January 1972

Model Study of the Manifold to be Used as a Component of the Virginia Electric and Power Company, 1974 Extension of Yorktown Power Station

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MODEL STUDY OF THE MANIFOLD TO BE USED AS A COMPONENT OF THE VIRGINIA ELECTRIC AND POWER COMPANY 1974 EXTENSION OF YORKTOWN POWER STATION

by

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October 1972

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INTRODUCTION

This report describes the fabrication and laboratory testing of a 1/12 scale model of the 5 branch converging manifold to be installed as a component of the Virginia Electric and Power Company 1974 extension of the Yorktown power station. The design of the manifold (see Fig. 1) was supplied by Brown & Root, Inc. The geometry of Branch number 1 as shown on Fig. 1 was modified slightly from the original design after conferring with Brown & Root, Inc. in order to facilitate the fabrication of this branch of the model.

In addition to the fabrication of the manifold model, facilities were constructed to carry out the testing of the model. These facilities consisted of: (1) a head box designed to force equal flow rates through all five inlet branches of the manifold (see Fig. 2), (2) five inlet pipes which convey the water from the five units in the head box to each of five branches, (3) a 20-foot long 14 inch inside diameter pipe which conveyed the discharge from the manifold, and (4) a discharge box with means for controlling the downstream head by means of two gates, one of which closes the discharge pipe and the other controls the water level in the box. The test facilities were located in the hydraulic laboratory of the Utah Water Research Laboratory taking the water supply from one of the 16 inch main supply lines and discharging the flow into a 3-foot

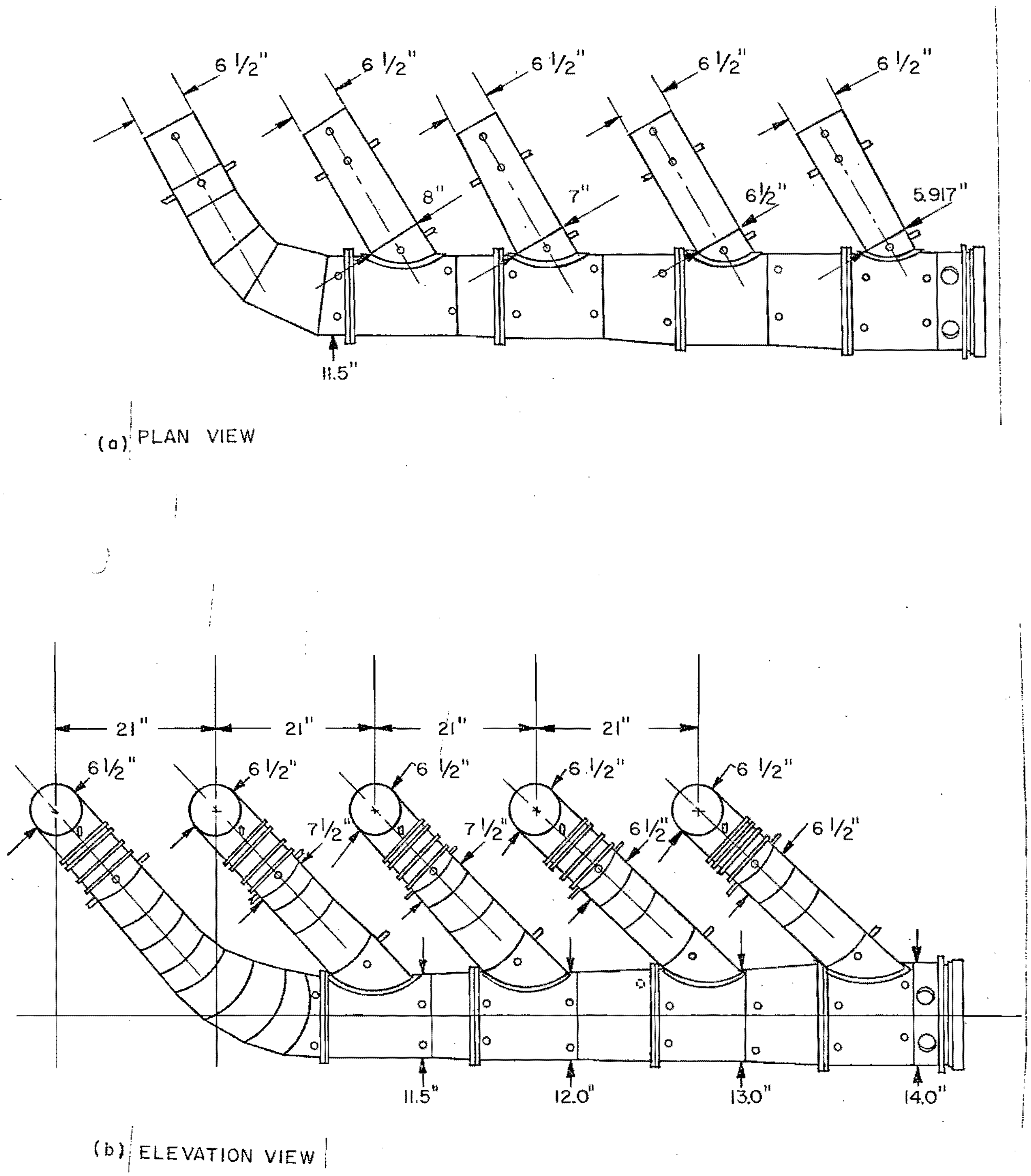


Fig. 1. Design of manifold model.

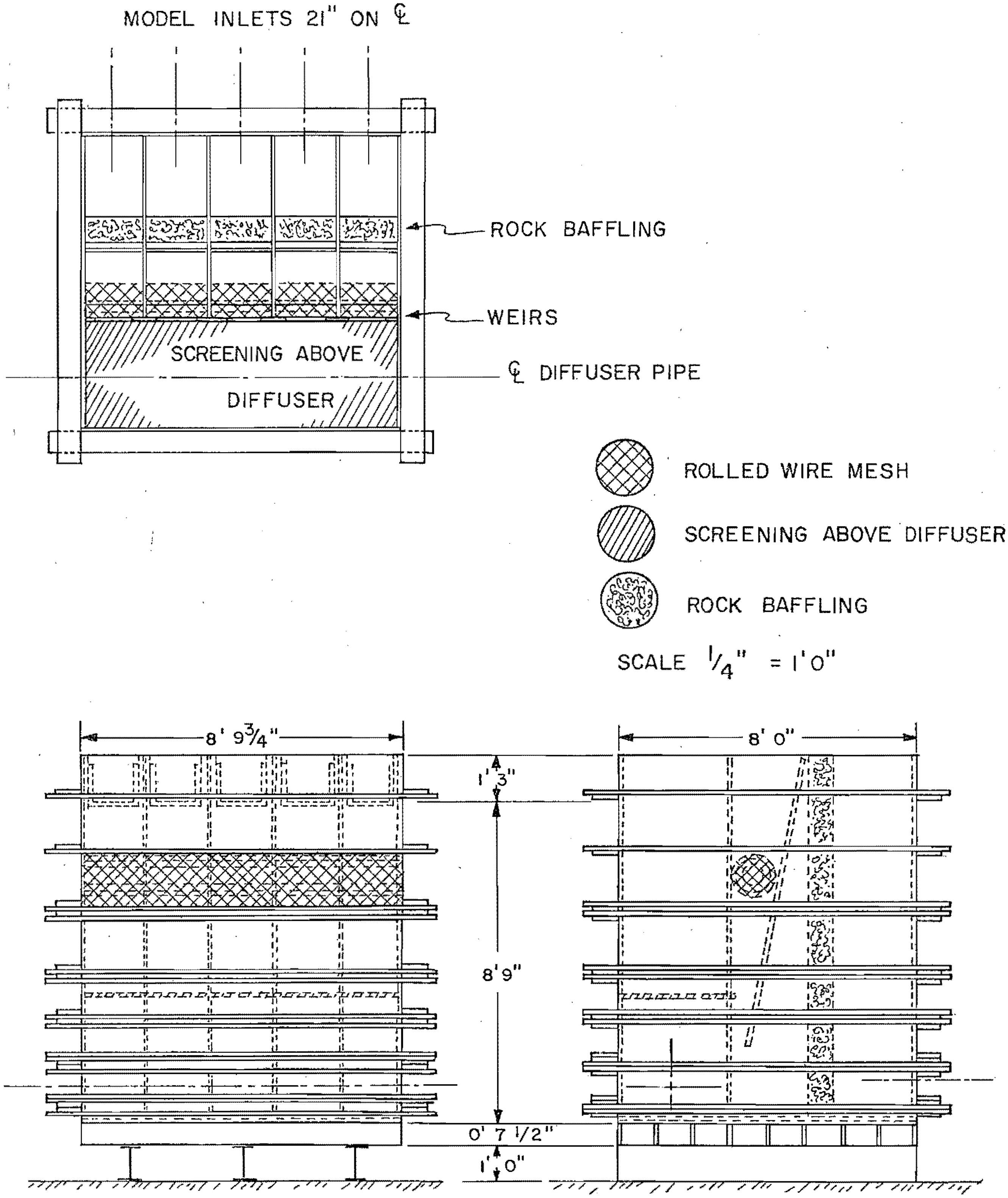
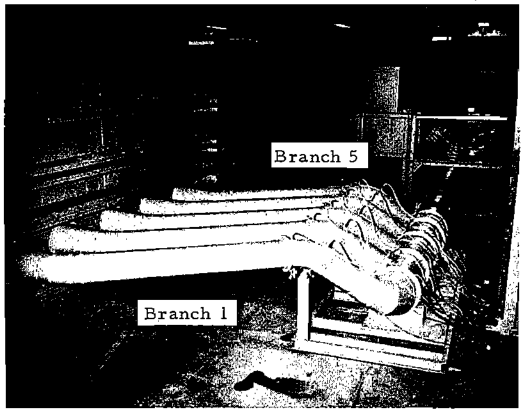
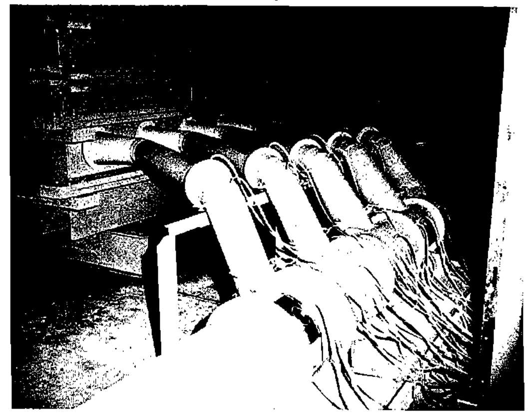


Fig. 2. Head box design.

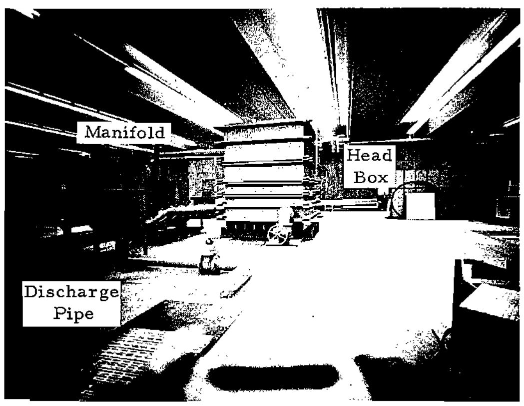
wide channel in the floor of the hydraulic laboratory which conveys the water to the weighing tanks for accurate flow rate determinations. The photographs on Fig. 3 show the manifold model, the test facilities and their layout.



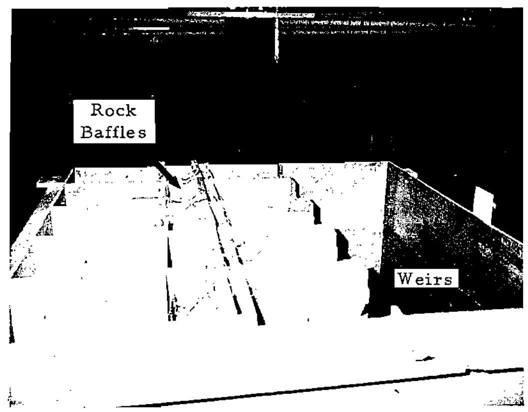
(a) Manifold model looking downstream



(b) Manifold model looking upstream

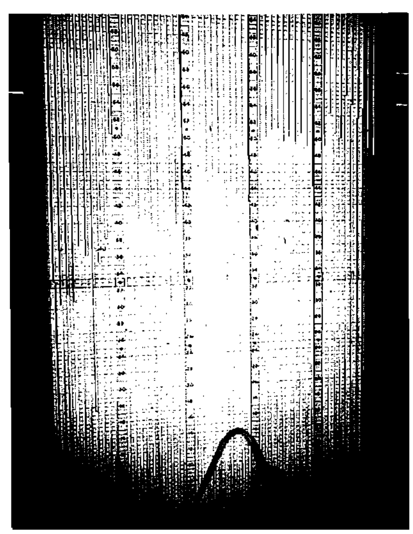


(c) Test layout showing head box in center of photograph



(d) Top view of head box

(e) Discharge box



(f) Piezometer board with a flow rate, Q = 10 cfs

Fig. 3. Photographs showing manifold model and test facilities.

CONSTRUCTION OF MANIFOLD MODEL

The manifold model was constructed from steel with four 3 inch diameter plexiglass windows located in the 14 inch discharge pipe immediately downstream of the last inlet branch. The work of fabricating the model was done by Technical Services, a unit within Utah State University with equipment and facilities to do this type of work. Each branch, with its mainline stem, was fabricated as a separate component of the model. The model was completed by bolting these five components together. The primary motivation for fabricating the model in these five separate components was to allow for possible subsequent testing involving changes in the design of individual branches of the manifold which might be proposed as a consequence of the present model's performance. The individual pieces used in each component of the model were individually fabricated within close tolerances, the ends of these pieces were grooved to ensure exact alignment and then welded together. After this assembly the interior of each component was hand worked to create as smooth a surface as practical. This working consisted of carefully grinding off any edges at the joints caused by temperature stresses during welding, applying several coats of paint and sanding the paint with fine sandpaper. This process produced a surface which felt perfectly smooth to the finger touch.

A total of 73 pressure taps were installed in the manifold including 4 taps in the 14 inch discharge pipe (see Figs. 1 and 3). The inlet of each branch contained such a tap on its top. Four taps were placed around the pipe of each branch immediately beyond its bend. Three taps were placed at the exit of each branch into the mainline. Four taps were also placed in the mainline immediately upstream and also immediately downstream from each of the branches and the mainline. In addition four pressure taps were inserted in the 14 inches discharge pipe at a distance of 4 feet beyond the end of the manifold.

These pressure taps were constructed by welding a nipple containing internal threads into a hole drilled into the wall of the manifold. The hole containing the nipple was drilled only part way through the wall. The remaining depth of approximately 1/16 inch was drilled through with a small diameter hole of 1/32 inch. A fitting over which the tygon tube which lead to the piezometer board and a small valve were screwed into the nipple.

For subsequent reference four subscripts will be used to denote the pressure head measurements and other quantities associated with the pressure taps. The first such subscript will be a "b" or "m" to denote branch or mainline respectively. The second subscript denotes the branch number if "b" is the first subscript, or if "m" is the first subscript, the second subscript denotes the number of the branch nearest the pressure tap. The third subscript denotes the position of tap along the branch or mainline. For the branches the inlet position is denoted by an "i," the position immediately beyond the bend by a "c," and the exit position by an "e." For the mainline taps, a "u" denotes immediately upstream from the branch entry and a "d" immediately downstream therefrom. The fourth subscripts will be a number 1 through 4 denoting the location of the tap at the section defined by the first three subscripts. A 1 denotes the top, a 2 the right side when facing in the direction of flow, a 3 the bottom, and a 4 the left side. Since only one tap exists at the inlet of each branch, the fourth subscript will be deleted when referring to taps denoted by (b1i), (b2i), ... (b5i). This subscript identification is consistent with and easily correlated with the columns and separate rows in the tables given subsequently which contain the data from the tests.

CONSTRUCTION OF HEAD BOX

The dimensions of the head box are given in Fig. 2. It is divided into three separate compartments. The first compartment receives the water from the laboratory supply line from a 14 inch perforated pipe. Grating is placed above this pipe for the purpose of damping out large scale turbulent eddies. Five identical shape rectangular contracted weirs were fabricated and installed near the top of the partition which separates the first and middle compartments of the head box. The crests of these weirs were all set at the same elevation and were used to provide identical flow rates to each of the branches of the manifold. Four parallel partitions divided the middle and final compartments of the head box into five separate units which supply the flow rate to each of the branches of the manifold. A 7 inch thick baffling of rock with diameter sizes up to approximately $1\frac{1}{2}$ inches were placed to separate the middle and final compartments of each unit.

Preliminary tests indicated that considerable air was entrained in the water upon falling from the weir into the water in the second compartments, and was carried through the rock baffles and into the manifold branches. Subsequently each unit of the second compartment was fitted with a sliding 3/4 inch sheet of plywood which sloped forward and downward. The water falling from the weirs was deflected forward by this sheet and forced to pond near its bottom. In addition rolls made of bug screen were placed on these inclined sheets causing the free overall of water to be broken up before entering the pond at the bottom and also providing for additional energy dissipation. After installation of the inclined sheets and bug screens within each unit of the second compartments no air was visible as the water emerged into the third compartments. However, particularly at the higher flow rates, a thin froth developed near the downstream end of the units in the third compartment, indicating that some small size air bubbles were still passing through the rock baffles. Since the head box was operated with 2 feet or more of water above the discharge pipes, it is doubtful whether any air bubbles with the capability of rising in the manifold were carried out of the head box. No air accumulated in the pressure taps, nor was any air visible in the manifold windows.

CALIBRATION OF WEIRS

Since it was desirable to measure the piezometric head at the various taps for specified flow rates, the relationship of flow rate to depth of water in the first compartment of the head box was determined. To determine this relationship the discharge from the manifold was directed into the automatic weighing tanks. A piezometer from the first compartment gave the head for each of these discharges. The results from this calibration are shown on Fig. 4. Fitting a straight line to the calibration data gives the following relationship of flow rate to height of head above the weir crest.

$$Q \text{ (cfs)} = 0.385\, h^{1.5} \text{ (in.)} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

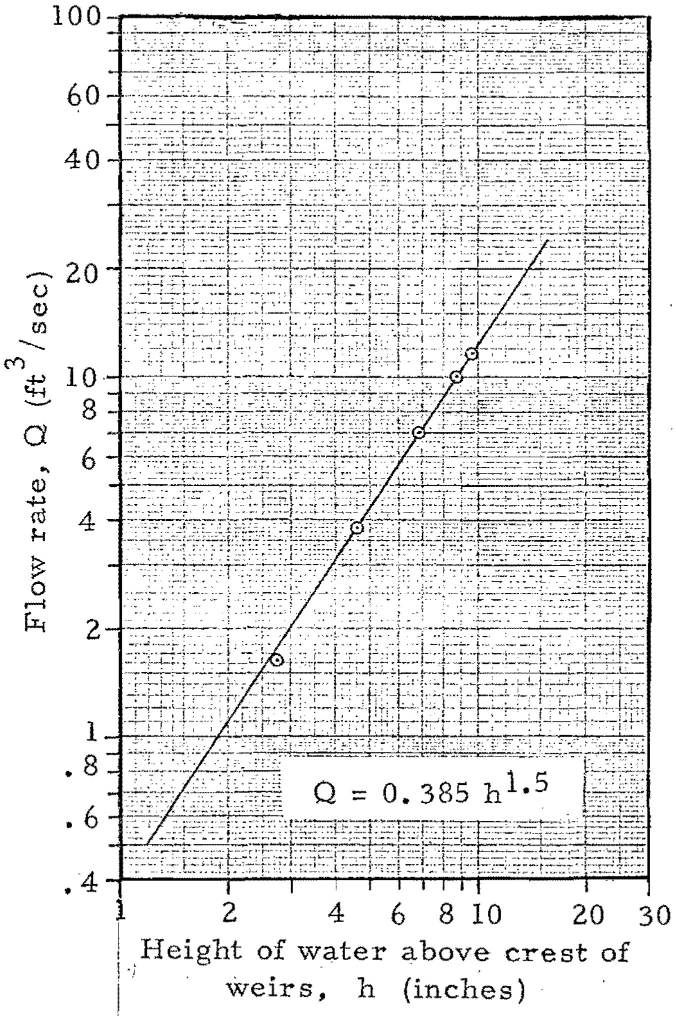


Fig. 4. Calibration of weirs.

TEST PROCEDURE

After adjusting the valves on the supply line so that the head on the weirs corresponded to the desired flow rate, the gates in the discharge box were adjusted so that 2 feet or more pressure head existed at the inlets to the manifold branches. Each of the piezometers were flushed of any air pockets entrapped in the tygon tubes due to start-up. After the flow was well established the piezometers were read and the height of water in each such column recorded. In obtaining this data it was necessary to switch the single tygon tube which serviced the four pressure taps just below the bend of each branch and the single tygon tube which serviced the three pressure taps at the exit of each branch. This procedure was necessary because the piezometer board which was used consisted of 50 glass tubes whereas the manifold contained 73 pressure taps. In obtaining the data for a few flow rates, the tubes were not switched to different pressure taps and consequently only 50 piezometric head measurements were obtained in these tests. In the majority of tests, however, 73 piezometric heads were recorded.

After collecting the piezometric head data for a given flow rate, the valves on the supply line were adjusted for the next flow rate and the procedure repeated. Four series of tests were performed in this manner. The first series began with a flow rate of 2 cfs and proceeded to a flow rate of 12 cfs in 2 cfs increments. In this series two sets of data were obtained for a flow rate of 4 cfs. On the following day the second series of test data were obtained starting with 14 cfs and decreasing to 2 cfs in increments of 2 cfs.

In obtaining the data from the first two series of tests it was observed that although the total flow rate through the system did not change, the water level in the piezometers did not completely stabilize, but fluctuated in a random fashion. From a number of spot checks it appeared that the magnitude of this fluctuation was as large as ± 1/2 inch in some of the piezometer tubes. When the large fluctuations occurred, the water level quite rapidly adjusted itself toward the mean position.

After working up the data from the first two series of tests, and examining the results and inconsistencies between equal flow rates in these test series, it was concluded that the observed fluctuation probably accounted for much of the inconsistency in the data. Consequently, in obtaining the data in the third and fourth series of tests it was decided that the manometer board would be photographed, and the piezometric heads read from the photographs. This procedure would at least insure that 50 of the piezometric heads would all be recorded at the same instant of time.

The third and fourth series of data were obtained during the same day with the system in continuous operation. The third series began with 2 cfs and the flow rate was increased in 2 cfs increments to 14 cfs. Then the fourth series began and the flow rate was decreased in 2 cfs increments down to 2 cfs. Only one set of piezometric head data were obtained at the 14 cfs flow rate in these two test series.

The pressure tap on the top of the 14 inch discharge pipe 4 feet from the end of the manifold was selected as a reference to adjust the piezometric heads record from switching the tygon tubes on the branches below the bend and their exits. This reference piezometer showed no fluctuation as did some of the piezometers attached to the manifold.

To evaluate the stability of the pressure at the downstream section and also the piezometer which records the head on the weirs, they were both monitored continually for a 2 hour period. During this period, these piezometers were very stable. The variation was within ± 0.005 inch. This stability indicates that the total flow passing through the system does not vary with time. Consequently, the fluctuation observed in the other piezometers is due to a low frequency transient which develops randomly between the 5 separate units of the head box and the 5 manifold branches. Such transients are characteristic of turbulent flows. In the flow system of the test set-up large turbulent eddies cause a momentary change in the flow conditions in the manifold. The effect of this change is passed to the head box reservoir with the result that its water level begins to rise (or falls) slightly. But since very little viscous damping exists for small secondary flows between manifold branches, water level in this unit of the head box unit continues to rise while that in another unit falls until gravity reverses the secondary flow. The turbulent eddies act as a triggering mechanism to keep the processing operating continually.

The magnitude of this fluctuation is of insignificant consequence in head loss determinations. Its only effect is that the recorded data may not represent the mean water depth in any particular piezometer. Consequently the data is not reliable to the precision with which it can be recorded, but rather it should be interpreted as being subject to a probable error in the magnitude of approximately ± 0.1 inch.

TEST DATA

The piezometric head data collected from the tests which have been referred to as series 1 and 2 are summarized in Table 1 along with other items of interest concerning the flows. Table 2 gives the same data from series 3 and 4. This latter data should be given greater weight than the former, for reasons explained above. The columns in these tables are ordered in a down flow direction starting with Branch 1 to the section 4 feet downstream in the discharge pipe where the pressure taps were placed. Under each branch, with the exception of the first branch where exit is also the mainline, three columns contain the data at its inlet, at the section immediately downstream from its bend (denoted by cent., for center) and its exit. The columns before and after each branch, denoted by mainline, contain the data from the section in the mainline where the pressure taps were installed immediately upstream and downstream respectively from the junctions of each branch with the mainline. Under each flow rate the lines in these tables give the following information.

Line 1 contains the mean velocities at each of the given sections in feet per second.

Line 2 gives the Reynolds number at each section multiplied by 10^{-5}. These values were computed using a water temperature of 48^{o}F (9^{o}C), (which was observed to be fairly constant during all tests), which gives a kinematic viscosity equal to 1.45×10^{-5} ft^{2}/sec.

Table 1. Summary of series 1 and 2 preliminary test data from the proposed Yorktown power station manifold.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
DIAMETERS (IN.)	6.5	6.5	11.5	6.5	7.5	8.0	11.5	12.0	6.5	7.5	7.0	12.0	13.0	6.5	6.5	6.5	13.0	14.0	6.5	6.5	5.917	14.0	14.0
AREAS (SQ. FT.)	.230	.230	.721	.230	.307	.349	.721	.785	.230	.307	.267	.785	.922	.230	.230	.230	.922	1.069	.230	.230	.191	1.069	1.069
Q (CFS) = 2.0																							
VELOCITIES (FPS)	1.7	1.7	.6	1.7	1.3	1.1	1.1	1.0	1.7	1.3	1.5	1.5	1.3	1.7	1.7	1.7	1.7	1.5	1.7	1.7	2.1	1.9	1.9
REY. NO. X10E-5	.6	.6	.4	.6	.6	.5	.7	.7	.6	.6	.6	1.1	1.0	.6	.6	.6	1.3	1.2	.6	.6	.7	1.5	1.5
PRESSURE H (IN)	50.1	50.2	50.3	50.2	50.2	50.3	50.1	50.2	50.2	50.3	50.2	49.9	49.9	50.2	50.2	50.0	49.7	49.8	50.2	50.2	49.7	49.7	49.5
		50.0	50.4		50.0	50.3	50.3	50.3		50.1	50.2	50.0	50.1		50.0	49.9	49.7	49.9		50.1	49.7	49.7	49.5
		49.8	50.3		49.7	50.3	50.1	50.2		49.7	49.7	49.9	49.9		49.5	50.0	49.7	49.8		49.9	49.6	49.6	49.5
		50.0	50.3		50.1		49.9	49.8		50.1		49.6	50.1		50.1		49.3	49.9		50.1		48.8	49.5
AV. PRES. H(IN)	50.1	50.0	50.3	50.2	50.0	50.3	50.1	50.1	50.2	50.0	50.0	49.8	50.0	50.2	49.9	50.0	49.6	49.8	50.2	50.1	49.7	49.5	49.5
VELOCITY H. (IN)	.56	.56	.06	.56	.32	.24	.23	.19	.56	.32	.42	.43	.32	.56	.56	.56	.56	.42	.56	.56	.82	.65	.65
TOTAL HEAD (IN)	50.7	50.6	50.4	50.8	50.3	50.5	50.3	50.3	50.8	50.3	50.4	50.3	50.3	50.7	50.5	50.5	50.2	50.3	50.8	50.6	50.5	50.1	50.1
TOTAL H ABOVE ℄	26.0	25.9	25.7	26.1	25.6	25.8	25.6	25.6	26.1	25.6	25.7	25.6	25.6	26.0	25.8	25.8	25.5	25.6	26.1	25.9	25.8	25.4	25.4
H ABOVE DOWNST.	.5	.4	.3	.6	.2	.4	.2	.2	.7	.2	.3	.1	.2	.6	.4	.4	.0	.1	.6	.5	.3	.0	.0
ΔH/VEL H DOWNS.	.83			.96					1.03					.91					.96				
Q (CFS) = 4.0																							
VELOCITIES (FPS)	3.5	3.5	1.1	3.5	2.6	2.3	2.2	2.0	3.5	2.6	3.0	3.1	2.6	3.5	3.5	3.5	3.5	3.0	3.5	3.5	4.2	3.7	3.7
REY. NO. X10E-5	1.3	1.3	.7	1.3	1.1	1.1	1.5	1.4	1.3	1.1	1.2	2.1	1.9	1.3	1.3	1.3	2.6	2.4	1.3	1.3	1.4	3.0	3.0
PRESSURE H (IN)	78.9	79.0	79.8	79.2	79.3	79.6	79.1	79.2	79.4	79.4	79.3	78.2	78.3	79.1	79.1	78.2	77.3	77.7	79.3	79.2	77.4	77.1	76.5
		78.5	79.9		78.7	79.7	79.4	79.4		78.9	79.2	78.4	78.7		78.5	78.1	77.4	77.9		78.8	77.3	77.3	76.4
		77.9	79.8		78.4	79.7	79.0	79.1		78.1	79.3	78.0	78.2		77.6	78.1	77.2	77.6		78.0	77.7	77.0	76.6
		78.4	79.6		78.8		78.3	79.2		78.9		76.9	78.4		78.6		76.0	77.8		78.8		74.3	76.4
AV. PRES. H(IN)	78.9	78.5	79.8	79.2	78.8	79.6	78.9	79.2	79.4	78.8	79.3	77.9	78.4	79.1	78.4	78.1	77.0	77.7	79.3	78.7	77.5	76.4	76.5
VELOCITY H. (IN)	2.25	2.25	.23	2.25	1.27	.98	.92	.77	2.25	1.27	1.67	1.74	1.26	2.25	2.25	2.25	2.25	1.67	2.25	2.25	3.27	2.61	2.61
TOTAL HEAD (IN)	81.2	80.7	80.0	81.4	80.0	80.6	79.9	80.0	81.6	80.1	80.9	79.6	79.7	81.3	80.7	80.4	79.2	79.4	81.5	81.0	80.7	79.1	79.1
TOTAL H ABOVE ℄	56.5	56.0	55.3	56.7	55.3	55.9	55.2	55.3	56.9	55.4	56.2	54.9	55.0	56.6	56.0	55.7	54.5	54.7	56.8	56.3	56.0	54.4	54.4
H ABOVE DOWNST.	2.1	1.6	.9	2.4	.9	1.5	.8	.9	2.5	1.0	1.8	.5	.6	2.3	1.6	1.3	.1	.3	2.5	1.9	1.6	-.0	.0
ΔH/VEL H DOWNS.	.79			.90					.96					.86					.94				
Q (CFS) = 4.0																							
VELOCITIES (FPS)	3.5	3.5	1.1	3.5	2.6	2.3	2.2	2.0	3.5	2.6	3.0	3.1	2.6	3.5	3.5	3.5	3.5	3.0	3.5	3.5	4.2	3.7	3.7
REY. NO. X10E-5	1.3	1.3	.7	1.3	1.1	1.1	1.5	1.4	1.3	1.1	1.2	2.1	1.9	1.3	1.3	1.3	2.6	2.4	1.3	1.3	1.4	3.0	3.0
PRESSURE H (IN)	76.9	76.4	77.7	77.1	76.7		77.0	77.1	77.4	76.9		76.4	76.4	77.1	76.7	76.3	75.3	75.7	77.1	76.8	75.4	75.1	74.4
			78.0			77.6	77.4	77.4			77.2	76.5	76.7				75.4	75.9				75.4	74.7
			77.7				77.0	77.1				76.0	76.4				75.2	75.6				75.0	74.4
			77.7				76.2	77.1				75.1	76.4				74.1	75.9				72.4	74.6
AV. PRES. H(IN)	76.9	76.4	77.8	77.1	76.7	77.6	76.9	77.2	77.4	76.9	77.2	76.0	76.5	77.1	76.7	76.3	75.0	75.8	77.1	76.8	75.4	74.5	74.5
VELOCITY H. (IN)	2.25	2.25	.23	2.25	1.27	.98	.92	.77	2.25	1.27	1.67	1.74	1.26	2.25	2.25	2.25	2.25	1.67	2.25	2.25	3.27	2.61	2.61
TOTAL HEAD (IN)	79.1	78.6	78.0	79.4	78.0	78.6	77.8	78.0	79.7	78.1	78.9	77.7	77.8	79.3	79.0	78.5	77.3	77.4	79.3	79.0	78.7	77.1	77.1
TOTAL H ABOVE ℄	54.4	53.9	53.3	54.7	53.3	53.9	53.1	53.3	55.0	53.4	54.2	53.0	53.1	54.6	54.3	53.8	52.6	52.7	54.6	54.3	54.0	52.4	52.4
H ABOVE DOWNST.	2.0	1.5	.9	2.3	.8	1.4	.7	.8	2.6	1.0	1.7	.6	.6	2.2	1.8	1.4	.1	.3	2.2	1.9	1.6	.0	.0
ΔH/VEL H DOWNS.	.76			.87					.98					.85					.85				

Table 1. Continued.

	BRANCH 1 INLET	BRANCH 1 CENT.	MAIN LINE	BRANCH 2 INLET	BRANCH 2 CENT.	BRANCH 2 EXIT	MAIN LINE	MAIN LINE	BRANCH 3 INLET	BRANCH 3 CENT.	BRANCH 3 EXIT	MAIN LINE	MAIN LINE	BRANCH 4 INLET	BRANCH 4 CENT.	BRANCH 4 EXIT	MAIN LINE	MAIN LINE	BRANCH 5 INLET	BRANCH 5 CENT.	BRANCH 5 EXIT	MAIN LINE	DOWN-STREAM
Q (CFS) = 6.0																							
VELOCITIES(FPS)	5.2	5.2	1.7	5.2	3.9	3.4	3.3	3.1	5.2	3.9	4.5	4.6	3.9	5.2	5.2	5.2	5.2	4.5	5.2	5.2	6.3	5.6	5.6
REY. NO. X10E-5	1.9	1.9	1.1	1.9	1.7	1.6	2.2	2.1	1.9	1.7	1.8	3.2	2.9	1.9	1.9	1.9	3.9	3.6	1.9	1.9	2.1	4.5	4.5
PRESSURE H (IN)	61.3	61.7	63.2	62.2	62.4		61.8	62.1	62.7	62.7		59.9	60.2	61.7	62.0	59.9	57.6	58.4	62.2	62.3	58.1	57.2	55.4
			64.1			63.2	62.7	62.7			62.1	60.2	60.7				57.8	59.1				57.5	56.0
			63.5				61.8	62.1			.0	59.4	59.9				57.2	58.4				56.7	55.2
			63.1				59.9	62.2			.0	56.6	60.0				54.3	58.9				50.5	55.6
AV. PRES. H(IN)	61.3	61.7	63.5	62.2	62.4	63.2	61.5	62.3	62.7	62.7	62.1	59.0	60.2	61.7	62.0	59.9	56.7	58.7	62.2	62.3	58.1	55.5	55.5
VELOCITY H.(IN)	5.05	5.05	.52	5.05	2.85	2.20	2.06	1.74	5.05	2.85	3.76	3.91	2.84	5.05	5.05	5.05	5.05	3.76	5.05	5.05	7.36	5.87	5.87
TOTAL HEAD (IN)	66.4	66.7	64.0	67.2	65.3	65.[illegible]	63.6	64.0	67.7	65.6	65.9	62.9	63.0	66.8	67.1	65.0	61.8	62.5	67.3	67.4	65.4	61.4	61.4
TOTAL H ABOVE ₵	41.7	42.0	39.3	42.5	40.6	40.7	38.9	39.3	43.0	40.9	41.2	38.2	38.3	42.1	42.4	40.3	37.1	37.8	42.6	42.7	40.7	36.7	36.7
H ABOVE DOWNST.	5.0	5.3	2.6	5.8	3.9	4.0	2.2	2.6	6.3	4.2	4.5	1.5	1.6	5.4	5.7	3.6	.4	1.1	5.9	6.0	4.0	.0	.0
ΔH/VEL H DOWNS.	.84			.99					1.07					.91					1.01				
Q (CFS) = 8.0																							
VELOCITIES(FPS)	6.9	6.9	2.2	6.9	5.2	4.6	4.4	4.1	6.9	5.2	6.0	6.1	5.2	6.9	6.9	6.9	6.9	6.0	6.9	6.9	8.4	7.5	7.5
REY. NO. X10E-5	2.6	2.6	1.5	2.6	2.2	2.1	2.9	2.8	2.6	2.2	2.4	4.2	3.9	2.6	2.6	2.6	5.2	4.8	2.6	2.6	2.8	6.0	6.0
PRESSURE H (IN)	81.5	82.1	85.3	83.2	83.8		82.5	83.0	83.4	83.9		79.0	79.6	82.0	82.7	79.1	75.0	76.9	82.9	83.1	75.9	74.6	71.4
			86.4			85.0	83.7	83.9			82.5	79.5	80.6				75.6	77.7				75.1	72.6
			85.4				82.7	83.0				78.1	79.1				74.6	76.6				74.1	71.1
			84.4				78.7	83.4				73.7	79.8				69.8	77.6				63.6	71.6
AV. PRES. H(IN)	81.5	82.1	85.4	83.2	83.8	85.0	81.9	83.3	83.4	83.9	82.5	77.6	79.8	82.0	82.7	79.1	73.7	77.2	82.9	83.1	75.9	71.8	71.7
VELOCITY H.(IN)	8.98	8.98	.92	8.98	5.07	3.91	3.67	3.09	8.98	5.07	6.68	6.96	5.05	8.98	8.98	8.98	8.98	6.68	8.98	8.98	13.08	10.44	10.44
TOTAL HEAD (IN)	90.5	91.1	86.3	92.2	88.9	88.9	85.6	86.4	92.4	89.0	89.2	84.5	84.8	91.0	91.7	88.1	82.7	83.9	91.9	92.1	89.0	82.3	82.1
TOTAL H ABOVE ₵	65.8	66.4	61.6	67.5	64.2	64.2	60.9	61.7	67.7	64.3	64.5	59.8	60.1	66.3	67.0	63.4	58.0	59.2	67.2	67.4	64.3	57.6	57.4
H ABOVE DOWNST.	8.4	9.0	4.2	10.1	6.8	6.8	3.5	4.3	10.3	6.9	7.1	2.4	2.7	8.9	9.6	6.0	.6	1.8	9.8	10.0	6.9	.2	.0
ΔH/VEL H DOWNS.	.80			.97					.98					.85					.94				
Q (CFS) = 10.0																							
VELOCITIES(FPS)	8.7	8.7	2.8	8.7	6.5	5.7	5.5	5.1	8.7	6.5	7.5	7.6	6.5	8.7	8.7	8.7	8.7	7.5	8.7	8.7	10.5	9.4	9.4
REY. NO. X10E-5	3.2	3.2	1.8	3.2	2.8	2.6	3.7	3.5	3.2	2.8	3.0	5.3	4.9	3.2	3.2	3.2	6.5	6.0	3.2	3.2	3.6	7.5	7.5
PRESSURE H (IN)	64.4	65.0	69.8	66.2	67.0		65.5	66.7	67.0	68.2		59.7	60.8	64.3	65.3	60.0	53.1	56.3	66.1	66.6	54.7	52.6	47.1
			71.8			69.4	67.7	67.7			65.6	61.1	62.4				54.3	57.5				53.6	49.4
			69.5				65.9	66.5				58.7	60.1				52.8	56.0				51.5	46.5
			68.4				60.3	67.1				51.1	60.6				44.0	57.5				33.3	47.6
AV. PRES. H(IN)	64.4	65.0	69.9	66.2	67.0	69.4	64.8	67.0	67.0	68.2	65.6	57.6	61.0	64.3	65.3	60.0	51.0	56.8	66.1	66.6	54.7	47.7	47.6
VELOCITY H.(IN)	14.04	14.04	1.43	14.04	7.92	6.12	5.73	4.83	14.04	7.92	10.44	10.87	7.90	14.04	14.04	14.04	14.04	10.44	14.04	14.04	20.44	16.31	16.31
TOTAL HEAD (IN)	78.4	79.0	71.3	80.2	74.9	75.5	70.6	71.8	81.0	76.1	76.0	68.5	68.9	78.3	79.3	74.0	65.1	67.3	80.1	80.6	75.1	64.1	64.0
TOTAL H ABOVE ₵	53.7	54.3	46.6	55.5	50.2	50.8	45.9	47.1	56.3	51.4	51.3	43.8	44.2	53.6	54.6	49.3	40.4	42.6	55.4	55.9	50.4	39.4	39.3
H ABOVE DOWNST.	14.5	15.1	7.4	16.3	11.0	11.6	6.6	7.9	17.1	12.2	12.1	4.6	4.9	14.4	15.4	10.1	1.1	3.3	16.2	16.7	11.2	.1	.0
ΔH/VEL H DOWNS.	.89			1.00					1.05					.88					.99				

Table 1. Continued.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
Q (CFS) = 12.0																							
VELOCITIES(FPS)	10.4	10.4	3.3	10.4	7.8	6.9	6.7	6.1	10.4	7.8	9.0	9.2	7.8	10.4	10.4	10.4	10.4	9.0	10.4	10.4	12.6	11.2	11.2
REY. NO. X10E-5	3.9	3.9	2.2	3.9	3.4	3.2	4.4	4.2	3.9	3.4	3.6	6.3	5.8	3.9	3.9	3.9	7.8	7.2	3.9	3.9	4.3	9.0	9.0
PRESSURE H (IN)	72.2	73.5	80.6	73.5	75.3		74.0	75.4	76.5	78.0		66.0	67.4	73.0	74.6	66.4	56.6	60.2	74.8	75.2	58.1	55.2	46.8
			83.6			79.3	77.2	77.5			74.6	67.8	69.8				57.6	62.3				56.2	50.6
			80.6				74.3	75.2				63.8	66.2				55.6	59.7				53.3	46.1
			78.9				67.2	76.8				53.5	68.0				43.2	61.8				30.0	47.7
AV. PRES. H(IN)	72.2	73.5	80.9	73.5	75.3	79.3	73.2	76.2	76.5	78.0	74.6	62.8	67.8	73.0	74.6	66.4	53.2	61.0	74.8	75.2	58.1	48.8	47.8
VELOCITY H.(IN)	20.21	20.21	2.06	20.21	11.40	8.81	8.25	6.96	20.21	11.40	15.03	15.66	11.37	20.21	20.21	20.21	20.21	15.03	20.21	20.21	29.43	23.48	23.48
TOTAL HEAD (IN)	92.4	93.7	83.0	93.7	86.7	88.1	81.4	83.2	96.7	89.4	89.6	78.4	79.2	93.2	94.8	86.6	73.5	76.0	95.0	95.4	87.5	72.3	71.3
TOTAL H ABOVE ¢	67.7	69.0	53.3	69.0	62.0	63.4	56.7	58.5	72.0	64.7	64.9	53.7	54.5	68.5	70.1	61.9	48.8	51.3	70.3	70.7	62.8	47.6	46.6
H ABOVE DOWNST.	21.1	22.4	11.7	22.4	15.4	16.8	10.1	11.9	25.4	18.1	18.3	7.2	7.9	21.9	23.5	15.3	2.2	4.7	23.7	24.1	16.3	1.0	.0
ΔH/VEL H DOWNS.	.90			.96					1.08					.93					1.01				
Q (CFS) = 14.0																							
VELOCITIES(FPS)	12.2	12.2	3.9	12.2	9.1	8.0	7.8	7.1	12.2	9.1	10.5	10.7	9.1	12.2	12.2	12.2	12.2	10.5	12.2	12.2	14.7	13.1	13.1
REY. NO. X10E-5	4.5	4.5	2.6	4.5	3.9	3.7	5.1	4.9	4.5	3.9	4.2	7.4	6.8	4.5	4.5	4.5	9.1	8.4	4.5	4.5	5.0	10.5	10.5
PRESSURE H (IN)	62.9	64.2	73.7	66.5	78.3	72.9	65.9	67.5	68.7	70.8	67.2	54.2	56.4	64.3	65.9	55.0	41.5	47.4	67.3	67.8	44.5	40.5	28.7
		57.5	78.2		59.2	73.5	69.6	70.2		63.5	66.5	56.7	59.6		58.5	56.0	43.8	49.9		61.8	43.3	42.2	34.3
		48.4	74.2		55.0	74.2	65.6	66.7		54.7	69.0	51.5	55.3		50.3	57.5	40.4	46.5		51.8	46.5	38.3	29.0
		56.7	71.5		61.1		54.5	69.0		62.3		37.2	56.8		59.0		23.9	50.0		62.5		4.5	29.6
AV. PRES. H(IN)	62.9	56.7	74.4	66.5	63.4	73.5	63.9	68.3	68.7	62.8	67.6	49.9	57.0	64.3	58.4	56.2	37.4	48.4	67.3	61.0	44.8	31.4	30.4
VELOCITY H.(IN)	27.51	27.51	2.81	27.51	15.52	11.99	11.23	9.47	27.51	15.52	20.45	21.31	15.47	27.51	27.51	27.51	27.51	20.45	27.51	27.51	40.06	31.96	31.96
TOTAL HEAD (IN)	90.4	84.2	77.2	94.0	78.9	85.5	75.1	77.8	96.2	78.3	88.0	71.2	72.5	91.8	85.9	83.7	64.9	68.9	94.8	88.5	84.8	63.3	62.4
TOTAL H ABOVE ¢	65.7	59.5	52.5	69.3	54.2	60.8	50.4	53.1	71.5	53.6	63.3	46.5	47.8	67.1	61.2	59.0	40.2	44.2	70.1	63.8	60.1	38.6	37.7
H ABOVE DOWNST.	28.1	21.9	14.8	31.7	16.6	23.2	12.8	15.5	33.9	16.0	25.7	8.9	10.1	29.5	23.6	21.3	2.6	6.5	32.5	26.1	22.5	1.0	.0
ΔH/VEL H DOWNS.	.88			.99					1.06					.92					1.02				
Q (CFS) = 12.0																							
VELOCITIES(FPS)	10.4	10.4	3.3	10.4	7.8	6.9	6.7	6.1	10.4	7.8	9.0	9.2	7.8	10.4	10.4	10.4	10.4	9.0	10.4	10.4	12.6	11.2	11.2
REY. NO. X10E-5	3.9	3.9	2.2	3.9	3.4	3.2	4.4	4.2	3.9	3.4	3.6	6.3	5.8	3.9	3.9	3.9	7.8	7.2	3.9	3.9	4.3	9.0	9.0
PRESSURE H (IN)	54.5	55.8	62.8	57.2	58.1	61.3	56.0	57.8	59.7	61.2	58.5	48.7	49.5	53.6	57.1	48.7	38.5	43.1	57.8	58.2	41.0	37.7	29.6
		50.6	65.5		51.7	61.5	59.5	60.0		55.9	57.6	49.8	51.6		51.1	49.6	40.5	45.0		53.5	40.2	39.3	31.4
		44.3	62.5		48.1	62.3	56.5	57.5		49.0	59.5	46.8	48.7		45.5	49.9	38.1	42.5		46.5	42.3	36.5	29.6
		49.8	61.3		52.4		49.0	59.0		54.9		35.5	49.1		51.7		26.0	44.9		53.7		10.5	30.3
AV. PRES. H(IN)	54.5	50.1	63.0	57.2	52.6	61.7	55.2	58.6	59.7	55.2	58.5	45.2	49.7	53.6	51.3	49.4	35.8	43.9	57.8	53.0	41.2	31.0	30.2
VELOCITY H.(IN)	20.21	20.21	2.06	20.21	11.40	8.81	8.25	6.96	20.21	11.40	15.03	15.66	11.37	20.21	20.21	20.21	20.21	15.03	20.21	20.21	29.43	23.48	23.48
TOTAL HEAD (IN)	74.7	70.3	65.1	77.4	64.0	70.5	63.5	65.5	79.9	66.7	73.6	60.9	61.1	73.8	71.6	69.6	56.0	58.9	78.0	73.2	70.6	54.5	53.7
TOTAL H ABOVE ¢	50.0	45.6	40.4	52.7	39.3	45.8	38.8	40.8	55.2	42.0	48.9	36.2	36.4	49.1	46.9	44.9	31.3	34.2	53.3	48.5	45.9	29.8	29.0
H ABOVE DOWNST.	21.0	16.6	11.4	23.7	10.3	16.8	9.8	11.8	26.2	12.9	19.9	7.2	7.4	20.1	17.9	15.9	2.3	5.2	24.3	19.5	16.9	.8	.0
ΔH/VEL H DOWNS.	.89			1.01					1.12					.86					1.04				

Table 1. Continued.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
Q (CFS) = 10.0																							
VELOCITIES(FPS)	8.7	8.7	2.8	8.7	6.5	5.7	5.5	5.1	8.7	6.5	7.5	7.6	6.5	8.7	8.7	8.7	8.7	7.5	8.7	8.7	10.5	9.4	9.4
REY. NO. X10E-5	3.2	3.2	1.8	3.2	2.8	2.6	3.7	3.5	3.2	2.8	3.0	5.3	4.9	3.2	3.2	3.2	6.5	6.0	3.2	3.2	3.6	7.5	7.5
PRESSURE H (IN)	60.5	61.1	65.9	62.6	63.4	65.4	61.9	62.6	63.9	64.7	62.9	56.0	56.9	60.9	61.4	56.1	49.3	52.4	62.8	62.9	50.7	48.5	43.1
		57.8	67.9		58.7	64.9	63.5	63.8		60.5	62.0	57.1	58.4		56.4	56.1	50.6	53.8		59.3	49.6	49.6	45.5
		53.0	65.8		56.1	65.4	61.8	62.5		56.6	63.5	54.9	56.5		52.9	56.5	49.0	52.2		55.2	51.5	47.6	43.0
		57.3	64.6		58.9		56.5	63.2		60.3		47.6	56.9		57.8		40.3	53.8		59.8		30.0	43.5
AV. PRES. H(IN)	60.5	57.3	66.0	62.6	59.3	65.2	60.9	63.0	63.9	60.5	62.8	53.9	57.2	60.9	57.1	56.2	47.3	53.0	62.8	59.3	50.6	43.9	43.8
VELOCITY H.(IN)	14.04	14.04	1.43	14.04	7.92	6.12	5.73	4.83	14.04	7.92	10.44	10.87	7.90	14.04	14.04	14.04	14.04	10.44	14.04	14.04	20.44	16.31	16.31
TOTAL HEAD (IN)	74.5	71.3	67.5	76.6	67.2	71.4	66.7	67.9	77.9	68.4	73.2	64.8	65.1	74.9	71.2	70.3	61.3	63.5	76.8	73.3	71.0	60.2	60.1
TOTAL H ABOVE ℄	49.8	46.6	42.8	51.9	42.5	46.7	42.0	43.2	53.2	43.7	48.5	40.1	40.4	50.2	46.5	45.6	36.6	38.8	52.1	48.6	46.3	35.5	35.4
H ABOVE DOWNST.	14.5	11.3	7.4	16.6	7.1	11.3	6.6	7.8	17.9	8.4	13.2	4.7	5.0	14.9	11.1	10.2	1.3	3.4	16.8	13.3	11.0	.2	.0
ΔH/VEL H DOWNS.	.89			1.02					1.10					.91					1.03				
Q (CFS) = 8.0																							
VELOCITIES(FPS)	6.9	6.9	2.2	6.9	5.2	4.6	4.4	4.1	6.9	5.2	6.0	6.1	5.2	6.9	6.9	6.9	6.9	6.0	6.9	6.9	8.4	7.5	7.5
REY. NO. X10E-5	2.6	2.6	1.5	2.6	2.2	2.1	2.9	2.8	2.6	2.2	2.4	4.2	3.9	2.6	2.6	2.6	5.2	4.8	2.6	2.6	2.8	6.0	6.0
PRESSURE H (IN)	60.5	61.2	63.5	61.1	62.1	63.5	61.4	61.8	62.6	63.0	62.2	57.4	58.0	61.1	61.5	57.8	52.5	55.4	61.8	61.9	54.5	53.0	49.7
		59.0	65.0		59.1	63.5	62.9	62.6		60.9	61.8	58.1	58.8		58.7	58.1	54.1	56.3		60.1	54.2	53.7	51.1
		55.7	63.8		57.0	63.3	61.3	61.8		58.5	62.8	57.1	57.7		56.2	58.3	53.2	55.1		57.0	54.7	52.4	49.7
		58.5	63.1		59.3		57.8	62.6		60.7		52.3	57.5		59.4		48.0	56.0		60.1		41.0	50.0
AV. PRES. H(IN)	60.5	58.6	63.8	61.1	59.4	63.4	60.8	62.2	62.6	60.8	62.3	56.2	58.0	61.1	58.9	58.1	51.9	55.7	61.8	59.8	54.5	50.0	50.1
VELOCITY H.(IN)	8.98	8.98	.92	8.98	5.07	3.91	3.67	3.09	8.98	5.07	6.68	6.96	5.05	8.98	8.98	8.98	8.98	6.68	8.98	8.98	13.08	10.44	10.44
TOTAL HEAD (IN)	69.5	67.6	64.8	70.1	64.4	67.3	64.5	65.3	71.6	65.8	68.9	63.2	63.1	70.1	67.9	67.0	60.9	62.4	70.8	68.8	67.5	60.5	60.6
TOTAL H ABOVE ℄	44.8	42.9	40.1	45.4	39.7	42.6	39.8	40.6	46.9	41.1	44.2	38.5	38.4	45.4	43.2	42.3	36.2	37.7	46.1	44.1	42.8	35.8	35.9
H ABOVE DOWNST.	8.9	7.0	4.2	9.5	3.9	6.8	4.0	4.7	11.0	5.3	8.4	2.6	2.5	9.5	7.4	6.5	.4	1.8	10.2	8.2	7.0	-.1	.0
ΔH/VEL H DOWNS.	.86			.91					1.06					.91					.98				
Q (CFS) = 6.0																							
VELOCITIES(FPS)	5.2	5.2	1.7	5.2	3.9	3.4	3.3	3.1	5.2	3.9	4.5	4.6	3.9	5.2	5.2	5.2	5.2	4.5	5.2	5.2	6.3	5.6	5.6
REY. NO. X10E-5	1.9	1.9	1.1	1.9	1.7	1.6	2.2	2.1	1.9	1.7	1.8	3.2	2.9	1.9	1.9	1.9	3.9	3.6	1.9	1.9	2.1	4.5	4.5
PRESSURE H (IN)	55.7	56.0	57.6	56.5	56.7	57.5	56.4	56.6	56.7	57.0	56.5	54.3	54.6	56.3	56.5	54.4	52.1	53.0	56.5	56.6	52.4	51.7	49.8
		54.7	58.5		55.0	57.4	56.9	57.0		55.8	56.1	54.6	55.2		54.8	54.4	52.1	53.3		55.5	52.1	51.9	50.5
		53.2	57.6		54.5	57.5	56.3	56.5		54.3	56.5	53.8	54.3		53.5	54.7	51.7	52.8		53.9	52.7	51.3	49.8
		54.5	57.2		55.3		54.3	56.7		55.5		51.3	54.5		55.1		48.9	53.2		55.7		45.3	50.0
AV. PRES. H(IN)	55.7	54.6	57.7	56.5	55.4	57.5	56.0	56.7	56.7	55.7	56.4	53.5	54.6	56.3	55.0	54.5	51.2	53.1	56.5	55.4	52.4	50.0	50.0
VELOCITY H.(IN)	5.05	5.05	.52	5.05	2.85	2.20	2.06	1.74	5.05	2.85	3.76	3.91	2.84	5.05	5.05	5.05	5.05	3.76	5.05	6.05	7.36	5.87	5.87
TOTAL HEAD (IN)	60.8	59.7	58.2	61.6	58.2	59.7	58.0	58.4	61.8	58.5	60.1	57.4	57.5	61.4	60.0	59.6	56.3	56.8	61.6	60.5	59.8	55.9	55.9
TOTAL H ABOVE ℄	36.1	35.0	33.5	36.9	33.5	35.0	33.3	33.7	37.1	33.8	35.4	32.7	32.8	36.7	35.3	34.9	31.6	32.1	36.9	35.8	35.1	31.2	31.2
H ABOVE DOWNST.	4.9	3.8	2.3	5.7	2.3	3.8	2.1	2.5	5.9	2.6	4.2	1.5	1.6	5.5	4.1	3.7	.4	.9	5.7	4.6	3.9	.0	.0
ΔH/VEL H DOWNS.	.83			.96					1.00					.93					.96				

Table 1. Continued.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
Q (CFS) = 4.0																							
VELOCITIES(FPS)	3.5	3.5	1.1	3.5	2.6	2.3	2.2	2.0	3.5	2.6	3.0	3.1	2.6	3.5	3.5	3.5	3.5	3.0	3.5	3.5	4.2	3.7	3.7
REY. NO. X10E-5	1.3	1.3	.7	1.3	1.1	1.1	1.5	1.4	1.3	1.1	1.2	2.1	1.9	1.3	1.3	1.3	2.6	2.4	1.3	1.3	1.4	3.0	3.0
PRESSURE H (IN)	51.6	51.7	52.5	52.0	52.1	52.4	51.8	51.9	52.0	52.1	51.9	50.9	51.0	51.8	52.0	51.0	49.9	50.4	51.9	52.0	50.0	49.7	49.0
		51.2	52.8		51.4	52.4	52.2	52.2		51.5	51.8	51.1	51.4		51.3	51.1	50.0	50.6		51.5	50.0	49.9	49.2
		50.5	52.5		50.8	52.3	51.8	51.9		50.9	52.0	50.8	50.9		50.8	51.1	49.8	50.2		50.8	50.3	49.5	49.0
		51.1	52.4		51.5		51.0	52.0		51.5		49.6	51.1		51.4		48.5	50.5		51.6		46.8	49.0
AV. PRES. H(IN)	51.6	51.1	52.5	52.0	51.4	52.4	51.7	52.0	52.0	51.5	51.9	50.6	51.1	51.8	51.4	51.1	49.5	50.4	51.9	51.5	50.1	49.0	49.0
VELOCITY H.(IN)	2.25	2.25	.23	2.25	1.27	.98	.92	.77	2.25	1.27	1.67	1.74	1.26	2.25	2.25	2.25	2.25	1.67	2.25	2.25	3.27	2.61	2.61
TOTAL HEAD (IN)	53.8	53.4	52.8	54.2	52.7	53.3	52.6	52.8	54.2	52.8	53.6	52.3	52.4	54.0	53.6	53.3	51.8	52.1	54.1	53.7	53.4	51.6	51.7
TOTAL H ABOVE ¢	29.1	28.7	28.1	29.5	28.0	28.6	27.9	28.1	29.5	28.1	28.9	27.6	27.7	29.3	28.9	28.6	27.1	27.4	29.4	29.0	28.7	26.9	27.0
H ABOVE DOWNST.	2.2	1.7	1.1	2.6	1.1	1.7	1.0	1.1	2.6	1.1	1.9	.7	.7	2.4	2.0	1.7	.1	.4	2.5	2.1	1.7	.	.0
ΔH/VEL H DOWNS.	.84			.99					.99					.91					.95				
Q (CFS) = 2.0																							
VELOCITIES(FPS)	1.7	1.7	.6	1.7	1.3	1.1	1.1	1.0	1.7	1.3	1.5	1.5	1.3	1.7	1.7	1.7	1.7	1.5	1.7	1.7	2.1	1.9	1.9
REY. NO. X10E-5	.6	.6	.4	.6	.6	.5	.7	.7	.6	.6	.5	1.1	1.0	.6	.6	.6	1.3	1.2	.6	.6	.7	1.5	1.5
PRESSURE H (IN)	44.7	44.8	44.9	44.7	44.8	44.9	44.7	44.8	44.9	44.9	44.8	44.5	44.6	44.8	44.9	44.6	44.3	44.4	44.8	44.8	44.4	44.2	44.1
		44.6	45.0		44.6	44.9	44.9	44.9		44.7	44.8	44.6	44.7		44.7	44.6	44.4	44.5		44.7	44.3	44.3	44.1
		44.5	44.9		44.5	44.9	44.8	44.8		44.6	44.9	44.5	44.6		44.5	44.6	44.3	44.4		44.5	44.4	44.2	44.1
		44.6	44.9		44.7		44.6	44.8		44.7		44.2	44.6		44.7		44.0	44.5		44.7		43.5	44.1
AV. PRES. H(IN)	44.7	44.6	44.9	44.7	44.6	44.9	44.7	44.8	44.9	44.7	44.8	44.4	44.6	44.8	44.7	44.6	44.2	44.4	44.8	44.7	44.4	44.0	44.1
VELOCITY H.(IN)	.56	.56	.06	.56	.32	.24	.23	.19	.56	.32	.42	.43	.32	.56	.56	.56	.56	.42	.56	.56	.82	.65	.65
TOTAL HEAD (IN)	45.3	45.2	45.0	45.3	45.0	45.1	45.0	45.0	45.5	45.0	45.3	44.9	44.9	45.4	45.3	45.2	44.8	44.9	45.4	45.2	45.2	44.7	44.8
TOTAL H ABOVE ¢	20.6	20.5	20.3	20.6	20.3	20.4	20.3	20.3	20.8	20.3	20.6	20.2	20.2	20.7	20.6	20.5	20.1	20.2	20.7	20.5	20.5	20.0	20.1
H ABOVE DOWNST.	.5	.4	.2	.5	.2	.4	.2	.3	.7	.3	.5	.1	.2	.6	.5	.4	.1	.1	.6	.5	.4	.0	.0
ΔH/VEL H DOWNS.	.78			.78					1.09					.93					.93				

Table 2. Summary of series 3 and 4 preliminary test data from the proposed Yorktown power station manifold.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
DIAMETERS (IN.)	6.5	6.5	11.5	6.5	7.5	8.0	11.5	12.0	6.5	7.5	7.0	12.0	13.0	6.5	6.5	6.5	13.0	14.0	6.5	6.5	5.917	14.0	14.0
AREAS (SQ. FT.)	.230	.230	.721	.230	.307	.349	.721	.785	.230	.307	.267	.785	.922	.230	.230	.230	.922	1.069	.230	.230	.191	1.069	1.069
Q (CFS) = 2.0																							
VELOCITIES(FPS)	1.7	1.7	.6	1.7	1.3	1.1	1.1	1.0	1.7	1.3	1.5	1.5	1.3	1.7	1.7	1.7	1.7	1.5	1.7	1.7	2.1	1.9	1.9
REY. NO. X10E-5	.6	.6	.4	.6	.6	.5	.7	.7	.6	.6	.6	1.1	1.0	.6	.6	.6	1.3	1.2	.6	.6	.7	1.5	1.5
PRESSURE H (IN)	46.8	46.8	47.0	46.9	46.9	47.0	46.8	46.9	46.9	47.0	46.9	46.6	46.6	46.9	47.0	46.6	46.4	46.4	46.9	47.0	46.4	46.3	45.8
			47.3				47.0	47.0				46.7	46.7				46.3	46.5				46.3	46.1
			47.1				46.8	46.9				46.5	46.6				46.3	46.4				46.1	46.0
			47.0				46.7	46.9				46.2	46.6				46.0	46.5				45.4	46.0
AV. PRES. H(IN)	46.8	46.8	47.1	46.9	46.9	47.0	46.8	46.9	46.9	47.0	46.9	46.5	46.6	46.9	47.0	46.6	46.2	46.4	46.9	47.0	46.4	46.0	46.0
VELOCITY H.(IN)	.56	.56	.06	.56	.32	.24	.23	.19	.56	.32	.42	.43	.32	.56	.56	.56	.56	.42	.56	.56	.82	.65	.65
TOTAL HEAD (IN)	47.4	47.4	47.2	47.5	47.2	47.2	47.1	47.1	47.5	47.3	47.3	46.9	46.9	47.5	47.6	47.2	46.8	46.9	47.5	47.6	47.2	46.7	46.6
TOTAL H ABOVE ℄	22.7	22.7	22.5	22.8	22.5	22.5	22.4	22.4	22.8	22.6	22.6	22.2	22.2	22.8	22.9	22.5	22.1	22.2	22.8	22.9	22.5	22.0	21.9
H ABOVE DOWNST.	.7	.7	.5	.8	.6	.6	.4	.5	.8	.7	.7	.3	.3	.8	.9	.5	.2	.2	.8	.9	.6	.0	.0
ΔH/VEL H DOWNS.	1.13			1.28					1.28					1.28					1.28				
Q (CFS) = 4.0																							
VELOCITIES(FPS)	3.5	3.5	1.1	3.5	2.6	2.3	2.2	2.0	3.5	2.6	3.0	3.1	2.6	3.5	3.5	3.5	3.5	3.0	3.5	3.5	4.2	3.7	3.7
REY. NO. X10E-5	1.3	1.3	.7	1.3	1.1	1.1	1.5	1.4	1.3	1.1	1.2	2.1	1.9	1.3	1.3	1.3	2.6	2.4	1.3	1.3	1.4	3.0	3.0
PRESSURE H (IN)	62.2	62.4	63.2	62.7	62.8	63.1	62.4	62.5	62.7	62.8	62.5	61.5	61.7	62.5	62.6	61.6	60.5	60.8	62.6	62.7	60.6	60.2	59.4
			63.4				62.8	62.8				61.7	62.0				60.6	61.2				60.5	59.7
			63.2				62.4	62.6				61.3	61.6				60.4	60.8				60.1	59.4
			63.0				61.6	62.6				60.2	61.7				59.1	61.0				57.2	59.6
AV. PRES. H(IN)	62.2	62.4	63.2	62.7	62.8	63.1	62.3	62.6	62.7	62.8	62.5	61.2	61.7	62.5	62.6	61.6	60.1	60.9	62.6	62.7	60.6	59.5	59.5
VELOCITY H.(IN)	2.25	2.25	.23	2.25	1.27	.98	.92	.77	2.25	1.27	1.67	1.74	1.26	2.25	2.25	2.25	2.25	1.67	2.25	2.25	3.27	2.61	2.61
TOTAL HEAD (IN)	64.4	64.6	63.4	64.9	64.1	64.1	63.2	63.4	64.9	64.1	64.2	62.9	63.0	64.7	64.8	63.8	62.4	62.6	64.8	64.9	63.9	62.1	62.1
TOTAL H ABOVE ℄	39.7	39.9	38.7	40.2	39.4	39.4	38.5	38.7	40.2	39.4	39.5	38.2	38.3	40.0	40.1	39.1	37.7	37.9	40.1	40.2	39.2	37.4	37.4
H ABOVE DOWNST.	2.3	2.5	1.3	2.8	1.9	1.9	1.1	1.3	2.8	1.9	2.0	.8	.9	2.6	2.7	1.7	.3	.5	2.7	2.8	1.7	.0	.0
ΔH/VEL H DOWNS.	.89			1.08					1.08					1.00					1.04				
Q (CFS) = 6.0																							
VELOCITIES(FPS)	5.2	5.2	1.7	5.2	3.9	3.4	3.3	3.1	5.2	3.9	4.5	4.6	3.9	5.2	5.2	5.2	5.2	4.5	5.2	5.2	6.3	5.6	5.6
REY. NO. X10E-5	1.9	1.9	1.1	1.9	1.7	1.6	2.2	2.1	1.9	1.7	1.8	3.2	2.9	1.9	1.9	1.9	3.9	3.6	1.9	1.9	2.1	4.5	4.5
PRESSURE H (IN)	61.5	61.8	63.7	62.5	62.7	63.5	62.0	62.2	62.7	63.0	62.3	59.9	60.3	61.7	62.2	60.1	57.7	58.7	62.4	62.5	58.1	57.2	55.4
		60.5	64.3		61.2	63.4	62.8	62.8		61.7	62.0	60.4	60.8		60.7	60.2	58.0	59.1		61.3	57.8	57.7	56.1
		58.7	63.7		60.1	63.4	62.0	62.2		60.0	62.4	59.6	60.1		58.7	60.7	57.3	58.4		59.8	58.6	56.8	55.5
		60.2	63.3		61.2		60.0	62.5		61.5		57.0	60.2		60.8		54.5	59.2		61.3		50.9	55.7
AV. PRES. H(IN)	61.5	60.3	63.7	62.5	61.3	63.4	61.7	62.4	62.7	61.5	62.2	59.2	60.3	61.7	60.6	60.3	56.9	58.8	62.4	61.2	58.2	55.6	55.7
VELOCITY H.(IN)	5.05	5.05	.52	5.05	2.85	2.20	2.06	1.74	5.05	2.85	3.76	3.91	2.84	5.05	5.05	5.05	5.05	3.76	5.05	6.05	7.36	5.87	5.87
TOTAL HEAD (IN)	66.6	65.4	64.3	67.6	64.2	65.6	63.8	64.2	67.8	64.4	66.0	63.1	63.2	66.8	65.7	65.4	61.9	62.6	67.5	66.3	65.5	61.5	61.5
TOTAL H ABOVE ℄	41.9	40.7	39.6	42.9	39.5	40.9	39.1	39.5	43.1	39.7	41.3	38.4	38.5	42.1	41.0	40.7	37.2	37.9	42.8	41.6	40.8	36.8	36.8
H ABOVE DOWNST.	5.0	3.8	2.7	6.0	2.6	4.1	2.2	2.6	6.2	2.9	4.4	1.6	1.6	5.2	4.1	3.8	.4	1.1	5.9	4.7	4.0	.0	.0
ΔH/VEL H DOWNS.	.85			1.02					1.06					.89					1.01				

Table 2. Continued.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
Q (CFS) = 8.0																							
VELOCITIES(FPS)	6.9	6.9	2.2	6.9	5.2	4.6	4.4	4.1	6.9	5.2	6.0	6.1	5.2	6.9	6.9	6.9	6.9	6.0	6.9	6.9	8.4	7.5	7.5
REY. NO. X10E-5	2.6	2.6	1.5	2.6	2.2	2.1	2.9	2.8	2.6	2.2	2.4	4.2	3.9	2.6	2.6	2.6	5.2	4.8	2.6	2.6	2.8	6.0	6.0
PRESSURE H (IN)	48.4	49.0	52.0	49.7	50.1	51.6	49.3	49.7	50.2	50.8	49.8	45.6	46.4	49.2	50.0	46.2	42.2	43.4	49.8	50.0	42.2	40.9	37.4
		46.5	53.3		47.4	51.5	50.6	50.7		48.7	49.3	46.5	47.5		47.3	46.3	42.0	44.1		48.1	41.8	41.6	38.9
		43.5	52.0		45.5	51.6	49.2	49.8		45.5	50.4	44.7	46.0		44.8	46.8	41.2	43.0		45.2	43.0	40.3	37.5
		46.2	51.2		47.2		45.7	50.3		48.3		40.1	46.5		47.6		36.0	43.8		48.1		28.9	38.0
AV. PRES. H(IN)	48.4	46.3	52.1	49.7	47.5	51.6	48.7	50.1	50.2	48.3	49.8	44.2	46.6	49.2	47.4	46.4	40.3	43.6	49.8	47.8	42.3	37.9	37.9
VELOCITY H.(IN)	8.98	8.98	.97	8.98	5.07	3.91	3.67	3.09	8.98	5.07	6.68	6.96	5.05	8.98	8.98	8.98	8.98	6.68	8.98	8.98	13.06	10.44	10.44
TOTAL HEAD (IN)	57.4	55.3	53.0	58.7	52.6	55.5	52.4	53.2	59.2	53.4	56.5	51.2	51.7	58.2	56.4	55.4	49.3	50.3	58.8	56.8	55.4	48.4	48.4
TOTAL H ABOVE ¢	32.7	30.6	28.3	34.0	27.9	30.8	27.7	28.5	34.5	28.7	31.8	26.5	27.0	33.5	31.7	30.7	24.6	25.6	34.1	32.1	30.7	23.7	23.7
H ABOVE DOWNST.	9.0	6.9	4.7	10.3	4.2	7.1	4.0	4.8	10.8	5.0	8.1	2.8	3.3	9.8	8.0	7.0	.9	1.9	10.4	8.4	7.0	-.0	.0
ΔH/VEL H DOWNS.	.86			.99					1.03					.94					1.00				
Q (CFS) = 10.0																							
VELOCITIES(FPS)	8.7	8.7	2.8	8.7	6.5	5.7	5.5	5.1	8.7	6.5	7.5	7.6	6.5	8.7	8.7	8.7	8.7	7.5	8.7	8.7	10.5	9.4	9.4
REY. NO. X10E-5	3.2	3.2	1.8	3.2	2.8	2.6	3.7	3.5	3.2	2.8	3.0	5.3	4.9	3.2	3.2	3.2	6.5	6.0	3.2	3.2	3.6	7.5	7.5
PRESSURE H (IN)	48.1	49.0	54.4	50.3	50.9	53.3	49.2	49.9	50.3	51.4	49.8	43.5	44.6	48.3	49.2	44.0	37.6	40.1	50.1	50.4	38.2	36.2	30.5
		45.0	55.5		46.6	53.0	50.8	51.2		47.9	49.3	44.8	46.2		45.4	44.1	38.0	41.3		47.3	37.5	37.3	33.2
		40.7	53.9		44.2	53.5	49.3	49.8		43.7	50.7	42.4	44.3		41.5	44.9	36.7	39.6		42.5	39.3	35.3	30.8
		44.8	52.7		47.2		44.0	50.4		47.1		35.4	44.7		45.8		28.5	40.8		47.7		17.5	31.7
AV. PRES. H(IN)	48.1	44.9	54.1	50.3	47.2	53.3	48.3	50.3	50.3	47.5	49.9	41.5	44.9	48.3	45.5	44.3	35.2	40.4	50.1	47.0	38.3	31.6	31.5
VELOCITY H.(IN)	14.04	14.04	1.43	14.04	7.92	6.12	5.73	4.83	14.04	7.92	10.44	10.87	7.90	14.04	14.04	14.04	14.04	10.44	14.04	14.04	20.44	16.31	16.31
TOTAL HEAD (IN)	62.1	58.9	55.6	64.3	55.1	59.4	54.1	55.2	64.3	55.4	60.4	52.4	52.8	62.3	59.5	58.4	49.2	50.9	64.1	61.0	58.8	47.9	47.9
TOTAL H ABOVE ¢	37.4	34.2	30.9	39.6	30.4	34.7	29.4	30.5	39.6	30.7	35.7	27.7	28.1	37.6	34.8	33.7	24.5	26.2	39.4	36.3	34.1	23.2	23.2
H ABOVE DOWNST.	14.3	11.1	7.7	16.5	7.3	11.5	6.2	7.3	16.5	7.6	12.5	4.5	5.0	14.5	11.7	10.5	1.4	3.0	16.3	13.2	10.9	.0	.0
ΔH/VEL H DOWNS.	.88			1.01					1.01					.89					1.00				
Q (CFS) = 12.0																							
VELOCITIES(FPS)	10.4	10.4	3.3	10.4	7.8	6.9	6.7	6.1	10.4	7.8	9.0	9.2	7.8	10.4	10.4	10.4	10.4	9.0	10.4	10.4	12.6	11.2	11.2
REY. NO. X10E-5	3.9	3.9	2.2	3.9	3.4	3.2	4.4	4.2	3.9	3.4	3.6	6.3	5.8	3.9	3.9	3.9	7.8	7.2	3.9	3.9	4.3	9.0	9.0
PRESSURE H (IN)	51.8	53.1	59.8	54.7	55.5	59.0	54.1	54.9	56.5	58.0	55.3	45.4	46.9	52.6	54.2	46.0	36.5	40.0	54.9	55.0	37.8	34.5	26.0
		48.2	62.8		50.0	59.6	56.1	56.6		53.6	55.0	47.0	48.8		48.5	46.8	37.0	41.8		51.2	36.9	36.0	30.3
		41.8	59.8		46.5	60.2	53.9	54.8		46.5	57.3	43.5	46.0		42.4	47.0	35.1	39.6		44.2	39.6	33.2	26.2
		47.8	58.2		50.4		45.8	56.0		52.6		32.8	46.2		50.0		23.3	41.1		51.2		7.6	27.5
AV. PRES. H(IN)	51.8	47.7	60.1	54.7	50.6	59.6	52.5	55.6	56.5	52.7	55.9	42.2	47.0	52.6	48.8	46.6	33.0	40.6	54.9	50.4	38.1	27.8	27.5
VELOCITY H.(IN)	20.21	20.21	2.06	20.21	11.40	8.81	8.25	6.96	20.21	11.40	15.03	15.66	11.37	20.21	20.21	20.21	20.21	15.03	20.21	20.21	29.43	23.48	23.48
TOTAL HEAD (IN)	72.0	67.9	62.2	74.9	62.0	68.4	60.7	62.5	76.7	64.1	70.9	57.8	58.3	72.8	69.0	66.8	53.2	55.7	75.1	70.6	67.5	51.3	51.0
TOTAL H ABOVE ¢	47.3	43.2	37.5	50.2	37.3	43.7	36.0	37.8	52.0	39.4	46.2	33.1	33.6	48.1	44.3	42.1	28.5	31.0	50.4	45.9	42.8	26.6	26.3
H ABOVE DOWNST.	21.0	17.0	11.2	23.9	11.0	17.4	9.7	11.6	25.7	13.1	19.9	6.9	7.4	21.8	18.0	15.8	2.2	4.7	24.1	19.6	16.6	.3	.0
ΔH/VEL H DOWNS.	.90			1.02					1.10					.93					1.03				

Table 2. Continued.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
Q (CFS) = 14.0																							
VELOCITIES(FPS)	12.2	12.2	3.9	12.2	9.1	8.0	7.8	7.1	12.2	9.1	10.5	10.7	9.1	12.2	12.2	12.2	12.2	10.5	12.2	12.2	14.7	13.1	13.1
REY. NO. X10E-5	4.5	4.5	2.6	4.5	3.9	3.7	5.1	4.9	4.5	3.9	4.2	7.4	6.8	4.5	4.5	4.5	9.1	8.4	4.5	4.5	5.0	10.5	10.5
PRESSURE H (IN)	64.0	65.8	75.9	68.0	69.3	74.1	67.2	68.3	69.8	71.8	68.3	55.1	56.8	65.5	67.5	56.0	43.7	48.0	68.5	68.7	44.0	40.0	27.5
		58.3	79.8		61.0	74.5	70.3	70.9		64.3	66.8	57.1	60.2		59.0	56.6	43.8	50.2		63.0	43.0	42.0	34.0
		49.3	75.8		55.8	73.8	66.3	67.6		55.0	70.2	52.0	56.0		52.0	58.4	40.7	47.0		53.0	46.4	37.9	28.0
		58.2	73.3		61.3		55.6	69.9		63.9		37.3	57.2		60.8		23.0	49.8		63.1			30.0
AV. PRES. H(IN)	64.0	57.9	76.2	68.0	61.8	74.1	64.8	69.2	69.8	63.7	68.4	50.4	57.5	65.5	59.8	57.0	37.8	48.7	68.5	61.9	44.5	40.0	29.9
VELOCITY H.(IN)	27.51	27.51	2.81	27.51	15.52	11.99	11.23	9.47	27.51	15.52	20.45	21.31	15.47	27.51	27.51	27.51	27.51	20.45	27.51	27.51	40.06	31.96	31.96
TOTAL HEAD (IN)	91.5	85.4	79.0	95.5	77.4	86.1	76.1	78.6	97.3	79.3	88.9	71.7	73.0	93.0	87.3	84.5	65.3	69.2	96.0	89.5	84.5	71.9	61.8
TOTAL H ABOVE ¢	66.8	60.7	54.3	70.8	52.7	61.4	51.4	53.9	72.6	54.6	64.2	47.0	48.3	68.3	62.6	59.8	40.6	44.5	71.3	64.8	59.8	47.2	37.1
H ABOVE DOWNST.	29.7	23.6	17.2	33.7	15.5	24.3	14.2	16.8	35.5	17.4	27.1	9.9	11.2	31.2	25.5	22.7	3.5	7.4	34.2	27.6	22.7	10.1	.0
ΔH/ VEL H DOWNS.	.93			1.05					1.11					.98					1.07				
Q (CFS) = 12.0																							
VELOCITIES(FPS)	10.4	10.4	3.3	10.4	7.8	6.9	6.7	6.1	10.4	7.8	9.0	9.2	7.8	10.4	10.4	10.4	10.4	9.0	10.4	10.4	12.6	11.2	11.2
REY. NO. X10E-5	3.9	3.9	2.2	3.9	3.4	3.2	4.4	4.2	3.9	3.4	3.6	6.3	5.8	3.9	3.9	3.9	7.8	7.2	3.9	3.9	4.3	9.0	9.0
PRESSURE H (IN)	51.3	52.7	60.1	54.5	55.5	59.0	53.5	54.6	55.6	57.2	54.5	44.7	46.0	51.9	53.2	45.3	36.0	39.8	54.5	54.6	37.1	34.0	25.5
		46.8	62.5		49.0	58.8	55.7	56.4		51.4	53.4	46.5	48.4		47.5	45.8	36.8	41.7		49.9	35.8	35.6	29.8
		40.8	59.9		45.5	59.5	53.4	54.5		46.2	56.3	43.3	45.6		41.8	46.7	34.5	39.0		43.7	38.5	32.6	25.9
		47.2	58.3		49.4		44.9	55.3		52.0		32.5	45.6		48.8		22.5	41.3		50.5		7.3	27.1
AV. PRES. H(IN)	51.3	46.9	60.2	54.5	49.8	59.1	51.9	55.2	55.5	51.7	54.7	41.7	46.4	51.9	47.8	45.9	32.4	40.4	54.5	49.7	37.1	27.4	27.1
VELOCITY H.(IN)	20.21	20.21	2.06	20.21	11.40	8.81	8.25	6.96	20.21	11.40	15.03	15.66	11.37	20.21	20.21	20.21	20.21	15.03	20.21	20.21	29.43	23.48	23.48
TOTAL HEAD (IN)	71.5	67.1	62.3	74.7	61.3	67.9	60.1	62.2	75.7	63.1	69.8	57.4	57.8	72.1	68.0	66.1	52.7	55.5	74.7	69.9	66.6	50.9	50.6
TOTAL H ABOVE ¢	46.8	42.4	37.6	50.0	36.6	43.2	35.4	37.5	51.0	38.4	45.1	32.7	33.1	47.4	43.3	41.4	28.0	30.8	50.0	45.2	41.9	26.2	25.9
H ABOVE DOWNST.	21.0	16.5	11.7	24.2	10.7	17.4	9.6	11.6	25.2	12.5	19.2	6.9	7.2	21.6	17.5	15.6	2.1	4.9	24.2	19.3	16.0	.3	.0
ΔH/ VEL H DOWNS.	.89			1.03					1.07					.92					1.03				
Q (CFS) = 10.0																							
VELOCITIES(FPS)	8.7	8.7	2.8	8.7	6.5	5.7	5.5	5.1	8.7	6.5	7.5	7.6	6.5	8.7	8.7	8.7	8.7	7.5	8.7	8.7	10.5	9.4	9.4
REY. NO. X10E-5	3.2	3.2	1.8	3.2	2.8	2.6	3.7	3.5	3.2	2.8	3.0	5.3	4.9	3.2	3.2	3.2	6.5	6.0	3.2	3.2	3.6	7.5	7.5
PRESSURE H (IN)	49.2	50.2	55.5	51.7	52.3	54.6	50.5	51.3	52.1	53.1	51.5	44.9	45.8	49.9	51.0	45.3	39.0	41.5	52.0	52.0	39.5	37.5	31.8
		46.5	56.9		47.8	54.6	52.5	52.9		49.9	51.0	46.0	47.4		47.2	46.0	39.5	42.7		48.6	38.7	38.5	34.5
		42.2	55.3		45.7	55.0	50.7	51.3		44.7	52.2	43.8	45.5		43.0	46.4	37.9	41.0		44.0	40.1	36.5	32.0
		46.3	54.0		48.4		45.1	52.2		49.6		36.3	45.7		47.5		29.7	42.4		49.2		17.5	32.5
AV. PRES. H(IN)	49.2	46.3	55.4	51.7	48.5	54.7	49.7	51.9	52.1	49.3	51.6	42.7	46.1	49.9	47.2	45.9	36.5	41.9	52.0	48.4	39.4	32.5	32.7
VELOCITY H.(IN)	14.04	14.04	1.43	14.04	7.92	6.12	5.73	4.83	14.04	7.92	10.44	10.87	7.90	14.04	14.04	14.04	14.04	10.44	14.04	14.04	20.44	16.31	16.31
TOTAL HEAD (IN)	63.2	60.3	56.9	65.7	56.5	60.9	55.4	56.8	66.1	57.2	62.0	53.6	54.0	63.9	61.2	59.9	50.6	52.3	66.0	62.5	59.9	48.8	49.0
TOTAL H ABOVE ¢	38.5	35.6	32.2	41.0	31.8	36.2	30.7	32.1	41.4	32.5	37.3	28.9	29.3	39.2	36.5	35.2	25.9	27.6	41.3	37.8	35.2	24.1	24.3
H ABOVE DOWNST.	14.2	11.3	7.9	16.7	7.5	11.8	6.4	7.8	17.1	8.2	13.0	4.6	5.0	14.9	12.2	10.9	1.6	3.3	17.0	13.5	10.9	-.2	.0
ΔH/ VEL H DOWNS.	.87			1.03					1.05					.92					1.04				

Table 2. Continued.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
Q (CFS) = 8.0																							
VELOCITIES(FPS)	6.9	6.9	2.2	6.9	5.2	4.6	4.4	4.1	6.9	5.2	6.0	6.1	5.2	6.9	6.9	6.9	6.9	6.0	6.9	6.9	8.4	7.5	7.5
REY. NO. X10E-5	2.6	2.6	1.5	2.6	2.2	2.1	2.9	2.8	2.6	2.2	2.4	4.2	3.9	2.6	2.6	2.6	5.2	4.8	2.6	2.6	2.8	6.0	6.0
PRESSURE H (IN)	49.6	50.2	53.2	51.3	51.7	53.1	50.6	51.0	51.1	52.0	51.0	46.4	47.2	50.2	51.0	47.1	42.5	44.2	50.8	50.9	43.1	41.7	38.1
		46.7	54.6		49.8	53.1	51.5	51.7		50.0	50.7	47.5	48.5		48.3	47.3	43.0	45.1		42.1	42.7	42.5	39.7
		45.0	53.3		47.2	53.4	50.8	51.1		46.7	51.5	45.8	47.0		45.7	47.5	42.0	44.0		46.0	43.9	41.1	38.2
		47.4	52.5		49.1		46.9	51.4		49.3		41.2	47.1		48.9		36.5	45.0		49.2		29.6	38.7
AV. PRES. H(IN)	49.6	47.3	53.4	51.3	49.4	53.2	49.9	51.3	51.1	49.5	51.1	45.2	47.4	50.2	48.5	47.3	41.0	44.6	50.8	47.0	43.2	38.7	38.7
VELOCITY H.(IN)	8.98	8.98	.92	8.98	5.07	3.91	3.67	3.09	8.98	5.07	6.68	6.96	5.05	8.98	8.98	8.98	8.98	6.68	8.98	8.98	13.08	10.44	10.44
TOTAL HEAD (IN)	58.6	56.3	54.3	60.3	54.5	57.1	53.6	54.4	60.1	54.6	57.7	52.2	52.5	59.2	57.5	56.3	50.0	51.3	59.8	56.0	56.3	49.2	49.1
TOTAL H ABOVE ₵	33.9	31.6	29.6	35.6	29.8	32.4	28.9	29.7	35.4	29.9	33.0	27.5	27.8	34.5	32.8	31.6	25.3	26.6	35.1	31.3	31.6	24.5	24.4
H ABOVE DOWNST.	9.5	7.2	5.2	11.2	5.4	8.0	4.5	5.3	11.0	5.5	8.6	3.1	3.4	10.1	8.3	7.2	.9	2.1	10.7	6.9	7.2	.0	.0
ΔH/VEL H DOWNS.	.91			1.07					1.05					.97					1.02				
Q (CFS) = 6.0																							
VELOCITIES(FPS)	5.2	5.2	1.7	5.2	3.9	3.4	3.3	3.1	5.2	3.9	4.5	4.6	3.9	5.2	5.2	5.2	5.2	4.5	5.2	5.2	6.3	5.6	5.6
REY. NO. X10E-5	1.9	1.9	1.1	1.9	1.7	1.6	2.2	2.1	1.9	1.7	1.8	3.2	2.9	1.9	1.9	1.9	3.9	3.6	1.9	1.9	2.1	4.5	4.5
PRESSURE H (IN)	52.4	52.7	54.5	53.1	53.3	54.2	52.9	53.1	53.5	53.7	53.1	50.7	51.0	52.8	53.1	50.9	48.6	49.3	53.1	53.2	48.7	47.9	46.0
		51.3	55.2		51.7	54.2	53.7	53.0		52.3	52.9	51.1	51.7		51.6	51.0	48.5	49.8		51.9	42.2	48.3	46.7
		49.7	54.5		51.1	54.3	52.8	53.6		50.6	53.4	50.2	51.0		50.4	51.4	48.1	49.1		50.3	48.9	47.5	46.0
		51.2	54.1		52.0		50.7	53.4		52.3		47.2	51.3		51.8		45.0	49.7		52.0		41.1	46.3
AV. PRES. H(IN)	52.4	51.2	54.6	53.1	52.0	54.2	52.5	53.3	53.5	52.2	53.1	49.8	51.2	52.8	51.7	51.1	47.5	49.5	53.1	51.8	46.6	46.2	46.2
VELOCITY H.(IN)	5.05	5.05	.52	5.05	2.85	2.20	2.06	1.74	5.05	2.85	3.76	3.91	2.84	5.05	5.05	5.05	5.05	3.76	5.05	5.05	7.36	5.87	5.87
TOTAL HEAD (IN)	57.5	56.3	55.1	58.2	54.9	56.4	54.6	55.0	58.6	55.1	56.9	53.7	54.1	57.9	56.8	56.2	52.6	53.2	58.2	56.9	54.0	52.1	52.1
TOTAL H ABOVE ₵	32.8	31.6	30.4	33.5	30.2	31.7	29.9	30.3	33.9	30.4	32.2	29.0	29.4	33.2	32.1	31.5	27.9	28.5	33.5	32.2	29.3	27.4	27.4
H ABOVE DOWNST.	5.3	4.2	3.0	6.0	2.8	4.3	2.5	2.9	6.4	3.0	4.8	1.6	2.0	5.7	4.7	4.0	.5	1.1	6.0	4.8	1.8	-.1	.0
ΔH/VEL H DOWNS.	.91			1.03					1.10					.98					1.03				
Q (CFS) = 4.0																							
VELOCITIES(FPS)	3.5	3.5	1.1	3.5	2.6	2.3	2.2	2.0	3.5	2.6	3.0	3.1	2.6	3.5	3.5	3.5	3.5	3.0	3.5	3.5	4.2	3.7	3.7
REY. NO. X10E-5	1.3	1.3	.7	1.3	1.1	1.1	1.5	1.4	1.3	1.1	1.2	2.1	1.9	1.3	1.3	1.3	2.6	2.4	1.3	1.3	1.4	3.0	3.0
PRESSURE H (IN)	49.7	49.8	50.6	50.0	50.1	50.5	49.8	50.0	50.2	50.4	50.1	48.9	49.1	50.0	50.2	49.2	48.0	48.4	50.2	50.2	48.0	47.7	46.9
		49.1	50.9		49.3	50.5	50.3	50.3		49.7	49.9	49.2	49.6		49.4	49.1	48.1	48.6		49.5	47.9	47.9	47.2
		48.5	50.6		48.7	50.5	49.9	50.0		49.0	50.2	48.7	49.1		48.7	49.2	47.8	48.3		48.8	48.2	47.5	46.9
		49.1	50.4		49.5		49.0	50.2		49.6		47.6	49.3		49.5		46.4	48.5		49.6		44.6	47.0
AV. PRES. H(IN)	49.7	49.1	50.6	50.0	49.4	50.5	49.7	50.1	50.2	49.7	50.1	48.6	49.3	50.0	49.4	49.2	47.6	48.4	50.2	49.5	48.0	46.9	47.0
VELOCITY H.(IN)	2.25	2.25	.23	2.25	1.27	.98	.92	.77	2.25	1.27	1.67	1.74	1.26	2.25	2.25	2.25	2.25	1.67	2.25	2.25	3.27	2.61	2.61
TOTAL HEAD (IN)	51.9	51.4	50.9	52.2	50.7	51.5	50.7	50.9	52.4	50.9	51.7	50.3	50.5	52.2	51.7	51.4	49.8	50.1	52.4	51.8	51.3	49.5	49.6
TOTAL H ABOVE ₵	27.2	26.7	26.2	27.5	26.0	26.8	26.0	26.2	27.7	26.2	27.0	25.6	25.8	27.5	27.0	26.7	25.1	25.4	27.7	27.1	26.6	24.8	24.9
H ABOVE DOWNST.	2.3	1.8	1.2	2.6	1.1	1.9	1.1	1.3	2.8	1.3	2.1	.7	.9	2.6	2.1	1.8	.2	.5	2.8	2.2	1.7	-.1	.0
ΔH/VEL H DOWNS.	.90			1.01					1.09					1.01					1.09				

Table 2. Continued.

	BRANCH 1		MAIN	BRANCH 2			MAIN	MAIN	BRANCH 3			MAIN	MAIN	BRANCH 4			MAIN	MAIN	BRANCH 5			MAIN	DOWN-
	INLET	CENT.	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	LINE	INLET	CENT.	EXIT	LINE	STREAM
Q (CFS) = 2.0																							
VELOCITIES(FPS)	1.7	1.7	.6	1.7	1.3	1.1	1.1	1.0	1.7	1.3	1.5	1.5	1.3	1.7	1.7	1.7	1.7	1.5	1.7	1.7	2.1	1.9	1.9
REY. NO. X10E-5	.6	.6	.4	.6	.6	.5	.7	.7	.6	.6	.6	1.1	1.0	.6	.6	.6	1.3	1.2	.6	.6	.7	1.5	1.5
PRESSURE H (IN)	44.0	44.0	44.2	44.0	44.1	44.2	44.0	44.1	44.1	44.2	44.0	43.8	43.8	44.0	44.1	43.8	43.5	43.6	44.1	44.0	43.5	43.4	43.2
		43.9	44.3		43.9	44.2	44.2	44.1		44.0	44.1	43.9	44.0		44.0	43.9	43.5	43.7		44.0	43.5	43.5	43.3
		43.7	44.2		43.8	44.1	44.0	44.1		43.8	44.1	43.7	43.8		43.8	43.9	43.5	43.6		43.8	43.6	43.4	43.2
		43.9	44.2		44.0		43.8	44.1		44.0		43.4	43.8		44.0		43.2	43.7		44.0		42.6	43.2
AV. PRES. H(IN)	44.0	43.9	44.2	44.0	43.9	44.2	44.0	44.1	44.1	44.0	44.1	43.7	43.8	44.0	44.0	43.9	43.4	43.6	44.1	43.9	43.5	43.2	43.2
VELOCITY H.(IN)	.56	.56	.06	.56	.32	.24	.23	.19	.56	.32	.42	.43	.32	.56	.56	.56	.56	.42	.56	.56	.82	.65	.65
TOTAL HEAD (IN)	44.6	44.4	44.3	44.6	44.3	44.4	44.2	44.3	44.7	44.3	44.5	44.1	44.2	44.6	44.5	44.4	44.0	44.1	44.7	44.5	44.4	43.9	43.9
TOTAL H ABOVE ₵	19.9	19.7	19.6	19.9	19.6	19.7	19.5	19.6	20.0	19.6	19.8	19.4	19.5	19.9	19.8	19.7	19.3	19.4	20.0	19.8	19.7	19.2	19.2
H ABOVE DOWNST.	.7	.6	.4	.7	.4	.5	.4	.4	.8	.4	.6	.3	.3	.7	.7	.6	.1	.2	.8	.6	.5	.0	.0
ΔH/VEL H DOWNS.	1.05			1.05					1.20					1.05					1.20				

Lines 3 through 6 contain the piezometric pressure heads which were recorded by the water levels in the piezometer tubes in inches above the base of the piezometer board. When more than one tap exists at a section, lines 3 through 6 contain this data, but if only one tap exists, as at the inlet to each branch, only line 3 contains data. In accordance with the subscript notation, which was described earlier, lines 4 through 6 contain the data fromthe taps in consecutive order from moving from the top most tap in the clockwise direction when facing downstream.

Line 7 contains the average piezometric heads from lines 3 through 6.

Line 8 contains the velocity heads in inches at each section computed from the average velocities in line 2 using a kinetic energy coefficient of unity.

Line 9 contains the sum of the heads in lines 7 and 8 and consequently gives the total hydraulic head at each section.

Line 10 gives the values of the total head above the centerline of the inlets of the branches. Since the branch inlets are 24.7 inches above the base of the piezometer board, the values in this line were obtained by substracting 24.7 inches from the values in line 9.

Line 11 contains the total head in inches above the average head at the downstream section. This line therefore gives the energy loss between the given section, as given by average of the piezometer taps, and the downstream section 4 feet beyond the manifold.

Line 12 contains the dimensionless values obtained by dividing the head loss from line 11 at each branch inlet by the velocity head at the downstream section.

To help interpret the data in Tables 1 and 2 it is important to understand that the placement of the pressure taps does determine how representative the recorded values are of the average piezometric head at that section. In general the placement used should provide a fairly representative value. An exception, however, is the piezometric head p_{m5d4}. This pressure tap is located very near the junction of branch 5 with the mainline, obviously in the wake region caused by the branch inflow. This placement was necessary because the window between the flange and junction require that it be very close to the junction. The low values recorded for p_{m5d4}, particularly at the higher flow rates, when averaged with the other three values have given a head which is likely less than the true average piezometric heat at this section. As a result the data indicates a very small head loss between this section and the downstream section or even an energy increase as at the 10 cfs flow rate in the fourth series of data. A more representative piezometric pressure for this section near the end of the manifold would probably result by deleting this head from the average as was done with the 14 cfs flow rate in Table 2. For this flow rate $p_{m5d4} = 0.0$ and the computer program was written in such a way that it did not include zero values in the averages.

Tables 3 and 4 contain dimensionless values of power-transfer coefficients, K_j and the energy-transfer coefficients $c_{\ell j}$ computed from the data in Tables 1 and 2 respectively. These coefficients have been described by Amorocho and DeVries.[1/] The energy-transfer coefficients are defined by

$$c_{\ell j} = \frac{H_{b\ell j} - H_{mkd}}{V_{mkd}^2/2g} \text{ for } \ell = 1, 2, 3, 4, 5;\ j = 1, 2, 3, \text{ and } k = 2, 3, 4, 5, 5' \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which the H's are the average total heads, and V is the velocity. The subscripts are as given earlier; b-denoting branch, m-mainline, ℓ is the branch number and j when equal to 1 denotes the inlet, when equal to 2 denotes center and when equal to 3 denotes the exit, k is the branch number immediately upstream from where the head H_{mkd} occurs. The fourth subscript is deleted since the average values are used. In Tables 3 and 4 the parenthesis enclose the values of subscripts ℓ and j, and the number of branches in the first column gives the value of k. The last line of coefficients for each flow rate given in Tables 3 and 4 used the average head at the downstream section $H_{m5d'}$, as the mainline head in Eq. 2. The power-transfer coefficients are defined by

$$K_j = \frac{1}{k} \sum_{n=1}^{k} c_{nj} \quad \text{for } j = 1, 2, 3 \text{ and } k = 2, 3, 4, 5, 5' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

[1/] Amorocho, J. and J. J. DeVries, "Power Losses and Flow Topologies in Converging Manifold." Journal of the Hydraulics Division, ASCE, Vol. 97, No. HY1, Proc. Paper 7791, Jan. 1971, pp. 81-99.

Table 3. Computed values of dimensionless power-transfer and energy-transfer coefficients from data in Table 1 for test series 1 and 2.

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 2.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.559	1.025	.640	1.340	1.340	.450	1.777	.709	.831									
3	1.134	.835	.701	.980	.980	.511	1.210	.648	.712	1.210	.878	.879						
4	1.113	.984	.728	.980	.980	.616	1.158	.722	.772	1.158	.900	.901	1.158	1.336	.623			
5	1.172	1.114	.832	1.049	1.049	.736	1.202	.827	.870	1.202	.981	.982	1.202	1.356	.742	1.202	1.356	.829
5′	1.248	1.190	.908	1.126	1.126	.813	1.279	.904	.947	1.279	1.057	1.058	1.279	1.432	.819	1.279	1.432	.905

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 4.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.613	1.243	.586	1.340	1.559	.232	1.886	.927	.940									
3	1.071	.773	.562	.880	.995	.296	1.167	.662	.669	1.167	.662	.721						
4	1.058	.895	.661	.913	1.002	.460	1.135	.744	.749	1.135	.744	.790	1.046	1.091	.646			
5	1.026	.922	.678	.896	.972	.506	1.087	.751	.755	1.087	.751	.790	1.011	1.049	.666	1.049	1.087	.675
5′	1.017	.912	.669	.886	.963	.497	1.078	.741	.745	1.078	.741	.780	1.001	1.040	.656	1.040	1.078	.666

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 6.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.595	.479	.576	1.353	.771	.244	1.837	.188	.908									
3	1.059	.382	.551	.872	.565	.288	1.127	.258	.637	1.178	.322	.728						
4	1.034	.586	.671	.915	.678	.463	1.113	.440	.734	1.153	.489	.804	.955	.737	.684			
5	.970	.621	.654	.857	.653	.468	1.028	.448	.701	1.062	.491	.762	.892	.704	.659	1.011	.811	.682
5′	.966	.617	.650	.853	.649	.464	1.024	.444	.697	1.058	.487	.757	.887	.700	.654	1.007	.806	.678

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 8.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.545	.432	.517	1.368	.795	.184	1.722	.068	.849									
3	1.039	.371	.550	.891	.589	.267	1.077	.206	.617	1.149	.317	.765						
4	1.005	.567	.643	.896	.662	.413	1.041	.366	.684	1.097	.452	.799	.985	.788	.677			
5	.966	.627	.653	.865	.663	.449	.989	.408	.682	1.037	.482	.781	.941	.771	.676	.999	.812	.676
5′	.964	.625	.650	.862	.661	.446	.987	.406	.680	1.035	.480	.779	.939	.769	.674	.996	.810	.674

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 10.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.602	.519	.596	1.410	.847	.262	1.794	.190	.930									
3	1.030	.377	.555	.895	.599	.290	1.098	.252	.642	1.098	.280	.733						
4	1.001	.571	.654	.919	.689	.450	1.076	.421	.723	1.076	.442	.793	.933	.732	.651			
5	.955	.621	.651	.874	.677	.471	1.009	.445	.706	1.009	.464	.766	.887	.713	.643	.997	.805	.668
5′	.957	.622	.652	.876	.678	.472	1.011	.447	.707	1.011	.465	.767	.888	.715	.645	.999	.807	.670

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 12.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.543	.514	.556	1.368	.874	.180	1.719	.159	.931									
3	1.067	.437	.596	.905	.645	.280	1.091	.266	.675	1.205	.399	.834						
4	1.035	.622	.687	.931	.730	.447	1.075	.436	.753	1.164	.539	.876	.971	.782	.674			
5	.980	.657	.676	.882	.708	.465	1.005	.456	.728	1.082	.544	.834	.916	.753	.660	1.014	.822	.691
5′	.994	.671	.690	.896	.722	.478	1.019	.469	.742	1.096	.558	.848	.930	.767	.674	1.028	.836	.705

Table 3. Continued.

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 14.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.552	.473	.577	1.374	.831	.261	1.730	.115	.894									
3	1.083	.422	.609	.930	.644	.343	1.118	.267	.677	1.202	.356	.807						
4	1.055	.619	.702	.952	.731	.498	1.098	.438	.756	1.163	.507	.857	1.007	.801	.698			
5	.712	.371	.397	.613	.422	.222	.738	.170	.444	.794	.230	.531	.660	.482	.394	.754	.549	.394
5′	1.028	.686	.713	.929	.738	.537	1.054	.486	.760	1.110	.546	.847	.976	.798	.710	1.069	.864	.710

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 12.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.574	.490	.601	1.380	.844	.259	1.768	.137	.943									
3	1.058	.409	.590	.901	.618	.310	1.105	.245	.670	1.159	.364	.789						
4	1.032	.604	.686	.933	.714	.475	1.091	.425	.754	1.140	.517	.846	.962	.761	.667			
5	.975	.640	.668	.880	.691	.486	1.016	.443	.726	1.059	.522	.805	.905	.732	.651	1.016	.811	.669
5′	.988	.652	.680	.893	.704	.499	1.029	.456	.739	1.071	.534	.818	.918	.745	.664	1.029	.823	.682

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 10.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.580	.519	.597	1.362	.856	.249	1.799	.181	.946									
3	1.049	.404	.577	.884	.617	.297	1.114	.262	.664	1.151	.333	.770						
4	1.012	.588	.666	.903	.696	.449	1.081	.421	.733	1.110	.476	.815	.953	.759	.668			
5	.994	.659	.681	.885	.707	.494	1.038	.470	.739	1.063	.518	.809	.928	.761	.683	1.057	.839	.679
5′	.982	.647	.668	.873	.695	.482	1.026	.458	.726	1.051	.505	.797	.916	.749	.670	1.044	.827	.667

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 8.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.586	.490	.572	1.354	.734	.191	1.818	.246	.954									
3	1.073	.423	.605	.919	.592	.306	1.164	.335	.708	1.135	.342	.799						
4	1.063	.638	.710	.957	.704	.482	1.147	.505	.794	1.124	.510	.864	1.024	.832	.701			
5	.993	.634	.689	.903	.685	.494	1.066	.513	.762	1.047	.518	.823	.960	.795	.683	1.018	.659	.686
5′	1.004	.639	.694	.908	.690	.499	1.071	.518	.767	1.051	.523	.827	.965	.800	.687	1.023	.663	.690

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 6.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.559	.479	.570	1.389	.819	.244	1.728	.140	.896									
3	1.108	.433	.619	.955	.655	.351	1.134	.297	.695	1.236	.348	.811						
4	1.069	.623	.700	.960	.727	.492	1.098	.450	.758	1.178	.489	.848	1.039	.826	.703			
5	1.016	.666	.619	.917	.717	.515	1.036	.478	.744	1.104	.512	.821	.985	.802	.696	1.036	.823	.322
5′	1.007	.658	.611	.909	.708	.506	1.028	.469	.735	1.096	.504	.813	.977	.794	.687	1.028	.815	.313

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 4.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.559	.384	.545	1.395	.768	.204	1.722	.000	.886									
3	1.076	.375	.584	.923	.592	.296	1.095	.188	.654	1.210	.346	.803						
4	1.069	.600	.690	.946	.690	.460	1.080	.377	.738	1.169	.499	.853	1.080	.835	.709			
5	1.047	.673	.699	.925	.704	.506	1.040	.434	.745	1.116	.540	.844	1.040	.829	.720	1.116	.857	.678
5′	1.018	.644	.670	.896	.675	.477	1.011	.406	.717	1.087	.511	.815	1.011	.800	.691	1.087	.829	.650

Table 3. Continued.

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 2.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(11)	C(12)	C(13)	C(21)	C(22)	C(23)	C(31)	C(32)	C(33)	C(41)	C(42)	C(43)	C(51)	C(52)	C(53)
2	1.450	.534	.513	1.450	.904	.232	1.450	.164	.795									
3	1.057	.471	.592	.980	.693	.339	.980	.303	.635	1.210	.418	.803						
4	1.069	.717	.739	1.024	.802	.527	1.024	.499	.757	1.202	.588	.886	1.024	.980	.787			
5	1.110	.822	.788	1.049	.857	.621	1.049	.597	.819	1.202	.674	.930	1.049	1.011	.845	1.202	.972	.726
5	1.110	.822	.788	1.049	.857	.621	1.049	.597	.819	1.202	.674	.930	1.049	1.011	.845	1.202	.972	.726

Table 4. Computed values of dimensionless power-transfer and energy-transfer coefficients from data in Table 2 for test series 3 and 4.

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 2.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.646	.419	.526	1.471	.991	.221	1.820	-.153	.831									
3	1.095	.310	.413	.934	.682	.275	1.118	.079	.597	1.233	.171	.366						
4	1.015	.454	.534	.899	.704	.389	1.042	.237	.638	1.131	.308	.459	.989	.570	.650			
5	.985	.553	.568	.880	.712	.441	1.003	.310	.655	1.080	.371	.501	.957	.597	.666	1.003	.777	.578
5′	.939	.507	.522	.834	.666	.395	.957	.264	.609	1.034	.325	.455	.911	.551	.620	.957	.731	.532

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 4.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.564	.553	.493	1.406	.918	.177	1.722	.188	.809									
3	1.020	.376	.515	.880	.623	.232	1.046	.238	.565	1.133	.267	.746						
4	.974	.527	.571	.872	.672	.370	1.001	.375	.628	1.068	.397	.768	.956	.665	.517			
5	.906	.554	.566	.806	.634	.374	.917	.378	.596	.974	.397	.716	.879	.627	.500	.955	.734	.641
5′	.892	.540	.551	.791	.620	.359	.902	.363	.582	.960	.383	.702	.864	.613	.486	.941	.719	.627

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 4.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.559	.523	.515	1.406	.893	.210	1.711	.153	.820									
3	.958	.292	.433	.794	.523	.163	.955	.133	.485	1.127	.220	.652						
4	.946	.517	.550	.825	.616	.337	.950	.313	.586	1.083	.380	.715	.927	.758	.562			
5	.885	.566	.564	.784	.603	.363	.891	.343	.578	1.006	.401	.689	.872	.726	.558	.872	.757	.632
5′	.859	.540	.538	.758	.578	.337	.865	.317	.552	.980	.375	.663	.846	.700	.532	.846	.731	.606

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 6.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.536	1.159	.529	1.330	1.499	.184	1.742	.819	.873									
3	1.061	.750	.550	.874	.963	.270	1.091	.605	.633	1.219	.682	.747						
4	1.033	.867	.647	.904	.973	.436	1.072	.696	.718	1.171	.755	.806	.983	1.042	.627			
5	.972	.859	.642	.851	.911	.449	.996	.672	.691	1.081	.723	.767	.919	.970	.613	1.013	1.021	.690
5′	.966	.853	.635	.845	.904	.442	.989	.665	.684	1.075	.717	.760	.913	.964	.606	1.007	1.015	.684

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 8.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.582	1.202	.556	1.346	1.504	.199	1.818	.900	.913									
3	1.029	.734	.515	.856	.939	.251	1.104	.621	.628	1.126	.642	.665						
4	.980	.828	.601	.866	.931	.398	1.059	.684	.690	1.076	.701	.719	.920	.998	.597			
5	.894	.794	.577	.789	.844	.386	.954	.632	.636	.969	.646	.662	.835	.902	.557	.921	.945	.643
5′	.909	.809	.592	.804	.860	.401	.970	.648	.652	.984	.662	.677	.850	.917	.572	.936	.960	.658

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 10.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.528	1.116	.494	1.371	1.476	.127	1.685	.757	.862									
3	1.046	.751	.530	.911	.967	.256	1.077	.588	.643	1.151	.698	.691						
4	1.028	.874	.651	.951	.994	.443	1.079	.701	.743	1.136	.786	.780	.944	1.015	.638			
5	.956	.856	.635	.882	.919	.445	.992	.666	.703	1.041	.740	.735	.876	.937	.612	.986	1.017	.680
5′	.962	.862	.641	.888	.925	.451	.999	.672	.709	1.048	.746	.741	.882	.943	.618	.992	1.023	.686

Table 4. Continued.

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 12.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.410	1.064	.500	1.331	1.489	.189	1.489	.639	.810									
3	1.012	.735	.541	.893	.976	.291	.976	.528	.618	1.167	.700	.715						
4	1.017	.875	.662	.938	1.002	.471	1.002	.659	.725	1.150	.789	.800	.977	1.056	.651			
5	.934	.840	.626	.857	.913	.456	.913	.614	.674	1.041	.729	.739	.892	.960	.610	.968	.985	.650
5′	.977	.883	.668	.900	.955	.499	.955	.657	.717	1.083	.772	.781	.934	1.002	.653	1.011	1.028	.692

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 14.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.521	.573	.555	1.360	.808	.185	1.681	.337	.925									
3	1.048	.435	.580	.901	.610	.281	1.070	.362	.671	1.173	.335	.788						
4	1.025	.616	.680	.927	.702	.447	1.058	.509	.749	1.138	.488	.840	.978	.764	.682			
5	.942	.621	.642	.847	.653	.434	.960	.488	.694	1.029	.470	.772	.891	.707	.637	.985	.787	.673
5′	.973	.652	.673	.878	.684	.465	.990	.518	.725	1.059	.500	.803	.922	.738	.667	1.015	.818	.703

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 12.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.522	.443	.521	1.359	.828	.192	1.686	.058	.849									
3	1.053	.391	.566	.885	.605	.270	1.057	.199	.616	1.217	.370	.811						
4	1.013	.601	.678	.926	.710	.450	1.060	.395	.718	1.184	.528	.869	.882	.771	.674			
5	.949	.625	.656	.862	.675	.452	.977	.405	.683	1.083	.518	.813	.823	.728	.644	1.002	.797	.687
5′	.982	.658	.689	.895	.708	.485	1.010	.438	.716	1.116	.551	.846	.856	.761	.677	1.035	.830	.720

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 10.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.559	.455	.482	1.375	.817	.144	1.742	.094	.819									
3	1.066	.388	.544	.898	.603	.249	1.091	.222	.605	1.210	.337	.778						
4	1.046	.584	.659	.940	.712	.438	1.090	.417	.713	1.183	.506	.848	.969	.700	.636			
5	.978	.617	.641	.877	.681	.445	1.006	.427	.682	1.086	.504	.798	.902	.670	.616	1.018	.804	.663
5′	.987	.626	.650	.887	.690	.454	1.015	.436	.691	1.095	.513	.807	.911	.680	.625	1.028	.813	.672

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 8.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.436	.408	.420	1.354	.836	.068	1.518	-.020	.772									
3	1.034	.398	.551	.905	.632	.227	.991	.181	.598	1.207	.382	.828						
4	1.044	.614	.678	.952	.740	.427	1.019	.391	.714	1.186	.547	.892	1.019	.779	.681			
5	.953	.618	.639	.865	.683	.413	.922	.382	.650	1.066	.516	.813	.922	.716	.631	.989	.795	.679
5′	.943	.609	.630	.855	.673	.403	.913	.372	.650	1.056	.506	.804	.913	.707	.622	.980	.786	.670

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 6.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.510	.437	.444	1.316	.783	.098	1.704	.091	.791									
3	1.006	.352	.493	.853	.572	.211	1.057	.207	.576	1.108	.277	.692						
4	1.009	.564	.622	.891	.673	.393	1.049	.390	.676	1.088	.445	.766	1.009	.747	.653			
5	.932	.589	.605	.823	.636	.395	.960	.393	.639	.994	.440	.716	.926	.700	.619	.960	.777	.654
5′	.937	.593	.609	.828	.640	.400	.964	.397	.643	.998	.444	.720	.930	.704	.623	.964	.781	.658

Table 4. Continued.

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 4.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.559	.466	.486	1.340	.822	.177	1.777	.109	.795									
3	1.019	.352	.512	.865	.592	.252	1.095	.217	.578	1.095	.245	.707						
4	1.024	.589	.648	.913	.701	.438	1.091	.410	.690	1.091	.432	.790	1.002	.813	.675			
5	.967	.635	.648	.867	.685	.458	1.020	.434	.675	1.020	.454	.761	.944	.781	.663	.982	.819	.685
5′	.938	.606	.620	.838	.656	.429	.992	.406	.646	.992	.425	.732	.915	.752	.634	.953	.790	.656

TABLE OF POWER-TRANSFER COEFFICEINTS AND ENERGY-TRANSFER COEFFICIENTS FOR Q= 2.000 CFS

NO OF BRANCHS	K(1)	K(2)	K(3)	C(1,1)	C(1,2)	C(1,3)	C(2,1)	C(2,2)	C(2,3)	C(3,1)	C(3,2)	C(3,3)	C(4,1)	C(4,2)	C(4,3)	C(5,1)	C(5,2)	C(5,3)
2	1.231	.425	.368	1.231	.904	.013	1.231	-.054	.722									
3	1.019	.414	.554	.865	.693	.224	.865	.188	.597	1.325	.360	.841						
4	.935	.539	.576	.802	.668	.304	.802	.277	.594	1.158	.410	.782	.980	.802	.623			
5	.980	.669	.678	.857	.742	.429	.857	.406	.678	1.164	.521	.841	1.011	.857	.704	1.011	.819	.739
5′	.903	.592	.602	.781	.666	.353	.781	.329	.602	1.087	.444	.764	.934	.781	.627	.934	.742	.662

SUGGESTIONS FOR EVALUATING THE PERFORMANCE OF THE MANIFOLD

In examining the performance of the manifold from the inlet of each branch to the downstream section, the last line of energy-transfer coefficients with a second subscript (or second number in the parenthesis) equal to 1 are of prime importance. With these values equal to each other the head losses between each inlet and the downstream section would be equal. Greater head losses would be evidenced by a larger such coefficient, and smaller head losses by a smaller coefficient. Furthermore at the same Reynolds number these coefficients should have the same magnitude in the prototype as in the model.

These energy-transfer coefficients c_{11}, c_{21}, c_{31}, c_{41} and c_{51} (from the last lines in Table 4) from the different flow rates have been plotted on Fig. 5 against the Reynolds number corresponding to the different flow rates used in the tests. This plotted data indicates that these energy-transfer coefficients for all branches of the manifold vary a relatively small amount with Reynolds number. While for rough calculations the prototype's performance may be predicted by taking the average value of the energy-transfer coefficient for each branch even though the Reynolds number from the model tests is different than the Reynolds number from the prototype's design operation, better estimates of these energy-transfer coefficients for the prototype might be obtained by extrapolation. It is generally not advisable to extrapolate data very far beyond the lower or upper values. When it is physically impossible

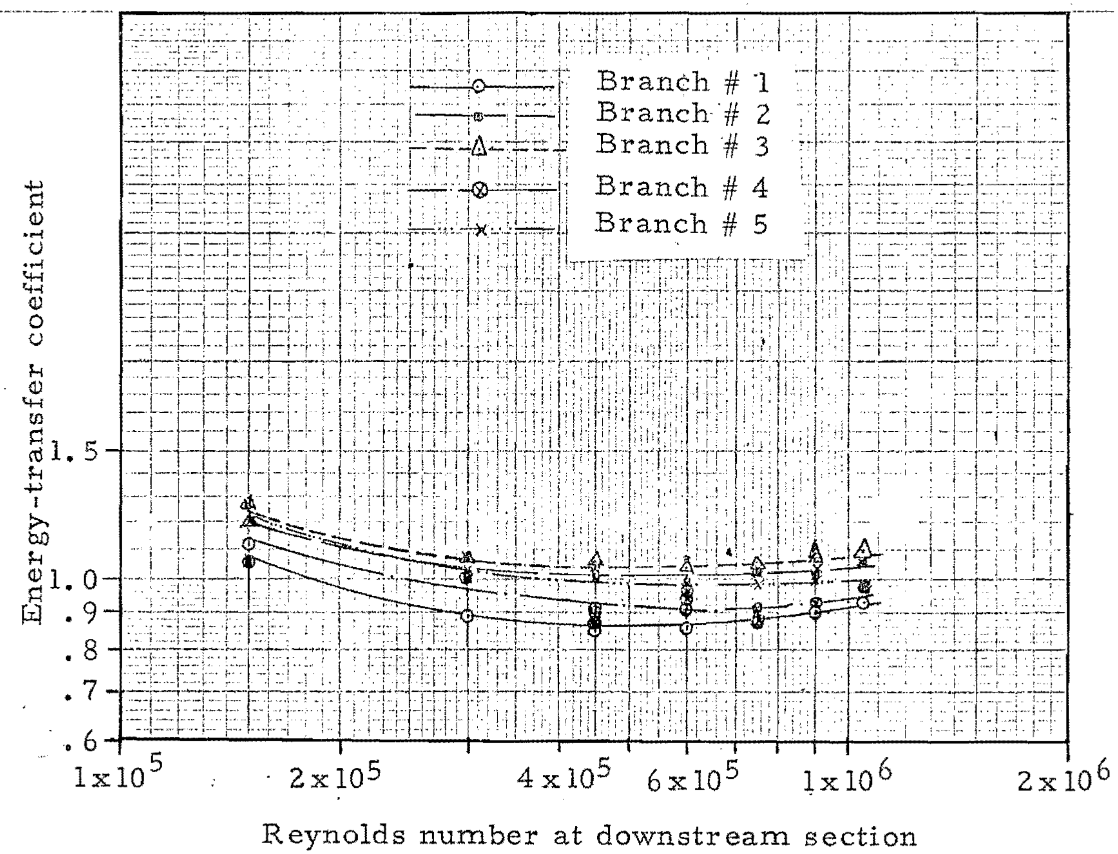


Fig. 5. Variation of energy-transfer coefficients between branch inlets and downstream section with Reynolds number.

to test the model at the appropriate Reynolds numbers, such extrapolation is necessary if the prototype performance is to be predicted from tests on a single model. Tests on a second model using a different geometric scale would aid considerably in evaluating such scale effects. Since Reynolds number for prototype operation at its design conditions equals 1.4×10^7 (assuming a flow rate of 2,200 cfs and kinematic viscosity of 1.45×10^{-5} ft^2/sec), over 10 times as large as the largest Reynolds for which data were obtained from the model, such extrapolation is associated with considerable risks, particularly since the separate curves on Fig. 5 are not well defined by the data.

This extrapolation might be aided by plotting head differences between each inlet and the downstream section against the Reynolds numbers as has been done in Fig. 6. The curves on the left portion of Fig. 6 were obtained using the data from test series 1 and 2 and those on the right portion from test series 3 and 4. Since the actual data points (not shown) from which the curves were drawn exhibit slightly less scatter for the right portion of the figure, it appears that photographing the piezometer board has provided better test data. Therefore the data from test series 3 and 4 should be given priority over those from test series 1 and 2.

From the slope of the lines on Fig. 6, particularly the upper portions, the following five equations have been obtained to predict the head loss between the inlet of each branch and the downstream section.

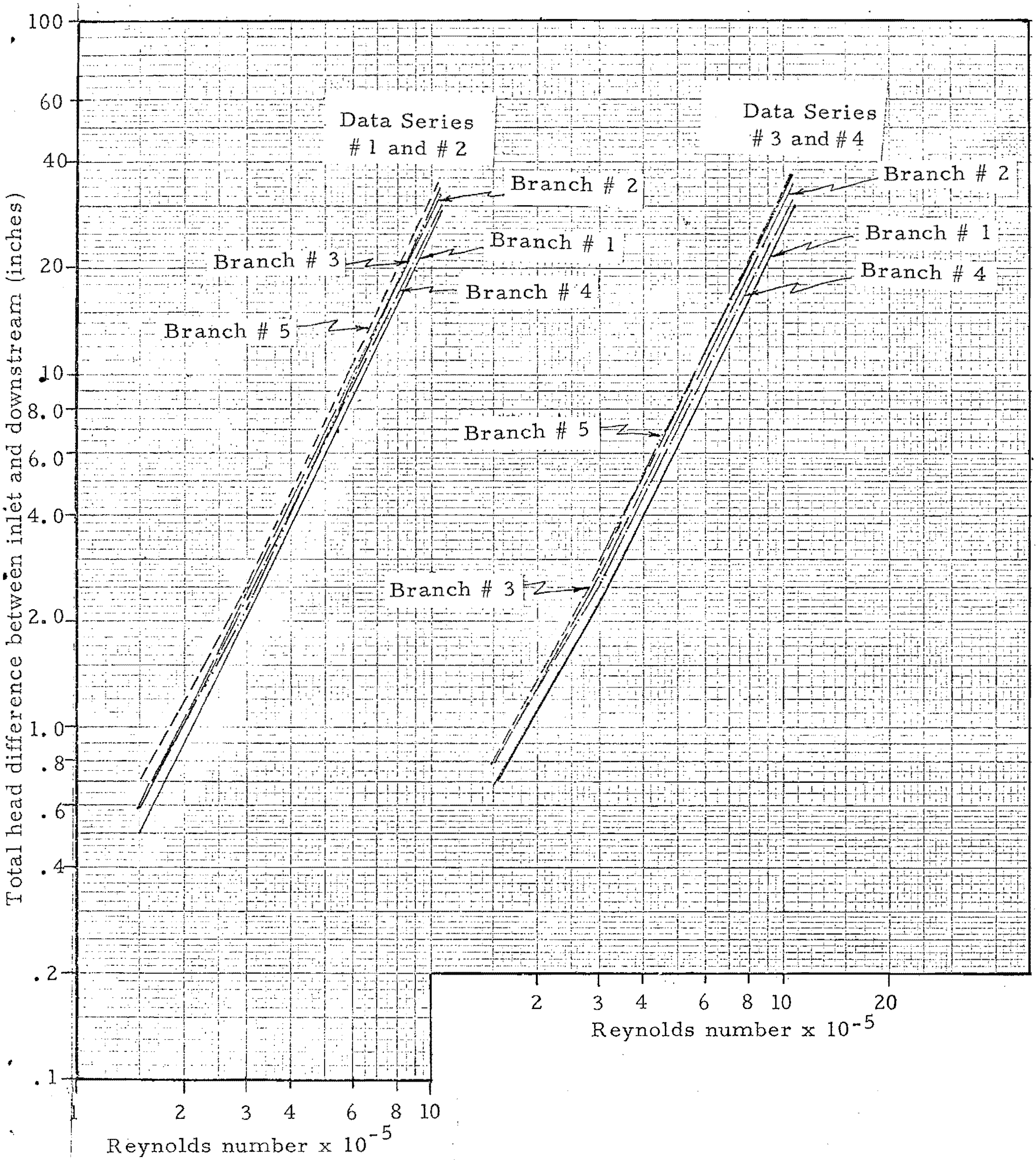


Fig. 6. Head loss between inlet of each branch of manifold model and a section 4 feet downstream from the end of the manifold.

Branch 1

$$\Delta H = .236\ (R_e \times 10^{-5})^{2.05} = 9.465\ \frac{V^{2.05}}{2g} = .1470\ V^{2.05} \qquad \ldots\ldots\ldots\ldots (4)$$

Branch 2

$$\Delta H = .300\ (R_e \times 10^{-5})^{2.005} = 11.547\ \frac{V^{2.005}}{2g} = .1793\ V^{2.005} \qquad \ldots\ldots\ldots\ldots (5)$$

Branch 3

$$\Delta H = .300\ (R_e \times 10^{-5})^{2.02} = 11.447\ \frac{V^{2.02}}{2g} = .1778\ V^{2.02} \qquad \ldots\ldots\ldots\ldots (6)$$

Branch 4

$$\Delta H = .275\ (R_e \times 10^{-5})^{2.005} = 9.362\ \frac{V^{2.005}}{2g} = .1454\ V^{2.005} \qquad \ldots\ldots\ldots\ldots (7)$$

Branch 5

$$\Delta H = .310\ (R_e \times 10^{-5})^{1.992} = 8.820\ \frac{V^{1.992}}{2g} = .1370\ V^{1.992} \qquad \ldots\ldots\ldots\ldots (8)$$

in which the ΔH's are in inches and the velocities in feet per second. Table 5 shows a comparison of the head losses computed from Eqs. 3 through 7 compared with the recorded values.

From Eqs. 3 through 7 the head loss can be predicted between the inlet of each branch and the section 4 feet downstream from the manifold. Thereafter, from considerations of dynamic similitude based on Reynolds

Table 5. Comparison of head losses (in inches) measured in manifold model and those predicted from Eqs. 3 through 7.

	Branch No.																								
	1					2					3					4					5				
	Series		Av	Comp.	Dif.	Series		Av	Comp.	Dif.	Series		Av	Comp.	Dif.	Series		Av	Comp.	Dif.	Series		Av	Comp.	Dif.
Q	3	4				3	4				3	4				3	4				3	4			
2	.7	.7	.7	.546	-.15	.8	.7	.75	.681	-.07	.8	.8	.8	.685	-.12	.8	.7	.75	.624	-.13	.8	.8	.8	.700	-.1
4	2.3	2.3	2.3	2.26	-.04	2.8	2.6	2.7	2.73	+.03	2.8	2.8	2.8	2.78	-.02	2.6	2.6	2.6	2.51	-.09	2.7	2.8	2.75	2.78	+.03
6	5.0	5.3	5.15	5.19	+.04	6.0	6.0	6.0	6.16	+.16	6.2	6.4	6.3	6.30	.0	5.2	5.7	5.45	5.65	+.20	5.9	6.0	5.95	6.25	+.30
8	9.0	9.5	9.25	9.36	+.11	10.3	11.2	11.25	10.98	-.27	10.8	11.0	10.9	11.27	+.37	9.8	10.1	9.95	10.06	+.11	10.4	10.7	10.55	11.08	+.53
10	14.3	14.2	14.25	14.79	+.54	16.5	16.7	16.6	17.17	+.57	16.5	17.1	16.8	17.69	+.89	14.5	14.9	14.7	15.74	+1.04	16.3	17.0	16.65	17.28	+.63
12	21.0	21.0	21.0	21.49	+.49	23.9	24.2	24.05	24.74	+.09	25.7	25.2	25.45	25.57	+.12	21.8	21.6	21.7	22.68	+.98	24.1	24.2	24.15	24.85	+.70
14	29.7		29.7	29.48	-.22	33.7		33.7	33.70	0	35.5		35.5	34.91	-.59	31.2		31.2	30.89	-.31	34.2		34.2	33.78	-.42

number modeling with the same fluid, the following equation can be used to predict head losses in the prototype.

$$\Delta H_p = \Delta H_m \left(\frac{V_p}{V_m}\right)^2 = \Delta H_m \left(\frac{L_m}{L_p}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Following the procedure outlined above, gives the values of head losses shown in Table 6.

Table 6. Extrapolated values of head loss in prototype manifold between branch inlet and downstream of manifold at a Reynolds number equal to 1.4×10^7.

Branch No.	1	2	3	4	5
Head loss (inches)	41.8	42.5	45.8	39.0	41.2
Head loss (feet)	3.48	3.54	3.82	3.25	3.43
Energy-transfer coefficient	1.05	1.07	1.15	.98	1.04

Note that the energy-transfer coefficients obtained from this procedure (which equal the head loss divided by the velocity head at the downstream section) represent a reasonable extrapolation from Fig. 5 under the assumption that the curves are very nearly horizontal at the larger Reynolds numbers. If the exponents in Eqs. 3 through 7 had all been 2.0, then the extrapolation would have assumed that the curves were horizontal, i.e. the energy-transfer coefficients were constant.

In interpreting the predicted head losses given in Table 6 it should be recognized that all of the head loss which may be attributed to the manifold are not included. The manifold, much as an elbow, valve, or other local change in a pipe, creates secondary flows which persist for 20 or more diameters downstream. An indication that considerable secondary flows exist at the section 4 feet downstream from the manifold is provided by the fact that the four pressure taps at this section give different piezometric heads. These secondary flows cause greater than the normal head loss in the pipe downstream from the disturbance. These additional losses are referred to as minor losses in pipe network analyses. A rough but reasonable estimate of these additional losses may assume that this secondary motion causes similar losses to those in a smooth 90° elbow with a radius to diameter ratio equal to unity. On this basis these additional losses could be roughly approximated by $.2 \frac{V^2}{2g} \approx .7$ ft. in the prototype.