 grate is demonstrated in figure 8 on the uniform roadway with a curb opening representing 12 inches. In comparing the photographs of figures 7 and 8, considerably more discharge is captured with the

combination grate and curb opening inlet as shown in figure 8 with the greater volume of water going through the weir than over the end of the roadway. These photographs show the flexibility that the design has for demonstrating many grate and curb opening combinations on the two roadways.

FLUME REPAIR

The flume was repaired and cartons for storing the models were refurbished and painted. Three models were replaced during the project: (1) the rock riprap energy dissipator, (2) the roughness ring energy dissipator, and (3) the hook energy dissipator. The rock energy dissipator was redesigned because the old model tended to float during use. The riprap, made of styrofoam in the original model, was replaced with small rocks that were glued to the urethane base with epoxy. The new model is shown in figures 9 and 10. The roughness ring energy dissipator, redesigned with new design data from the Ohio Highway Department, is shown in the photograph of figure 11. The operation of the roughness ring energy dissipator is shown in figure 12. The new hook energy dissipator was redesigned with a trapezoidal section scaled from the prototype. A photograph of the new model is shown in figure 13.

Several other models, for example the box culvert inlet, required minor repairs. Two smooth tubes of 3 inches in diameter by 27.5 inches and 38.5 inches in length were constructed for the flume. The flume lifting motor was repaired, new wheels for the flume were provided, the aluminum supports of the flume were replaced and a new pump was purchased. The storage cartons were cleaned, and a new storage carton was built to store the new inlet models. The outside covers were patched and painted to enhance their appearance.

FLUME INSTRUMENTATION

To demonstrate the inlet models, additional instrumentation for the portable flume was required. It was necessary to numerically show the amount of discharge entering the portable flume and the amount of discharge being intercepted by the inlet models. A paddle-wheel flow sensor was installed in the pipe between the pump and the entrance to the flume, and a digital display of the discharge was mounted on top of the portable flume. The display was set to read in gallons per minute. This discharge is compared to the amount of discharge being intercepted by the inlet models through the v-notch weir located in the weir box. The flume with the digital display of the discharge is shown in figure 14.

A pressure transducer with a digital display was also mounted on the portable flume. These instruments will be used to demonstrate the difference in head losses through various culvert pipes. As part of the second work amendment, the digital readouts of the pressure transducer and the flow meter were placed in a box which was mounted on the flume. The box could be rotated for viewing by the entire group watching the flume demonstration.

SUMMARY

The work completed for the Federal Highway Administration is described in this report. Photographs are included to document the completion of the grate and inlet models and to show the flexibility of the design in demonstrating many combinations of grate and curb-opening inlet models. Three energy dissipators were replaced during the contract. The flume instrumentation was augmented by the addition of a flow meter with a digital readout, and head loss measurements were improved by providing a pressure transducer with a digital display. The flume was repaired and painted and the pump was replaced.

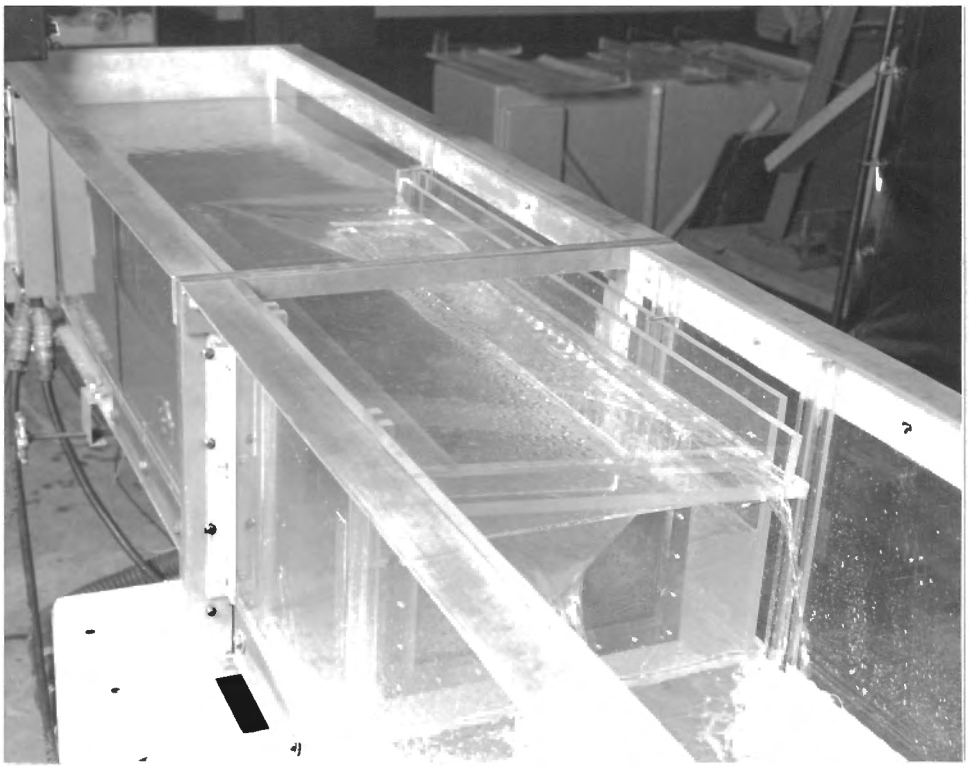

Figure 1. - General photograph showing the weir box and roadway with the slotted drain inlet model.

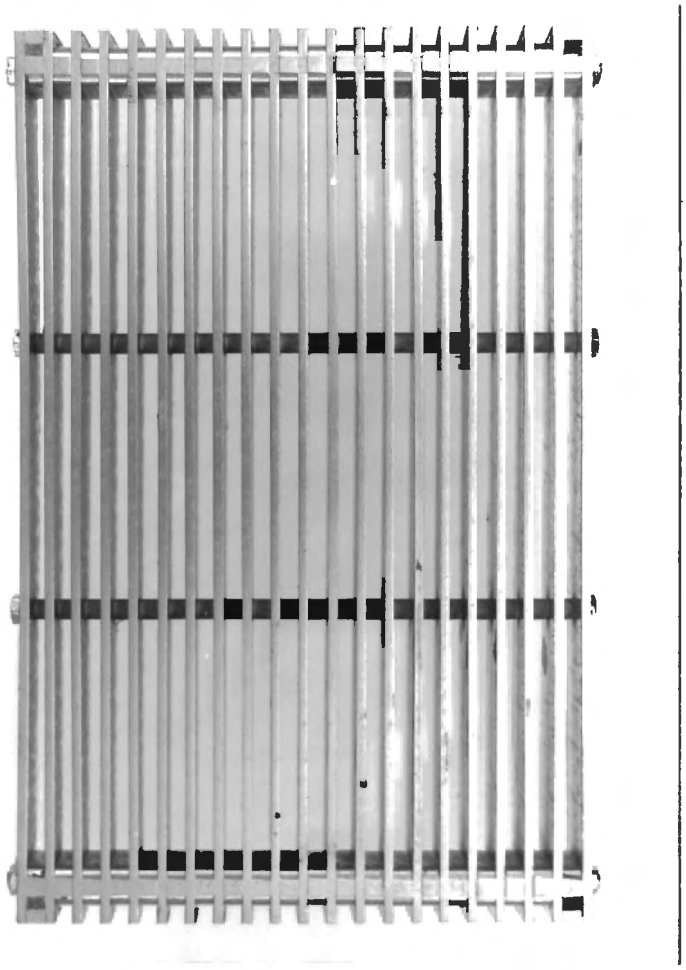

Figure 2. - P-1 1/8 grate.

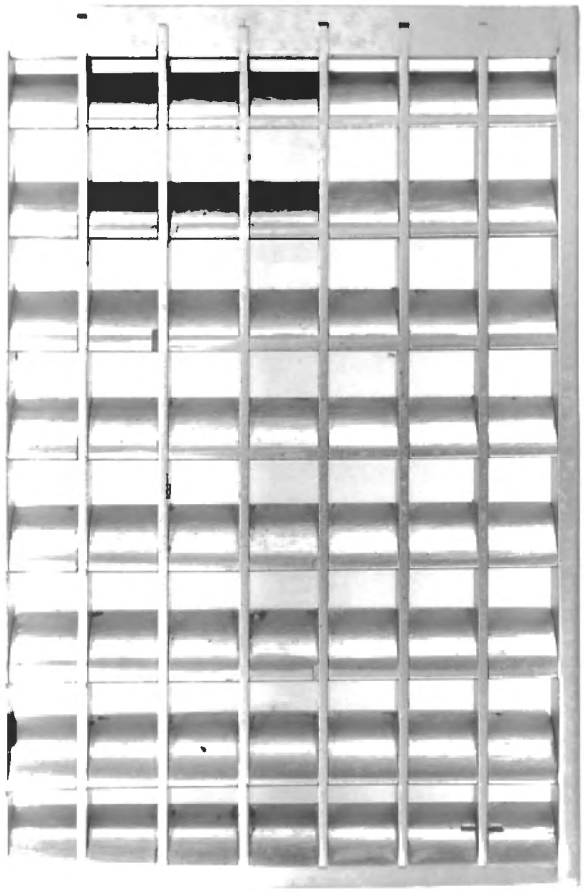

Figure 3. - Curved vane grate.

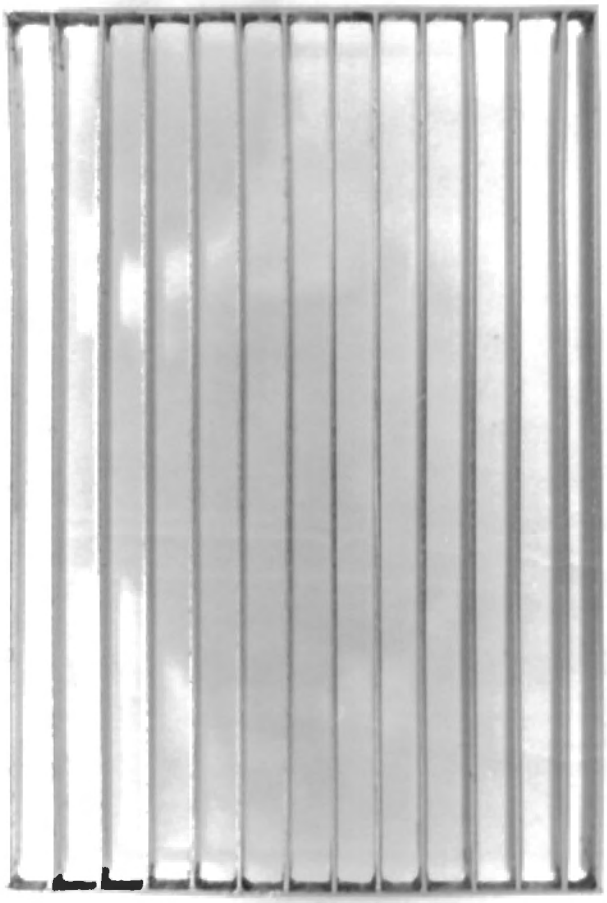

Figure 4. - Parallel bar grate.

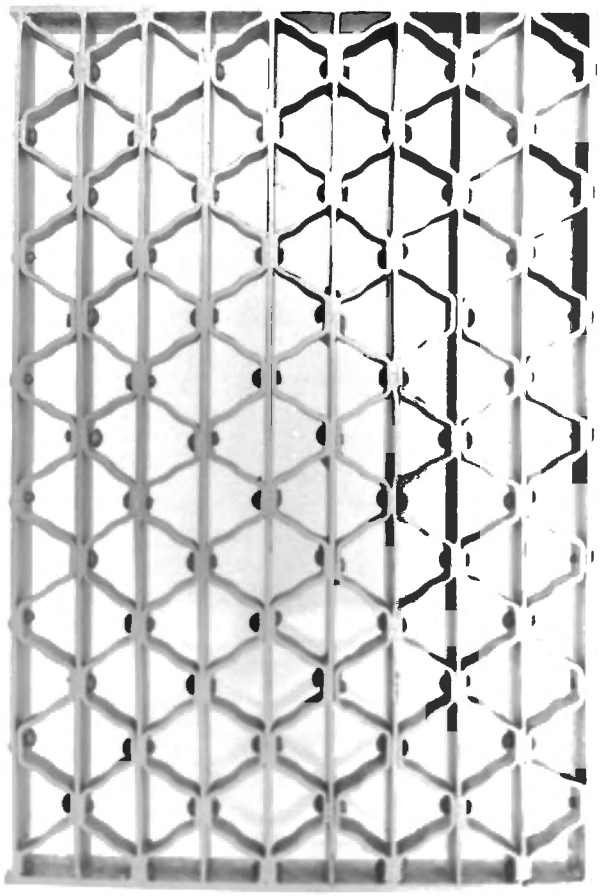

Figure 5. - Reticuline grate.

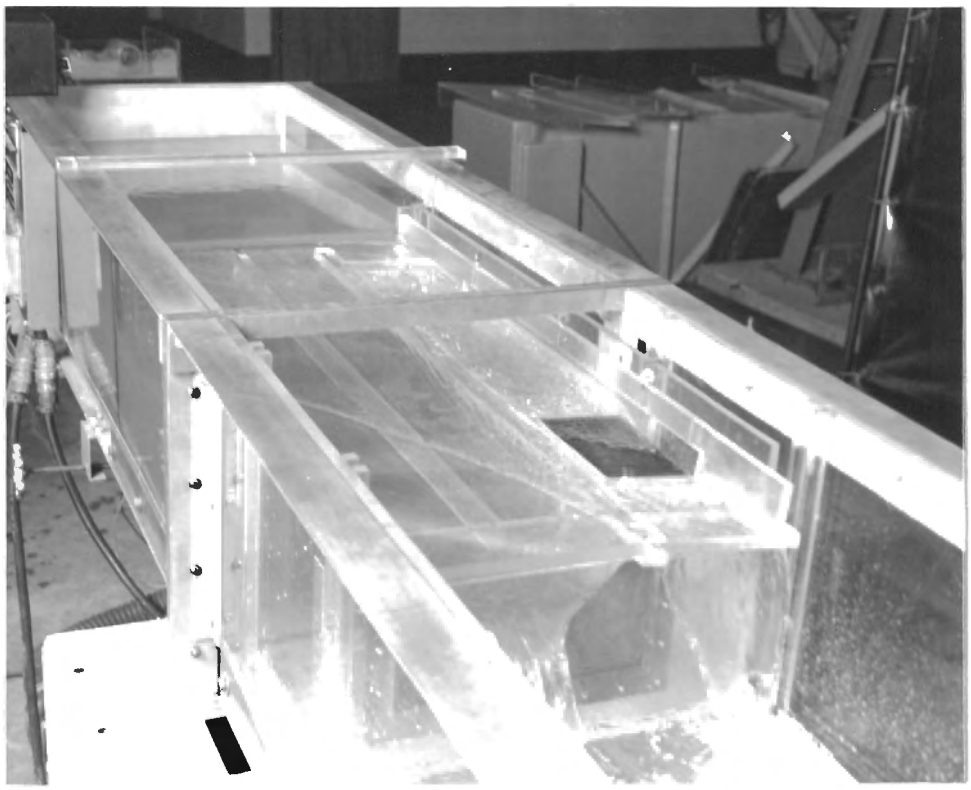

Figure 6. - Composite roadway with transverse bar grate and 6-inch curb opening.

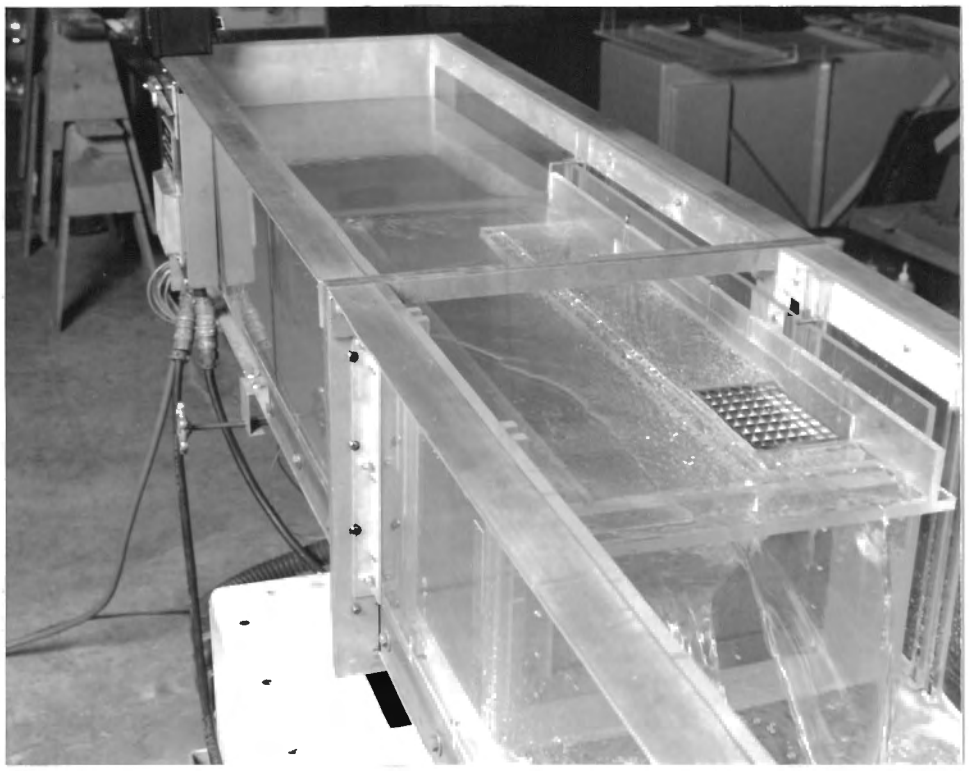

Figure 7. - Uniform roadway with curved vane grate and no curb opening inlet model.

Figure 8. - Uniform roadway with P-1 7/8 grate and 12-inch curb opening.

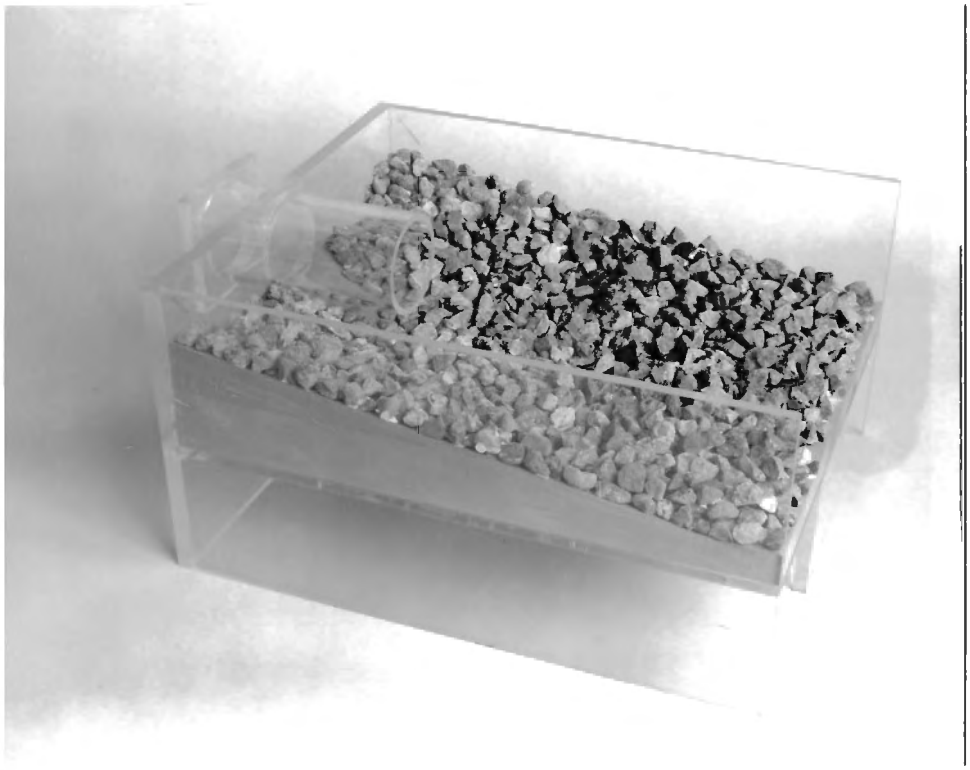

Figure 9. - Rock riprap energy dissipator.

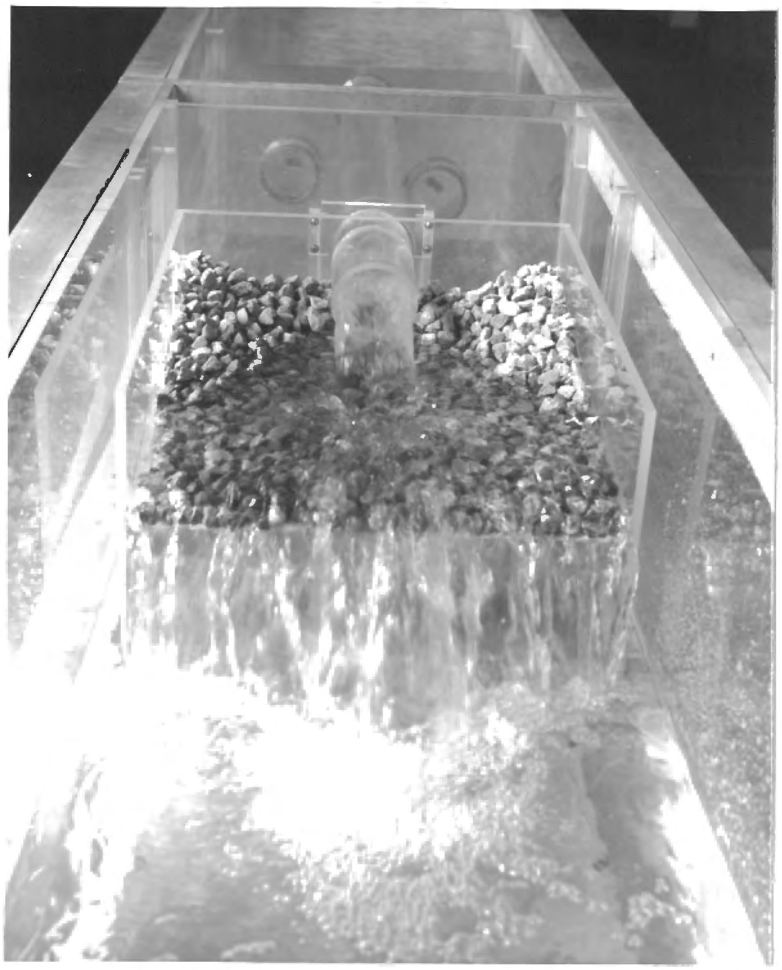

Figure 10. - Operation of the rock riprap energy dissipator in the portable flume.

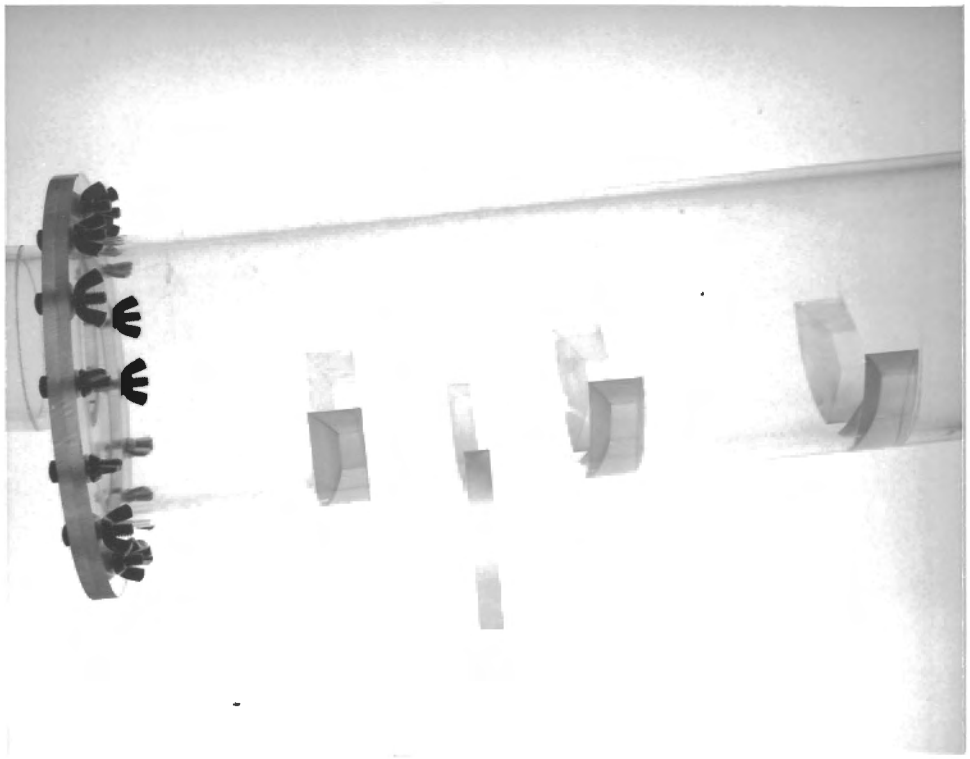

Figure 11. - Roughness rings energy dissipator.

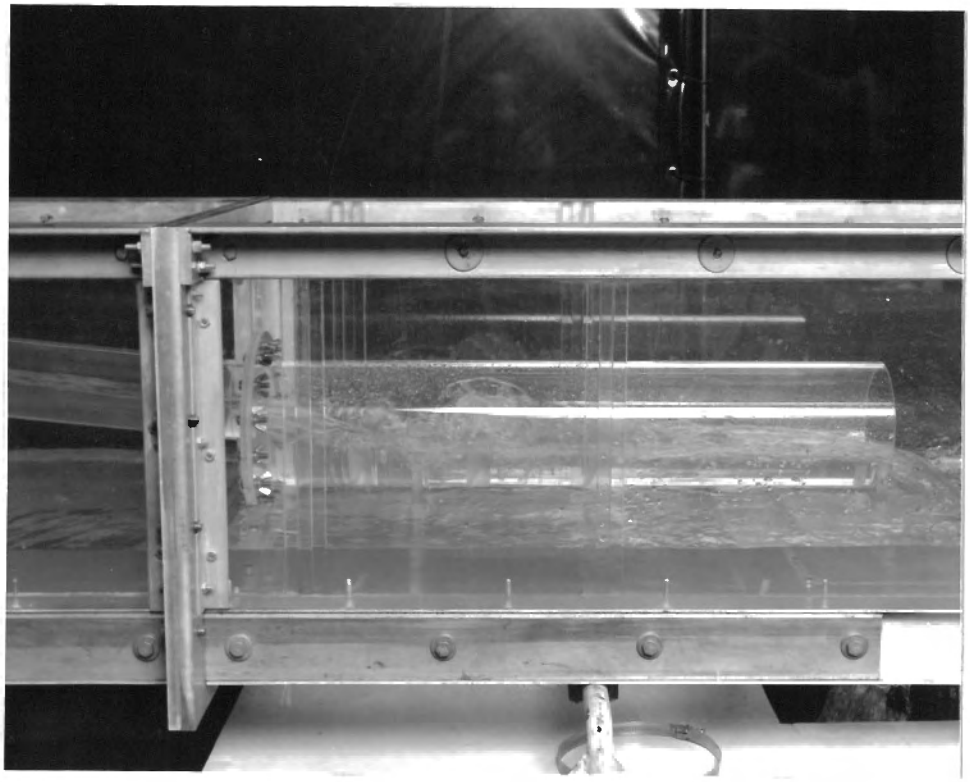

Figure 12. - Operation of the roughness ring energy dissipator in the portable flume.

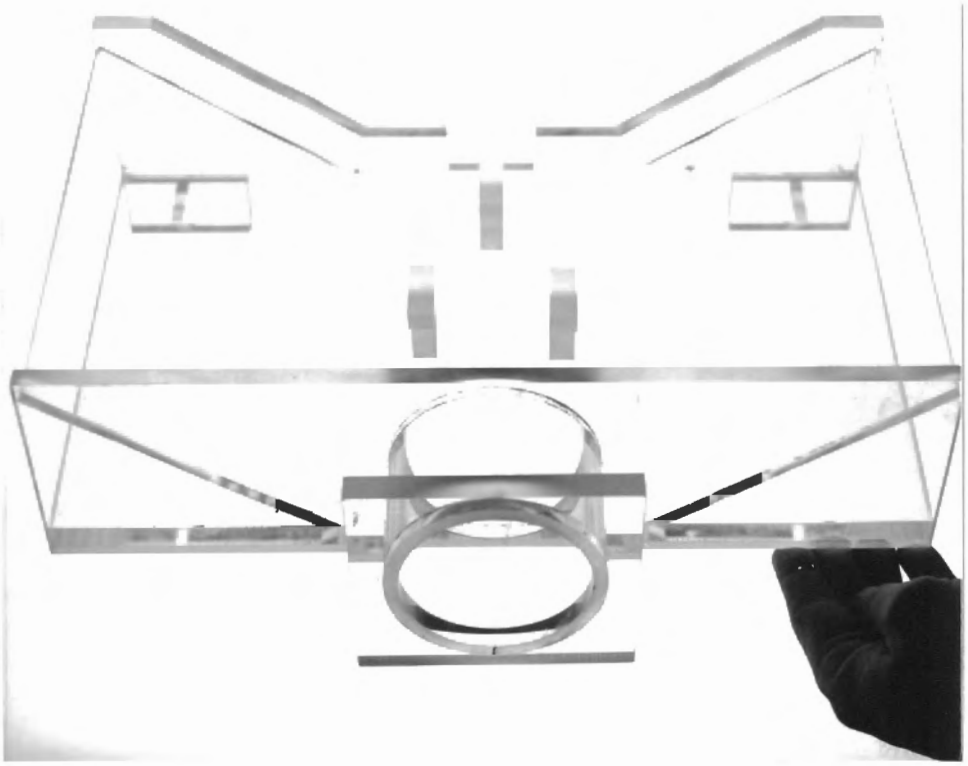

Figure 13. - Hook energy dissipator.

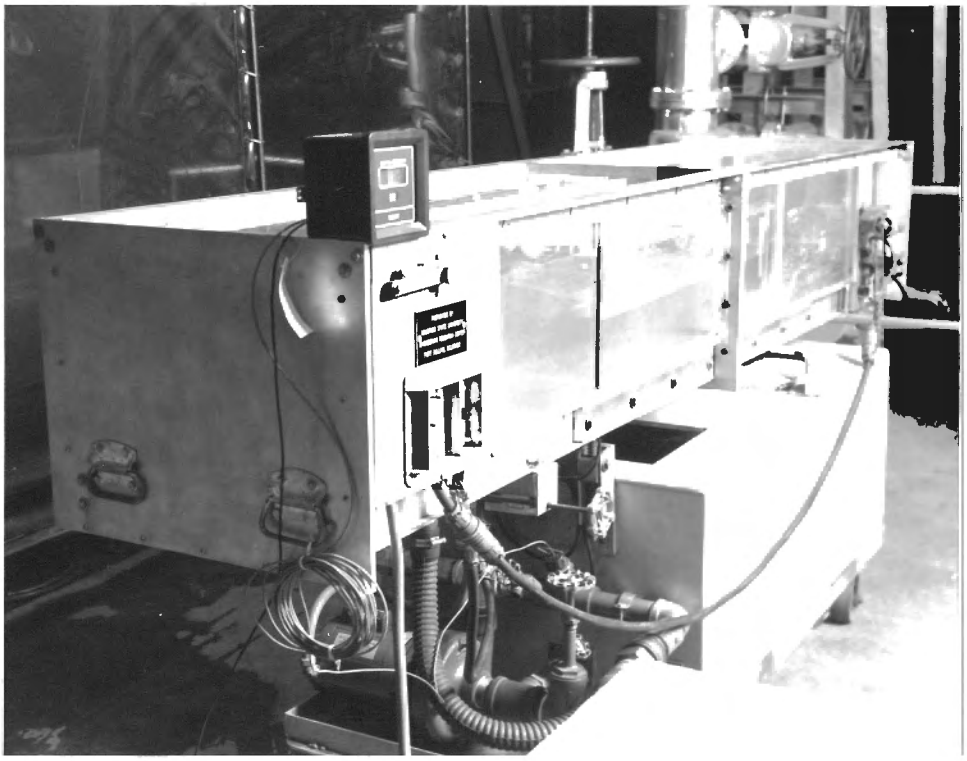

Figure 14. - Flume instrumentation.