HEAD LOSSES RESULTING FROM FLOW THROUGH WYES AND MANIFOLDS

by

HUA WANG

B.S., Taiwan Cheng Kung University, 1964

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF APPLIED SCIENCE

in the Department

of

Civil Engineering

We accept this thesis as conforming to the

required standard

THE UNIVERSITY OF BRITISH COLUMBIA

September, 1967

Department of **Civil Engineering,**

The University of British Columbia
Vancouver 8, Canada

Date **September 1967.**

ABSTRACT

Laboratory tests were conducted to determine the head losses in wyes and manifolds of conventional type, both with and without an internal tie-rod at the theoretical centre of the wye. These wyes and manifolds, having 45^o, 60^o and 90^o subtending angles of the wyes, were symmetrical about the longitudinal axis of the main pipe. The apparatus and method of testing used in the tests are described. The experiment spans a range of Reynold's numbers from 85,000 to 420,000 in the influent main pipe. The analysis of experimental data is based on the energy equation of Bernoulli for the one-dimensional condition. The results of the tests are given in both tabular and graphical form. It appears that the coefficient of the form loss (the ratio of the form loss of a wye or manifold to the velocity head in the main pipe) is a function of the proportional flow of water through the branches, the size of the tie-rod used and the subtending angle of the wye.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES -- (Continued)

LIST OF FIGURES

LIST OF FIGURES -- (Continued)

LIST OF FIGURES -- (Continued)

LIST OF PLATES

NOMENCLATURE

The following symbols are used in this thesis:

A = Average internal cross-sectional area, in sq. ft;

D = Average internal diameter, in inches;

g = Acceleration of gravity, in ft/sec^2;

h_f = Skin friction loss of pipe, in ft;

h_p = Pressure head in piezometric ring, in ft;

h_v = Velocity head, in ft;

Δh = Form loss of wye or manifold, in ft;

Δh_E = Elbow loss, in ft;

Δh_p = Difference of pressure heads in piezometric rings between main pipe and one of branch pipes, in ft;

k = Form loss coefficient of wye or manifold;

k_E = Elbow loss coefficient;

L = Length of pipe, in ft;

N_F = Froude number;

p = Hydraulic power loss in dimensionless expression;

P_v = Hydraulic power loss, in ft-lb/sec;

P_m = Hydraulic power in main pipe, in ft-lb/sec;

Q = Discharge in pipe, in cfs;

Re = Reynold's number

t = Time interval, in sec;

V = Mean velocity in pipe, in fps;

ν = Kinematic viscosity, in ft^2/sec;

NOMENCLATURE -- (Continued)

w = Unit weight of water, in lb/cu.ft;

W = Weight of water, in lbs;

Subscripts:

m = Occurrence in main pipe;

b = Occurrence in branch pipe;

r = Occurrence in right branch pipe;

l = Occurrence in left branch pipe;

i = Occurrence in inlet pipe.

ACKNOWLEDGMENT

The author is indebted to his supervisor, Dr. E. Ruus, for his constant encouragement and invaluable guidance throughout the preparation of the work.

He wishes to express his appreciation to Professor J.F. Muir for suggestions and criticism in preparing this thesis, to the staff of the Civil Engineering Instrument Shop for their assistance in the construction of the models, and to the National Research Council of Canada for financial support given through grants in aid of this research.

INTRODUCTION

In recent hydro-electric development, a power plant of high capacity is often proposed with a large diameter penstock to convey water from the overhead reservoir to the powerhouse. A detailed study of the head loss in the penstock becomes necessary for an economic design of the penstock. A major portion of the total head loss in the penstock results from the flow through branched pipe junctions. Research in hydraulics is required to determine the exact amount of the head losses at these pipe junctions and to study the various parameters governing such head losses. The author deals specifically with those investigations that concerned the head losses at wyes and manifolds.

The study described in this thesis was made to determine the head losses for various flow conditions at symmetrically branched pipe junctions having different subtending angles of the wyes. It is primarily concerned with the form losses resulting from the flows through wyes and manifolds.

Definition of Terms

A wye (or a bifurcation) is a branched fitting used to connect an influent main pipe to two effluent branch pipes. (See Figure I-8). When a branched fitting is used to connect an influent main pipe to three effluent branch pipes, it is called a trifurcation.

A manifold is a branched fitting wherein the effluent branch pipes are brought back parallel to the influent main pipe by the connection of elbows to each limb of a wye. The subtending angle of a manifold is considered to be the angle between the limbs of the wye. (See Figure I-9). For example, a 45^{o} manifold consists of a 45^{o} wye followed by two $22\text{-}1/2^{o}$ elbows connected to the downstream limbs of the wye.

The form loss is the head loss arising from turbulence in a branched pipe system excluding the skin friction loss of head in the system.

The form loss coefficient is the ratio between the form loss of a wye or manifold and the velocity head in the main pipe.

When the experimental results are adopted to estimate the head losses in geometrically similar prototypes, the application of Froude law ($N_F = V / \sqrt{gD}$) as the criterion for dynamic similarity in interpreting the hydraulic models will lead to reliable prediction of prototype performance.

PREVIOUS RESEARCH

The earliest important experimental investigation of the head losses in branched pipe systems was undertaken in 1928 by Vogel[(1)*], who dealt only with pipe tees. Later in 1929, Petermann[(2)] made a detailed study of the head losses in piping bifurcations with a main pipe that continued straight after the junction, a branch of which subtended at an angle of 45° to the longitudinal axis of the main pipe.

Since 1957, numerous theoretical and experimental investigations of hydraulic behaviour in branched pipe systems have been undertaken in many countries. In Switzerland, Cardel[(3)] made tests to determine the head losses produced in several types of wye branches where the main pipe 150 mm in diameter was joined by branch pipes ranging from 60 mm to 150 mm, the angles between the branches varying from 45° to 135°. In Italy, Marchetti and Noseda[(4)] investigated the hydraulic behaviour of five symmetrical bifurcations with the angles between the branches varying from 60° to 180°. In Norway, Fritjof Salvesen[(5)] conducted model tests on a 60° wye using in turn four different internal ribs in the fork of the wye to find which rib provided the lowest head loss. In Canada, at the University of British Columbia, Ahmed[(6)] conducted a series of head loss tests on five symmetrical wyes of conventional and spherical types having the angles of 90° and 60° between the branches. In the United States, several basic studies of the mechanism of instability of flow through a symmetrically

---

* Numbers in parentheses refer to the Bibliography.

branched pipe system were made at the University of Kansas[7]. Hydraulic model studies to determine the head loss in a manifold consisting of a 45^{o} wye followed by two $22\text{-}1/2^{o}$ elbows were conducted by staff members at Colorado State University[8]. A series of model tests was made by Gladwell, Tinney and Kreuzer[9], [10], [11] at Washington State University on a large penstock trifurcation to determine flow patterns, static and dynamic pressures, energy losses and the shed vorticity from a central tie-bar.

CHAPTER I

DESCRIPTION OF EXPERIMENT

1.1 LAYOUT

The experimental investigation was conducted in the Hydraulic Laboratory at the University of British Columbia in 1966-67.

The water was pumped from a sump into an overhead tank with a surface level about 55 ft. above ground and holding about 1760 cubic feet of water. Through a control valve this supply led to the test section. The pipes and fittings of the model rested upon a wooden frame, the tightness of all joints being under observation. The model area extended from the control valve to the outlets of the branch pipes. From the outlets of the branch pipes ran two troughs which enabled the flow through each branch pipe to be guided into a weighing tank or the sump as required in the experiment.

The general arrangement of the model in elevation is shown in Figure I-1. The plan views of a wye arrangement are shown in Figures I-2 and I-3, and Plate 1. The plan views of a manifold arrangement are shown in Figures I-4 and I-5, and Plate 2.

Due to the existence of many elbows and tees on the line prior to entering the model area, a great amount of turbulence-induced pressure fluctuations occurred. Two flow straighteners each 2 ft. long were provided in the upstream main pipe to dampen these fluctuations as well as to obtain a symmetrical velocity distribution in the entrance section of a wye or manifold. These flow straighteners were made of thin aluminum tubes varying from one to two inches in diameter.

PLATE 1 Model Layout for Wye Arrangement

Looking Downstream

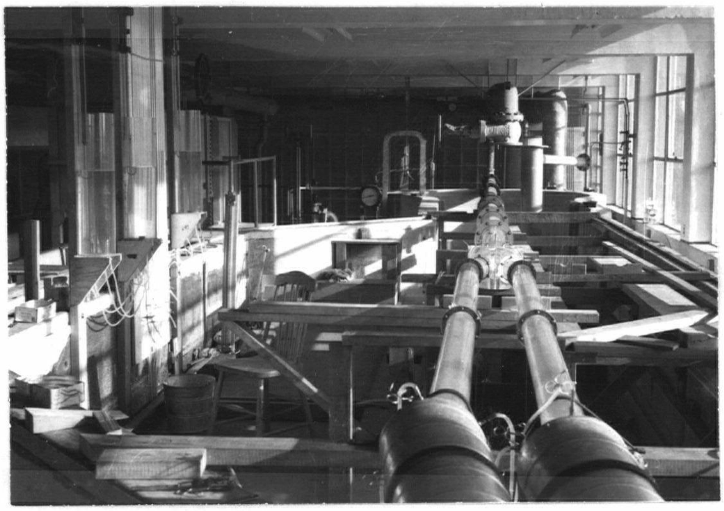


PLATE 2 Model Layout for Manifold Arrangement

Looking Upstream

The first one was located downstream from the bend below the control valve, and the other downstream from the first reducer, as shown in Figure I-6.

1.2 MODEL

The model was made of lucite except for the portion upstream from the second reducer to the control valve where steel pipes were used. (See Figure I-1). This set-up had the advantages of (1) enabling the different parts of the model to be replaced easily, (2) permitting the hydraulic behaviour throughout the model area to be observed clearly, and (3) showing any entrapment of air which would affect the piezometric heads.

A. Main Pipe and Branch Pipes

The main pipe, of lucite, comprised of three sections of equal length, had an internal diameter of 5.25 inch and a total length of 13.5 ft. It was fitted on both ends of the sections with lucite flanges which connected the pipes to each other and to the upstream face of a wye or manifold. Each flange was glued to one end of a section with the face perpendicular to the pipeline. Two piezometric rings were fitted on the downstream section of the main pipe close to its ends. A velocity traverse station was set up at 6 inches from the downstream end of the main pipe. Details of the main pipe from the control valve to a wye are shown in Figure I-6.

Four sections of the branch pipes, designated as A, B, C and D, having an internal diameter of approximately 3.75 inch and a length of 4.5 ft., were fitted with lucite flanges and piezometric rings to from the right and left branches. Throughout the experiment, sections A and C formed the left branch, and sections B and D the right branch.

The length of the main pipe from the downstream end of the first reducer to the upstream end of a wye was 33 ft., the length-diameter ratio being 75. The length-diameter ratio was equal to 30 for each of the branch pipes. This ratio was considered adequate to obtain a reasonably uniform velocity distribution, and to achieve accurate pressure head measurements at the downstream piezometric rings at the branch pipes.

An inlet pipe was used to determine the skin friction losses in the branch pipes and the head losses in the elbows. (See Figures IV-2 and A-1).

B. Wyes

Three symmetrically tapered wyes with subtending angles 45^o, 60^o and 90^o respectively were investigated. Details of the outlines and dimensions of the wyes are illustrated in Figures I-7 and I-8, and Plates 3 and 4. These carefully constructed models were symmetrical about the longitudinal axis of the main pipe.

In preparing each wye, the outer faces were first machined. The theoretical centre and the length from the theoretical centre to the points of inlet and outlets were determined. The conical water passages were turned on a lathe; the inner surface of the wye was polished by emery paper, then by crocus paper, and finally by polishing liquid to make the inner surface of the wye as smooth as possible for the purpose of decreasing skin friction loss.

For all wyes, the diameter of the inlet was 5.25 inch and of both outlets 3.75 inch; the tapering was done at an angle of 10^o.

C. Manifolds

Three symmetrical manifolds with 45^o, 60^o and 90^o subtending angles of the wyes were investigated. The 45^o manifold consisted of a 45^o wye followed by a 22-1/2^o elbow, which was built up from a 15^o and a 7-1/2^o elbow, connected to each downstream limb of the wye. A similar set-up was made for the 90^o manifold, replacing the 45^o wye with the 90^o wye and the elbows with 15^o and 30^o elbows. For the 60^o manifold, 30^o elbows, one on each limb of the 60^o wye, were used. Details of the outlines and dimensions of the manifolds are illustrated in Figure I-9.

These elbows, of constant diameter, consisted of a series of small-angle mitre bends joined together without any rounding at the planes of intersection. Each elbow was designed according to the recommendation of Bier[12], with bend radius (15 inch) equal to four times the diameter of the mitre bend (3.75 inch) and a deflection angle of 7-1/2^o between segments. Details of the outlines of the elbows are shown in Figure I-9 and Plate 5.

Since the segments of the elbows were glued together, final machining of the flanges at the ends of each elbow was necessary in order to achieve accurate alignment. (It is essential that the main pipe and the branch pipes are parallel and lie in the same horizontal plane.) When two elbows were connected to form a required deflection angle for a manifold, two locating pins were installed on each side of the elbow flanges to eliminate any distortion in the horizontal plane and to fix the combined elbow into final position.

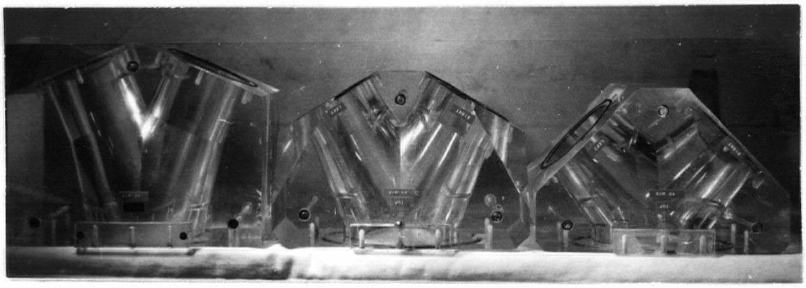


PLATE 3 Tapered Wyes in Vertical View

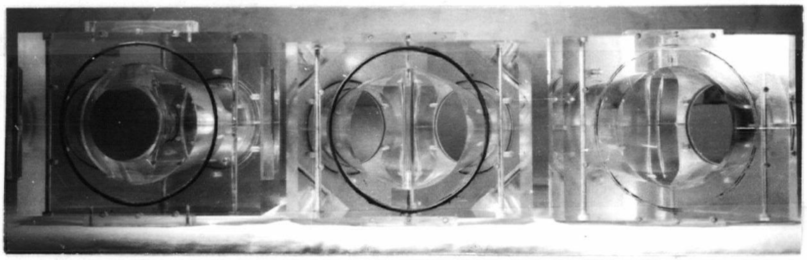


PLATE 4 Tapered Wyes in Horizontal View

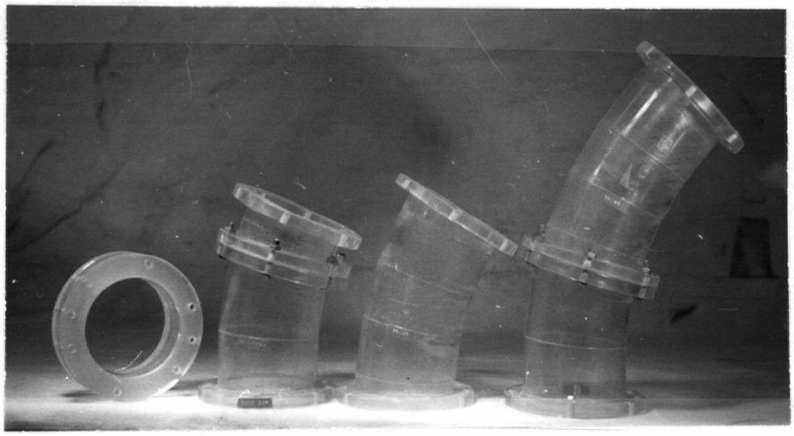


PLATE 5 Elbows

D. Tie-rods

Four tie-rods designated as TR1, TR2, TR3, and TR4 having diameters 0.187, 0.380, 0.562 and 0.754 inches respectively were used in the investigation of the head losses in wyes and manifolds. All of them were made of lucite except the TR1 tie-rod which was made of brass. Each of the four tie-rods was placed in turn at the theoretical centre of a wye, and screwed tight to its inner surface.

E. Orifices

The variation of discharges was controlled at the inlet by the control valve and at the two outlets by orifices. Table I-2 and Plate 6 show the details of the orifices. These orifices were placed, one at a time, at the downstream end of the branch pipe. Each orifice was machined on one side to obtain a clean and sharp edge free from burrs. Throughout the experiments, the orifices were placed in such a way that the sharp edges were facing the flow with the centerlines of the orifices at the same elevation.

F. Set-up of Model

(1) For wye arrangements:

A wye was first bolted to the branch pipes. The joints were checked by hand to ensure a proper alignment. The connection of the wye to the main pipe (see Plate 7) was made with the help of two locating pins installed in the downstream flange of the main pipe to eliminate any offset between the wye and the main pipe.

(2) For manifold arrangements:

Elbows were first bolted to the branch pipes, then to a wye (see Plate 8).

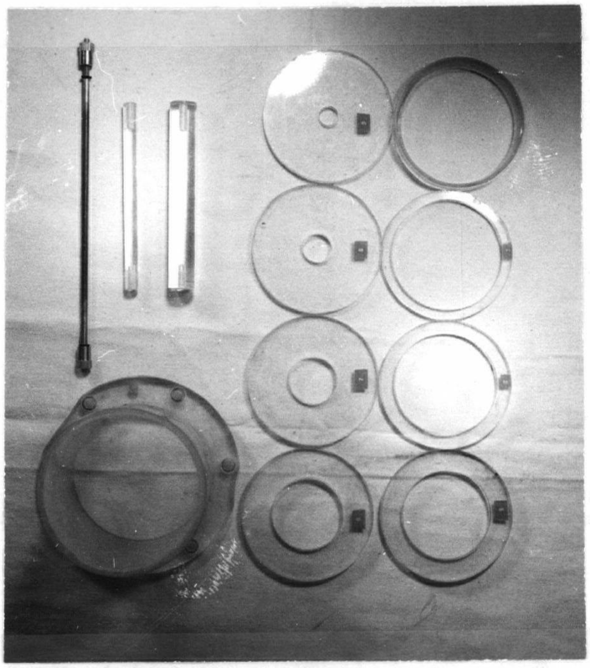


PLATE 6 Orifices and Tie-rods

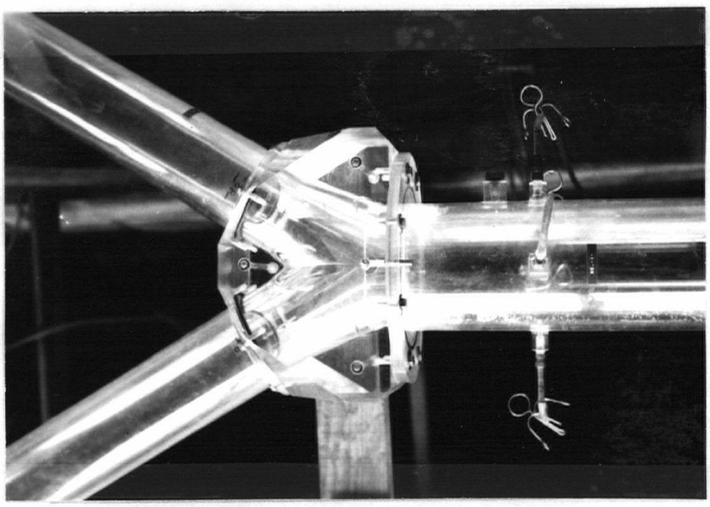


PLATE 7 Top View of Wye in Place

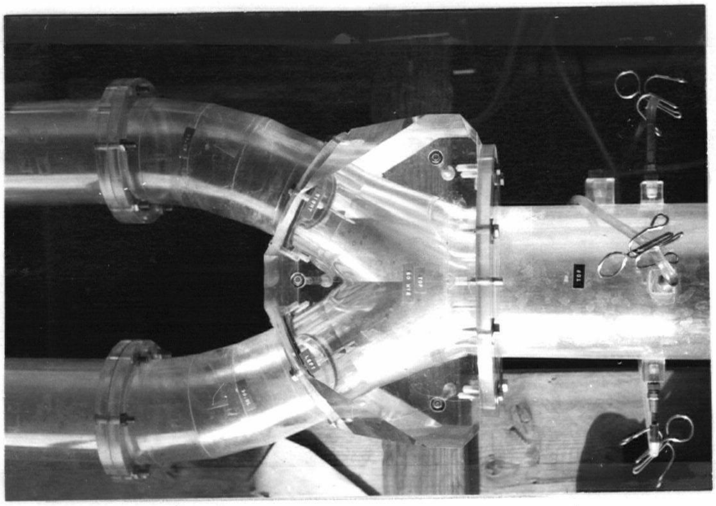


PLATE 8 Top View of Manifold in Place

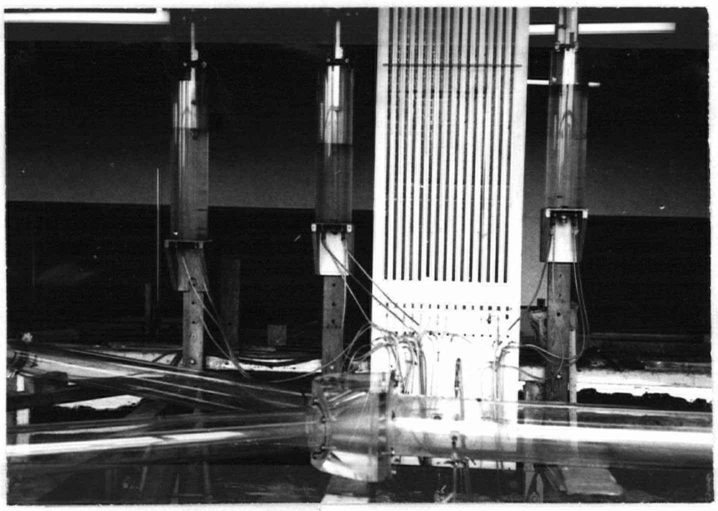


PLATE 9 Manometric Board with Gauge Tanks

For the final set-up of the whole system, the main pipe was aligned by means of a theodolite, and the pipes were leveled accurately with a carpenter's level. Leather belts were used on the main pipe and at places close to the outlets of the branch pipes to prevent vibration.

1.3 INSTRUMENTATION

The following instrumentation was used to measure pressure heads, and determine discharges.

A. Pressure Taps

A typical pressure tap with an opening of 1/8 inch, as shown in Figure I-11, was used in the experiment. The brass tube was held in position by a 1/8 inch National Taper Pipe threaded screw (NTP) in a 7/8 inch lucite tube. The NTP in turn was connected to a 3/16 Imperial threaded nut with rubber ring at the junction to eliminate possibility of any leakage.

The opening of the pressure tap should be small enough to prevent any disturbance in the flow along the pipe wall. It must be normal to the wall and free from any burrs. Any inclination of the opening, either towards or away from the flow, may cause false manometer readings.

B. Piezometric Connections

The pressure taps on the piezometric rings were connected to manometers and gauge tanks by flexible, transparent tubing. The manometers were installed in groups and connected to the gauge tanks as shown in Plate 9. Figures I-3 and I-5 show the connections of the manometer tubes and gauge tanks to the piezometric rings on the main pipe, and the left and right branch pipes for both wye and manifold arrangements.

C. Gauge Tanks, Hook Gauges and Verniers

In spite of efforts to minimize the turbulence-induced pressure fluctuations by providing the flow straighteners, small oscillations of the water levels in the manometers were observed. The water levels in three gauge tanks corresponding to the average levels in the manometers were used to measure the pressure heads in each of the piezometric rings in order to achieve a satisfactory degree of accuracy. The pressure fluctuations in the manometers were automatically smoothed out in these tanks.

In this series of tests, three gauge tanks, each of diameter 5.5 inches, connected with four corresponding manometers on the main and branch pipes, were fitted with hook gauges and verniers to indicate the average pressure heads in the related piezometric rings. Each pressure head was measured to one thousandth of a foot. By the use of extension rods fitted to the hook gauges when required, the range of difference in pressure heads would be increased from 2 ft. to 3 ft. (i.e., 6 inch additional at the top and 6 inch at the bottom) using the same verniers. The vernier in the upstream gauge tank was set an arbitrary 0.210 ft. higher than those in the central and downstream gauge tanks to facilitate measuring.

1.4 EXPERIMENTAL MEASUREMENTS

A. Measurement of Weight of Water

A weighing tank with maximum capacity of 20,000 lbs. was used to measure the weight of water. The scales of the weighing tank were checked and found correct before starting the experiment.

B. Measurement of Time

The time interval for a particular weight of water, which was collected in the weighing tank, was recorded by an electric clock to 0.1 second.

C. Measurement of Temperature

For each test, the temperature of water was read by thermometer and the density and the kinematic viscosity were determined for the purpose of calculating discharges and Reynold's numbers ($Re = V D / \nu$) in the corresponding main and branch pipes.

D. Measurement of Pressure Head

The pressure head was measured from the water levels of three gauge tanks under the assumption that the flow was in the steady state condition, and that the water levels in the gauge tanks were constant. Since the area ratio of a manometer tube (1/4 inch in diameter) to a gauge tank (5.5 inches in diameter) was approximately 1 : 480, a period of not less than 2 hours was considered necessary to adjust the water levels in the gauge tanks to the steady state condition.

In measuring the pressure heads, the presence of air bubbles in the flexible tubing connected to the piezometric points will greatly affect the accuracy. Great care was taken to ensure that all air bubbles were removed prior to taking any readings.

E. Discharge Determination

The discharge was determined from the weight of water discharged within a certain time interval, During the experiment, discrepancies were found in measuring the weight of water unless a sufficiently long time interval was adopted. For all tests, a time interval of approximately 300 seconds was required in order to achieve an accurate discharge determination.

The discharge and the velocity head in each pipe was obtained from the formulas as follows:

$$Q = W / (t \times w) \qquad (1)$$

$$h_v = \frac{V^2}{2g} \qquad (2)$$

in which Q = discharge, in cfs; W = weight of water, in lbs; t = time interval, in secs; w = unit weight of water, in lbs/ft^3; V = mean velocity in pipe, in fps; h_v = velocity head, in ft; and g = acceleration of gravity, in ft/sec^2.

CHAPTER II

BASIC CONCEPTS RELATING TO HEAD LOSSES

When water flows through a closed conduit, certain resistances are created which oppose the motion, and depend upon the geometrical form of the conduit. They are caused by friction, changes in flow direction and cross section, merging and dividing of flows and from other causes. Kinetic energy is converted into heat energy through the action of turbulence. As far as the head losses at the junctions for divided flows in branched pipe systems are concerned, the continuity, momentum, and energy equations, and the free-streamline theory have been applied to evaluate the approximate head losses for flow through bifurcations and trifurcations [(13), (14), (15), (16)]. Accurate determination of such head losses, if required, can only be obtained by model tests.

In this study, the model tests of the head losses resulting from the flow through both a wye and a manifold were based on the energy equation of Bernoulli for the one-dimensional condition. These losses were calculated under the following assumptions:

(1) the mean velocity at each cross-section is representative of the flow at that section.

(2) the flow passing through the cross-section where the measurement of pressure head was made is in steady and irrotational motion.

(3) the longitudinal axis of the whole system is horizontal.

2.1 FORM LOSSES OF WYES

The energy equation of Bernoulli for the one-dimensional condition states that the total head -- consisting of the sum of the velocity head, pressure head and geometric head of the fluid -- above an arbitrary horizontal reference plane must be equal to that above the same reference plane at any successive section, plus the intervening head losses. For a horizontal wye arrangement as shown in Figure I-3, the energy gradient lines are extrapolated to the theoretical centre of the wye on the basis of a sudden transition at that point. (See Figure II-1). The form loss of the wye is determined as the difference between the energy gradient lines upstream and downstream of the wye measured at its centre. This form loss, Δh, can be expressed from the energy equation as follows:

$$h_{pm} + h_{vm} = h_{pb} + h_{vb} + \Delta h + h_{fm} + h_{fb} \qquad \text{----------} \quad (3)$$

or

$$\Delta h = \Delta h_p + (h_{vm} - h_{vb}) - (h_{fm} + h_{fb}) \qquad \text{----------} \quad (4)$$

in which h_{pm}, h_{vm} and h_{fm} = piezometric head, velocity head and skin friction loss of head in the main pipe, in ft; h_{pb}, h_{vb} and h_{fb} = piezometric head, velocity head and skin friction loss of head in one of the branch pipes, in ft; and $\Delta h_p = h_{pm} - h_{pb}$ = difference of piezometric heads, in ft.

The wye loss coefficient, k, based on the velocity head in the main pipe can be expressed as

$$k = \frac{\Delta h}{h_{vm}} \qquad \text{------------------------------------} \quad (5)$$

When the velocity, the skin friction loss and the pressure head at the piezometric ring on each pipe for a particular discharge are known, the form loss of a wye can be obtained from Equation (4). The loss coefficient of the wye is determined from Equation (5).

The distance from the theoretical centre of each wye to the piezometric rings on the main and branch pipes is tabulated in Table II-1. The skin friction losses for the particular lengths from S to T in the main pipe and from T to D_1 or D_2 in the branch pipes are determined in Section 4.1. The pressure heads at the piezometric rings are obtained from the steady water levels of the three gauge tanks connected to the manometers. The velocity heads are obtained from Equation (2).

2.2 FORM LOSSES OF MANIFOLDS

For a manifold as shown in Figure II-2, the energy equation can be derived in the same way as Equation (3) where Δh is the form loss of a manifold instead of a wye. From Equation (4), the form loss of a manifold is obtained. The manifold loss coefficient, k, based on the velocity head in the main pipe is obtained from Equation (5).

The distance from the theoretical centre of each wye to the piezometric rings on the main and branch pipes for manifold arrangement is given in Table II-2.

2.3 HYDRAULIC POWER LOSSES IN WYE AND MANIFOLD ARRANGEMENTS

In most instances, the determination of the hydraulic power loss resulting from the passing of flow from the main pipe into the branch pipes is necessary. This study was made to ascertain the relationship between the hydraulic power loss and the proportional flow of water through the branches of the wye and manifold arrangements.

The hydraulic power loss in a branched pipe system can be expressed as

$$P_v = w\,(Q_r \Delta h_r + Q_l \Delta h_l) \qquad (6)$$

in which P_v = hydraulic power loss, in ft-lb/sec; Q_r and Q_l = discharges in the right and left branches respectively, in cfs; and Δh_r and Δh_l = form losses of wye or manifold resulting from the flow passing through the wye or manifold into the right and left branches respectively, in ft.

The above equation can be made more useful for direct application by reducing all the terms of it into a dimensionless expression. The hydraulic power in the main pipe, P_m, is expressed as

$$P_m = w\,Q_m\,h_{vm} \qquad (7)$$

Then Equation (6) can be converted into a dimensionless form as

$$p = \frac{P_v}{P_m} = k_r \frac{Q_r}{Q_m} + k_l \frac{Q_l}{Q_m} \qquad (8)$$

in which p = hydraulic power loss in dimensionless form; Q_m = discharge in the main pipe, in cfs; and k_r and k_l = the coefficient of Δh_r, and of Δh_l based on the velocity head in the main pipe.

CHAPTER III

EXPERIMENTAL INVESTIGATIONS

3.1 PRELIMINARY INVESTIGATION

In the initial stage of the study an experimental model was set up and subsequently modified to meet certain proposed hydraulic requirements as follows:

A. Symmetrical Velocity-Distribution in Main Pipe Close to Wye

Horizontal velocity traverse tests were performed across the main pipe at a section about 6 inches upstream from the wye. These tests were made by Ahmed[(6)] who provided maximum discharge of 0.92 cfs in one branch with the other branch completely closed. After the length of the influent main pipe was increased to 75 pipe-diameters and two flow straighteners installed in the upstream main pipe, the test showed that a symmetrical velocity-distribution about the longitudinal axis of the main pipe across the test section was achieved. Since the symmetrical velocity-distribution was demonstrated, the flow patterns for a symmetrical flow condition in each of the branch pipes would have to be identical.

B. Characteristic Velocity-Distribution at Piezometric Stations at Branch Pipes

The disturbance arising from the flow passing through a wye or manifold can influence pressure readings for some distance downstream of the wye or manifold. Experience has shown that a minimum distance of 25 pipe-diameters is necessary for gradual modification of the velocity distribution to a characteristic form through the remainder of the straight pipe. Therefore, a piezometric ring was provided at the downstream end of each branch pipe, resulting in a length-diameter ratio of approximately 30.

C. Condition of Discharges into Free Atmosphere at Outlets

Large troughs were provided at the outlets of the branch pipes to ensure atmospheric pressure at the orifices.

3.2 FLOW PATTERNS

A few of many possible flow patterns under different flow conditions, i.e., symmetrical, unsymmetrical and one-leg flows, are shown in Figures III-1 and III-2. It was observed that the region of the eddies formed in a wye or manifold was influenced directly by the discharge, the velocity, the size of the tie-rod, the subtending angle of the wye and the proportional flow of water through the branches.

CHAPTER IV

EXPERIMENTAL PROCEDURES

4.1 DETERMINATION OF SKIN FRICTION LOSSES IN MAIN PIPE AND BRANCH PIPES

The form loss of a wye or manifold was obtained from Equation (4) with the skin friction losses in the main and branch pipes determined in advance. For any given lengths, the skin friction losses in either the main pipe or each branch pipe under various discharges were determined by interpolation and by proportion from the empirical equations as derived below.

A. Skin Friction Loss In Main Pipe

The installation, as shown in Firuge I-3, was used to determine the skin friction loss in the main pipe for length SS_1 (3.375 ft.). Two of the gauge tanks were connected to the piezometric rings at the cross-sections of S and S_1. (See Figure I-3). As the velocity heads at these sections were equal, no velocity-head correction was required, therefore the difference of pressure heads between these two sections indicated the skin friction loss.

The main pipe was tested with various discharges ranging from 0.32 to 1.50 cfs and the results tabulated in Table IV-1. When the results were plotted on a log-log scale as shown in Figure IV-1, a linear relation between the skin friction loss and the corresponding discharge was detected. Hence, by using the method of least squares for curve fitting, the following empirical equation was obtained.

$$h_{f\ (SS_1)} = 0.0825\ Q^{1.789} \quad \text{-----------------------} \quad (9)$$

in which $h_{f\ (SS_1)}$ = skin friction loss in the main pipe for length SS_1, in ft.

B. Skin Friction Losses in Branch Pipes

The experimental set-up for the determination of the skin friction loss, for length BB_1 (9.0 ft.), in each of the branch pipes is shown in Figure IV-2. The tests were conducted similarly to those which determined the skin friction loss in the main pipe. Correction for velocity head between the upstream piezometric ring of the inlet pipe and the downstream piezometric ring of the branch pipe was made in the computations.

Each branch pipe was tested with various discharges ranging from 0.32 to 0.75 cfs and the results tabulated in Table IV-2. When the results were plotted on log-log graph papers as shown in Figures IV-3 and IV-4, similar linear relationships for each branch pipe as for the main pipe were found. By using least squares curve fitting, the empirical equations for the friction loss in each branch pipe were obtained as follows:

(1) For the right branch pipe (Sections B and D)

$$h_{fr} = 1.0696\ Q^{1.821} \quad \text{-----------------------} \quad (10)$$

(2) For the left branch pipe (Sections A and C)

$$h_{fl} = 1.0667\ Q^{1.811} \quad \text{-----------------------} \quad (11)$$

in which h_{fr} and h_{fl} = skin friction losses in the right and left branches pipe respectively for length B_1B_1 (9.0 ft.), in ft.

4.2 SEQUENCE OF EXPERIMENT

In each testing arrangement, a series of head loss tests was made to determine the losses in the wye or manifold under different flow conditions.

The tests were started with symmetrical flow condition. Orifices of equal size were placed at the outlets of the branch pipes and the control valve was then adjusted to the required discharge. For each test the discharge in the main pipe was set at approximately 1.50, 1.10, 0.92, 0.75, 0.50 and 0.32 cfs in turn. When the water levels in the gauge tanks became constant, the measurement of combined discharge, right and left branch discharges, the measurement of pressure head from the gauge readings and the measurement of water temperature were taken.

The tests of unsymmetrical flow conditions were carried out next. Orifices of different sizes were placed to control the proportional flow of water through each of the branches. The ratio of branch discharge to the main pipe discharge varied from 0 to 100%. For the purpose of comparing the form losses of wyes and manifolds, a constant discharge in the main pipe was maintained at 0.75 cfs for the testing arrangements with the subtending angles of 90^{o} and 60^{o}, and 0.92 cfs for that with the subtending angle of 45^{o}. Measurements were then taken as in the foregoing paragraph.

The tests of one-leg flow conditions, where one branch was completely blocked off and an orifice of appropriate size was placed at the outlet of the other branch, were finally conducted. The discharge in the open branch varied from 0.32 to 0.92 cfs.

CHAPTER V

RESULTS AND CONCLUSIONS

5.1 RESULTS

A. Form Losses of Wyes

Tables V-1 to V-10 give the hydraulic computations of the form losses and loss coefficients for the 90^o, 60^o and 45^o wyes in the wye arrangements:

Tables V-1 to V-5 give the computations for the 90^o wye without any tie-rod, and with the TR1, TR2, TR3 and TR4 tie-rods placed in turn at the theoretical centre of the wye respectively.

Tables V-6 to V-9 give the computations for the 60^o wye without any tie-rod, and with the TR2, TR3, and TR4 tie-rods respectively.

Table V-10 gives the computation for the 45^o wye without any tie-rod.

The results of the above computations are plotted in Figures V-1 to V-9:

Figures V-1, V-4 and V-7 show the form loss coefficient vs. discharge under symmetrical flow conditions for the 90^o, 60^o and 45^o wyes respectively.

Figures V-2, V-5 and V-7 show the form loss coefficient vs. discharge under one-leg flow conditions for the 90^o, 60^o and 45^o wyes respectively.

Figures V-3, V-6 and V-8 show the form loss coefficient vs. the ratio of branch discharge to the main discharge under unsymmetrical flow conditions for the 90°, 60° and 45° wyes respectively.

Figure V-9 shows the comparisons of the form loss coefficients

(a) among the three wyes without any tie-rod, and

(b) between the 90° and 60° wyes with the TR3 tie-rod,

under unsymmetrical flow conditions.

B. Form Losses of Manifolds

Tables V-11 to V-15 give the hydraulic computations of the form losses and loss coefficients for the 90°, 60° and 45° manifolds in the manifold arrangements:

Tables V-11, V-13 and V-15 give the computations for the 90°, 60° and 45° manifolds respectively without any tie-rod.

Tables V-12 and V-14 give the computations for the 90° and 60° manifolds respectively with the TR3 tie-rod.

The results of the above computations are plotted in Figures V-10 to V-14 under symmetrical, one-leg and unsymmetrical flow conditions respectively.

Figures V-13 and V-14 show the comparisons of wye and manifold loss coefficients without any tie-rod, and with the TR3 tie-rod under unsymmetrical flow conditions respectively.

The same coordinate systems for plotting have been adopted as in Section 5.1.A.

C. Hydraulic Power Losses in Wye and Manifold Arrangements

Tables V-16 and V-17 give the computation of the hydraulic power losses for the wye and manifold arrangements respectively.

Figures V-15 and V-16 show the hydraulic power loss vs. the ratio of branch discharge to the main discharge for both arrangements respectively.

5.2 CONCLUSIONS

(1) The form loss coefficient of a wye or manifold is a function of the proportional flow of water through the branches, the size of the tie-rod used and the subtending angle of the wye.

(2) Separate head loss tests for wyes, manifolds and elbows indicated that the form loss of a manifold -- consisting of a wye and two elbows -- is less than the sum of the individual form losses of the wye and elbows.

(3) An internal tie-rod placed at the theoretical centre of a wye tends to create considerable pressure fluctuations and disturbance in the downstream branched flow, as well as increasing the form loss.

(4) The form loss coefficient of a wye or manifold is not necessarily a minimum for a symmetrical flow condition.

(5) For a symmetrical flow condition, the form loss coefficient of a wye or manifold is not greatly affected by the amount of discharge. The form loss coefficient increases as the subtending angle of the wye and the size of the tie-rod are increased. The system without any tie-rod in either the 45° wye or the 45° manifold had the lowest form loss coefficient.

(6) For a one-leg flow condition, due to the turbulence associated with eddies in the closed branch of a wye or manifold, the head loss in the closed branch is generally greater than the head loss in the open branch.

(7) All the tests indicate that a one-leg flow condition is the most inefficient.

(8) For an unsymmetrical flow condition, the form loss coefficient of a wye or manifold is greatly affected by the proportional flow of water through the branches and the size of the tie-rod. For any fixed ratio of branch discharge to the main discharge, the form loss coefficient increases as the size of the tie-rod is increased.

(9) For an unsymmetrical flow condition in a wye or manifold without any tie-rod, the form loss coefficient is a minimum when the ratio of branch discharge to the main discharge is approximately 0.6. Under the same flow condition with a tie-rod, the form loss coefficient is a minimum when the ratio of branch discharge to the main discharge is approximately 0.4.

(10) Referring to Figures V-13 and V-14, the curves of form loss coefficient vs. discharge ratio obtained for both a wye and a manifold are similar under the conditions that (1) no tie-rod is used in either the wye or manifold; (2) if a tie-rod be used, it shall be identical in both arrangements; and (3) there shall be an identical subtending angle of the wye.

APPENDIX

HEAD LOSSES IN ELBOWS

The head loss in an elbow is considered herein to be the loss in excess of that in a straight pipe of equal length. It is primarily caused by the induced spiral motions of flow in the elbow which are probably independent of its length and create a considerable disturbance downstream. The motion around the elbow tends to take on the characteristics of a free vortex having a larger velocity at the inside of the elbow than that at the outside. Correspondingly, the pressure at the inside is less than that at the outside. At the downstream end of the elbow, the velocity distribution depends on the flow in the elbow. This distribution changes gradually in the downstream straight pipe until it assumes the characteristic form of that in a straight pipe.

This study is mainly concerned with the head losses of the elbows which are used to construct the manifolds. The purpose of the study is to determine the head losses in the elbows alone.

From the set-up shown in Figure A-2, for horizontal piping, the localized elbow loss can be expressed from the energy equation as follows:

$$h_{pi} + h_{vi} = h_b + h_{vb} + \Delta h_E + h_{fi} + h_{fb} \qquad \text{----------- (12)}$$

or

$$\Delta h_E = \Delta h_p + (h_{vi} - h_{vb}) - (h_{fi} + h_{fb}) \qquad \text{---------- (13)}$$

in which Δh_E = head loss in an elbow, in ft; h_{pi}, h_{vi} and h_{fi} = piezometric head, velocity head and skin friction loss of head in the upstream inlet pipe, in ft; and h_{pb}, h_{vb} and h_{fb} = piezometric head, velocity head and skin friction loss of head in the downstream straight pipe, in ft.

The elbow loss coefficient, k_E, based on the mean velocity head in the upstream pipe is thus expressed by

$$k_E = \frac{\Delta h_E}{V_i^2 / 2g} \qquad \text{------------------------------} \quad (14)$$

in which V_i = velocity in the upstream pipe.

Table A-1 gives the distance from the theoretical centre of each elbow to both upstream and downstream piezometric rings. The downstream piezometric ring has a distance of approximately 30 pipe-diameters downstream of the elbow.

The results of the tests are tabulated in Tables A-2, A-3 and A-4 for 45^o, 30^o and $22\text{-}1/2^o$ elbows respectively. The loss coefficients of the elbows versus discharges are plotted in Figure A-3.

BIBLIOGRAPHY

(1) Vogel, G., "UNTERSUCHUNGEN UBER DEN VERLUST IN RECHTWINKLIGEN ROHRVERZWEIGUNGEN", Mitt. des Hydr. Instituts der Technischen Hochschule, Munchen, No. 2, 1928.
(Investigations of the Losses in Right Angle Piping Bifurcations.)

(2) Thoma, D. and Collaborator, "Transactions of the Munich Hydraulic Institute", Bulletin 3, Translated by A.S.M.E., 1935.

(3) Cardel, A., "LES PERTES DE CHARGE DANS LES ECOULEMENTS AU TRAVERS DE BRANCHEMENTS EN TE", Bulletin Techique de la Suisse Romanda, Nos. 9 & 10, 1957.
(The Loss of Head in the Flow through Tee Branches.)

(4) Marchetti, M. and Noseda, G., "PERDITE DI CARICO NELLE BIFORCAZIONI SIMMETRICHE A DIAMETRO CONSTANTE, DELLE CONDOTTE FORZATE", L'ENERGIA ELLETTRICA NO. 4, 1960.
(Loss of Head in Symmetrical Bifurcations of Constant Diameter in a Penstock Conduit.)

(5) Fritjof Salvesen, "Hydraulic Losses in Branchpipes", The Water Power Laboratory, The Technical University of Norway, Oct. 1962.

(6) Ahmed, S., "Head Loss in Symmetrical Bifurcations", Master's Thesis, University of British Columbia, 1965.

(7) Herakovich, Carl T., and Otts, J.V., "Characteristics of Flow through Symmetrical Laterals", Report No. 13, Studies in Engrg. Mechanics, Center for Research in Engrg. Science, Univ. of Kansas (Laurence), 1962.

(8) Karake, S. and Ruff, T.F., "Final Report of Hydraulic Model Studies for Diversion, Power and Irrigation Tunnels", Civil Engineering Dept., Colorado State Univ., Jan. 1965.

(9) Gladwell, J.S. and Tinney, E.R., "Hydraulic Studies of Large Penstock Trifurcation", Journal of the Power Division, ASCE, Vol. 91, No. PO1, 1965.

(10) Gladwell, J.S. and Tinney, E.R., "Round Butte Penstock Trifurcation", Bulletin 260, Washington State Institute of Technology, Div. of Industrial Research, Washington State Univ., 1962.

(11) Gladwell, J.S., Tinney, E.R. and Kreuzer, H., "The Round Butte Penstock Trifurcation Tie-Bar", Research Report No. 63/9-80, Washington State Univ., 1963.

(12) Bier, P.J., "Welded Steel Penstocks, Design and Construction", Engineering Monography No. 3, U.S. Bureau of Reclamation.

(13) Favre, H., "On the Law which Govern the Movement of Fluids in Conduits having Lateral Abductions", Rev. Univ. Minnes., 1937.

(14) McNown, J.S., "Mechanics of Manifold Flow", Transactions of ASCE, Vol. 119, 1954.

(15) McNown, J.S. and Hsu, E.Y., "Application of Conformal Mapping to Divided Flow", Proceedings, Midwestern Conference on Fluid Dynamics (ed. by J.W. Edwards), Michigan, 1951.

(16) Lakshmana Rao, N.S., Syamala Rao, B.C. and Ramaswamy, R.I., "Pressure Losses at Trifurcations in Closed Conduits", Journal of the Hydraulics Division, ASCE, Vol. 93, No. HY3, May 1967.

(17) Freeman, J.R., "The Flow of Water in Pipes and Pipe Fittings", Published by A.S.M.E., 1941.

(18) Yarnell, D.L. and Nagler, F.A., "Flow of Water Around Bends in Pipes", Transactions of ASCE, Vol. 100, 1935.

(19) A.S.M.E., "Fluid Meters", 4th ed., 1937.

(20) Streeter, V.L., "Fluid Mechanics", McGraw-Hill, 1962.

(21) Jaeger, C., "Engineering Fluid Mechanics", McGraw-Hill, 1962.

(22) Rouse, H., "Advanced Mechanics of Fluids", John Wiley, 1959.

(23) King, H.W. and Brater, E.F., "Handbook of Hydraulics", 4th ed., McGraw-Hill, 1954.

(24) Bakhmetefv, B.A., "The Mechanics of Turbulent Flow", Princeton Univ. Press, 1941.

TABLE I-1 Areas of Main, Branch and Inlet Pipes

Description	Mean Diameter (inch)	Mean Area (sq.ft.)	Diameter at Piezometric Ring (inch)	Area at Piezometric Ring (sq.ft.)
Main Pipe	5.252	0.1503	5.251	0.1503
Right Branch	3.746	0.0764	3.750	0.0766
Left Branch	3.750	0.0766	3.748	0.0766
Inlet Pipe			3.734	0.0759

TABLE I-2 Orifice Arrangement

Numerical Designation of orifice	External Diameter (inch)	Internal Diameter (inch)	Remark
X	3.720	3.622)	Rounded edge orifices
1	3.720	3.300)	
2	3.720	3.175	
3	3.720	2.913	
4	3.720	2.749	
5	3.720	2.490	
6	3.720	2.000	
7	3.720	1.342	
8	3.720	0.840	
9	3.720	0.542	

TABLE II-1 Distance from Theoretical Centre of Wyes to Piezometric Rings on Main and Branch Pipes *
(For Wye Arrangement)

Particulars	Distance SS_4 (ft)	Distance S_4T (ft)	Distance ST (ft)	Distance TS_1 or TS_2 (ft)	Distance S_1D_1 or S_2D_2 (ft)	Distance TD_1 or TD_2 (ft)
90^o Wye	0.500	0.125	0.625	0.374	8.833	9.207
60^o Wye	0.500	0.083	0.583	0.497	8.833	9.330
45^o Wye	0.500	0.060	0.560	0.608	8.833	9.441

* See Figure II-1.

TABLE II-2 Distance from Theoretical Centre of Wyes to Piezometric Rings on Main and Branch Pipes **
(For Manifold Arrangement)

Particulars	Distance ST (ft)	Distance TS_1 or TS_2 (ft)	Distance S_1C_1 or S_2C_2 (ft)	Distance C_1F_1 or C_2F_2 (ft)	Distance F_1D_1 or F_2D_2 (ft)	Distance TC_1D_1 or TC_2D_2 (ft)
90^o Manifold	0.625	0.374	0.641	0.500	8.833	10.348
60^o Manifold	0.583	0.497	0.333	0.333	8.833	9.996
45^o Manifold	0.560	0.608	0.370	0.238	8.833	10.049

** See Figure II-2.

TABLE IV-1 Data of Skin Friction Loss in Main Pipe for Length SS_1 (3.375 ft.)

Test No.	Weight of Water from Main Pipe (lbs.)	Time Interval (secs)	Ave. Time Interval (secs)	Temp. in ^oF & Specific Wt. of Water (lb/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Velocity Head Correction (ft.)	Friction Loss (ft.)	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12
1	19000	199.5 199.5	199.5	67.5^o 62.32	1.528	1.270	1.300	0.210	0.000	0.180	4.05
2	19000	277.5 277.3	277.4	67.5^o 62.32	1.099	0.199	0.312	0.210	0.000	0.097	2.91
3	19000	328.3 328.5	328.4	67.5^o 62.32	0.928	1.900	2.039	0.210	0.000	0.071	2.46
4	15000	320.4 320.4	320.4	68^o 62.32	0.751	0.858	1.019	0.210	0.000	0.049	2.00
5	10000	321.3 321.2	321.25	71^o 62.32	0.500	0.840	1.026	0.210	0.000	0.024	1.39
6	7500	355.3 355.2	355.25	70^o 62.31	0.339	1.299	1.497	0.210	0.000	0.012	0.93

TABLE IV-2 Data of Skin Friction Losses in Branch Pipes for Length BB_1 (9.0 ft.)

Description	Weight of Water from Main Pipe (lbs.)	Time Interval (secs)	Ave. Time Interval (secs)	Temp. in ^oF & Specific Wt. of Water (lb/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Velocity Head Correction (ft.)	Friction Loss (ft.)	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12
Right Branch	15000	327.8 327.8	327.8	68^o 62.32	0.734	1.805	1.430	0.210	0.026	0.611	2.74
	12000	379.5 379.5	379.5	68.5^o 62.31	0.507	1.096	1.007	0.210	0.013	0.312	1.91
	9000	357.2 357.2	357.2	68.5^o 62.31	0.404	2.001	2.015	0.210	0.008	0.204	1.52
	4600	385.0 384.8	384.9	68^o 62.32	0.191	1.969	2.128	0.210	0.002	0.053	0.72
Left Branch	15000	328.4 328.4	328.4	68^o 62.32	0.733	1.794	1.424	0.210	0.019	0.599	2.74
	12000	398.2 398.2	398.2	68.5^o 62.31	0.484	1.008	0.932	0.210	0.008	0.294	1.82
	9000	372.6 372.4	372.5	68^o 62.32	0.388	1.706	1.731	0.210	0.005	0.190	1.45
	4600	373.4 373.4	373.4	68^o 62.32	0.198	2.146	2.301	0.210	0.001	0.056	0.74

TABLE V-1 Form Loss Data for 90° Wye Without Tie-rod.

Test No.	Orifice No.	Weight of Water (lbs.) from M Main Pipe; R Right Branch; L Left Branch	Time Interval (secs.)	Average Time Interval (secs.)	Temperature in °F and Specific Weight of Water (lbs/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft.) in Main Pipe for Length 3.375 ft.	Friction Loss (ft.) in Main Pipe for Length ST	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft.) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	206.0 205.9	205.95	73°	1.481	0.954	0.381	0.357	0.210			0.167	0.031				9.856	1.508				(0.126)	4.42
1	1+1	R 15000	325.3 325.3	325.3	62.28	0.740					0.807				0.619	0.633	0.664			9.666	1.451	0.201	0.133	2.96
		L 15000	325.6 325.5	325.55		0.740					0.783				0.618	0.632	0.663			9.658	1.448	0.180	0.119	2.96
2	R L	M 19000	274.9 274.9	274.9	73.5°	1.110	0.135	-0.113	-0.130	0.210			0.099	0.018				7.384	0.847				(0.129)	3.19
2	1+1	R 12000	348.0 348.0	348.0	62.28	0.554					0.475				0.365	0.373	0.391			7.228	0.811	0.119	0.140	2.23
		L 12000	347.8 347.9	347.85		0.554					0.458				0.366	0.374	0.393			2.231	0.812	0.100	0.118	2.23
3	R L	M 15000	321.7 321.7	321.7	74°	0.749	0.881	0.863	0.859	0.210			0.049	0.009				4.982	0.385				(0.134)	2.17
	3+3	R 7500	322.2 322.2	322.2	62.27	0.374					0.232				0.178	0.182	0.191			4.880	0.370	0.056	0.145	1.52
		L 7500	321.1 321.2	321.15		0.375					0.228				0.181	0.185	0.194			4.896	0.372	0.047	0.123	1.52
4	R L	M 10000	320.3 320.3	320.3	74.5°	0.501	0.863	0.966	0.956	0.210			0.024	0.004				3.336	0.173				(0.150)	1.46
	5+5	R 5000	318.5 318.5	318.5	62.27	0.252					0.117				0.087	0.089	0.093			3.291	0.168	0.028	0.163	1.03
		L 5000	322.7 322.7	322.7		0.249					0.107				0.086	0.088	0.092			3.248	0.164	0.024	0.137	1.02
5	R L	M 7000	356.5 356.6	356.55	74°	0.315	1.017	1.179	1.178	0.210			0.010	0.002				2.098	0.068				(0.164)	0.91
	6+6	R 3500	356.9 356.8	356.85	62.27	0.158					0.049				0.037	0.038	0.040			2.056	0.066	0.012	0.175	0.64
		L 3500	357.1 357.3	357.2		0.157					0.048				0.037	0.038	0.040			2.054	0.066	0.011	0.154	0.64
6	R L	M 15000	320.5 320.5	320.5	73.5°	0.752	1.260	1.646	-0.343	0.210			0.050	0.009				5.000	0.388					2.16
	X+9	R 15000	325.6 325.7	325.65	62.28	0.740					1.813	0.984			0.618	0.632	0.641			9.655	1.448	0.113	0.290	2.98
		L 300	387.4 387.8	387.6		0.012					-0.176	0.016			0.000	0.000	0.010			0.162	0.000	0.202	0.321	0.05
7	R L	M 15000	321.9 321.9	321.9	73.5°	0.748	1.781	2.172	0.309	0.210			0.049	0.009				4.978	0.385					2.15
	1+8	R 15000	336.0 336.1	336.05	62.28	0.717					1.682	0.957			0.583	0.597	0.606			9.356	1.359	0.102	0.264	2.88
		L 600	299.4 299.6	299.5		0.032					-0.181	0.043			0.002	0.002	0.011			0.420	0.003	0.190	0.493	0.13
8	R L	M 15000	320.7 320.8	320.75	73°	0.751	1.411	1.806	0.182	0.210			0.049	0.009				4.996	0.388					2.14
	1+7	R 15000	357.3 357.3	357.3	62.28	0.674					1.439	0.895			0.522	0.534	0.543			8.800	1.202	0.061	0.210	2.69
		L 1600	327.2 327.4	327.3		0.078					-0.185	0.105			0.011	0.011	0.020			1.025	0.016	0.166	0.429	0.31
9	R L	M 15000	320.0 320.1	320.05	73.5°	0.752	0.813	1.184	-0.022	0.210			0.050	0.009				5.007	0.389					2.16
	1+6	R 12000	324.0 324.0	324.0	62.28	0.595					1.045	0.791			0.415	0.425	0.434			7.764	0.936	0.084	0.166	2.39
		L 3500	356.9 357.1	357.0		0.157					-0.161	0.209			0.038	0.038	0.048			2.055	0.066	0.115	0.896	0.63

TABLE V-1 Form Loss Data for 90° Wye Without Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft.) in Main Pipe for Length 3.375 ft.	Friction Loss (ft.) in Main Pipe for Length ST	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft.) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10	R L	M 15000	322.4 322.4	322.4	74°	0.747	1.881	2.216	1.230	0.210			0.049	0.009				4.971	0.384					2.16
	2+6	R 12000	348.9 348.9	348.9	62.27	0.552					0.861	0.740			0.363	0.371	0.380			7.211	0.807	0.057	0.149	2.24
		L 4000	330.4 330.2	330.3		0.195					-0.125	0.260			0.055	0.056	0.065			2.539	0.100	0.093	0.243	0.79
11	R L	M 15000	319.7 319.9	319.8	74°	0.753	1.099	1.320	0.740	0.210			0.050	0.009				5.012	0.390					2.18
	2+5	R 10000	335.6 335.6	335.6	62.27	0.479					0.569	0.638			0.279	0.286	0.295			6.247	0.606	0.058	0.148	1.94
		L 6000	352.6 352.7	352.65		0.273					-0.011	0.362			0.102	0.104	0.113			3.567	0.198	0.068	0.175	1.11
12	R L	M 15000	320.1 320.0	320.05	74°	0.753	1.742	1.891	1.513	0.210			0.050	0.009				5.008	0.389					2.18
	3+5	R 9000	325.7 325.8	325.75	62.27	0.444					0.439	0.591			0.244	0.249	0.258			5.792	0.521	0.049	0.126	1.80
		L 6000	312.8 312.6	312.7		0.308					0.061	0.409			0.127	0.129	0.139			4.023	0.251	0.060	0.155	1.25
13	R L	M 15000	321.0 320.8	320.9	74°	0.751	2.275	2.363	2.131	0.210			0.049	0.009				4.994	0.387					2.17
	4+5	R 8000	308.7 308.7	308.7	62.27	0.416					0.354	0.555			0.217	0.222	0.231			5.433	0.458	0.052	0.134	1.69
		L 7000	336.3 336.2	336.25		0.334					0.122	0.445			0.147	0.150	0.159			4.364	0.296	0.054	0.140	1.36
14	R L	M 18000	339.1 339.2	339.15	74°	0.852	1.980	2.415	-0.213	0.210			0.062	0.011				5.671	0.499					2.47
	X+0	R 18000	339.1 339.2	339.15	62.27	0.852					2.403				0.800	0.818	0.829			11.127	1.922	0.150	0.301	3.46
		L 0	-	-		0.000					-0.225				0.000	0.000	0.011			0.000	0.000	0.263	0.526	0.00
15	R L	M 15000	322.0 322.0	322.0	73°	0.748	2.061	2.444	0.397	0.210			0.049	0.009				4.977	0.385					2.13
	1+0	R 15000	322.0 322.0	322.0	62.28	0.748					1.874				0.630	0.645	0.654			9.765	1.481	0.124	0.322	2.99
		L 0	-	-		0.000					-0.173				0.000	0.000	0.009			0.000	0.000	0.202	0.526	0.00
16	R L	M 11000	323.7 323.8	323.75	74°	0.546	2.002	2.306	1.186	0.210			0.028	0.005				3.630	0.205					1.58
	2+0	R 11000	323.7 323.8	323.75	62.27	0.546					1.026				0.355	0.363	0.368			7.123	0.788	0.074	0.364	2.21
		L 0	-	-		0.000					-0.094				0.000	0.000	0.005			0.000	0.000	0.105	0.515	0.00
17	R L	M 9000	329.6 329.6	329.6	74°	0.439	1.926	2.196	1.463	0.210			0.019	0.003				2.918	0.132					1.27
	3+0	R 9000	329.6 329.6	329.6	62.27	0.439					0.673				0.238	0.244	0.247			5.725	0.509	0.049	0.370	1.78
		L 0	-	-		0.000					-0.060				0.000	0.000	0.003			0.000	0.000	0.069	0.520	0.00
18	R L	M 7000	384.1 384.3	384.2	74°	0.293	0.728	0.963	0.632	0.210			0.009	0.002				1.967	0.059					0.85
	4+0	R 7000	384.1 384.3	384.2	62.27	0.293					0.306				0.114	0.117	0.118			3.820	0.227	0.020	0.337	1.19
		L 0	-	-		0.000					-0.025				0.000	0.000	0.002			0.000	0.000	0.032	0.546	0.00

TABLE V-2 Form Loss Data for 90° Wye with TR1 Tie-rod

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft.) in Main Pipe for Length 3.375 ft.	Friction Loss (ft.) in Main Pipe for Length ST	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft.) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	204.0 204.0	204.0	66°	1.494	1.046	0.403	0.330	0.210			0.169	0.031				9.942	1.535				(0.174)	3.88
	1+1	R 15000	320.7 320.6	320.75	62.33	0.750					0.906				0.634	0.649	0.680			9.795	1.490	0.271	0.177	2.73
		L 15000	324.2 324.1	324.15		0.743					0.853				0.622	0.636	0.668			9.692	1.459	0.261	0.170	2.70
2	R L	M 19000	279.1 279.1	279.1	65°	1.092	0.125	-0.143	-0.180	0.210			0.097	0.018				7.267	0.820				(0.180)	2.89
	1+1	R 11000	321.5 321.5	321.5	62.33	0.549					0.515				0.359	0.367	0.385			7.166	0.797	0.153	0.186	1.97
		L 11000	325.6 325.5	325.55		0.542					0.478				0.352	0.360	0.378			7.077	0.778	0.142	0.174	1.95
3	R L	M 19000	332.8 332.7	332.75	67°	0.916	1.782	1.641	1.628	0.210			0.071	0.013				6.096	0.577				(0.182)	2.41
	3+3	R 10000	350.2 350.1	350.15	62.32	0.458					0.364				0.258	0.264	0.277			5.983	0.556	0.108	0.187	[illegible]
		L 10000	352.0 351.9	351.95		0.456					0.351				0.257	0.263	0.276			5.952	0.550	0.102	0.176	1.68
4	R L	M 15000	321.2 321.1	321.15	69°	0.750	0.869	0.837	0.826	0.210			0.049	0.009				4.987	0.386				(0.178)	2.03
	3+3	R 7500	320.4 320.3	320.35	62.31	0.376					0.253				0.180	0.184	0.193			4.905	0.374	0.072	0.187	1.42
		L 7500	321.9 322.0	321.95		0.374					0.242				0.180	0.184	0.193			4.881	0.370	0.065	0.170	1.42
5	R L	M 10000	321.8 322.0	321.9	73°	0.499	0.822	0.920	0.909	0.210			0.024	0.004				3.319	0.171				(0.189)	1.42
	5+5	R 5000	319.0 319.1	319.05	62.28	0.252					0.123				0.087	0.089	0.093			3.285	0.168	0.033	0.195	1.00
		L 5000	325.7 325.5	325.6		0.247					0.112				0.085	0.086	0.091			3.219	0.161	0.031	0.183	0.99
6	R L	M 7000	357.0 357.1	357.05	72.5°	0.315	0.985	1.144	1.143	0.210			0.010	0.002				2.094	0.068				(0.207)	0.89
	6+6	R 3500	356.6 356.7	356.65	62.28	0.158					0.052				0.037	0.038	0.040			2.057	0.066	0.015	0.215	0.62
		L 3500	357.5 357.7	357.6		0.157					0.051				0.037	0.038	0.040			2.052	0.065	0.014	0.199	0.62
7	R L	M 15000	321.1 321.0	321.05	73°	0.750	1.231	[illegible]	-0.382	0.210			0.049	0.009				4.991	0.387					2.16
	X+9	R 15000	326.2 326.2	326.2	62.28	0.738					1.823	0.984			0.616	0.630	0.639			9.639	1.443	0.128	0.331	2.97
		L 300	401.2 400.6	400.9		0.012					-0.168	0.016			0.000	0.000	0.010			0.157	0.000	0.209	0.540	0.05
8	R L	M 15000	320.9 321.0	320.95	70.5°	0.750	1.774	2.157	0.272	0.210			0.049	0.009				4.991	0.387					2.06
	1+8	R 15000	335.2 335.0	335.1	62.30	0.718					1.712	0.957			0.586	0.599	0.608			9.380	1.366	0.124	0.321	2.76
		L 700	348.4 348.6	348.5		0.032					-0.173	0.043			0.002	0.002	0.011			0.421	0.003	0.200	0.516	0.12
9	R L	M 15000	321.0 321.0	321.0	71°	0.750	1.376	1.764	0.136	0.210			0.049	0.009				4.991	0.387					2.09
	1+7	R 14000	334.3 334.2	334.25	62.29	0.672					1.450	0.896			0.519	0.531	0.540			8.778	1.197	0.100	0.258	2.62
		L 1600	328.6 328.8	328.7		0.078					-0.178	0.104			0.011	0.011	0.020			1.020	0.016	0.173	0.447	0.30

TABLE V-2 Form Loss Data for 90° Wye with TR1 Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs) from M.Main Pipe; R.Right Branch; L.Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10	R L	M 15000	320.3 320.4	320.35	72°	0.752	0.784	1.148	-0.067	0.210			0.050	0.009				5.001	0.388					2.11
	1+6	R 12000	324.0 323.9	323.95	62.29	0.595					1.061	0.792			0.415	0.425	0.434			7.763	0.936	0.080	0.205	2.34
		L 3400	348.4 348.2	348.3		0.157					-0.154	0.208			0.037	0.038	0.047			2.046	0.065	0.122	0.315	0.62
11	R L	M 15000	320.7 320.7	320.7	72°	0.751	1.884	2.216	1.210	0.210			0.049	0.009				4.996	0.388					2.11
	2+6	R 11000	317.9 317.9	317.9	62.29	0.556					0.884	0.740			0.367	0.375	0.384			7.252	0.817	0.071	0.182	2.19
		L 4000	328.6 328.7	328.65		0.195					-0.122	0.260			0.055	0.057	0.066			2.551	0.101	0.099	0.254	0.77
12	R L	M 15000	320.8 320.8	320.8	71.5°	0.751	1.060	1.277	0.686	0.210			0.049	0.009				4.994	0.387					2.10
	2+5	R 10000	335.3 335.3	335.3	62.29	0.479					0.584	0.639			0.280	0.286	0.295			6.251	0.607	0.069	0.179	1.88
		L 5000	295.8 296.0	295.9		0.271					-0.007	0.361			0.100	0.103	0.112			3.561	0.195	0.074	0.190	1.06
13	R L	M 15000	320.7 320.7	320.7	72°	0.751	1.717	1.863	1.467	0.210			0.049	0.009				4.996	0.388					2.11
	3+5	R 9000	325.8 326.0	325.9	62.29	0.443					0.460	0.591			0.243	0.249	0.258			5.788	0.520	0.069	0.179	1.74
		L 6000	313.3 313.3	313.3		0.307					0.064	0.409			0.126	0.129	0.138			4.014	0.250	0.063	0.163	1.21
14	R L	M 15000	321.0 321.0	321.0	73°	0.750	2.257	2.340	2.092	0.210			0.049	0.009				4.992	0.387					2.14
	4+5	R 8000	308.5 308.5	308.5	62.28	0.416					0.375	0.555			0.217	0.222	0.231			5.436	0.459	0.072	0.186	1.66
		L 7000	336.2 336.3	336.25		0.334					0.127	0.445			0.147	0.150	0.159			4.364	0.296	0.059	0.153	1.34
15	R L	M 15000	320.9 320.9	320.9	70°	0.750	2.064	2.441	0.370	0.210			0.049	0.009				4.992	0.387					2.06
	1+0	R 15000	320.9 320.9	320.9	62.30	0.750					1.904				0.634	0.649	0.658			9.795	1.490	0.144	0.371	2.88
		L 0	-	-		0.000					-0.167				0.000	0.000	0.009			0.000	0.000	0.211	0.545	0.00
16	R L	M 11000	318.2 318.3	318.25	74°	0.555	2.064	2.367	1.212	0.210			0.029	0.005				3.693	0.212					1.61
	2+0	R 11000	318.2 318.3	318.25	62.27	0.555					1.062				0.366	0.375	0.380			7.246	0.815	0.078	0.370	2.25
		L 0	-	-		0.000					-0.093				0.000	0.000	0.005			0.000	0.000	0.113	0.536	0.00
17	R L	M 9000	324.9 325.0	324.95	75°	0.445	1.977	2.246	1.492	0.210			0.019	0.004				2.960	0.136					1.30
	3+0	R 9000	324.9 325.0	324.95	62.26	0.445					0.695				0.245	0.250	0.254			5.807	0.524	0.053	0.392	1.82
		L 0	-	-		0.000					-0.059				0.000	0.000	0.004			0.000	0.000	0.073	0.540	0.00
18	R L	M 7000	355.0 355.0	355.0	74°	0.317	1.024	1.263	0.870	0.210			0.011	0.002				2.107	0.069					0.92
	4+0	R 7000	355.0 355.0	355.0	62.27	0.317					0.364				0.132	0.135	0.137			4.134	0.265	0.031	0.447	1.28
		L 0	-	-		0.000					-0.029				0.000	0.000	0.002			0.000	0.000	0.038	0.551	0.00

TABLE V-3 Form Loss Data for 90° Wye With [illegible] Tie-rod.

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		M 19000	204.6 204.4	204.5	69.5°	1.491	1.160	0.414	0.365	0.210			0.169	0.031				9.921	1.528				(0.237)	4.06
	R L	R 15000	320.6 320.7	320.65	62.31	0.750					1.005				0.635	0.649	0.680			9.801	1.492	0.361	0.236	2.86
	1+1	L 15000	324.6 324.6	324.6		0.742					0.956				0.621	0.635	0.666			9.682	1.456	0.362	0.237	2.83
2		M 19000	278.3 278.2	278.25	67°	1.096	0.199	-0.126	-0.166	0.210			0.097	0.018				7.290	0.825				(0.246)	2.88
	R L	R 11000	319.8 320.0	319.9	62.32	0.552					0.575				0.362	0.371	0.389			7.203	0.806	0.206	0.250	2.03
	1+1	L 11000	324.9 325.1	325.0		0.543					0.535				0.353	0.361	0.379			7.090	0.781	0.200	0.243	2.01
3		M 19000	333.4 333.5	333.45	68.5°	0.914	1.818	1.636	1.627	0.210			0.070	0.013				6.084	0.575				(0.251)	2.46
	R L	R 9500	333.0 333.0	333.0	62.31	0.458					0.401				0.238	0.264	0.277			5.977	0.555	0.144	0.251	1.72
	3+3	L 9500	335.2 335.2	335.2		0.455					0.392				0.236	0.262	0.275			5.938	0.547	0.144	0.251	1.71
4		M 15000	320.1 320.2	320.15	69.5°	0.752	0.913	0.852	0.841	0.210			0.030	0.009				5.003	0.389				(0.249)	2.05
	R L	R 7500	318.6 318.7	318.65	62.31	0.378					0.282				0.182	0.186	0.195			4.931	0.378	0.098	0.252	1.44
	3+3	L 7500	321.5 321.7	321.6		0.374					0.271				0.180	0.184	0.193			4.886	0.371	0.096	0.246	1.43
5		M 10000	322.4 322.5	322.45	70°	0.498	-0.152	-0.065	-0.076	0.210			0.024	0.004				3.312	0.170				(0.253)	1.37
	R L	R 5000	319.8 320.0	319.9	62.30	0.251					0.134				0.086	0.088	0.093			3.275	0.167	0.045	0.265	0.96
	3+3	L 5000	325.3 325.2	325.25		0.247					0.123				0.085	0.087	0.091			3.221	0.161	0.041	0.242	0.95
6		M 8000	343.7 343.7	343.7	71°	0.374	1.803	1.939	1.937	0.210			0.014	0.003				2.486	0.096				(0.248)	1.04
	R L	R 4000	343.0 342.9	342.95	62.30	0.187					0.076				0.051	0.052	0.054			2.444	0.093	0.025	0.258	0.73
	6+6	L 4000	343.9 343.7	343.8		0.187					0.074				0.051	0.052	0.055			2.438	0.092	0.023	0.237	0.73
7		M 15000	320.7 320.8	320.75	66°	0.750	1.267	1.640	-0.384	0.210			0.049	0.009				4.992	0.387					1.95
	R L	R 15000	325.9 326.1	326.0	62.33	0.738					1.861	0.984			0.615	0.630	0.639			9.637	1.442	0.167	0.432	2.68
	8+9	L 300	394.0 393.8	393.9		0.012					-0.163	0.016			0.000	0.000	0.010			0.160	0.000	0.214	0.553	0.04
8		M 15000	322.7 322.7	322.7	69°	0.746	1.766	2.148	0.258	0.210			0.049	0.009				4.963	0.383					2.02
	R L	R 14000	314.4 314.3	314.35	62.31	0.715					1.718	0.957			0.580	0.594	0.603			9.331	1.352	0.146	0.381	2.71
	1+8	L 700	352.2 352.4	352.3		0.032					-0.166	0.043			0.002	0.002	0.011			0.416	0.003	0.203	0.530	0.12
9		M 15000	321.4 321.5	321.45	70°	0.749	1.389	1.771	0.134	0.210			0.049	0.009				4.983	0.386					2.06
	R L	R 13000	311.0 310.8	310.9	62.30	0.671					1.465	0.896			0.518	0.529	0.539			8.762	1.192	0.120	0.311	2.58
	1+7	L 1500	308.6 308.8	308.7		0.078					-0.172	0.104			0.011	0.011	0.020			1.018	0.016	0.178	0.461	0.30

TABLE V-3 Form Loss Data for 90° Wye with TR2 Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft) in Main Pipe for Length 3.375 ft.	Friction Loss (ft), in Main Pipe for Length ST	Friction Loss (ft), in Right or Left Branch for Length 9.0ft.	Friction Loss (ft), in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 15000	319.2 319.2	319.2	65°	0.754	0.825	1.182	-0.060	0.210			0.050	0.009				5.016	0.391					1.93
	R L	R 12000	322.6 322.4	322.5	62.33	0.597					1.095	0.791			0.418	0.428	0.437			7.793	0.943	0.106	0.270	2.14
	1+6	L 3200	325.5 325.6	325.55		0.158					-0.167	0.209			0.038	0.038	0.048			2.059	0.066	0.130	0.333	0.57
11		M 15000	323.4 323.4	323.4	66°	0.744	1.859	2.180	1.175	0.210			0.049	0.009				4.951	0.381					1.93
	R L	R 11000	320.5 320.4	320.45	62.33	0.551					0.894	0.740			0.361	0.369	0.378			7.190	0.803	0.094	0.246	2.00
	2+6	L 4000	331.6 331.4	331.5		0.194					-0.111	0.260			0.055	0.056	0.065			2.527	0.099	0.106	0.278	0.70
12		M 15000	321.9 321.8	321.85	67°	0.748	1.741	1.870	1.452	0.210			0.049	0.009				4.976	0.384					1.97
	R L	R 9000	328.0 327.9	327.95	62.32	0.440					0.499	0.588			0.240	0.246	0.255			5.749	0.513	0.115	0.300	1.62
	3+5	L 6500	339.4 339.4	339.4		0.307					0.081	0.412			0.126	0.129	0.138			4.012	0.250	0.078	0.202	1.13
13		M 15000	322.5 322.6	322.55	70°	0.747	2.213	2.281	2.012	0.210			0.049	0.009				4.966	0.383					2.05
	R L	R 8000	308.7 308.7	308.7	62.30	0.416					0.411	0.557			0.217	0.222	0.231			5.430	0.458	0.105	0.275	1.60
	4+5	L 7000	339.9 340.0	339.95		0.331					0.142	0.443			0.144	0.147	0.156			4.315	0.289	0.080	0.208	1.27
14		M 18000	337.0 336.9	336.95	70°	0.857	2.035	2.456	-0.239	0.210			0.063	0.012				5.705	0.505					2.35
	R L	R 18000	337.0 336.9	336.95	62.30	0.857					2.484				0.808	0.827	0.839			11.194	1.946	0.205	0.406	3.30
	X+0	L 0	-	-		0.000					-0.211				0.000	0.000	0.012			0.000	0.000	0.283	0.560	0.00
15		M 15000	321.9 321.8	321.85	67°	0.748	1.340	1.710	-0.374	0.210			0.049	0.009				4.976	0.384					1.97
	R L	R 15000	321.9 321.8	321.85	62.32	0.748					1.924				0.630	0.645	0.654			9.763	1.480	0.175	0.454	2.76
	X+0	L 0	-	-		0.000					-0.160				0.000	0.000	0.009			0.000	0.000	0.215	0.560	0.00
16		M 12000	355.0 354.8	354.9	70°	0.543	1.944	2.240	1.122	0.210			0.028	0.005				3.611	0.202					1.49
	R L	R 12000	355.0 354.8	354.9	62.30	0.543					1.032				0.352	0.360	0.365			7.085	0.780	0.090	0.446	2.09
	3+0	L 0	-	-		0.000					-0.086				0.000	0.000	0.005			0.000	0.000	0.111	0.550	0.00
17		M 10000	357.3 357.1	357.2	68.5°	0.449	2.022	2.289	1.513	0.210			0.020	0.004				2.989	0.139					1.21
	R L	R 10000	357.3 357.1	357.2	62.31	0.449					0.719				0.249	0.255	0.259			5.865	0.534	0.065	0.468	1.69
	3+0	L 0	-	-		0.000					-0.057				0.000	0.000	0.004			0.000	0.000	0.078	0.563	0.00
18		M 8000	352.2 352.4	352.3	69°	0.364	1.630	1.878	1.356	0.210			0.014	0.003				2.425	0.091					0.99
	R L	R 8000	352.2 352.4	352.3	62.31	0.364					0.484				0.170	0.174	0.177			4.758	0.351	0.047	0.517	1.38
	4+0	L 0	-	-		0.000					-0.038				0.000	0.000	0.003			0.000	0.000	0.051	0.556	0.00

TABLE V-4 Form Loss Data for 90° Wye with TRJ Tie-rod.

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft).	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		M 19000	205.0 204.9	204.95	55.5°	1.486	1.243	0.386	0.353	0.210			0.168	0.031				9.886	1.518				(0.309)	3.32
	R L	R 15000	322.5 322.4	322.45	62.39	0.745					1.100				0.627	0.641	0.672			8.734	1.471	0.474	0.313	2.34
	1+1	L 15000	324.2 324.2	324.2		0.742					1.067				0.621	0.635	0.666			9.681	1.455	0.463	0.305	2.33
2		M 19000	331.0 331.1	331.05	60.5°	0.920	1.896	1.670	1.664	0.210			0.071	0.013				6.123	0.582				(0.310)	2.21
	R L	R 10000	348.2 348.2	348.2	62.36	0.460					0.442				0.261	0.267	0.280			6.012	0.561	0.183	0.314	1.55
	3+3	L 10000	348.5 348.7	348.6		0.460					0.436				0.261	0.267	0.281			6.005	0.560	0.179	0.303	1.55
3		M 15000	321.1 321.1	321.1	61.5°	0.749	0.933	0.845	0.838	0.210			0.049	0.009				4.984	0.386				(0.318)	1.83
	R L	R 7500	320.2 320.4	320.3	62.36	0.375					0.305				0.180	0.184	0.193			4.902	0.373	0.125	0.323	1.29
	3+3	L 7500	321.4 321.6	321.5		0.374					0.298				0.180	0.184	0.193			4.884	0.370	0.120	0.312	1.28
4		M 10000	321.0 320.9	320.95	63°	0.500	0.859	0.926	0.928	0.210			0.084	0.004				3.325	0.172				(0.329)	1.25
	R L	R 5000	322.1 322.1	322.1	62.35	0.249					0.141				0.085	0.087	0.091			3.250	0.164	0.057	0.333	0.87
	5+5	L 5000	320.3 320.5	320.4		0.250					0.143				0.087	0.089	0.093			3.267	0.166	0.056	0.324	0.88
5		M 8000	372.2 372.1	372.15	65°	0.345	1.350	1.487	1.490	0.210			0.012	0.002				2.295	0.082				(0.334)	0.88
	R L	R 3500	327.6 327.7	327.65	62.33	0.171					0.070				0.043	0.044	0.046			2.237	0.078	0.028	0.338	0.62
	6+6	L 3500	323.6 323.5	323.55		0.174					0.073				0.045	0.046	0.048			2.266	0.080	0.027	0.330	0.62
6		M 15000	320.3 320.4	320.35	70°	0.752	1.292	1.656	-0.383	0.210			0.050	0.009				5.001	0.388					2.06
	R L	R 15000	325.9 325.8	325.85	62.30	0.739					1.885	0.984			0.617	0.631	0.640			9.646	1.445	0.189	0.486	2.84
	X+9	L 300	396.2 395.6	395.9		0.012					-0.154	0.016			0.000	0.000	0.010			0.159	0.000	0.224	0.578	0.05
7		M 15000	321.5 321.6	321.55	66.5°	0.748	1.800	2.167	0.252	0.210			0.049	0.009				4.980	0.385					1.96
	R L	R 15000	336.0 336.0	336.0	62.33	0.716					1.758	0.957			0.583	0.596	0.605			9.350	1.358	0.180	0.469	2.62
	1+8	L 700	348.7 348.8	348.75		0.032					-0.157	0.043			0.002	0.002	0.011			0.420	0.003	0.214	0.556	0.12
8		M 15000	320.4 320.4	320.4	67°	0.751	1.424	1.793	0.130	0.210			0.049	0.009				4.998	0.388					1.98
	R L	R 13000	309.8 310.0	309.9		0.673					1.504	0.895			0.520	0.532	0.541			8.788	1.199	0.151	0.390	2.48
	1+7	L 1700	347.6 347.7	347.65	62.32	0.078					-0.159	0.105			0.011	0.011	0.020			1.024	0.016	0.193	0.496	0.29
9		M 15000	321.6 321.6	321.6	67.5°	0.748	0.803	1.145	-0.078	0.210			0.049	0.009				4.980	0.385					1.98
	R L	R 12000	325.2 325.3	325.25	62.32	0.592					1.091	0.791			0.412	0.421	0.430			7.729	0.928	0.118	0.307	2.20
	1+6	L 3500	358.9 359.2	359.05		0.156					-0.132	0.209			0.037	0.038	0.047			2.042	0.065	0.141	0.367	0.58

TABLE V-4 Form Loss Data for 90° Wye with TR3 Tie-rod (continued)

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main Pipe; R Right Branch; L. Left Branch	Time Interval (secs.)	Average Time Interval (secs.)	Temperature in °F and Specific Weight of Water (lbs/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft.) in Main Pipe for Length 3.375 ft.	Friction Loss (ft.) in Main Pipe for Length ST	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft.) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft./sec)	Vlocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft./sec)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number (x10^5)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 15000	322.1 322.0	322.05	68°	0.747	1.895	2.205	1.191	0.210			0.049	0.009				4.973	0.384					2.00
	R L	R 11000	319.1 319.2	319.15	62.32	0.553					0.914	0.740			0.364	0.372	0.381			7.220	0.809	0.107	0.279	2.07
	2+6	L 4000	330.1 330.0	330.05		0.194					-0.100	0.260			0.055	0.056	0.065			2.539	0.100	0.110	0.309	0.73
11		M 15000	321.3 321.2	321.25	66°	0.749	1.116	1.309	0.678	0.210			0.049	0.009				4.984	0.386					1.95
	R L	R 10000	336.8 337.0	336.9	62.33	0.476					0.648	0.636			0.277	0.283	0.293			6.217	0.600	0.141	0.366	1.73
	2+5	L 6000	352.8 352.8	352.8		0.273					0.017	0.364			0.102	0.104	0.113			3.562	0.197	0.093	0.240	0.99
12		M 15000	321.6 321.4	321.5	68°	0.749	1.771	1.886	1.443	0.210			0.049	0.009				4.981	0.385					2.00
	R L	R 9000	327.7 327.5	327.6	62.32	0.441					0.538	0.588			0.241	0.246	0.255			5.755	0.514	0.154	0.399	1.[illegible]
	3+5	L 6000	312.3 312.3	312.3		0.308					0.095	0.412			0.127	0.130	0.139			4.025	0.252	0.090	0.234	1.15
13		M 15000	322.0 322.0	322.0	69.5°	0.748	2.290	2.337	2.064	0.210			0.049	0.009				4.974	0.384					2.04
	R L	R 8000	310.0 310.1	310.05	62.31	0.414					0.436	0.553			0.215	0.220	0.229			5.406	0.454	0.138	0.358	1.58
	4+5	L 7000	336.6 336.6	336.6		0.334					0.163	0.447			0.148	0.150	0.159			4.357	0.295	0.094	0.244	1.28
14		M 18000	341.6 341.4	341.5	58°	0.845	2.024	2.428	-0.256	0.210			0.061	0.011				5.623	0.491					1.97
	R L	R 18000	341.6 341.4	341.5	62.37	0.845					2.490				0.787	0.803	0.817			11.033	1.890	0.274	0.558	2.76
	3+0	L 0	-	-		0.000					-0.194				0.000	0.000	0.011			0.000	0.000	0.286	0.582	0.00
15		M 15000	321.5 321.5	321.5	64°	0.748	2.113	2.475	0.367	0.210			0.049	0.009				4.979	0.385					1.89
	R L	R 15000	321.5 321.5	321.5	62.34	0.748					1.956				0.631	0.646	0.655			9.770	1.482	0.204	0.530	2.65
	1+0	L 0	-	-		0.000					-0.152				0.000	0.000	0.009			0.000	0.000	0.224	0.582	0.00
16		M 12000	348.8 348.9	348.85	65°	0.552	2.057	2.349	1.181	0.210			0.029	0.005				3.672	0.209					1.42
	R L	R 12000	348.8 348.9	348.88	62.33	0.552					1.086				0.362	0.371	0.376			7.205	0.806	0.113	0.541	1.98
	2+0	L 0	-	-		0.000					-0.082				0.000	0.000	0.005			0.000	0.000	0.122	0.583	0.00
17		M 10000	359.4 359.3	359.35	65.5°	0.446	2.019	2.283	1.505	0.210			0.020	0.004				2.970	0.137					1.15
	R L	R 10000	359.4 359.3	359.35	62.33	0.446					0.724				0.246	0.252	0.256			5.828	0.528	0.078	0.568	1.61
	3+0	L 0	-	-		0.000					-0.054				0.000	0.000	0.004			0.000	0.000	0.079	0.579	0.00
18		M 7500	373.5 373.7	373.6	64°	0.322	1.102	1.340	0.923	0.210			0.011	0.002				2.143	0.071					0.82
	R L	R 7500	373.5 373.7	373.6	62.34	0.322					0.389				0.136	0.139	0.141			4.204	0.274	0.043	0.629	1.14
	4+0	L 0	-	-		0.000					-0.028				0.000	0.000	0.002			0.000	0.000	0.041	0.579	0.00

TABLE V-5 Form Loss Data for 90° Wye with TR4 Tie-Rod

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs.)	Average Time Interval (secs.)	Temperature in °F. and Specific Weight of Water (lbs./cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio [Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft.) in Main Pipe for Length 3.375 ft	Friction Loss (ft.) in Main Pipe for Length ST	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft.) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity Head in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft./sec.)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		M 19000	205.0 205.1	205.05	68°	1.486	1.302	0.389	0.352	0.210			0.168	0.031				9.893	1.520				(0.351)	3.97
	R L	R 15000	324.2 324.4	324.3	62.32	0.742					1.160				0.622	0.636	0.667			9.689	1.458	0.555	0.365	2.77
	1+1	L 15000	323.9 323.8	323.85		0.743					1.123				0.623	0.638	0.669			9.703	1.462	0.512	0.337	2.78
2		M 19000	278.5 278.6	278.55	65°	1.094	0.292	-0.137	-0.164	0.210			0.097	0.018				7.281	0.823				(0.366)	2.80
	R L	R 11000	322.2 322.3	322.25	62.33	0.548					0.666				0.357	0.366	0.384			7.149	0.794	0.312	0.379	1.97
	1+1	L 11000	323.1 323.1	323.1		0.546					0.639				0.357	0.365	0.383			7.131	0.790	0.290	0.352	1.96
3		M 19000	333.5 333.4	333.45	67°	0.914	1.900	1.649	1.640	0.210			0.070	0.013				6.083	0.575				(0.371)	2.41
	R L	R 10000	351.5 351.5	351.5	62.32	0.457					0.470				0.257	0.262	0.275			5.960	0.552	0.218	0.379	1.68
	3+3	L 10000	351.6 351.8	351.7		0.456					0.461				0.258	0.264	0.277			5.956	0.551	0.208	0.362	1.68
4		M 15000	320.9 320.9	320.9	66°	0.750	0.965	0.854	0.845	0.210			0.049	0.009				4.990	0.387				(0.380)	1.95
	R L	R 7500	320.7 320.8	320.75	62.33	0.375					0.330				0.179	0.184	0.193			4.897	0.372	0.151	0.392	1.36
	3+3	L 7500	321.1 321.1	321.1		0.375					0.321				0.180	0.185	0.194			4.892	0.372	0.142	0.368	1.36
5		M 10000	321.1 321.0	321.05	68°	0.500	0.884	0.937	0.940	0.210			0.024	0.004				3.325	0.172				(0.404)	1.33
	R L	R 5000	322.5 322.6	322.55	62.32	0.249					0.154				0.085	0.087	0.091			3.274	0.164	0.070	0.412	0.93
	5+5	L 5000	319.5 319.6	319.45		0.251					0.157				0.087	0.089	0.094			3.279	0.167	0.068	0.396	0.94
6		M 7000	355.8 355.6	355.7	69°	0.316	1.023	1.167	1.165	0.210			0.011	0.002				2.101	0.069				(0.432)	0.86
	R L	R 3500	355.6 355.4	355.5	62.31	0.158					0.068				0.037	0.038	0.040			2.063	0.066	0.031	0.445	0.60
	6+6	L 3500	357.0 356.9	356.95		0.157					0.066				0.037	0.038	0.040			2.054	0.066	0.029	0.419	0.60
7		M 15000	321.0 321.1	321.05	70.5°	0.750	1.313	1.660	-0.381	0.210			0.049	0.009				4.990	0.387					2.07
	R L	R 15000	326.1 326.2	326.15	62.30	0.738					1.904	0.984			0.615	0.630	0.639			9.637	1.442	0.210	0.542	2.86
	2+9	L 300	393.2 393.8	393.5		0.012					-0.137	0.016			0.000	0.000	0.010			0.160	0.000	0.240	0.620	0.05
8		M 15000	321.1 321.0	321.05	66°	0.750	1.851	2.200	0.272	0.210			0.049	0.009				4.987	0.386					1.95
	R L	R 15000	335.4 335.3	335.35	62.33	0.718					1.789	0.957			0.585	0.598	0.607			4.368	1.363	0.203	0.531	2.61
	1+8	L 700	348.2 348.4	348.3		0.032					-0.139	0.043			0.002	0.002	0.011			0.421	0.003	0.233	0.604	0.12
9		M 15000	320.8 320.8	320.8	67.5°	0.750	1.449	1.799	0.141	0.210			0.049	0.009				4.992	0.387					1.99
	R L	R 14000	334.2 334.2	334.2	62.32	0.672					1.518	0.895			0.519	0.531	0.540			8.775	1.196	0.169	0.437	2.50
	1+7	L 1700	347.2 347.2	347.2		0.078					-0.140	0.105			0.011	0.011	0.020			1.026	0.016	0.211	0.544	0.29

TABLE V-5 Form Loss Data for 90° Wye with TR4 Tie-Rod (continued)

Test No.	Orifice No.	Weight of Water (Lbs.) from M. Main Pipe; R. Right Branch; L. Left Branch.	Time Interval	Average Time Interval (secs)	Temperature in °F. and Specific Weight of Water (lbs./cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft.) in Main Pipe for Length 3.375 ft.	Friction Loss (ft.) in Main Pipe for Length ST.	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft.) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft./sec)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 15000	320.9 320.9	320.9	64°	0.750	0.831	1.855	-0.071	0.210			0.049	0.009				4.989	0.386					1.90
	R L	R 12000	324.7 324.8	324.75	62.34	0.593					1.112	0.791			0.413	0.422	0.431			7.738	0.930	0.137	0.355	2.10
	1+6	L 3500	357.7 357.5	357.6		0.157					-0.114	0.209			0.037	0.038	0.047			2.050	0.065	0.160	0.414	0.56
11		M 15000	321.6 321.7	321.65	65°	0.748	1.919	2.210	1.192	0.210			0.049	0.009				4.978	0.385					1.92
	R L	R 11000	319.2 319.1	319.15	62.33	0.553					0.937	0.739			0.364	0.372	0.381			7.219	0.809	0.131	0.342	1.98
	2+6	L 4000	329.0 329.1	329.05		0.195					-0.081	0.261			0.055	0.057	0.066			2.546	0.101	0.137	0.357	0.70
12		M 15000	320.2 320.1	320.15	66°	0.752	1.173	1.346	0.681	0.210			0.050	0.009				5.001	0.388					1.95
	R L	R 10000	336.6 336.7	336.65	62.33	0.477					0.702	0.634			0.277	0.284	0.293			6.222	0.601	0.196	0.506	1.73
	2+5	L 6000	349.4 349.5	349.45		0.275					0.037	0.366			0.103	0.106	0.115			3.596	0.201	0.110	0.282	1.00
13		M 15000	321.3 321.3	321.3	67.5°	0.749	1.803	1.901	1.484	0.210			0.049	0.009				4.984	0.386					1.99
	R L	R 9000	327.7 327.8	327.75	62.32	0.441					0.589	0.588			0.241	0.246	0.255			5.752	0.514	0.206	0.534	1.64
	3+5	L 6000	311.7 311.5	311.6		0.309					0.112	0.412			0.127	0.130	0.139			4.034	0.253	0.106	0.274	1.15
14		M 15000	321.3 321.3	321.3	68°	0.749	2.331	2.357	2.069	0.210			0.049	0.009				4.984	0.386					2.00
	R L	R 8000	309.5 309.5	309.5	62.32	0.415					0.472	0.553			0.215	0.220	0.229			5.415	0.455	0.173	0.448	1.55
	4+5	L 7000	335.0 335.0	335.0		0.335					0.184	0.447			0.147	0.151	0.160			4.377	0.298	0.112	0.291	1.26
15		M 15000	320.8 320.9	320.85	69°	0.750	2.146	2.491	0.370	0.210			0.049	0.009				4.992	0.387					2.03
	R L	R 15000	320.8 320.9	320.85	62.31	0.750					1.986				0.634	0.649	0.658			9.785	1.490	0.226	0.583	2.84
	1+0	L 0	-	-		0.000					-0.135				0.000	0.000	0.009			0.000	0.000	0.243	0.628	0.00
16		M 11000	322.6 322.5	322.55	62.5°	0.547	2.037	2.319	1.136	0.210			0.028	0.005				3.639	0.206					1.35
	R L	R 11000	322.6 322.5	322.55	62.35	0.547					1.091				0.357	0.365	0.370			7.141	0.792	0.135	0.656	1.90
	2+0	L 0	-	-		0.000					-0.072				0.000	0.000	0.005			0.000	0.000	0.128	0.625	0.00
17		M 9000	325.6 325.5	325.55	65.5°	0.444	2.002	2.260	1.485	0.210			0.019	0.004				2.951	0.135					1.14
	R L	R 9000	325.6 325.5	325.55	62.33	0.444					0.727				0.243	0.249	0.253			5.790	0.521	0.089	0.658	1.60
	3+0	L 0	-	-		0.000					-0.048				0.000	0.000	0.004			0.000	0.000	0.084	0.619	0.00
18		M 7000	360.1 360.1	360.1	69°	0.312	0.933	1.165	0.774	0.210			0.010	0.002				2.076	0.067					0.84
	R L	R 7000	360.1 360.1	360.1	62.31	0.312					0.369				0.128	0.131	0.133			4.073	0.238	0.045	0.676	1.18
	4+0	L 0	-	-		0.000					-0.022				0.000	0.000	0.002			0.000	0.000	0.043	0.643	0.00

TABLE V-6 Form Loss Data for 60° Wye without Tie-Rod

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main Pipe; R. Right Branch; L. Left Branch.	Time Interval (secs.)	Average Time Interval (secs.)	Temperature in °F. and Specific Weight of Water (lbs./cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe.	Friction Loss (ft.) in Main Pipe for Length 3.375 ft.	Friction Loss (ft.) in Main Pipe for Length ST	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft.) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft./sec.)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft./sec.)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		M 19000	205.9 205.9	235.9	72.5°	1.482	0.806	0.316	0.335	0.210			0.167	0.029				9.856	1.509				(0.043)	4.19
	R L	R 15000	324.8 325.0	324.9	62.29	0.741					0.681				0.620	0.643	0.672			9.676	1.454	0.064	0.043	2.94
	1+1	L 15000	323.6 323.6	323.6		0.744					0.700				0.625	0.648	0.676			9.715	1.465	0.0 67	0.044	2.95
2		M 19000	273.7 273.7	273.7	72°	1.115	0.072	-0.122	-0.140	0.210			0.100	0.017				7.415	0.854				(0.046)	2.13
	R L	R 11000	314.6 314.7	314.65	62.29	0.561					0.422				0.374	0.387	0.405			7.327	0.834	0.037	0.044	2.21
	1+1	L 11000	317.7 317.8	317.75		0.556					0.404				0.368	0.382	0.399			7.255	0.817	0.041	0.048	2.19
3		M 19000	329.3 329.3	329.3	72°	0.926	1.788	1.703	1.697	0.210			0.072	0.012				6.163	0.590				(0.054)	2.60
	R L	R 10000	345.8 345.8	345.8	62.29	0.464					0.301				0.265	0.276	0.287			6.061	0.570	0.034	0.057	1.83
	3+3	L 10000	346.5 346.5	346.5		0.463					0.295				0.265	0.275	0.287			6.049	0.568	0.030	0.050	1.83
4		M 18000	321.2 321.1	321.15	71°	0.750	0.848	0.854	0.848	0.210			0.049	0.009				4.989	0.386				(0.069)	2.08
	R L	R 7500	320.6 320.6	320.6	62.29	0.376					0.210				0.180	0.186	0.195			4.903	0.373	0.028	0.073	1.46
	3+3	L 7500	321.8 321.8	321.8		0.374					0.204				0.180	0.186	0.195			4.885	0.370	0.025	0.065	1.45
5		M 10000	322.0 322.1	322.05	71°	0.498	0.823	0.939	0.928	0.210			0.024	0.004				3.317	0.171				(0.080)	1.39
	R L	R 5000	319.7 319.7	319.7	62.29	0.251					0.105				0.086	0.090	0.094			3.278	0.167	0.015	0.090	0.98
	5+5	L 5000	325.3 325.3	325.3		0.247					0.094				0.085	0.088	0.092			3.221	0.161	0.012	0.069	0.96
6		M 7000	345.2 345.2	345.2	71.5°	0.325	1.138	1.302	1.301	0.210			0.011	0.002				2.166	0.073				(0.089)	0.91
	R L	R 3500	345.0 345.0	345.0	62.29	0.163					0.047				0.039	0.042	0.043			2.126	0.070	0.007	0.096	0.64
	6+6	L 3500	345.9 346.1	346.0		0.162					0.046				0.040	0.041	0.043			2.120	0.070	0.006	0.083	0.64
7		M 15000	321.5 321.5	321.5	72°	0.749	1.225	1.600	-0.367	0.210			0.049	0.009				4.983	0.386					2.10
	R L	R 15000	326.7 326.8	326.75	62.29	0.737					1.802	0.984			0.614	0.636	0.645			9.621	1.437	0.106	0.274	2.90
	3+9	L 300	395.6 395.2	395.3		0.012					-0.165	0.016			0.000	0.000	0.009			0.159	0.000	0.211	0.348	0.05
8		M 15000	321.5 321.4	321.45	72°	0.749	1.720	2.102	0.264	0.210			0.049	0.009				4.984	0.386					2.11
	R L	R 15000	335.6 335.6	335.6	62.29	0.717					1.666	0.958			0.584	0.606	0.618			9.367	1.363	0.075	0.194	2.82
	1+8	L 600	282.7 282.3	282.5		0.034					-0.172	0.042			0.002	0.002	0.011			0.445	0.003	0.200	0.518	0.13
9		M 15000	321.1 320.9	321.0	71.5°	0.750	1.347	1.740	0.142	0.210			0.049	0.009				4.991	0.387					2.10
	R L	R 14000	333.7 333.6	333.65	62.29	0.673					1.415	0.897			0.521	0.540	0.549			8.794	1.201	0.052	0.135	2.64
	1+7	L 1500	305.2 305.0	305.1		0.079					-0.183	0.103			0.011	0.011	0.020			1.030	0.016	0.168	0.434	0.31

TABLE V-6 Form Loss Data for 60° Wye without Tie-rod (continued)

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 15000	320.1 320.2	320.15	71°	0.752	0.763	1.140	-0.054	0.210			0.050	0.009				5.004	0.389					2.09
	R L	R 12000	323.1 323.0	323.05	62.29	0.596					1.027	0.793			0.417	0.433	0.441			7.785	0.941	0.034	0.086	2.32
	1+6	L 3000	306.3 306.3	306.3		0.157					-0.167	0.207			0.037	0.039	0.047			2.053	0.065	0.109	0.281	0.61
11		M 15000	321.8 321.7	321.75	71.5°	0.748	1.839	2.185	1.208	0.210			0.049	0.009				4.980	0.385					2.09
	R L	R 11000	318.3 318.2	318.25	62.29	0.555					0.841	0.742			0.366	0.379	0.388			7.244	0.815	0.023	0.060	2.17
	2+6	L 4000	328.8 328.6	328.7		0.195					-0.136	0.258			0.055	0.057	0.066			2.550	0.101	0.082	0.213	0.77
12		M 15000	320.9 320.9	320.9	71°	0.750	1.037	1.280	0.705	0.210			0.049	0.009				4.993	0.387					2.09
	R L	R 10000	334.5 334.7	334.6	62.29	0.480					0.542	0.640			0.281	0.291	0.300			6.264	0.609	0.020	0.052	1.87
	2+5	L 5500	325.7 325.6	325.65		0.271					-0.033	0.360			0.100	0.104	0.113			3.540	0.195	0.047	0.121	1.06
13		M 15000	321.5 321.5	321.5	71.5°	0.749	2.230	2.342	2.112	0.210			0.049	0.009				4.983	0.386					2.09
	R L	R 8000	308.7 308.5	308.6	62.29	0.416					0.328	0.556			0.217	0.225	0.233			5.433	0.458	0.022	0.057	1.63
	4+5	L 7000	338.2 338.1	338.15		0.332					0.098	0.444			0.145	0.150	0.159			4.339	0.292	0.032	0.084	1.30
14		M 17000	317.8 317.7	317.75	72°	0.859	2.011	2.436	-0.219	0.210			0.063	0.011				5.715	0.507					2.41
	R L	R 17000	317.8 317.7	317.75	62.29	0.859					2.440				0.811	0.841	0.851			1111461	1.952	0.143	0.283	3.38
	X+0	L 0	-	-		0					-0.215				0.000	0.000	0.011			0.000	0.000	0.281	0.554	0.00
15		M 15000	321.1 321.1	321.1	72°	0.750	2.040	2.414	0.370	0.210			0.049	0.009				4.990	0.387					2.11
	R L	R 15000	321.1 321.1	321.1	62.29	0.750					1.880				0.633	0.657	0.665			9.790	1.488	0.113	0.292	2.95
	1+0	L 0	-	-		0					-0.164				0.000	0.000	0.009			0.000	0.000	0.214	0.554	0.00
16		M 10500	326.5 326.5	326.5	72°	0.516	1.665	1.952	0.955	0.210			0.025	0.004				3.435	0.183					1.45
	R L	R 10500	326.5 326.5	326.5	62.29	0.516					0.920				0.321	0.333	0.337			6.740	0.705	0.061	0.332	2.03
	2+0	L 0	-	-		0					-0.077				0.000	0.000	0.004			0.000	0.000	0.102	0.556	0.00
17		M 6500	309.5 309.5	309.5	72°	0.337	1.307	1.550	1.109	0.210			0.012	0.002				2.243	0.078					0.95
	R L	R 6500	309.5 309.5	309.5	62.29	0.337					0.408				0.148	0.153	0.155			4.402	0.301	0.039	0.385	1.33
	4+0	L 0	-	-		0					-0.033				0.000	0.000	0.002			0.000	0.000	0.043	0.552	0.00

TABLE V-7 Form Loss Data for 60° Wye with TR2 Tie-rod

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R.Right Branch; L.Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		M 19000	201.3 201.5	201.4	67°	1.514	1.055	0.361	0.368	0.210			0.173	0.030				10.072	1.575				(0.167)	3.98
	R L	R 12000	254.5 254.5	254.5	62.32	0.757					0.897				0.644	0.667	0.697			9.877	1.515	0.260	0.165	2.79
	1+1	L 12000	254.4 254.5	254.45		0.757					0.904				0.644	0.668	0.697			9.879	1.516	0.266	0.169	2.79
2		M 19000	276.9 276.8	276.85	67.5°	1.101	0.111	-0.182	-0.182	0.210			0.098	0.017				7.327	0.834				(0.171)	2.92
	R L	R 11000	320.5 320.5	320.5	62.32	0.551					0.503				0.361	0.374	0.391			7.190	0.803	0.143	0.171	2.05
	3+3	L 11000	320.6 320.5	320.55		0.551					0.503				0.362	0.375	0.392			7.189	0.802	0.142	0.170	2.05
3		M 18000	313.9 313.8	313.85	59°	0.920	1.796	1.641	1.630	0.210			0.071	0.012				6.118	0.581				(0.188)	2.16
	R L	R 9000	313.3 313.3	313.3	62.37	0.461					0.376				0.261	0.270	0.283			6.013	0.561	0.113	0.195	1.51
	3+3	L 9000	314.2 314.2	314.2		0.459					0.365				0.261	0.270	0.283			5.996	0.558	0.106	0.182	1.51
4		M 15000	321.3 321.4	321.35	74°	0.750	0.831	0.800	0.797	0.210			0.049	0.009				4.987	0.386				(0.161)	2.17
	R L	R 7500	321.2 321.2	321.2	62.27	0.375					0.244				0.179	0.186	0.194			4.895	0.372	0.064	0.165	1.52
	3+3	L 7500	321.4 321.6	321.5		0.375					0.241				0.180	0.187	0.195			4.891	0.371	0.060	0.157	1.52
5		M 10000	323.5 323.5	323.5	68°	0.496	0.782	0.880	0.870	0.210			0.024	0.004				3.300	0.169				(0.185)	1.32
	R L	R 5000	321.0 320.9	320.95	62.32	0.250					0.122				0.086	0.089	0.093			3.263	0.165	0.033	0.194	0.93
	5+5	L 5000	326.2 326.3	326.25		0.246					0.112				0.084	0.087	0.091			3.210	0.160	0.030	0.176	0.92
6		M 7500	379.4 379.3	379.35	68°	0.317	1.011	1.168	1.168	0.210			0.011	0.002				2.111	0.069				(0.212)	0.85
	R L	R 3750	378.4 378.6	378.5	62.32	0.159					0.053				0.038	0.039	0.041			2.075	0.067	0.015	0.210	0.59
	6+6	L 3750	380.2 380.2	380.2		0.158					0.053				0.038	0.039	0.041			2.066	0.066	0.015	0.214	0.59
7		M 15000	321.9 322.0	321.95	74.5°	0.748	1.216	1.578	-0.409	0.210			0.049	0.009				4.978	0.385					2.18
	R L	R 15000	327.4 327.2	327.3	62.27	0.736					1.835	0.984			0.612	0.635	0.643			9.608	1.433	0.143	0.372	3.00
	X+9	L 300	398.7 398.5	398.6		0.012					-0.152	0.016			0.000	0.000	0.009			0.158	0.000	0.224	0.581	0.05
8		M 15000	322.1 322.3	322.2	75°	0.748	1.741	2.110	0.240	0.210			0.049	0.009				4.975	0.384					2.19
	R L	R 15000	336.6 336.7	336.65	62.26	0.716					1.711	0.957			0.582	0.603	0.611			9.343	1.355	0.128	0.334	2.93
	1+8	L 700	351.4 351.6	351.5		0.032					-0.159	0.043			0.002	0.002	0.011			0.418	0.003	0.212	0.552	0.13
9		M 15000	321.3 321.1	321.2	75°	0.750	1.361	1.739	0.113	0.210			0.049	0.009				4.991	0.387					2.19
	R L	R 14000	334.4 334.2	334.3	62.26	0.673					1.458	0.899			0.520	0.539	0.547			8.781	1.197	0.100	0.259	2.75
	1+7	L 1600	339.0 339.2	339.1		0.076					-0.168	0.101			0.010	0.010	0.019			0.989	0.015	0.185	0.478	0.31

TABLE V-7 Form Loss Data for 60° Wye with TR2 Tie-rod (continued)

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft).	Form Loss (ft).	(Average) Form Loss Coefficient	Raynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 15000	323.0 322.9	322.95	75.5°	0.746	1.827	2.166	1.160	0.210			0.049	0.009				4.963	0.383					2.20
	R L	R 11000	320.8 320.8	320.8	62.26	0.551					0.877	0.739			0.361	0.374	0.38[illegible]			7.190	0.803	0.076	0.196	2.27
	2+6	L 4000	329.5 329.5	329.5		0.195					-0.129	0.261			0.055	0.057	0.066			2.545	0.101	0.087	0.228	0.80
11		M 15000	321.6 321.5	321.55	73.5°	0.749	1.671	1.834	1.415	0.210			0.049	0.009				4.984	0.386					2.15
	R L	R 10000	364.7 364.8	364.75	62.28	0.440					0.466	0.590			0.240	0.249	0.257			5.747	0.513	0.081	0.211	1.77
	3+5	L 6000	312.3 312.5	312.4		0.308					0.047	0.410			0.127	0.131	0.140			4.026	0.252	0.041	0.106	1.24
12		M 15000	322.3 322.2	322.25	75.5°	0.748	2.161	2.259	1.993	0.210			0.049	0.009				4.974	0.384					2.20
	R L	R 8000	309.3 309.4	309.35	62.26	0.415					0.378	0.556			0.216	0.224	0.2[illegible]			5.423	0.457	0.073	0.191	1.71
	4+5	L 7000	339.1 339.2	339.15		0.332					0.112	0.444			0.144	0.150	0.158			4.328	0.291	0.047	0.123	1.37
13		M 15000	320.5 320.5	320.5	75°	0.752	1.327	1.688	-0.391	0.210			0.050	0.009				5.001	0.388					2.20
	R L	R 15000	320.5 320.5	320.5	62.26	0.752					1.928				0.636	0.659	0.668			9.814	1.495	0.153	0.394	3.08
	X+0	L 0	-	-		0.000					-0.151				0.000	0.000	0.009			0.000	0.000	0.229	0.589	0.00
14		M 12000	357.4 357.2	357.3	66°	0.539	1.897	2.187	1.073	0.210			0.027	0.005				3.585	0.200					1.40
	R L	R 12000	357.4 357.2	357.3	62.33	0.539					1.034				0.347	0.360	0.364			7.034	0.768	0.101	0.505	1.96
	2+0	L 0	-	-		0.000					-0.080				0.000	0.000	0.005			0.000	0.000	0.115	0.576	0.00
15		M 10000	345.4 345.5	345.45	66°	0.464	2.249	2.514	1.680	0.210			0.021	0.004				3.090	0.148					1.21
	R L	R 10000	345.4 345.5	345.45	62.33	0.464					0.779				0.265	0.274	0.278			6.063	0.571	0.078	0.529	1.89
	3+0	L 0	-	-		0.000					-0.055				0.000	0.000	0.004			0.000	0.000	0.090	0.605	0.00
16		M 8000	324.0 324.0	324.0	66°	0.396	2.170	2.426	1.808	0.210			0.016	0.003				2.636	0.108					1.03
	R L	R 8000	324.0 324.0	324.0	62.33	0.396					0.572				0.198	0.205	0.208			5.172	0.415	0.056	0.523	1.44
	4+0	L 0	-	-		0.000					-0.046				0.000	0.000	0.003			0.000	0.000	0.059	0.548	0.00

TABLE V-8 Form Loss Data for 60° Wye with TR3 Tie-rod

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		M 19000	200.5 200.4	200.45	69°	1.521	1.158	0.380	0.369	0.210			0.175	0.030				10.121	1.591				(0.219)	4.12
	R L	R 15000	316.0 315.9	315.95	62.31	0.762					0.999				0.652	0.676	0.706			9.947	1.536	0.347	0.218	2.89
	1+1	L 15000	316.9 316.9	316.9		0.760					0.988				0.648	0.672	0.702			9.917	1.527	0.349	0.220	2.88
2		M 19000	294.6 294.7	294.65	69.5°	1.035	2.575	2.296	2.296	0.210			0.088	0.015				6.885	0.736				(0.227)	2.82
	R L	R 10000	310.2 310.0	310.1	62.31	0.518					0.489				0.322	0.334	0.349			6.756	0.709	0.167	0.227	1.98
	3+3	L 10000	310.4 310.4	310.4		0.517					0.489				0.323	0.335	0.350			6.750	0.707	0.168	0.228	1.98
3		M 19000	324.6 324.5	324.55	68.5°	0.940	1.941	1.744	1.738	0.210			0.074	0.013				6.231	0.607				(0.229)	2.52
	R L	R 9500	323.9 324.0	323.95	62.31	0.471					0.413				0.271	0.281	0.294			6.144	0.586	0.140	0.230	1.77
	3+3	L 9500	324.9 325.0	324.95		0.469					0.407				0.271	0.281	0.294			6.125	0.583	0.138	0.227	1.77
4		M 15000	321.1 321.2	321.15	74.5°	0.750	0.863	0.804	0.803	0.210			0.049	0.009				4.991	0.387				(0.230)	2.18
	R L	R 7500	321.2 321.0	321.1	62.27	0.375					0.270				0.179	0.186	0.194			4.897	0.372	0.090	0.232	1.53
	3+3	L 7500	321.1 321.3	321.2		0.375					0.269				0.181	0.187	0.196			4.895	0.372	0.088	0.227	1.53
5		M 10000	322.5 322.3	322.4	69.5°	0.498	0.806	0.882	0.890	0.210			0.024	0.004				3.312	0.170				(0.256)	1.36
	R L	R 5000	324.5 324.4	324.45	62.31	0.247					0.126				0.084	0.087	0.091			3.229	0.162	0.043	0.254	0.94
	5+5	L 5000	320.4 320.2	320.3		0.251					0.134				0.087	0.090	0.094			3.271	0.166	0.044	0.258	0.96
6		M 8000	338.1 338.2	338.15	75.5°	0.380	1.870	2.002	2.002	0.210			0.015	0.003				2.528	0.099				(0.251)	1.12
	R L	R 4000	337.8 337.7	337.75	62.26	0.190					0.078				0.052	0.054	0.057			2.483	0.096	0.025	0.252	0.78
	6+6	L 4000	338.4 338.4	338.4		0.190					0.078				0.053	0.055	0.057			2.479	0.095	0.025	0.250	0.78
7		M 15000	321.9 322.0	321.95	76°	0.748	1.237	1.587	-0.409	0.210			0.049	0.009				4.980	0.385					2.22
	R L	R 15000	327.4 327.3	327.35	62.25	0.736					1.856	0.984			0.612	0.635	0.64?			9.610	1.434	0.164	0.426	3.06
	X+9	L 300	397.3 397.5	397.4		0.012					-0.140	0.016			0.000	0.000	0.009			0.158	0.000	0.236	0.612	0.05
8		M 15000	323.6 323.5	323.55	74°	0.745	1.747	2.100	0.236	0.210			0.049	0.009				4.953	0.381					2.21
	R L	R 15000	338.3 338.1	338.2	62.27	0.712					1.721	0.957			0.577	0.598	0.606			9.298	1.343	0.153	0.402	2.89
	1+8	L 700	351.0 351.9	350.95		0.032					-0.143	0.043			0.002	0.002	0.011			0.418	0.003	0.225	0.590	0.13
9		M 15000	322.7 322.5	322.6	74.5°	0.747	1.368	1.731	0.109	0.210			0.049	0.009				4.968	0.383					2.17
	R L	R 15000	360.3 360.2	360.25	62.27	0.669					1.469	0.896			0.514	0.533	0.541			8.729	1.183	0.128	0.333	2.72
	1+7	L 1900	392.4 392.0	392.2		0.078					-0.153	0.104			0.010	0.011	0.019			1.016	0.016	0.195	0.509	0.32

TABLE V-8 Form Loss Data for 60^{0} Wye with TR3 Tie-Rod (continued)

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch.	Time Interval (secs)	Average Time Interval (secs)	Temperature in ^{o}F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio. (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft.) in Main Pipe for Length 3,375 ft.	Friction Loss (ft) in Main Pipe for Length ST	Friction Loss (ft) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 15000	322.9 322.9	322.9	74.5^{o}	0.746	1.385	1.669	0.858	0.210			0.049	0.009				4.963	0.383					2.17
	R L	R 10000	315.7 315.7	315.7	62.27	0.509					0.737	0.682			0.312	0.324	0.332			6.641	0.685	0.102	0.268	2.07
	2+6	L 5000	337.8 337.9	337.85		0.238					-0.074	0.318			0.079	0.082	0.090			3.103	0.149	0.069	0.180	0.97
11		M 150000	323.8 323.6	323.7	75.5^{o}	0.744	1.673	1.826	1.383	0.210			0.049	0.009				4.952	0.381					2.19
	R L	R 9000	330.1 330.2	330.15	62.26	0.438					0.500	0.588			0.238	0.246	0.255			5.716	0.507	0.119	0.311	1.81
	3+5	L 7000	366.4 366.6	366.5		0.307					0.057	0.412			0.126	0.130	0.139			4.005	0.249	0.050	0.132	1.27
12		M 15000	324.7 324.6	324.65	75.5^{o}	0.742	2.178	2.257	1.982	0.210			0.048	0.009				4.938	0.379					2.17
	R L	R 8000	313.1 313.1	313.1	62.26	0.410					0.406	0.553			0.211	0.219	0.227			5.358	0.446	0.111	0.244	1.68
	4+5	L 7000	339.7 339.7	339.7		0.331					0.131	0.447			0.144	0.149	0.158			4.321	0.290	0.062	0.164	1.36
13		M 15000	321.9 321.8	321.85	76^{o}	0.749	1.334	1.680	-0.392	0.210			0.049	0.009				4.981	0.385					2.22
	R L	R 15000	321.9 321.8	321.85	62.25	0.749					1.936				0.631	0.655	0.663			9.774	1.483	0.175	0.454	3.11
	1+0	L 0	-	-		0.000					-0.136				0.000	0.000	0.008			0.000	0.000	0.241	0.625	0.00
14		M 12000	351.4 351.5	351.45	71^{o}	0.548	2.011	2.295	1.149	0.210			0.028	0.005				3.646	0.206					1.53
	R L	R 12000	351.4 351.5	351.45	62.30	0.548					1.072				0.358	0.371	0.376			7.155	0.795	0.108	0.522	2.14
	2+0	L 0	-	-		0.000					-0.074				0.000	0.000	0.005			0.000	0.000	0.128	0.618	0.00
15		M 10000	347.7 347.9	347.8	71^{o}	0.462	2.191	2.452	1.638	0.210			0.021	0.004				3.071	0.146					1.28
	R L	R 10000	347.7 347.9	347.8	62.30	0.462					0.763				0.262	0.271	0.275			6.025	0.564	0.071	0.484	1.80
	3+0	L 0	-	-		0.000					-0.051				0.000	0.000	0.004			0.000	0.000	0.092	0.627	0.00
16		M 8000	327.5 327.3	327.4	71.5^{o}	0.392	2.050	2.296	1.690	0.210			0.015	0.003				2.610	0.106					1.10
	R L	R 8000	327.5 327.3	327.4	62.29	0.392					0.570				0.195	0.202	0.204			5.121	0.407	0.064	0.606	1.34
	4+0	L 0	-	-		0.000					-0.036				0.000	0.000	0.003			0.000	0.000	0.067	0.634	0.00

TABLE V-9 Form Loss Data for 60° Wye with TR4 Tie-rod

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	204.4 204.2	204.3	71.5°	1.493	1.195	0.330	0.326	0.210			0.169	0.029				9.934	1.532				(0.295)	4.18
	1+1	R 14000	300.4 300.3	300.35	62.29	0.748					1.079				0.631	0.654	0.683			9.769	1.482	0.446	0.291	2.93
		L 14000	301.5 301.7	301.6		0.745					1.075				0.626	0.649	0.678			9.729	1.470	0.459	0.299	2.92
2	R L	M 19000	298.5 298.5	298.5	73°	1.022	2.544	2.223	2.224	0.210			0.086	0.015				6.800	0.718				(0.303)	2.92
	3+3	R 10000	313.8 313.8	313.8	62.28	0.512					0.530				0.316	0.327	0.342			6.680	0.693	0.213	0.297	2.04
		L 10000	315.4 315.2	315.3		0.509					0.531				0.314	0.326	0.341			6.648	0.686	0.222	0.309	2.04
3	R L	M 19000	332.2 332.2	332.2	73.5°	0.918	1.857	1.632	1.631	0.210			0.071	0.012				6.110	0.580				(0.302)	2.64
	3+3	R 9500	331.8 331.9	331.85	62.28	0.460					0.436				0.260	0.269	0.282			6.001	0.559	0.175	0.302	1.85
		L 9500	332.4 332.2	332.3		0.459					0.435				0.260	0.270	0.282			5.993	0.558	0.175	0.302	1.85
4	R L	M 15000	320.9 320.9	320.9	74°	0.751	0.900	0.811	0.812	0.210			0.049	0.009				4.994	0.387				(0.806)	2.17
	3+3	R 7500	320.5 320.6	320.55	62.27	0.376					0.298				0.180	0.187	0.195			4.905	0.374	0.117	0.301	1.52
		L 7500	321.7 321.7	321.7		0.374					0.299				0.180	0.187	0.195			4.888	0.371	0.120	0.318	1.51
5	R L	M 10000	324.3 324.5	324.4	74°	0.495	0.797	0.862	0.870	0.210			0.023	0.004				3.294	0.168				(0.330)	1.43
	5+5	R 5000	326.0 326.2	326.1	62.27	0.246					0.137				0.083	0.086	0.090			3.214	0.160	0.055	0.324	1.00
		L 5000	322.7 322.8	822.75		0.249					0.145				0.086	0.089	0.093			3.248	0.164	0.057	0.336	1.01
6	R L	M 8000	333.2 333.2	333.2	75°	0.386	1.988	2.110	2.111	0.210			0.015	0.003				2.566	0.102				(0.334)	1.13
	6+6	R 4000	334.0 333.8	333.9	62.26	0.192					0.087	0.984			0.053	0.055	0.058			2.512	0.098	0.034	0.324	0.79
		L 4000	332.9 332.9	332.9		0.193					0.088	0.016			0.054	0.056	0.059			2.519	0.098	0.033	0.344	0.79
7	R L	M 15000	321.8 321.8	321.8	76°	0.749	1.260	1.390	-0.415	0.210			0.049	0.009				4.982	0.385					2.22
	X+9	R 15000	327.2 327.3	327.25	62.25	0.786					1.885	0.957			0.613	0.635	0.644			9.613	1.435	0.192	0.498	3.06
		L 300	397.2 397.0	397.1		0.012					-0.120	0.043			0.000	0.000	0.009			0.158	0.000	0.256	0.665	0.05
8	R L	M 15000	323.0 322.9	322.95	74.5°	0.746	1.786	2.119	0.238	0.210			0.049	0.009				4.963	0.382					2.17
	1+8	R 14000	315.3 315.3	315.3	62.27	0.713					1.758	0.896			0.578	0.599	0.607			9.309	1.346	0.187	0.490	2.90
		L 700	349.8 349.4	349.6		0.032					-0.123	0.104			0.002	0.002	0.011			0.420	0.003	0.246	0.643	0.13
9	R L	M 15000	321.3 321.4	321.35	75°	0.750	1.409	1.753	0.114	0.210			0.049	0.009				4.988	0.386					2.19
	1+7	R 14000	334.8 334.6	334.7	62.26	0.672					1.505	0.790			0.518	0.537	0.546			8.771	1.194	0.151	0.391	2.75
		L 1600	328.6 328.4	328.5		0.078					-0.134	0.210			0.011	0.011	0.019			1.021	0.016	0.217	0.561	0.32

TABLE V-2 Form Loss Data for 60° Wye with TRA Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft).	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Raynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10	R L	M 15000	321.6 321.5	321.55	77°	0.750	0.788	1.128	-0.099	0.210			0.049	0.009				4.987	0.386					2.25
	1+6	R 12000	325.7 325.7	325.7	62.24	0.592					1.097	0.790			0.412	0.427	0.435			7.728	0.927	0.120	0.312	2.49
		L 3000	306.1 305.9	306.0		0.158					-0.130	0.210			0.038	0.039	0.047			2.056	0.066	0.143	0.370	0.66
11	R L	M 15000	323.7 323.5	323.6	77°	0.745	1.853	2.170	1.140	0.210			0.049	0.009				4.955	0.381					2.23
	2+6	R 11000	321.4 321.4	321.4	62.24	0.550					0.923	0.738			0.360	0.373	0.382			7.179	0.800	0.122	0.321	2.31
		L 8400	362.5 362.4	362.45		0.195					-0.107	0.262			0.055	0.057	0.066			2.546	0.101	0.108	0.283	0.82
12	R L	M 15000	321.8 321.9	321.85	75°	0.749	1.154	1.387	0.677	0.210			0.049	0.009				4.980	0.385					2.19
	2+5	R 10000	334.9 334.8	334.85	62.26	0.480					0.687	0.641			0.281	0.291	0.300			6.262	0.609	0.164	0.425	1.96
		L 5000	298.6 298.7	298.65		0.269					-0.023	0.359			0.099	0.103	0.111			3.511	0.191	0.060	0.155	1.10
13	R L	M 15000	321.8 321.8	321.8	75.5°	0.749	1.744	1.883	1.401	0.210			0.049	0.009				4.981	0.385					2.21
	3+5	R 8000	293.4 293.5	293.45	62.26	0.438					0.553	0.587			0.238	0.246	0.255			5.716	0.507	0.176	0.457	1.81
		L 7000	362.4 362.3	362.35		0.310					0.071	0.413			0.128	0.133	0.141			4.051	0.255	0.060	0.156	1.28
14	R L	M 15000	323.0 323.1	323.05	76°	0.746	2.205	2.273	1.937	0.210			0.049	0.009				4.963	0.382					2.21
	4+5	R 8000	310.6 310.7	310.65	62.25	0.414					0.458	0.554			0.214	0.222	0.231			5.401	0.453	0.157	0.410	1.72
		L 7000	338.1 338.2	338.15		0.332					0.142	0.446			0.145	0.151	0.159			4.341	0.293	0.073	0.190	1.38
15	R L	M 15000	322.1 322.0	322.05	76°	0.748	1.350	1.676	-0.400	0.210			0.049	0.009				4.978	0.385					2.22
	1+0	R 15000	322.1 322.0	322.05	62.25	0.748					1.960				0.631	0.654	0.662			9.768	1.482	0.201	0.522	3.11
		L 0	-	-		0.000					-0.116				0.000	0.000	0.009			0.000	0.000	0.260	0.677	0.00
16	R L	M 11000	329.2 329.0	329.1	75.5°	0.537	1.898	2.168	1.069	0.210			0.027	0.005				3.572	0.198					1.58
	2+0	R 11000	329.2 329.0	329.1	62.26	0.537					1.039				0.345	0.357	0.362			7.009	0.763	0.112	0.568	2.22
		L 0	-	-		0.000					-0.060				0.000	0.000	0.005			0.000	0.000	0.133	0.674	0.00
17	R L	M 9000	327.1 327.1	327.1	75.5°	0.442	1.967	2.219	1.462	0.210			0.019	0.003				2.940	0.134					1.30
	3+0	R 9000	327.1 327.1	327.1	62.26	0.442					0.715				0.242	0.251	0.254			5.769	0.517	0.028	0.384	1.82
		L 0	-	-		0.000					-0.042				0.000	0.000	0.003			0.000	0.000	0.089	0.662	0.00
18	R L	M 7500	321.3 321.5	321.4	75.5°	0.375	1.787	2.027	1.475	0.210			0.014	0.002				2.494	0.097					1.10
	4+0	R 7500	321.3 321.5	321.4	62.26	0.375					0.522				0.179	0.186	0.188			4.893	0.372	0.059	0.607	1.55
		L 0	-	-		0.000					-0.030				0.000	0.000	0.002			0.000	0.000	0.064	0.664	0.00

TABLE V-10 Form Loss Data for 45° Wye without Tie-rod

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft), in Main Pipe for Length 3.375 ft.	Friction Loss (ft), in Main Pipe for Length ST	Friction Loss (ft), in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft), in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft).	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	208.3 208.4	208.35	72.5°	1.464	0.807	0.368	0.345	0.210			0.163	0.027				9.741	1.473				(0.032)	4.15
	1+1	R 15000	327.5 327.5	327.5	62.29	0.735					0.672				0.611	0.641	0.668			9.599	1.431	0.046	0.032	2.92
		L 15000	329.3 329.5	329.5		0.731					0.649				0.605	0.634	0.661			9.541	1.413	0.047	0.032	2.90
2	R L	M 19000	270.8 270.8	270.8	71.5°	1.126	0.098	-0.091	-0.118	0.210			0.102	0.017				7.494	0.872				(0.042)	3.15
	1+1	R 11000	312.0 312.0	312.0	62.29	0.566					0.426				0.379	0.398	0.415			7.389	0.848	0.035	0.041	2.22
		L 11000	316.0 316.0	316.0		0.559					0.399				0.372	0.390	0.407			7.296	0.826	0.038	0.043	2.19
3	R L	M 19000	330.5 330.5	330.5	72°	0.923	1.752	1.672	1.674	0.210			0.071	0.012				6.141	0.585				(0.046)	2.59
	3+3	R 10000	348.0 347.9	347.95	62.29	0.461					0.288				0.262	0.274	02286			6.023	0.563	0.024	0.041	1.82
		L 10000	349.1 349.1	349.1		0.460					0.290				0.261	0.274	0.286			6.003	0.560	0.030	0.051	1.81
4	R L	M 15000	321.2 321.2	321.2	74.5°	0.750	0.848	0.863	0.856	0.210			0.049	0.008				4.990	0.387				(0.042)	2.18
	3+3	R 7500	320.1 320.1	320.1	62.27	0.376					0.202				0.180	0.189	0.197			4.912	0.375	0.016	0.043	1.53
		L 7500	322.4 322.3	322.35		0.374					0.195				0.179	0.188	0.196			4.878	0.369	0.016	0.041	1.52
5	R L	M 10000	322.5 322.5	322.5	75°	0.498	0.819	0.932	0.934	0.210			0.024	0.004				3.314	0.170				(0.055)	1.46
	5+5	R 5000	323.6 323.6	323.6	62.26	0.248					0.093				0.085	0.089	0.093			3.240	0.163	0.010	0.068	1.02
		L 5000	322.4 322.3	322.35		0.249					0.097				0.086	0.090	0.094			3.252	0.164	0.009	0.083	1.02
6	R L	M 18000	321.7 321.8	321.75	72°	0.898	2.070	2.541	-0.222	0.210			0.068	0.011				5.976	0.554					2.52
	8+8	R 17500	325.6 325.5	325.55	62.29	0.863					2.502	0.960			0.818	0.858	0.869			11.204	1.971	0.216	0.390	3.40
		L 750	348.7 348.9	348.8		0.035					-0.261	0.040			0.002	0.003	0.014			0.451	0.003	0.276	0.499	0.14
7	R L	M 19000	330.9 330.9	330.9	72°	0.922	1.776	2.278	-0.257	0.210			0.071	0.012				6.133	0.584					2.59
	1+7	R 17000	326.6 326.5	328.55	62.29	0.836					2.243	0.906			0.772	0.809	0.821			10.908	1.848	0.157	0.270	3.29
		L 1800	336.4 336.8	336.6		0.086					-0.292	0.094			0.013	0.013	0.025			1.121	0.020	0.248	0.424	0.34
8	R L	M 19000	330.5 330.6	330.55	72°	0.923	1.628	2.118	0.300	0.210			0.071	0.012				6.140	0.585					2.59
	1+6	R 15000	330.5 330.5	330.5	62.29	0.729					1.538	0.789			0.601	0.630	0.642			9.512	1.405	0.076	0.130	3.29
		L 4000	332.8 332.9	332.85		0.193					-0.280	0.211			0.054	0.057	0.069			2.519	0.099	0.138	0.236	0.34
9	R L	M 19000	330.7 330.6	330.65	72°	0.922	0.935	1.324	0.070	0.210			0.071	0.012				6.138	0.585					1.59
	1+5	R 13000	323.0 323.0	323.0	62.29	0.646					1.075	0.700			0.483	0.507	0.518			8.435	1.105	0.037	0.063	2.87
		L 6000	349.8 349.8	349.8		0.275					-0.179	0.300			0.103	0.108	0.120			3.595	0.201	0.085	0.146	0.76

TABLE V-10 Form Loss Data for 45° Wye without Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs) from M.Main Pipe; R.Right Branch; L.Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10	R L	M 19000	330.6 330.5	330.55	72°	0.923	2.048	2.323	1.469	0.210			0.071	0.012				6.140	0.585					2.59
	2+5	R 12000	327.6 327.6	327.6	62.29	0.588					0.789	0.637			0.407	0.427	0.439			7.677	0.915	0.021	0.035	2.32
		L 7000	336.4 336.4	336.4		0.334					-0.065	0.363			0.146	0.154	0.166			4.361	0.295	0.059	0.102	1.32
11	R L	M 19000	330.5 330.5	330.5	72°	0.923	1.477	1.632	1.108	0.210			0.071	0.012				6.141	0.585					2.59
	2+4	R 11000	327.1 327.2	327.15	62.29	0.540					0.579	0.585			0.348	0.365	0.377			7.047	0.771	0.016	0.028	2.12
		L 7500	315.5 315.4	315.45		0.382					0.055	0.415			0.186	0.196	0.207			4.983	0.386	0.047	0.081	1.50
12	R L	M 19000	361.5 361.4	361.45	72°	0.844	2.010	2.436	-0.246	0.210			0.061	0.010				5.615	0.490					2.37
	X+0	R 19000	361.5 361.4	361.45	62.29	0.844					2.466				0.785	0.824	0.834			11.022	1.885	0.237	0.484	3.32
		L 0	-	-		0.000					-0.216				0.000	0.000	0.010			0.000	0.000	0.263	0.538	0.00
13	R L	M 15000	321.4 321.3	321.35	72°	0.749	2.118	2.498	0.358	0.210			0.049	0.008				6.986	0.386					2.11
	1+0	R 15000	321.4 321.3	321.35	62.29	0.749					1.970				0.633	0.664	0.672			9.783	1.486	0.198	0.514	2.95
		L 0	-	-		0.000					-0.170				0.000	0.000	0.000			0.000	0.000	0.208	0.538	0.00
14	R L	M 11000	326.3 326.4	326.35	72°	0.541	1.960	2.259	1.115	0.210			0.028	0.005				3.600	0.201					1.52
	2+0	R 11000	326.3 326.4	326.35	62.29	0.541					1.055				0.350	0.367	0.371			7.064	0.775	0.110	0.547	2.13
		L 0	-	-		0.000					-0.089				0.000	0.000	0.005			0.000	0.000	0.108	0.535	0.00
15	R L	M 6500	307.0 306.9	306.95	73.5°	0.340	1.357	1.604	1.135	0.210			0.012	0.002				2.262	0.079					0.98
	4+0	R 6500	307.0 306.9	306.95	62.29	0.340					0.432				0.150	0.157	0.159			4.438	0.306	0.046	0.582	1.37
		L 0	-	-		0.000					-0.037				0.000	0.000	0.002			0.000	0.000	0.040	0.509	0.00

TABLE V-11 Form Loss Data for 90° Manifold without Tie-rod

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	207.5 207.6	207.55	69°	1.469	1.030	0.310	0.338	0.210			0.164	0.030				9.775	1.484				(0.156)	3.97
	1+1	R 14000	306.4 306.5	306.45	62.31	0.733					0.902				0.608	0.699	0.729			9.572	1.423	0.234	0.158	2.78
		L 14000	304.0 304.1	304.05		0.739					0.930				0.617	0.709	0.740			9.647	1.445	0.229	0.154	2.80
2	R L	M 19000	276.6 276.5	276.55	69°	1.103	0.174	-0.171	-0.147	0.210			0.098	0.018				7.336	0.836				(0.167)	2.98
	1+1	R 11000	321.5 321.6	321.55	62.31	0.549					0.531				0.359	0.413	0.431			7.167	0.798	0.158	0.165	2.08
		L 11000	318.9	318.85		0.554					0.555				0.366	0.420	0.439			7.228	0.811	0.161	0.168	2.10
3	R L	M 18000	313.3 313.2	313.25	68°	0.922	1.852	1.667	1.670	0.210			0.071	0.013				6.135	0.584				(0.171)	2.46
	3+3	R 9000	313.1 313.1	313.1	62.32	0.461					0.392				0.261	0.301	0.314			6.021	0.563	0.100	0.170	1.72
		L 9000	312.8 312.9	312.85		0.462					0.395				0.263	0.303	0.316			6.026	0.564	0.100	0.171	1.73
4	R L	M 15000	320.5 320.4	320.45	68°	0.751	0.898	0.834	0.836	0.210			0.049	0.009				4.997	0.388				(o.184)	2.01
	3+3	R 7500	321.1 321.1	321.1	62.32	0.375					0.272				0.179	0.206	0.215			4.893	0.372	0.073	0.188	1.40
		L 7500	320.1 320.0	320.05		0.376					0.274				0.181	0.209	0.218			4.909	0.374	0.070	0.180	1.41
5	R L	M 10000	318.9 318.8	318.85	68°	0.503	0.867	0.947	0.941	0.210			0.024	0.004				3.348	0.174				(0.203)	1.84
	5+5	R 5000	318.0 317.9	317.95	62.32	0.252					0.136				0.087	0.100	0.105			3.294	0.169	0.037	0.212	0.94
		L 5000	320.5 320.5	320.5		0.250					0.130				0.087	0.100	0.104			3.268	0.166	0.034	0.195	0.94
6	R L	M 7000	321.3 321.3	321.3	67°	0.350	1.452	1.592	1.593	0.210			0.013	0.002				2.326	0.084				(0.225)	0.92
	6+6	R 3500	322.8 322.8	322.8	62.32	0.174					0.069				0.044	0.051	0.053			2.271	0.080	0.020	0.234	0.64
		L 3500	320.6 320.8	320.7		0.175					0.070				0.045	0.052	0.055			2.286	0.081	0.018	0.217	0.65
7	R L	M 15000	320.8 320.8	320.8	67°	0.750	1.297	1.678	-0.393	0.210			0.049	0.009				4.992	0.387					1.98
	X+9	R 15000	325.7 325.8	325.75	62.32	0.739					1.900	0.984			0.617	0.709	0.718			9.646	1.445	0.124	0.320	2.73
		L 300	387.2 386.8	387.0		0.012					-0.171	0.016			0.000	0.000	0.080			0.162	0.000	0.206	0.532	0.05
8	R L	M 15000	320.9 321.0	320.95	67.5°	0.750	1.170	1.552	-0.412	0.210			0.049	0.009				4.990	0.387					1.99
	X+8	R 15000	334.3 334.4	334.35	62.32	0.720					1.792	0.962			0.588	0.676	0.686			9.398	1.371	0.122	0.315	2.68
		L 600	333.6 334.0	333.8		0.029					-0.172	0.038			0.002	0.002	0.011			0.377	0.002	0.201	0.521	0.11
9	R L	M 15000	320.9 320.9	320.9	67.5°	0.750	1.412	1.794	0.118	0.210			0.049	0.009				4.990	0.387					1.99
	1+7	R 14000	334.4 334.5	334.45	62.32	0.672					1.504	0.895			0.519	0.597	0.606			8.760	1.194	0.091	0.235	2.50
		L 2000	404.8 405.0	404.9		0.079					-0.172	0.105			0.011	0.012	0.021			1.035	0.017	0.177	0.457	0.29

TABLE V-11 Form Loss Data for 90° Manifold without Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft), in Main Pipe for Length 3.375 ft.	Friction Loss (ft), in Main Pipe for Length ST	Friction Loss (ft), in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft), in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10	R L	M 15000	320.1 320.2	320.15	67.5°	0.752	0.813	1.161	-0.082	0.210			0.050	0.009				5.002	0.389					1.99
	1+6	R 12000	324.2 324.3	324.25	62.32	0.594					1.105	0.788			0.415	0.477	0.487			7.753	0.933	0.074	0.190	2.21
		L 3200	323.5 323.7	323.6		0.159					-0.138	0.212			0.037	0.063	0.052			2.072	0.067	0.132	0.339	0.59
11	R L	M 15000	320.6 320.6	320.6	67°	0.751	1.924	2.234	1.206	0.210			0.049	0.009				4.995	0.387					1.98
	2+6	R 11000	318.0 318.0	318.0	62.32	0.555					0.928	0.736			0.367	0.422	0.432			7.246	0.815	0.069	0.177	2.05
		L 4000	324.6 325.0	324.8		0.198					-0.100	0.264			0.056	0.064	0.073			2.580	0.103	0.111	0.286	0.73
12	R L	M 15000	320.9 321.1	321.0	67.5°	0.750	1.087	1.273	0.682	0.210			0.049	0.009				4.989	0.386					1.99
	2+5	R 9000	302.1 302.2	302.15	62.32	0.478					0.615	0.037			0.280	0.322	0.331			6.240	0.605	0.066	0.170	1.78
		L 5500	324.3 324.4	324.35		0.272					0.024	0.363			0.100	0.115	0.124			3.552	0.196	0.090	0.234	1.01
13	R L	M 15000	320.6 320.7	320.65	67°	0.751	1.747	1.857	1.470	0.210			0.049	0.009				4.994	0.387					1.98
	3+5	R 8500	308.3 308.5	308.4	62.32	0.442					0.487	0.590			0.243	0.280	0.289			5.774	0.518	0.068	0.175	1.63
		L 6000	312.7 312.9	312.8		0.308					0.100	0.410			0.125	0.144	0.153			4.018	0.251	0.084	0.216	1.14
14	R L	M 15000	320.9 321.0	320.95	67°	0.750	2.239	2.291	2.044	0.210			0.049	0.009				4.990	0.387					1.97
	4+5	R 8000	307.8 307.8	307.8	62.32	0.417					0.405	0.557			0.219	0.252	0.261			5.445	0.460	0.070	0.182	1.54
		L 7000	338.8 338.9	338.85		0.332					0.158	0.443			0.143	0.165	0.174			4.327	0.281	0.080	0.207	1.22
15	R L	M 17000	322.6 322.6	322.6	67.5°	0.846	2.010	2.436	-0.261	0.210			0.061	0.011				5.626	0.491					2.24
	X+0	R 17000	322.6 322.6	322.6	62.32	0.846					2.481				0.787	0.905	0.917			11.039	1.892	0.164	0.331	3.14
		L 0	-	-		0.000					-0.216				0.000	0.000	0.011			0.000	0.000	0.264	0.538	0.00
16	R L	M 15000	321.1 321.1	321.1	67.5°	0.750	1.384	1.762	-0.378	0.210			0.049	0.009				4.987	0.386					1.99
	X+0	R 15000	321.1 321.1	321.1	62.32	0.750					1.972				0.633	0.728	0.737			9.786	1.487	0.134	0.348	2.79
		L 0	-	-		0.000					-0.168				0.000	0.000	0.009			0.000	0.000	0.209	0.541	0.00
17	R L	M 10000	314.3 314.4	314.35	67.5°	0.510	1.623	1.910	0.886	0.210			0.025	0.005				3.396	0.179					1.35
	2+0	R 10000	314.3 314.4	314.35	62.32	0.510					0.947				0.316	0.363	0.368			6.664	0.690	0.069	0.385	1.90
		L 0	-	-		0.000					-0.077				0.000	0.000	0.005			0.000	0.000	0.098	0.544	0.00
18	R L	M 7000	321.7 321.6	321.65	67.5°	0.349	1.420	1.665	1.170	0.210			0.013	0.002				2.323	0.084					0.93
	4+0	R 7000	321.7 321.6	321.65	62.32	0.349					0.460				0.159	0.183	0.185			4.559	0.323	0.036	0.433	1.30
		L 0	-	-		0.000					-0.035				0.000	0.000	0.002			0.000	0.000	0.046	0.555	0.00

TABLE V-12 Form Loss Data for 90° Manifold with TR3 Tie-rod

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft) in Main Pipe for Length 3.375 ft.	Friction Loss (ft) in Main Pipe for Length ST	Friction Loss (ft) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	212.1 212.2	212.15	69.5°	1.437	1.136	0.261	0.267	0.210			0.158	0.029				9.563	1.420				(0.308)	3.92
	1+1	R 14500	324.9 324.8	324.85	62.31	0.716					1.079				0.583	0.670	0.699			7.352	1.358	0.442	0.311	2.73
		L 14500	323.8 323.8	323.8		0.719					1.085				0.586	0.674	0.704			9.382	1.367	0.435	0.306	2.75
2	R L	M 19000	277.2 277.3	277.25	69°	1.100	0.277	-0.177	-0.162	0.210			0.098	0.018				7.318	0.831				(0.307)	2.98
	1+1	R 11000	321.9 322.1	322.0	62.31	0.548					0.649				0.358	0.412	0.430			7.157	0.795	0.255	0.307	2.08
		L 11000	320.1 320.0	320.05		0.552					0.664				0.363	0.418	0.436			7.201	0.805	0.255	0.306	2.09
3	R L	M 19000	329.3 329.3	329.3	69°	0.926	1.938	1.669	1.674	0.210			0.072	0.013				6.161	0.589				(0.313)	2.51
	3+3	R 9000	313.2 313.3	313.25	62.31	0.461					0.474				0.261	0.300	0.314			6.020	0.563	0.187	0.317	1.75
		L 9000	311.8 311.7	311.75		0.463					0.479				0.265	0.305	0.318			6.049	0.568	0.182	0.310	1.76
4	R L	M 15000	320.6 320.7	320.65	69°	0.751	0.937	0.820	0.826	0.210			0.049	0.009				4.995	0.387				(o.315)	2.03
	3+3	R 7500	321.5 321.7	321.6	62.31	0.374					0.321				0.179	0.205	0.215			4.886	0.371	0.123	0.318	1.42
		L 7500	319.7 319.8	319.75		0.376					0.327				0.182	0.209	0.218			4.914	0.375	0.121	0.313	1.43
5	R L	M 10000	318.4 318.5	318.45	68°	0.504	0.887	0.944	0.939	0.210			0.024	0.004				3.353	0.175				(0.327)	1.35
	5+5	R 5000	317.5 317.6	317.55	62.32	0.253					0.158				0.087	0.100	0.105			3.298	0.169	0.059	0.336	0.94
		L 5000	319.4 319.5	319.45		0.251					0.153				0.087	0.100	0.105			3.279	0.167	0.056	0.319	0.94
6	R L	M 6700	314.1 314.0	314.05	69.5°	0.342	1.370	1.502	1.502	0.210			0.012	0.002				2.278	0.081				(0.359)	0.93
	6+6	R 3400	320.3 320.4	320.35	62.31	0.170					0.078				0.043	0.049	0.051			2.224	0.077	0.031	0.379	0.65
		L 3400	317.1 317.0	317.05		0.172					0.078				0.044	0.051	0.053			2.247	0.078	0.027	0.338	0.66
7	R L	M 15000	320.9 321.0	320.95	69.5°	0.750	1.864	2.229	0.241	0.210			0.049	0.009				4.990	0.387					2.04
	1+8	R 15000	335.1 335.3	335.2	62.31	0.718					1.833	0.956			0.586	0.673	0.683			9.376	1.365	0.172	0.445	2.74
		L 600	295.6 295.8	295.7		0.033					-0.155	0.044			0.002	0.002	0.012			0.425	0.003	0.217	0.562	0.12
8	R L	M 15000	321.2 321.3	321.25	69°	0.749	1.455	1.815	0.110	0.210			0.049	0.009				4.986	0.386					2.03
	1+7	R 13500	322.9 322.9	322.9	62.31	0.671					1.555	0.895			0.518	0.595	0.605			8.759	1.191	0.145	0.376	2.55
		L 1500	304.3 304.7	304.5		0.079					-0.150	0.105			0.011	0.012	0.021			1.032	0.017	0.198	0.514	0.30
9	R L	M 15000	320.5 320.6	320.55	69.5°	0.751	0.847	1.170	-0.090	0.210			0.049	0.009				4.997	0.388					2.05
	1+6	R 12000	325.3 325.5	325.4	62.31	0.592					1.147	0.789			0.413	0.474	0.484			7.726	0.927	0.124	0.320	2.26
		L 3200	324.0 324.3	324.15		0.158					-0.113	0.211			0.037	0.043	0.052			2.068	0.066	0.156	0.403	0.61

TABLE V-12 Form Loss Data for 90° Manifold with TR3 Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft) in Main Pipe for Length 3.375 ft.	Friction Loss (ft) in Main Pipe for Length ST	Friction Loss (ft) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft) in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft.)	Form Loss (ft.)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10	R L	M 15000	321.1 321.2	321.15	69°	0.750	1.930	2.217	1.169	0.210			0.049	0.009				4.987	0.386					2.03
	2+6	R 11000	318.8 318.9	318.85	62.31	0.554					0.971	0.739			0.366	0.420	0.430			7.228	0.811	0.116	0.301	2.10
		L 4000	327.8 327.9	327.85		0.196					-0.077	0.261			0.055	0.063	0.072			2.556	0.101	0.135	0.351	0.74
11	R L	M 15000	320.8 320.9	320.85	69°	0.750	1.138	1.301	0.655	0.210			0.049	0.009				4.992	0.387					2.03
	2+5	R 9500	319.8 319.7	319.75	62.31	0.477					0.693	0.636			0.279	0.321	0.330			6.225	0.602	0.148	0.383	1.81
		L 5500	323.2 323.3	323.25		0.273					0.047	0.364			0.101	0.116	0.125			3.565	0.197	0.112	0.289	1.04
12	R L	M 15000	321.0 321.0	321.0	69°	0.750	1.797	1.879	1.435	0.210			0.049	0.009				4.990	0.387					2.03
	3+5	R 9000	327.5 327.6	327.55	62.31	0.441					0.572	0.588			0.242	0.278	0.288			5.757	0.515	0.156	0.405	1.67
		L 6000	311.8 311.9	311.85		0.309					0.128	0.412			0.126	0.145	0.154			4.031	0.252	0.108	0.280	1.17
13	R L	M 15000	321.2 321.2	321.2	69°	0.750	2.281	2.299	2.013	0.210			0.049	0.009				4.987	0.386					2.03
	4+5	R 8000	307.9 307.8	307.85	62.31	0.417					0.478	0.556			0.144	0.166	0.175			5.757	0.515	0.156	0.405	1.58
		L 7000	337.6 337.7	337.65		0.333					0.192	0.444			0.210	0.252	0.261			4.031	0.252	0.108	0.280	1.26
14	R L	M 18000	343.5 343.6	343.55	67.5°	0.841	2.050	2.450	-0.274	0.210			0.061	0.011				5.594	0.486					2.23
	3+0	R 18000	343.5 343.6	343.55	62.32	0.841					2.534				0.779	0.896	0.907			10.976	1.871	0.242	0.499	3.12
		L 0	-	-		0.000					-0.190				0.000	0.000	0.011			0.000	0.000	0.285	0.586	0.00
15	R L	M 15000	321.0 321.1	321.05	69°	0.750	2.164	2.524	0.342	0.210			0.049	0.009				4.989	0.386					2.00
	1+0	R 15000	321.0 321.1	321.05	62.31	0.750					2.032				0.633	0.728	0.737			9.789	1.488	0.193	0.500	2.81
		L 0	-	-		0.000					-0.150				0.000	0.000	0.009			0.000	0.000	0.227	0.588	0.00
16	R L	M 10000	318.3 318.4	318.35	69°	0.504	1.568	1.844	0.829	0.210			0.024	0.004				3.354	0.175					1.35
	2+0	R 10000	318.3 318.4	318.35	62.31	0.504					0.949				0.309	0.355	0.359			6.581	0.673	0.092	0.526	1.89
		L 0	-	-		0.000					-0.066				0.000	0.000	0.004			0.000	0.000	0.104	0.596	0.00
17	R L	M 7100	323.1 323.2	323.15	69°	0.353	1.469	1.711	1.199	0.210			0.013	0.002				2.346	0.085					0.94
	4+0	R 7100	323.1 323.2	323.15	62.31	0.353					0.480				0.162	0.186	0.188			4.603	0.329	0.048	0.565	1.32
		L 0	-	-		0.000					-0.032				0.000	0.000	0.002			0.000	0.000	0.051	0.598	0.00

TABLE V-13 Form Loss Data for 60° Manifold without Tie-Rod

Test No.	Orifice No.	Weight of Water (lbs) from M.Main Pipe; R.Right Branch; L.Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft), in Main Pipe for Length 3.375 ft.	Friction Loss (ft), in Main Pipe for Length ST	Friction Loss (ft), in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft), in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	222.3 222.3	222.3	68°	1.372	0.608	0.170	0.181	0.210			0.145	0.025				9.125	1.293				(0.051)	3.66
	1+1	R 15000	350.5 350.5	350.5	62.32	0.687					0.637				0.540	0.599	0.624			8.965	1.248	0.058	0.045	2.57
		L 15000	351.0 351.1	351.05		0.685					0.648				0.539	0.598	0.623			8.951	1.244	0.074	0.057	2.57
2	R L	M 19000	276.7 276.6	276.65	68.5°	1.102	0.058	-0.170	-0.159	0.210			0.098	0.017				7.333	0.835				(0.053)	2.96
	1+1	R 11500	334.7 334.7	334.7	62.31	0.551					0.427				0.362	0.402	0.419			7.199	0.805	0.039	0.046	2.08
		L 11500	334.9 334.9	334.9		0.551					0.438				0.363	0.403	0.420			7.194	0.804	0.050	0.059	2.08
3	R L	M 18500	321.0 320.9	320.95	68°	0.925	1.779	1.667	1.676	0.210			0.072	0.012				6.154	0.588				(0.060)	2.47
	3+3	R 10000	347.5 347.4	347.45	62.32	0.462					0.313				0.262	0.291	0.303			6.029	0.564	0.033	0.056	1.73
		L 10000	346.8 346.8	346.8		0.463					0.322				0.264	0.293	0.306			6.040	0.567	0.038	0.064	1.73
4	R L	M 15000	321.0 321.0	321.0	68.5°	0.750	0.831	0.819	0.827	0.210			0.049	0.009				4.990	0.387				(0.060)	2.01
	3+3	R 7500	321.1 321.2	321.15	62.31	0.375					0.214				0.179	0.199	0.207			4.893	0.372	0.021	0.055	1.41
		L 7500	320.3 320.3	320.3		0.376					0.222				0.181	0.201	0.210			4.906	0.374	0.025	0.065	1.42
5	R L	M 10500	332.9 333.0	332.95	68°	0.506	0.855	0.950	0.960	0.210			0.024	0.004				3.367	0.176				(0.088)	1.35
	5+5	R 5000	320.9 320.8	320.85	62.32	0.250					0.105				0.086	0.095	0.099			3.264	0.165	0.016	0.091	0.94
		L 5000	314.7 314.6	314.65		0.255					0.115				0.090	0.100	0.104			3.329	0.172	0.015	0.085	0.95
6	R L	M 15000	321.1 321.0	321.05	68°	0.750	1.778	2.160	0.266	0.210			0.049	0.009				4.988	0.386					2.00
	1+6	R 15000	334.9 335.0	334.95	62.32	0.718					1.720	0.956			0.586	0.651	0.660			9.381	1.367	0.080	0.207	2.69
		L 600	292.7 293.1	292.9		0.033					-0.174	0.444			0.002	0.002	0.011			0.429	0.003	0.199	0.514	0.12
7	R L	M 15000	321.2 321.2	321.2	68°	0.749	1.371	1.759	0.131	0.210			0.049	0.009				4.986	0.386					2.00
	1+7	R 13500	322.4 322.3	322.35	62.32	0.672					1.450	0.895			0.519	0.577	0.585			8.773	1.195	0.056	0.144	2.52
		L 1600	327.2 327.6	327.4		0.078					-0.178	0.105			0.010	0.012	0.020			1.024	0.016	0.172	0.445	0.29
8	R L	M 15000	320.6 320.7	320.65	69°	0.751	0.746	1.112	-0.079	0.210			0.049	0.009				4.995	0.387					2.03
	1+6	R 12000	324.6 324.6	324.6	62.31	0.593					1.035	0.788			0.414	0.460	0.469			7.745	0.932	0.022	0.057	2.25
		L 3200	322.4 322.4	322.4		0.159					-0.156	0.212			0.038	0.042	0.050			2.080	0.067	0.114	0.294	0.60
9	R L	M 15000	321.3 321.3	321.3	69°	0.749	1.840	2.180	1.182	0.210			0.049	0.009				4.985	0.386					2.03
	2+6	R 11000	318.3 318.4	318.35	62.34	0.554					0.868	0.739			0.367	0.407	0.416			7.239	0.814	0.024	0.063	2.10
		L 4000	328.1 328.3	328.2		0.196					-0.130	0.261			0.055	0.061	0.069			2.553	0.101	0.085	0.221	0.74

TABLE V-13 Form Loss Data for 60° Manifold without Tie-Rod (cont'd)

Test No.	Orifice No.	Weight of Water (lbs). from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft).	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10	R L	M 15000	321.2 321.3	321.25	68°	0.749	1.027	1.259	0.675	0.210			0.049	0.009				4.985	0.386					2.00
	2+5	R 9500	318.6 318.7	318.65	62.32	0.478					0.562	0.638			0.281	0.312	0.320			6.245	0.606	0.022	0.057	1.79
		L 5500	326.1 326.2	326.15		0.271					-0.022	0.362			0.099	0.110	0.118			3.533	0.194	0.052	0.134	1.01
11	R L	M 15000	320.5 320.6	320.55	68°	0.751	1.683	1.845	1.460	0.210			0.049	0.009				4.996	0.388					2.00
	3+5	R 9000	325.7 325.7	325.7	62.32	0.443					0.433	0.591			0.245	0.272	0.280			5.789	0.520	0.020	0.052	1.66
		L 6000	313.8 313.8	313.8		0.307					0.048	0.409			0.124	0.138	0.147			4.005	0.249	0.040	0.103	1.15
12	R L	M 15000	321.4 321.3	321.35	67.5°	0.749	2.161	2.268	2.019	0.210			0.049	0.009				4.983	0.386					1.99
	4+5	R 8000	307.4 307.3	307.35	62.32	0.418					0.352	0.559			0.220	0.244	0.252			5.453	0.462	0.024	0.061	1.55
		L 7000	340.1 340.0	340.05		0.330					0.103	0.441			0.142	0.158	0.167			4.312	0.289	0.033	0.086	1.23
13	R L	M 18000	337.0 337.0	337.0	68°	0.857	2.020	2.448	-0.250	0.210			0.063	0.011				5.702	0.505					2.29
	X+0	R 18000	337.0 337.0	337.0	62.32	0.857					2.480				0.807	0.896	0.907			11.189	1.944	0.134	0.266	3.21
		L 0	-	-		0.000					-0.218				0.000	0.000	0.011			0.000	0.000	0.276	0.547	0.00
14	R L	M 15000	320.9 320.9	320.9	68°	0.750	2.067	2.444	0.353	0.210			0.049	0.009				4.990	0.387					2.00
	1+0	R 15000	320.9 320.9	320.9	62.32	0.750					1.924				0.634	0.704	0.712			9.792	1.489	0.110	0.283	2.81
		L 0	-	-		0.000					-0.167				0.000	0.000	0.009			0.000	0.000	0.211	0.546	0.00
15	R L	M 10000	320.6 320.5	320.55	68°	0.501	1.499	1.782	0.820	0.210			0.024	0.004				3.331	0.172					1.34
	2+0	R 10000	320.6 320.5	320.55	62.32	0.501					0.889				0.305	0.338	0.343			6.535	0.663	0.056	0.323	1.87
		L 0	-	-		0.000					-0.073				0.000	0.000	0.004			0.000	0.000	0.095	0.552	0.00
16	R L	M 6500	333.2 333.3	333.25	68°	0.313	0.935	1.172	0.781	0.210			0.010	0.002				2.082	0.067					0.84
	4+0	R 6500	333.2 333.3	333.25	62.32	0.313					0.364				0.130	0.145	0.146			4.086	0.259	0.026	0.382	1.17
		L 0	-	-		0.000					-0.027				0.000	0.000	0.002			0.000	0.000	0.039	0.573	0.00

TABLE V-14 Form Loss Data for 60° Manifold with TR3 Tie-Rod

Test No.	Orifice No.	Weight of Water (lbs.) from M. Main; R. Right Branch; L. Left Branch.	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft.)	Hook Gauge Reading in Central Tank (ft.)	Hook Gauge Reading in Downstream Tank (ft.)	Vernier Correction (ft.)	Pressure Head Difference (ft.) between Main Pipe & Right Branch or Main Pipe & Left Branch.	Discharge Ratio. (Discharge in Branch Pipe/ Discharge in Main Pipe.)	Friction Loss (ft.) in Main Pipe for Length 3.375 ft.	Friction Loss (ft.) in Main Pipe for Length 5T	Friction Loss (ft.) in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft) in Right or Left Branch for Length TD_1 TD_2	Total Friction Loss (ft.)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft.)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	R L	M 19000	219.7 219.7	219.7	70°	1.391	0.877	0.190	0.218	0.210			0.149	0.026				9.257	1.331				(0.218)	3.82
	1+1	R 14000	322.1 322.2	322.15	62.30	0.697					0.869				0.355	0.617	0.642			9.107	1.288	0.270	0.203	2.68
		L 14000	323.4 323.4	323.4		0.695					0.897				0.352	0.613	0.639			9.071	1.278	0.311	0.234	2.67
2	R L	M 19000	277.6 277.6	277.6	70°	1.099	0.193	-0.180	-0.155	0.210			0.098	0.017				7.309	0.830				(0.224)	3.02
	1+1	R 11500	335.6 335.7	335.65	62.30	0.550					0.358				0.360	0.400	0.417			7.180	0.800	0.170	0.206	2.11
		L 11500	336.6 336.6	336.6		0.548					0.383				0.359	0.399	0.416			7.159	0.796	0.201	0.242	2.11
3	R L	M 19000	329.0 329.1	329.05	69°	0.927	1.887	1.665	1.694	0.210			0.072	0.012				6.166	0.590				(0.227)	2.51
	3+3	R 9000	312.0 312.1	312.05	62.31	0.463					0.403				0.263	0.292	0.305			6.043	0.567	0.122	0.206	1.75
		L 9000	311.5 311.6	311.55		0.464					0.432				0.265	0.295	0.307			6.052	0.569	0.147	0.248	1.76
4	R L	M 15000	321.1 321.1	321.1	70°	0.750	0.883	0.802	0.822	0.210			0.049	0.009				4.989	0.386				(0.218)	2.06
	3+3	R 7500	321.0 321.0	321.0	62.30	0.375					0.271				0.179	0.199	0.208			4.896	0.372	0.078	0.201	1.44
		L 7500	319.6 319.6	319.6		0.376					0.291				0.182	0.202	0.211			4.917	0.375	0.091	0.236	1.45
5	R L	M 10000	332.4 332.4	332.4	70°	0.483	0.717	0.798	0.801	0.210			0.022	0.004				3.213	0.160				(0.249)	1.33
	5+5	R 5000	331.3 331.2	331.25	62.30	0.242					0.126				0.081	0.090	0.094			3.163	0.155	0.037	0.232	0.93
		L 5000	333.7 333.7	333.7		0.241					0.129				0.081	0.090	0.094			3.140	0.153	0.043	0.266	0.93
6	R L	M 15000	320.7 320.7	320.7	70°	0.751	1.846	2.199	0.258	0.210			0.049	0.009				4.995	0.387					2.06
	1+8	R 15000	335.4 335.4	335.35	62.30	0.718					1.798	0.955			0.385	0.650	0.659			9.373	1.364	0.163	0.419	2.76
		L 600	384.6 285.2	384.9		0.034					-0.143	0.045			0.002	0.002	0.011			0.441	0.003	0.230	0.595	0.13
7	R L	M 15000	321.1 321.2	321.15	70°	0.750	1.644	1.803	0.129	0.210			0.049	0.009				4.988	0.386					2.06
	1+7	R 13500	322.7 322.8	322.75	62.30	0.671					1.525	0.893			0.518	0.576	0.584			8.765	1.193	0.134	0.347	2.38
		L 1800	322.6 323.0	322.8		0.080					-0.149	0.107			0.011	0.012	0.020			1.039	0.017	0.200	0.518	0.31
8	R L	M 19000	406.5 406.5	406.5	70°	0.750	0.829	1.172	-0.079	0.210			0.049	0.009				4.992	0.387					2.06
	1+6	R 15000	406.6 406.6	406.6	62.30	0.592					1.118	0.788			0.413	0.459	0.467			7.730	0.928	0.110	0.284	2.28
		L 3500	353.7 353.7	353.7		0.159					-0.133	0.212			0.038	0.042	0.050			2.074	0.067	0.137	0.354	0.61
9	R L	M 19000	406.4 406.5	406.45	70°	0.750	1.902	2.221	1.166	0.210			0.049	0.009				4.992	0.387					2.06
	2+6	R 14000	405.0 405.0	405.0	62.30	0.555					0.946	0.739			0.367	0.408	0.416			7.244	0.815	0.102	0.264	2.16
		L 5000	408.7 408.7	408.7		0.196					-0.109	0.261			0.055	0.061	0.070			2.564	0.102	0.106	0.274	0.76

TABLE V-14 Form Loss Data for 60° Manifold with TR3 Tie-rod (continued)

Test No.	Orifice No.	Weight of Water (lbs) from M.Main Pipe; R.Right Branch; L.Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in $^{\circ}F$ and Specific Weight of Water (lbs/cu.ft).	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft). between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe).	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 19000	406.7 406.7	406.7	70°	0.750	1.080	1.302	0.642	0.210			0.049	0.009				4.989	0.387					2.06
	R L	R 15000	505.1 505.0	505.05	62.30	0.477					0.648	0.635			0.279	0.310	0.318			6.224	0.601	0.115	0.297	1.83
	2+5	L 8000	467.9 468.0	467.95		0.274					-0.012	0.365			0.102	0.113	0.121			3.582	0.199	0.054	0.140	1.06
11		M 19000	407.3 407.3	407.3	70°	0.749	2.185	2.270	1.955	0.210			0.049	0.009				4.982	0.385					2.06
	R L	R 11000	424.7 424.7	424.7	62.30	0.416					0.440	0.557			0.218	0.242	0.250			5.427	0.457	0.118	0.306	1.60
	4+5	L 9000	435.3 435.3	435.3		0.332					0.125	0.443			0.144	0.159	0.168			4.332	0.291	0.051	0.132	1.28
12		M 19000	360.2 360.3	360.25	70°	0.847	2.038	2.423	-0.268	0.210			0.061	0.011				5.633	0.493					2.32
	R L	R 19000	360.2 360.3	360.25	62.30	0.847					2.516				0.789	0.876	0.887			11.052	1.897	0.225	0.457	3.26
	X+9	L 0	-	-		0.000					-0.175				0.000	0.000	0.011			0.000	0.000	0.307	0.623	0.00
13		M 15000	321.1 321.0	321.05	70°	0.750	2.122	2.468	0.339	0.210			0.049	0.009				4.990	0.387					2.06
	R L	R 15000	321.1 321.0	321.05	62.30	0.750					1.993				0.634	0.704	0.712			9.790	1.488	0.179	0.463	2.89
	1+0	L 0	-	-		0.000					-0.136				0.000	0.000	0.009			0.000	0.000	0.242	0.626	0.00
14		M 15000	429.3 429.3	429.3	70°	0.561	2.144	2.430	1.215	0.210			0.029	0.005				3.731	0.216					1.54
	R L	R 15000	429.3 429.3	429.3	62.30	0.561					1.139				0.374	0.416	0.421			7.322	0.838	0.102	0.472	2.16
	2+0	L 0	-	-		0.000					-0.076				0.000	0.000	0.005			0.000	0.000	0.135	0.625	0.00
15		M 10000	445.5 445.7	445.6	70°	0.360	1.331	1.771	1.256	0.210			0.013	0.002				2.397	0.089					0.99
	R L	R 10000	445.5 445.7	445.6	62.30	0.360					0.485				0.168	0.186	0.189			4.703	0.343	0.042	0.471	1.39
	4+0	L 0	-	-		0.000					-0.030				0.000	0.000	0.002			0.000	0.000	0.057	0.638	0.00

TABLE V-15 Form Loss Data for 45° Manifold without Tie-rod

Test No.	Orifice No.	Weight of Water (lbs) from M.Main Pipe; R. Right Branch; L.Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Raynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		M 19000	212.2 212.2	212.2	69°	1.437	0.715	0.250	0.268	0.210			0.158	0.026				9.561	1.419				(0.026)	3.92
	R L	R 19000	425.1 425.0	425.05	62.31	0.717					0.657				0.584	0.652	0.679			9.365	1.362	0.036	0.025	2.74
	1+1	L 19000	423.5 423.5	423.5		0.720					0.675				0.588	0.657	0.683			9.400	1.372	0.039	0.027	2.75
2		M 19000	274.6 274.6	274.6	69°	1.110	0.045	-0.171	-0.159	0.210			0.100	0.017				7.388	0.848				(0.030)	3.00
	R L	R 15000	434.0 434.1	434.05	62.31	0.555					0.414				0.366	0.408	0.425			7.240	0.814	0.023	0.027	2.10
	1+1	L 15000	433.0 433.1	433.05		0.556					0.426				0.368	0.411	0.428			7.257	0.818	0.028	0.033	2.11
3		M 19000	331.0 331.0	331.0	69.5°	0.921	1.741	1.645	1.659	0.210			0.071	0.012				6.129	0.583				(0.036)	2.51
	R L	R 11000	384.9 384.9	384.9	62.31	0.459					0.292				0.259	0.289	0.301			5.988	0.557	0.018	0.031	1.75
	3+3	L 11000	383.3 383.4	383.35		0.461					0.306				0.262	0.292	0.304			6.012	0.561	0.024	0.041	1.76
4		M 19000	405.2 405.2	405.2	70°	0.753	0.827	0.823	0.832	0.210			0.050	0.008				5.008	0.389				(0.034)	2.07
	R L	R 10000	426.8 426.9	426.85	62.30	0.376					0.205				0.180	0.201	0.209			4.909	0.374	0.011	0.028	1.45
	3+3	L 10000	425.8 425.8	425.8		0.377					0.214				0.182	0.204	0.212			4.921	0.376	0.016	0.040	1.45
5		M 12000	393.1 393.1	393.1	70°	0.490	0.725	0.838	0.836	0.210			0.023	0.004				3.260	0.165				(0.048)	1.35
	R L	R 6500	424.9 424.9	424.9	62.30	0.246					0.099				0.083	0.093	0.096			3.206	0.160	0.008	0.049	0.94
	5+5	L 6500	427.3 427.3	427.3		0.244					0.097				0.083	0.093	0.097			3.188	0.158	0.008	0.047	0.94
6		M 19000	343.9 344.0	343.95	69°	0.887	2.028	2.492	-0.259	0.210			0.067	0.011				5.898	0.540					2.40
	R L	R 19000	357.5 357.3	357.4	62.31	0.853					2.497	0.962			0.800	0.893	0.904			11.138	1.926	0.206	0.382	3.24
	X+8	L 900	425.3 425.9	425.6		0.034					-0.254	0.038			0.002	0.003	0.014			0.443	0.003	0.270	0.499	0.13
7		M 19000	330.7 330.7	330.7	69°	0.922	1.800	2.300	-0.285	0.210			0.071	0.012				6.135	0.584					2.50
	R L	R 19000	364.9 364.9	364.9	62.31	0.836					2.295	0.906			0.771	0.860	0.872			10.909	1.848	0.159	0.272	3.17
	X+7	L 1800	334.2 333.8	334.0		0.086					-0.290	0.094			0.012	0.014	0.026			1.129	0.020	0.249	0.426	0.33
8		M 19000	330.9 331.0	330.95	70°	0.922	1.635	2.119	0.274	0.210			0.071	0.012				6.131	0.584					2.53
	R L	R 17000	374.7 374.8	374.75	62.30	0.728					1.571	0.790			0.601	0.671	0.682			9.506	1.403	0.069	0.118	2.80
	1+6	L 4000	330.6 330.7	330.65		0.194					-0.274	0.210			0.054	0.060	0.072			2.535	0.100	0.138	0.236	0.75
9		M 19000	330.5 330.6	330.55	70°	0.923	0.940	1.327	0.044	0.210			0.071	0.012				6.139	0.585					2.53
	R L	R 16000	397.3 397.4	397.35	62.30	0.646					1.106	0.700			0.484	0.540	0.552			8.438	1.106	0.033	0.057	2.49
	1+5	L 6500	377.5 377.5	377.5	.	0.276					-0.177	0.300			0.103	0.115	0.127			3.608	0.202	0.079	0.135	1.06

<u>TABLE V-15</u> Form Loss Data for 45° Manifold without Tie-rod (Cont'd)

Test No.	Orifice No.	Weight of Water (lbs) from M. Main Pipe; R. Right Branch; L. Left Branch	Time Interval (secs)	Average Time Interval (secs)	Temperature in °F and Specific Weight of Water (lbs/cu.ft)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Central Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Vernier Correction (ft)	Pressure Head Difference (ft) between Main Pipe & Right Branch or Main Pipe & Left Branch	Discharge Ratio (Discharge in Branch Pipe/ Discharge in Main Pipe)	Friction Loss (ft). in Main Pipe for Length 3.375 ft.	Friction Loss (ft). in Main Pipe for Length ST	Friction Loss (ft). in Right or Left Branch for Length 9.0 ft.	Friction Loss (ft). in Right or Left Branch for Length TD_1 or TD_2	Total Friction Loss (ft)	Velocity in Main Pipe (ft/sec)	Velocity Head in Main Pipe (ft)	Velocity in Right or Left Branch (ft/sec)	Velocity Head in Right or Left Branch (ft)	Form Loss (ft)	(Average) Form Loss Coefficient	Reynold's Number ($x10^5$)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
10		M 19000	331.0 331.0	331.0	67°	0.921	2.038	2.313	1.426	0.210			0.071	0.012				6.128	0.583					2.43
	R L	R 16000	437.2 437.2	437.2	62.32	0.587					0.822	0.638			0.407	0.454	0.466			7.666	0.913	0.026	0.065	2.17
	2+5	L 8000	384.9 384.7	384.8		0.334					-0.065	0.362			0.145	0.162	0.174			4.355	0.295	0.050	0.086	1.23
11		M 19000	330.7 330.7	330.7	67°	0.922	1.444	1.592	1.054	0.210			0.071	0.012				6.134	0.584					2.43
	R L	R 12000	358.2 358.3	358.25	62.32	0.538					0.600	0.584			0.347	0.387	0.399			7.017	0.765	0.021	0.036	1.98
	2+4	L 9000	376.2 376.3	376.25		0.384					0.062	0.416			0.187	0.209	0.221			5.011	0.390	0.036	0.061	1.42
12		M 19000	359.8 359.9	359.85	67.5°	0.847	2.078	2.507	-0.265	0.210			0.061	0.010				5.637	0.493					2.25
	R L	R 19000	359.8 359.9	359.85	62.32	0.847					2.553				0.790	0.882	0.892			11.061	1.900	0.254	0.516	3.15
	X+0	L 0	-	-		0.000					-0.219				0.000	0.000	0.010			0.000	0.000	0.264	0.536	0.00
13		M 18000	388.6 388.7	388.65	66.5°	0.743	2.110	2.489	0.337	0.210			0.069	0.008				4.944	0.380					1.94
	R L	R 18000	388.6 388.7	388.65	62.33	0.743					1.983				0.623	0.696	0.704			9.700	1.461	0.198	0.521	2.72
	1+0	L 0	-	-		0.000					-0.169				0.000	0.000	0.008			0.000	0.000	0.202	0.534	0.00
14		M 14000	399.0 399.1	399.05	67°	0.563	2.194	2.501	1.240	0.210			0.030	0.005				3.746	0.218					1.48
	R L	R 14000	399.0 399.1	399.05	62.32	0.563					1.164				0.377	0.421	0.426			7.349	0.839	0.117	0.539	2.08
	2+0	L 0	-	-		0.000					-0.097				0.000	0.000	0.005			0.000	0.000	0.116	0.532	0.00
15		M 8000	345.0 345.1	345.05	67.5°	0.372	1.738	1.990	1.422	0.210			0.014	0.002				2.475	0.095					0.99
	R L	R 8000	345.0 345.1	345.05	62.32	0.372					0.526				0.178	0.199	0.201			4.857	0.366	0.054	0.565	1.38
	4+0	L 0	-	-		0.000					-0.042				0.000	0.000	0.002			0.000	0.000	0.051	0.534	0.00

TABLE V-16 Data of Hydraulic Power Losses in Wye Arrangements

A. 90° Wye Without Tie-rod

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.748				M 0.747			
R 0.748	1.000	0.322	0.322	R 0.552	0.740	0.149	0.173
L 0.000	0.000	0.526		L 0.195	0.260	0.243	
M 0.752				M 0.753			
R 0.740	0.984	0.290	0.294	R 0.479	0.638	0.148	0.158
L 0.012	0.016	0.521		L 0.273	0.362	0.175	
M 0.748				M 0.753			
R 0.717	0.957	0.264	0.274	R 0.444	0.591	0.126	0.138
L 0.032	0.043	0.493		L 0.308	0.409	0.155	
M 0.751				M 0.751			
R 0.674	0.895	0.210	0.233	R 0.416	0.555	0.134	0.137
L 0.078	0.105	0.429		L 0.334	0.445	0.140	
M 0.752				M 0.749			
R 0.595	0.791	0.166	0.193	R 0.374	0.499	0.146	0.134
L 0.157	0.209	0.296		L 0.375	0.501	0.123	

B. 90° Wye with TR3 Tie-rod

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.748				M 0.747			
R 0.748	1.000	0.530	0.530	R 0.553	0.740	0.279	0.287
L 0.000	0.000	0.582		L 0.194	0.260	0.309	
M 0.752				M 0.749			
R 0.739	0.984	0.486	0.487	R 0.476	0.636	0.366	0.320
L 0.012	0.016	0.578		L 0.273	0.364	0.240	
M 0.748				M 0.749			
R 0.716	0.957	0.469	0.473	R 0.441	0.588	0.399	0.331
L 0.032	0.043	0.556		L 0.308	0.412	0.234	

TABLE V-16 -- (Continued)

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.751				M 0.748			
R 0.673	0.895	0.390	0.401	R 0.414	0.553	0.358	0.307
L 0.078	0.105	0.496		L 0.334	0.447	0.244	
M 0.748				M 0.749			
R 0.592	0.791	0.307	0.320	R 0.375	0.501	0.323	0.317
L 0.156	0.209	0.367		L 0.374	0.499	0.312	

C. 60° Wye without Tie-rod

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.750				M 0.749			
R 0.750	1.000	0.292	0.292	R 0.555	0.742	0.060	0.100
L 0.000	0.000	0.554		L 0.195	0.258	0.213	
M 0.749				M 0.750			
R 0.737	0.984	0.274	0.278	R 0.480	0.640	0.052	0.077
L 0.012	0.016	0.548		L 0.271	0.360	0.121	
M 0.749				M 0.749			
R 0.717	0.958	0.194	0.207	R 0.416	0.556	0.057	0.069
L 0.034	0.042	0.518		L 0.332	0.444	0.084	
M 0.750				M 0.750			
R 0.673	0.897	0.135	0.166	R 0.376	0.501	0.073	0.069
L 0.079	0.103	0.434		L 0.374	0.499	0.065	
M 0.752							
R 0.596	0.793	0.086	0.126				
L 0.157	0.207	0.281					

TABLE V-16 -- (Continued)

D. 60^{o} Wye with TR3 Tie-rod

Q (cfs)	Qb/Qm	K	P
M 0.749			
R 0.749	1.000	0.454	0.454
L 0.000	0.000	0.625	
M 0.748			
R 0.736	0.984	0.426	0.428
L 0.012	0.016	0.612	
M 0.745			
R 0.712	0.957	0.402	0.409
L 0.032	0.043	0.590	
M 0.747			
R 0.669	0.896	0.333	0.351
L 0.078	0.104	0.509	
M 0.746			
R 0.509	0.682	0.268	0.240
L 0.238	0.318	0.180	
M 0.744			
R 0.438	0.588	0.311	0.237
L 0.307	0.412	0.132	
M 0.742			
R 0.411	0.553	0.294	0.236
L 0.331	0.447	0.164	
M 0.750			
R 0.375	0.500	0.232	0.230
L 0.375	0.500	0.227	

E. 45^{o} Wye without Tie-rod

Q (cfs)	Qb/Qm	K	P
M 0.844			
R 0.844	1.000	0.484	0.484
L 0.000	0.000	0.538	
M 0.898			
R 0.863	0.960	0.390	0.394
L 0.035	0.040	0.499	
M 0.922			
R 0.836	0.906	0.270	0.284
L 0.086	0.094	0.424	
M 0.923			
R 0.729	0.789	0.130	0.152
L 0.193	0.211	0.236	
M 0.922			
R 0.646	0.700	0.063	0.088
L 0.275	0.300	0.146	
M 0.923			
R 0.588	0.637	0.035	0.059
L 0.334	0.363	0.102	
M 0.923			
R 0.540	0.585	0.028	0.050
L 0.382	0.415	0.081	
M 0.923			
R 0.462	0.501	0.041	0.046
L 0.460	0.499	0.051	

TABLE V-17 Data of Hydraulic Power Losses in Manifold Arrangements

A. 90° Manifold without Tie-rod

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.750				M 0.751			
R 0.750	1.000	0.348	0.348	R 0.555	0.736	0.177	0.206
L 0.000	0.000	0.541		L 0.197	0.264	0.286	
M 0.750				M 0.750			
R 0.739	0.984	0.320	0.323	R 0.478	0.637	0.170	0.193
L 0.012	0.016	0.532		L 0.272	0.363	0.234	
M 0.750				M 0.751			
R 0.720	0.962	0.315	0.323	R 0.442	0.590	0.175	0.192
L 0.029	0.038	0.521		L 0.308	0.410	0.216	
M 0.750				M 0.750			
R 0.672	0.895	0.235	0.258	R 0.417	0.557	0.182	0.203
L 0.079	0.105	0.457		L 0.332	0.443	0.207	
M 0.752				M 0.751			
R 0.594	0.788	0.190	0.221	R 0.375	0.499	0.188	0.184
L 0.159	0.212	0.339		L 0.376	0.501	0.180	

B. 90° Manifold with TR3 Tie-rod

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.750				M 0.750			
R 0.750	1.000	0.500	0.500	R 0.447	0.636	0.383	0.349
L 0.000	0.000	0.588		L 0.273	0.364	0.289	
M 0.750				M 0.750			
R 0.718	0.956	0.445	0.450	R 0.441	0.588	0.405	0.353
L 0.033	0.044	0.562		L 0.309	0.412	0.280	
M 0.749				M 0.750			
R 0.671	0.895	0.376	0.390	R 0.417	0.556	0.370	0.333
L 0.079	0.105	0.514		L 0.333	0.444	0.286	

TABLE V-17 -- (Continued)

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.751				M 0.751			
R 0.592	0.789	0.320	0.337	R 0.374	0.499	0.318	0.315
L 0.158	0.211	0.403		L 0.376	0.501	0.313	
M 0.750							
R 0.554	0.739	0.301	0.314				
L 0.196	0.261	0.351					

C. 60° Manifold without Tie-rod

Q (cfs)	Qb/Qm	K	P	Q (cfs)	Qb/Qm	K	P
M 0.750				M 0.749			
R 0.750	1.000	0.283	0.283	R 0.478	0.638	0.057	0.085
L 0.000	0.000	0.546		L 0.271	0.362	0.134	
M 0.750				M 0.751			
R 0.718	0.956	0.207	0.220	R 0.443	0.591	0.052	0.072
L 0.033	0.044	0.514		L 0.307	0.409	0.102	
M 0.749				M 0.749			
R 0.672	0.895	0.144	0.175	R 0.418	0.559	0.061	0.072
L 0.078	0.105	0.445		L 0.330	0.441	0.086	
M 0.751				M 0.750			
R 0.593	0.788	0.057	0.107	R 0.375	0.499	0.055	0.060
L 0.159	0.212	0.294		L 0.376	0.501	0.065	
M 0.749							
R 0.554	0.739	0.063	0.104				
L 0.196	0.261	0.221					

TABLE V-17 -- (Continued)

D. 60° Manifold with TR3 Tie-rod

Q (cfs)	Qb/Qm	K	P
M 0.750			
R 0.750	1.000	0.463	0.463
L 0.000	0.000	0.626	
M 0.751			
R 0.718	0.955	0.419	0.427
L 0.034	0.045	0.595	
M 0.750			
R 0.671	0.893	0.347	0.365
L 0.080	0.107	0.518	
M 0.750			
R 0.592	0.788	0.284	0.299
L 0.159	0.212	0.354	
M 0.750			
R 0.555	0.739	0.264	0.266
L 0.196	0.261	0.274	
M 0.750			
R 0.477	0.635	0.297	0.239
L 0.274	0.365	0.140	
M 0.749			
R 0.416	0.557	0.306	0.229
L 0.332	0.443	0.132	
M 0.750			
R 0.375	0.499	0.201	0.218
L 0.376	0.501	0.236	

E. 45° Manifold without Tie-rod

Q (cfs)	Qb/Qm	K	P
M 0.847			
R 0.847	1.000	0.516	0.516
L 0.000	0.000	0.536	
M 0.887			
R 0.853	0.962	0.382	0.386
L 0.034	0.038	0.499	
M 0.922			
R 0.836	0.906	0.272	0.286
L 0.086	0.094	0.426	
M 0.922			
R 0.728	0.790	0.118	0.143
L 0.194	0.210	0.236	
M 0.922			
R 0.646	0.700	0.057	0.080
L 0.276	0.300	0.135	
M 0.921			
R 0.587	0.638	0.045	0.060
L 0.334	0.362	0.086	
M 0.922			
R 0.538	0.584	0.036	0.046
L 0.384	0.416	0.061	
M 0.921			
R 0.459	0.499	0.031	0.037
L 0.461	0.501	0.041	

TABLE A-1 Distance from Theoretical Center of Elbows to Piezometric Rings on Straight Pipe *

Particulars	Distance SS' ft.	Distance S'C ft.	Distance CF ft.	Distance FD ft.	Distance SD ft.
45^o elbows	0.167	0.641	0.5	8.833	10.141
30^o elbows	0.167	0.333	0.333	8.833	9.666
$22\frac{1}{2}^o$ elbows	0.167	0.370	0.238	8.833	9.608

Note: the average radius of each elbow is 15 inches.

* See Figure A-2

TABLE A-2 Head Loss Data for 45° Elbows

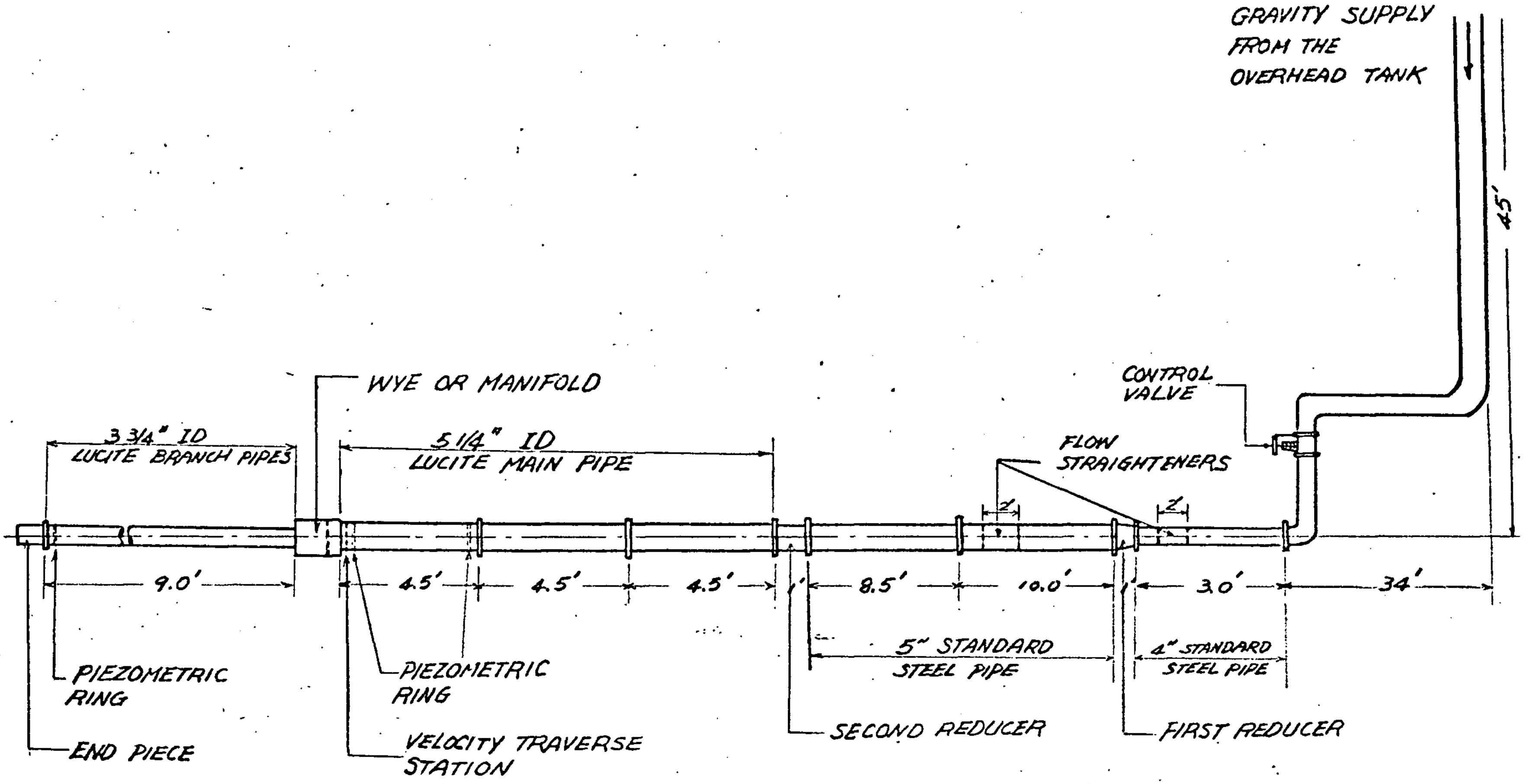
Description	Weight of Water from Main Pipe (lbs)	Time Interval (secs)	Ave. Time Interval (secs)	Temp. in °F & Specific Wt. of Water (lb/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Pressure Head Difference (ft) (Vernier Correction 0.210 ft.)	Total Friction Loss (ft)	Velocity Head Correction (ft)	Elbow Loss (ft)	Elbow Loss Coefficient
1	2	3	4	5	6	7	8	9	10	11	12	13
Right Elbow	19000	334.3 334.3	334.3	69° 62.31	0.912	0.664	-0.242	1.116	1.018	0.041	0.139	0.063
	15000	319.1 319.1	319.1	69.5° 62.31	0.754	0.897	0.314	0.793	0.722	0.028	0.099	0.066
	10000	316.3 316.3	316.3	69.5° 62.31	0.507	0.987	0.807	0.390	0.352	0.013	0.051	0.075
	6500	334.4 334.4	334.4	69.5° 62.31	0.312	1.804	1.851	0.163	0.146	0.004	0.022	0.086
Left Elbow	19000	330.3 330.4	330.35	70° 62.30	0.934	0.702	-0.225	1.137	1.040	0.042	0.139	0.062
	16000	341.3 341.3	341.3	70° 62.30	0.754	0.883	0.306	0.787	0.718	0.028	0.097	0.065
	10000	317.7 317.7	317.7	70° 62.30	0.506	0.928	0.752	0.386	0.349	0.012	0.049	0.073
	6500	335.4 335.4	335.4	70° 62.30	0.313	1.782	1.830	0.162	0.145	0.005	0.022	0.085

TABLE A-3 Head Loss Data for 30° Elbows

Description	Weight of Water from Main Pipe (lbs)	Time Interval (secs)	Ave. Time Interval (secs)	Temp. in °F & Specific Wt. of Water (lb/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Pressure Head Difference (ft) (Vernier Correction 0.210 ft.)	Total Friction Loss (ft)	Velocity Head Correction (ft)	Elbow Loss (ft)	Elbow Loss Coefficient
1	2	3	4	5	6	7	8	9	10	11	12	13
Right Elbow	19000	328.8 328.9	328.85	69.5° 62.31	0.927	0.551	-0.299	1.060	0.999	0.043	0.103	0.045
	15000	315.6 315.6	315.6	69.5° 62.31	0.763	0.798	0.262	0.746	0.702	0.028	0.073	0.047
	10000	318.6 318.7	318.65	69.5° 62.31	0.504	0.847	0.702	0.355	0.331	0.013	0.037	0.055
	6500	328.7 328.8	328.75	69.5° 62.31	0.317	1.575	1.630	0.155	0.143	0.005	0.017	0.063
Left Elbow	19000	326.6 326.7	326.65	69° 62.31	0.933	0.567	-0.293	1.070	1.011	0.043	0.101	0.044
	15000	319.2 319.2	319.2	69° 62.31	0.754	0.750	0.231	0.729	0.687	0.028	0.070	0.046
	10000	317.4 317.4	317.4	69° 62.31	0.506	0.862	0.714	0.358	0.333	0.012	0.037	0.055
	6500	332.8 332.8	332.8	69° 62.31	0.313	1.736	1.794	0.152	0.140	0.005	0.017	0.064

TABLE A-4 Head Loss Data for $22\frac{1}{2}^{o}$ Elbows

Description	Weight of Water from Main Pipe (lbs)	Time Interval (secs)	Ave. Time Interval (secs)	Temp. in ^{o}F & Specific Wt. of Water (lb/cu.ft.)	Discharge (cfs)	Hook Gauge Reading in Upstream Tank (ft)	Hook Gauge Reading in Downstream Tank (ft)	Pressure Head Difference (ft) (Vernier Correction 0.210 ft.)	Total Friction Loss (ft)	Velocity Head Correction (ft)	Elbow Loss (ft)	Elbow Loss Coefficient
1	2	3	4	5	6	7	8	9	10	11	12	13
Right Elbow	19000	331.1 331.1	331.1	69^{o} 62.31	0.922	0.647	-0.162	1.019	0.983	0.042	0.078	0.035
	15000	317.5 317.5	317.5	69^{o} 62.31	0.760	0.837	0.325	0.722	0.692	0.028	0.058	0.038
	10000	320.7 320.6	320.65	69.5^{o} 62.31	0.501	0.913	0.781	0.342	0.325	0.012	0.029	0.044
	6000	326.4 326.3	326.35	69.5^{o} 62.31	0.295	1.474	1.551	0.133	0.125	0.005	0.012	0.054
Left Elbow	19000	321.2 321.3	321.25	69.5^{o} 62.31	0.921	0.642	-0.172	1.024	0.980	0.041	0.085	0.038
	15000	321.1 321.0	321.05	69^{o} 62.31	0.750	0.802	0.302	0.710	0.676	0.027	0.061	0.041
	10000	318.6 318.7	318.65	69^{o} 62.31	0.504	0.942	0.803	0.349	0.329	0.013	0.033	0.049
	6000	322.4 322.5	322.45	69^{o} 62.31	0.299	1.530	1.603	0.137	0.128	0.004	0.014	0.058



ELEVATION

FIGURE I-1 Details of General Arrangement

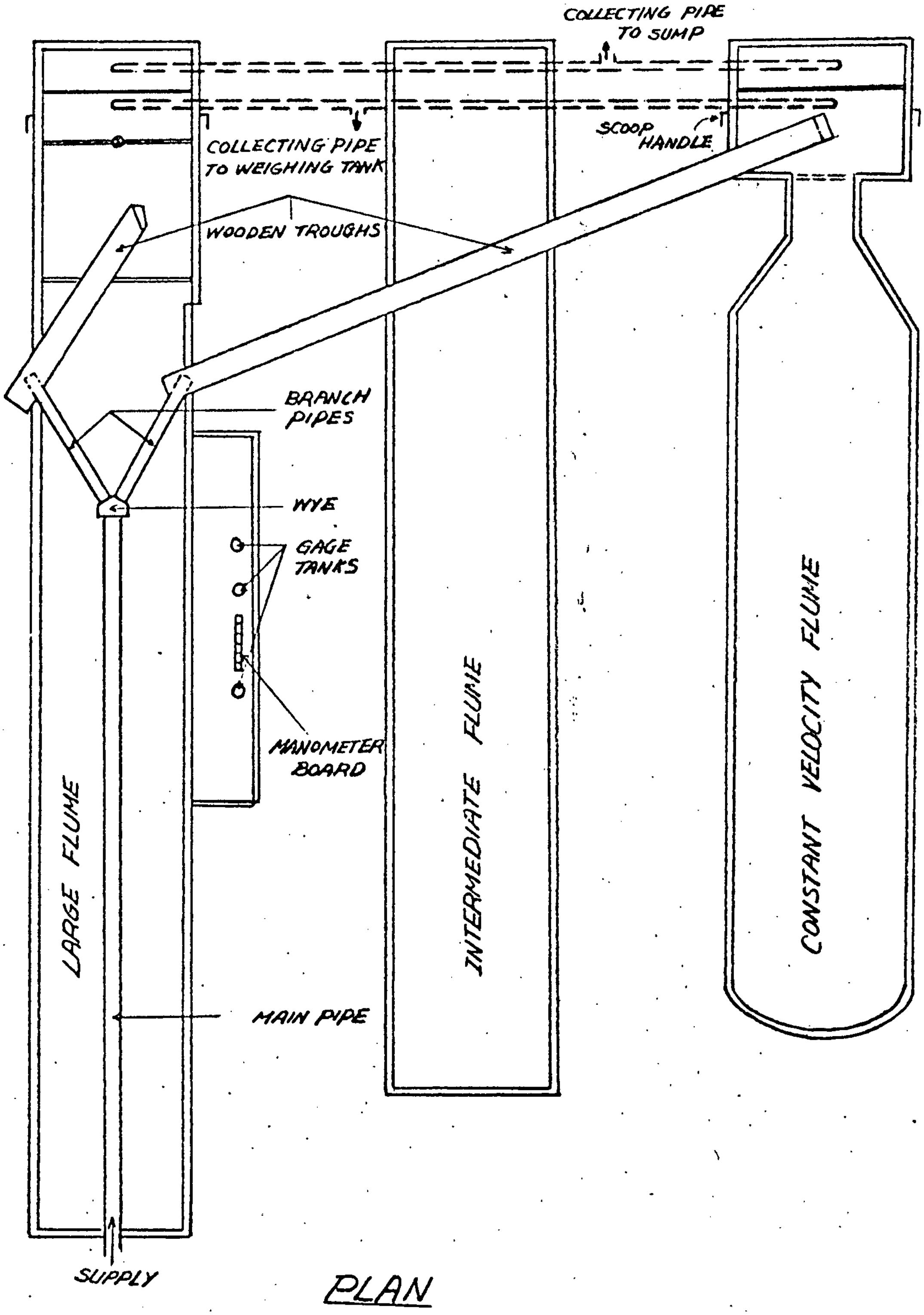


FIGURE I-2 Details of Wye Arrangement

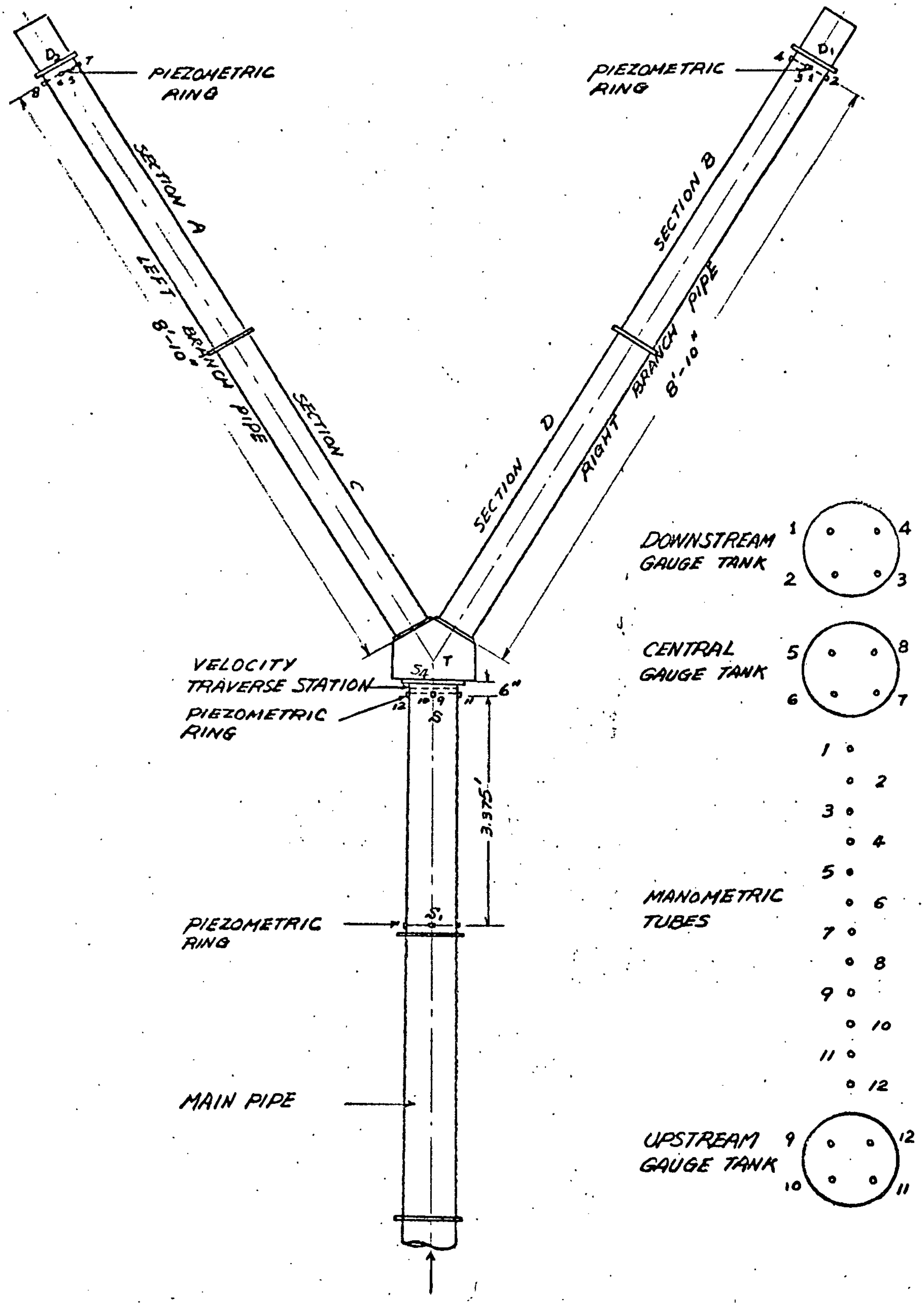


FIGURE I-3 Model Layout and Manometric Locations for Wye Arrangement

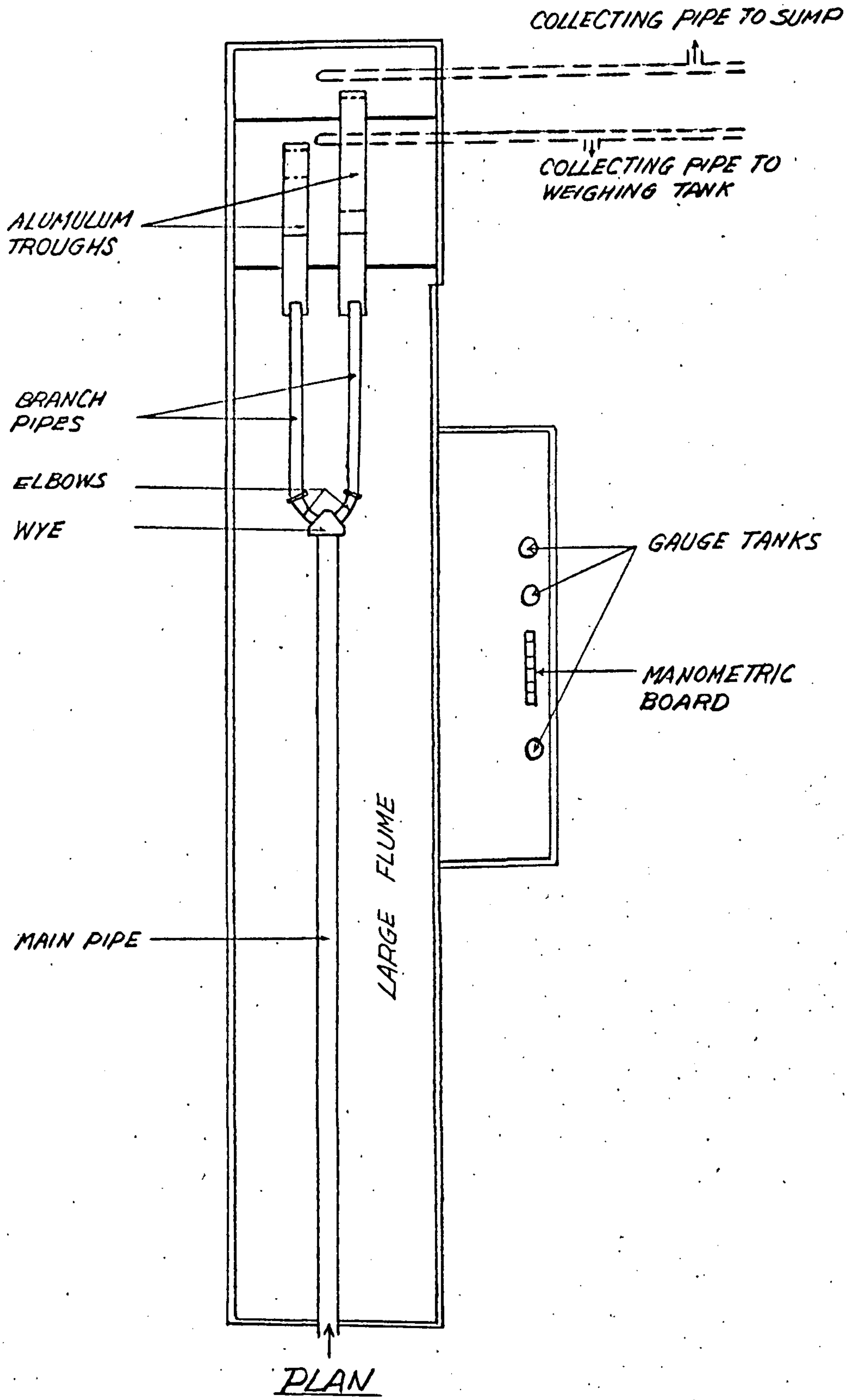


FIGURE I-4 Details of Manifold Arrangement

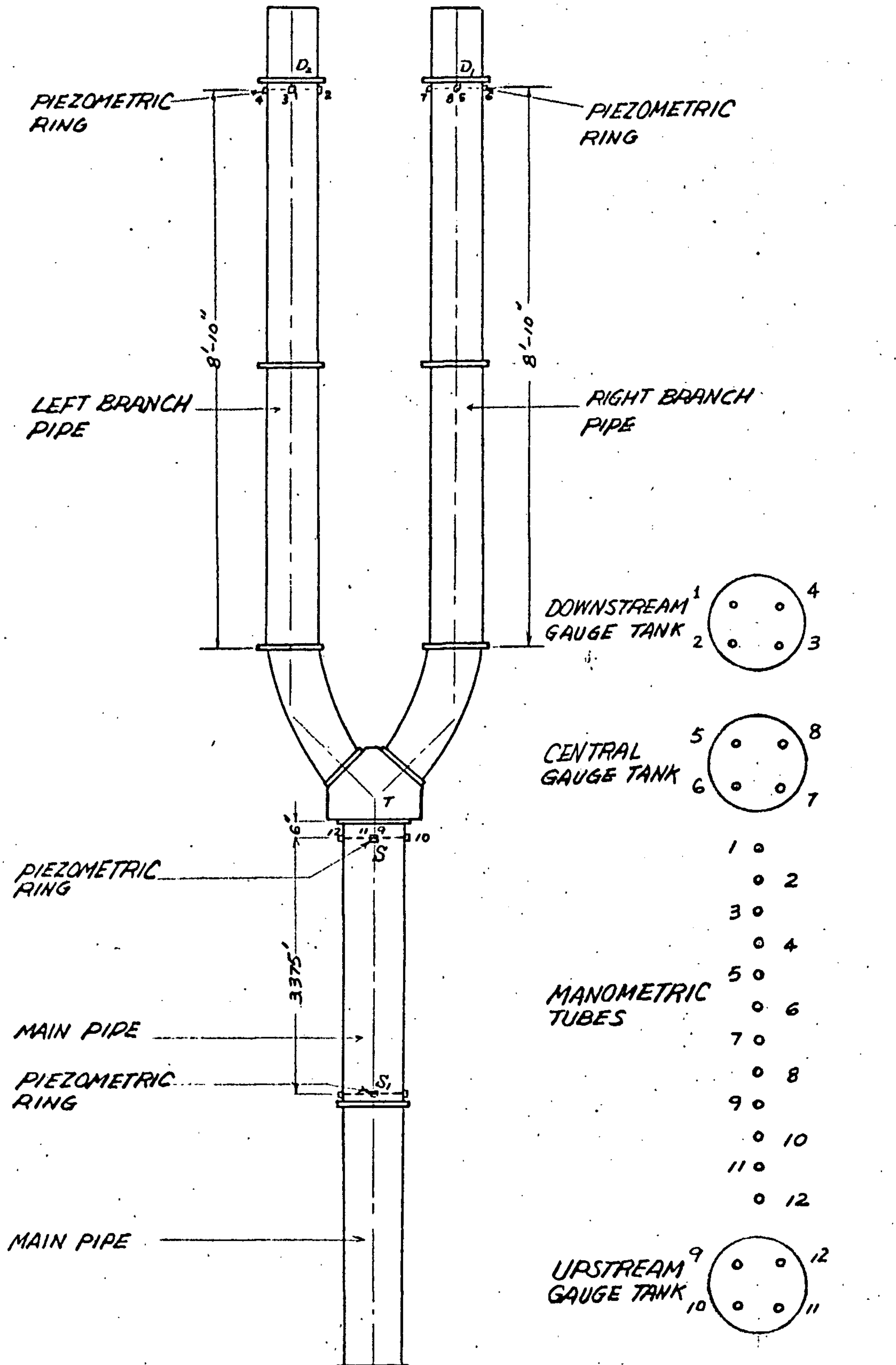


FIGURE I-5 Model Layout and Manometric Locations for Manifold Arrangement

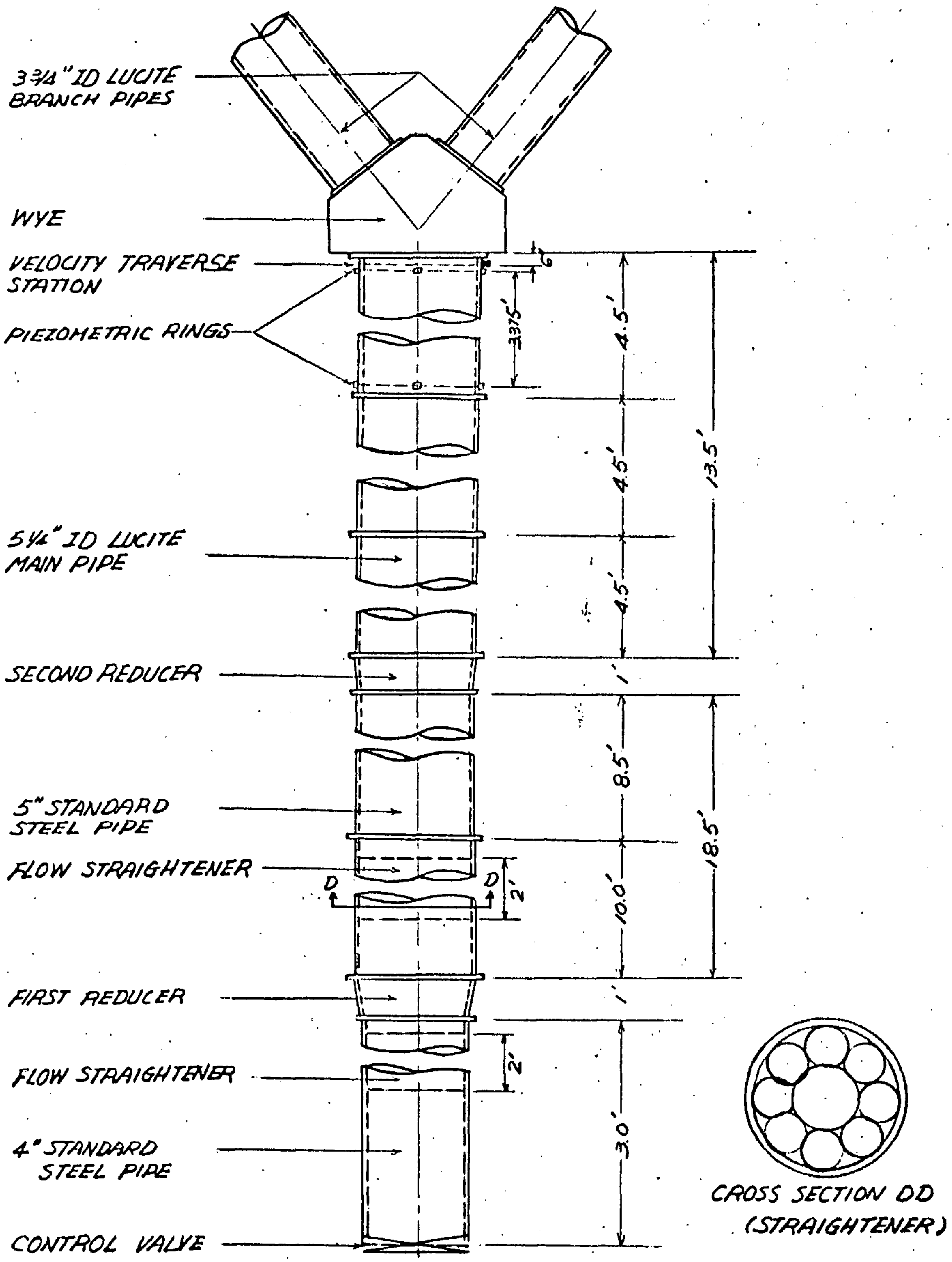


FIGURE I-6 Details of Main Pipe from Control Valve to Wye

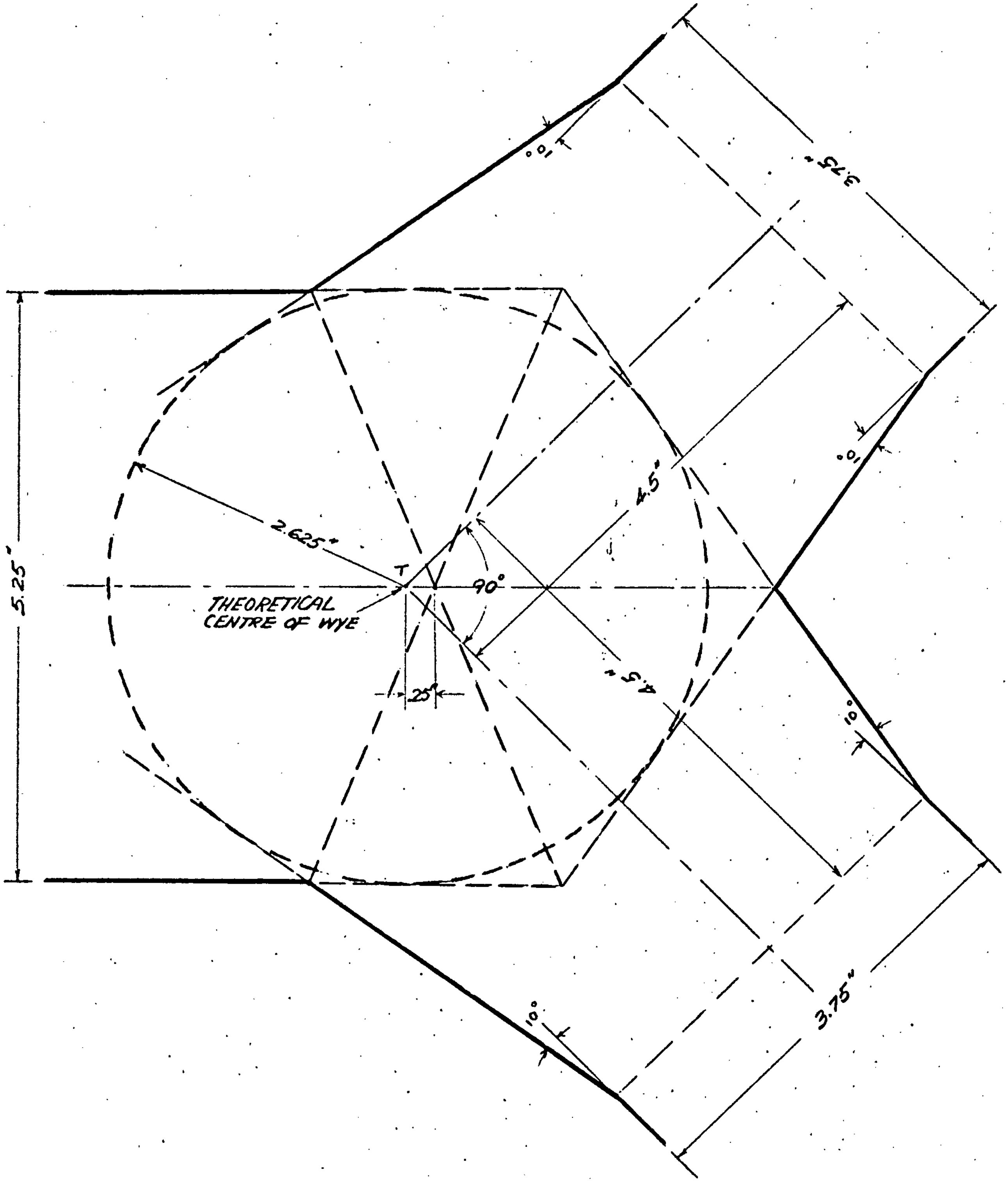
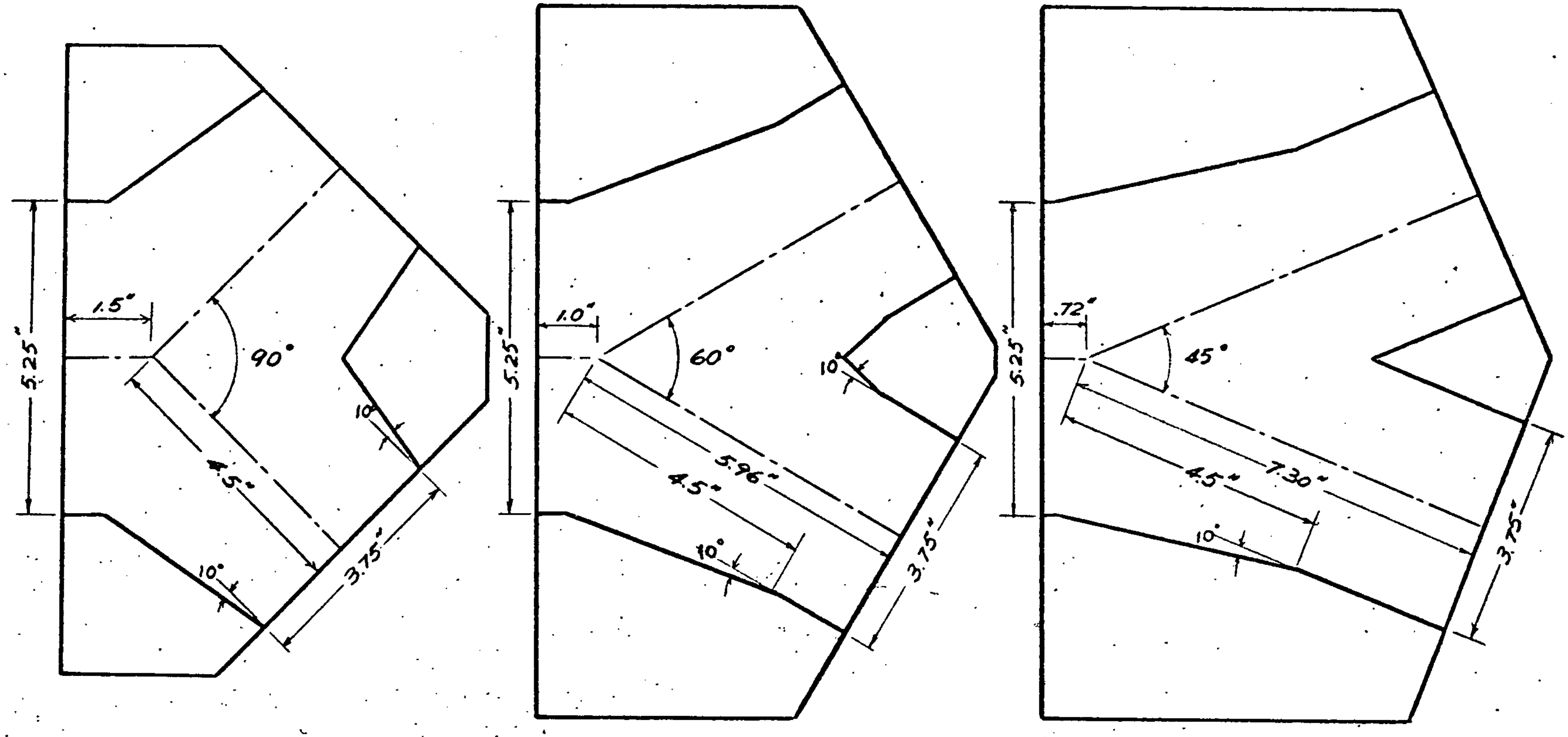
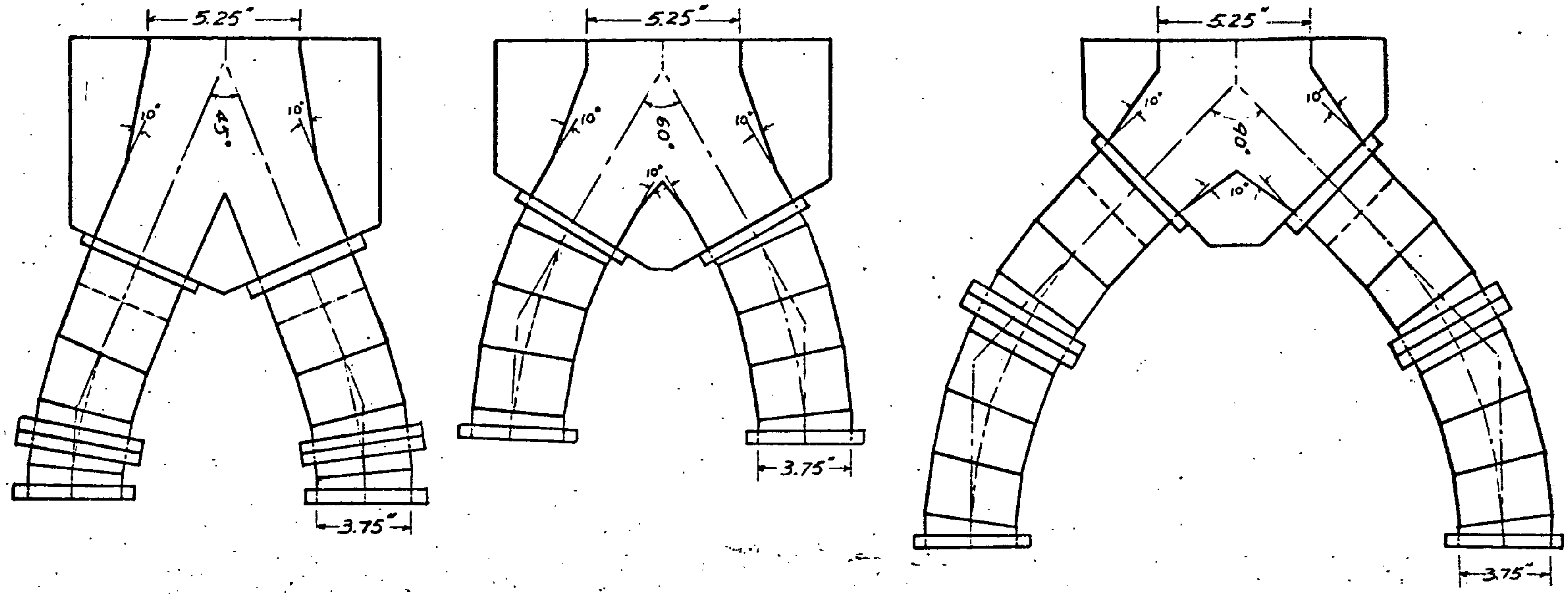


FIGURE I-7 Geometrical Details of 90° Tapered Wye



90° TAPERED WYE   60° TAPERED WYE   45° TAPERED WYE

FIGURE I-8 Details of Wye



45° MANIFOLD   60° MANIFOLD   90° MANIFOLD

FIGURE I-9 Details of Manifolds

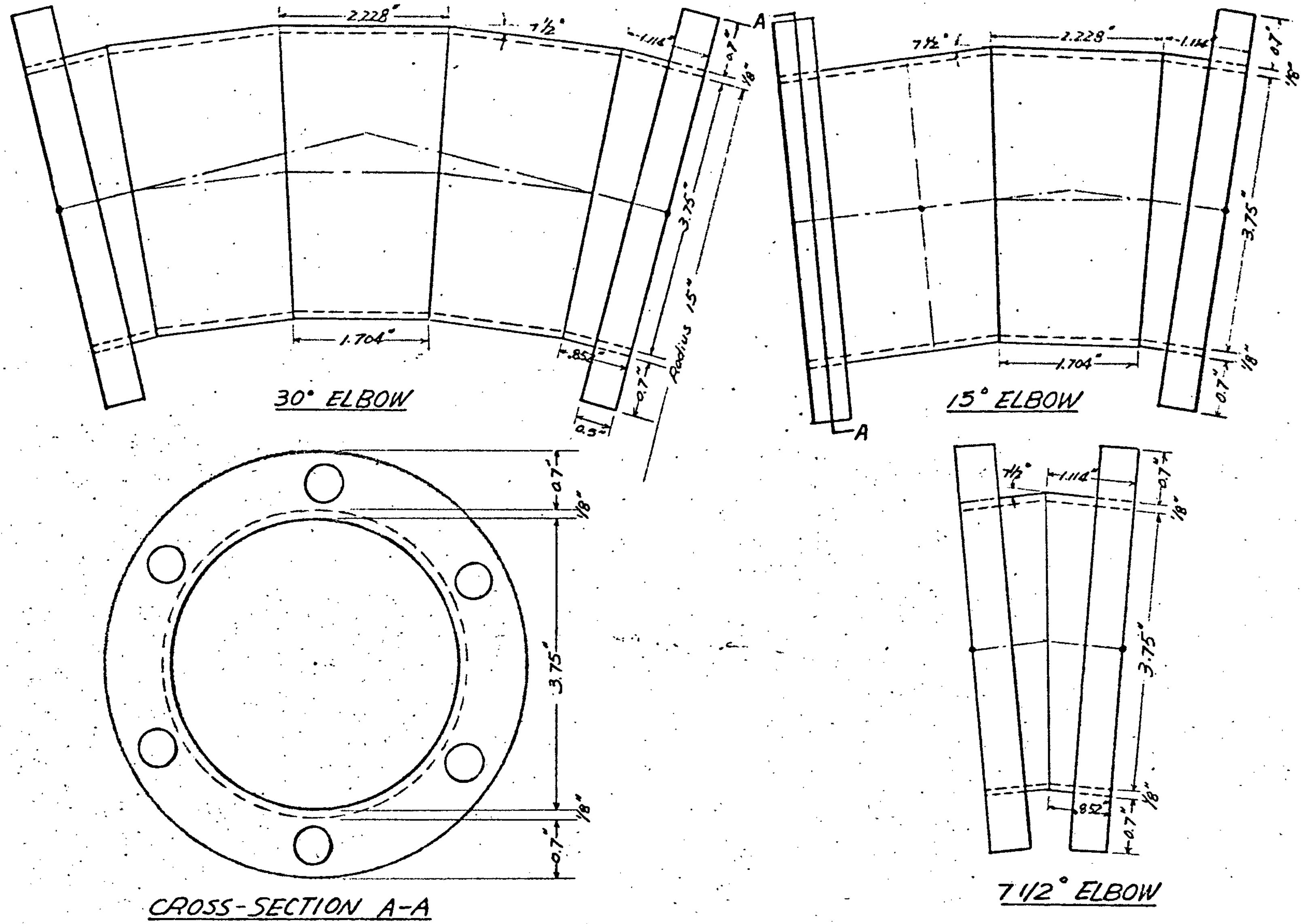


FIGURE I-10 Details of Elbows

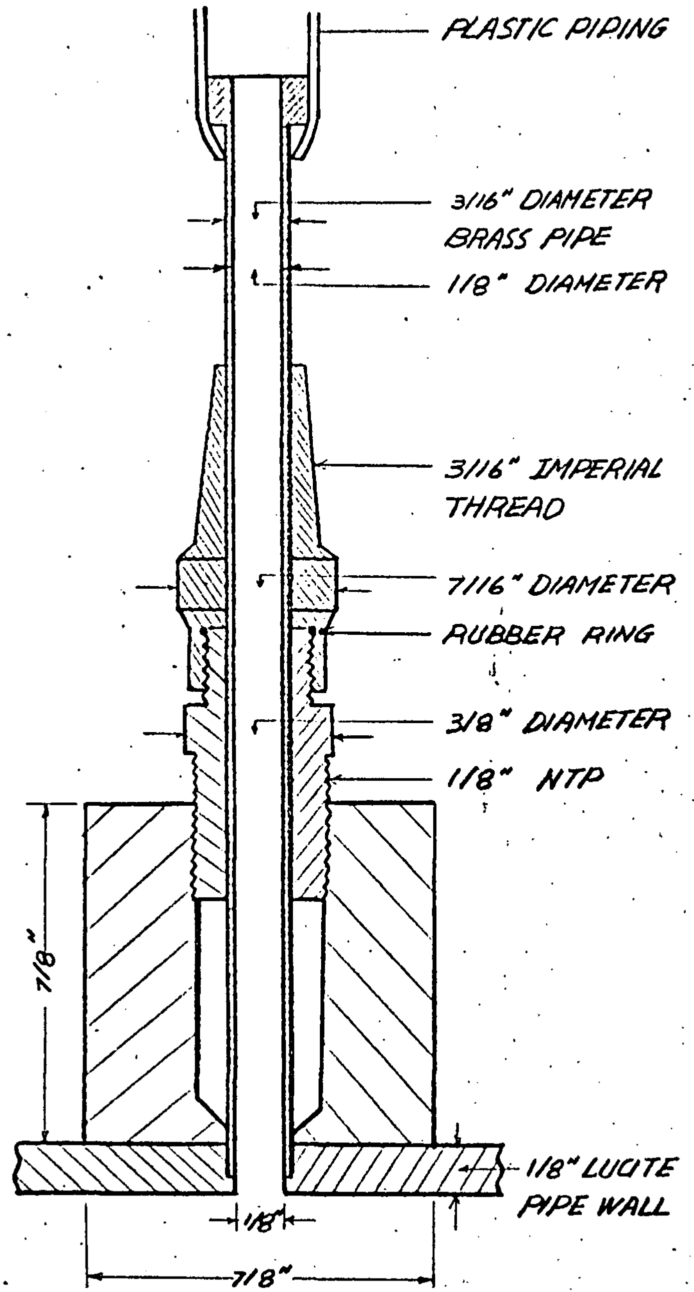


FIGURE I-11 Details of Pressure Tap

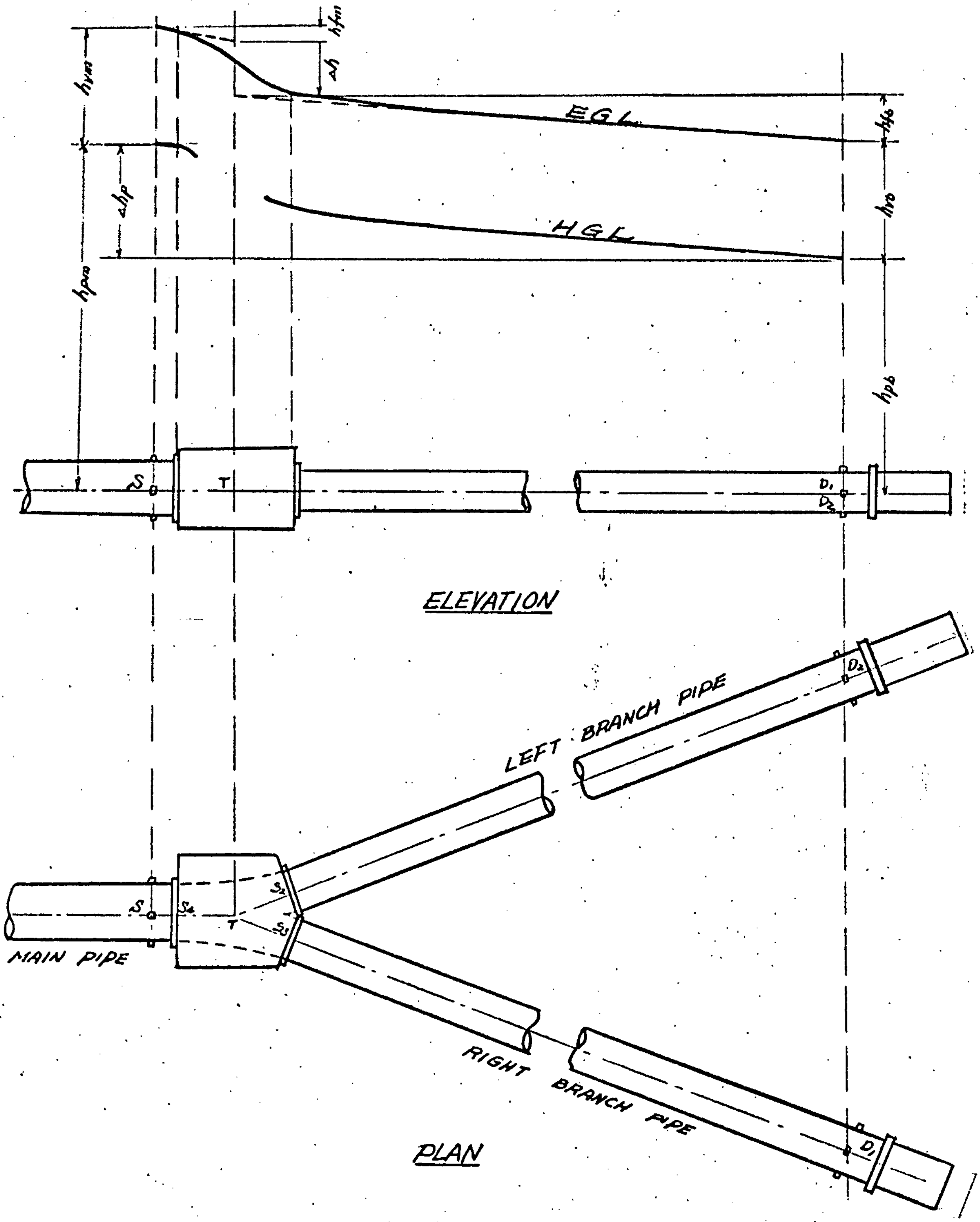


FIGURE II-1 Hydraulic & Energy Gradient Lines for Wye

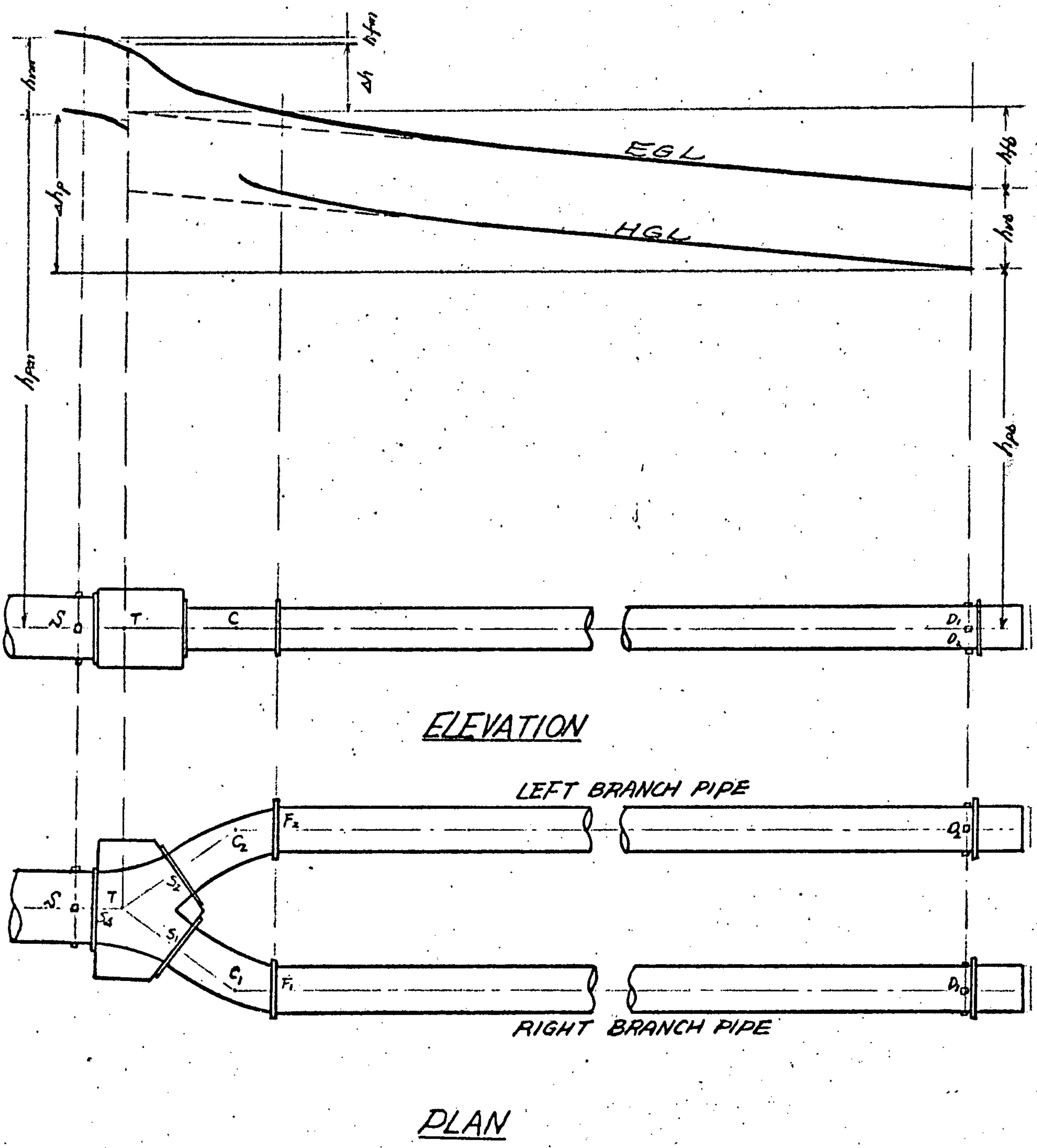


FIGURE II-2 Hydraulic & Energy Gradient Lines for Manifold

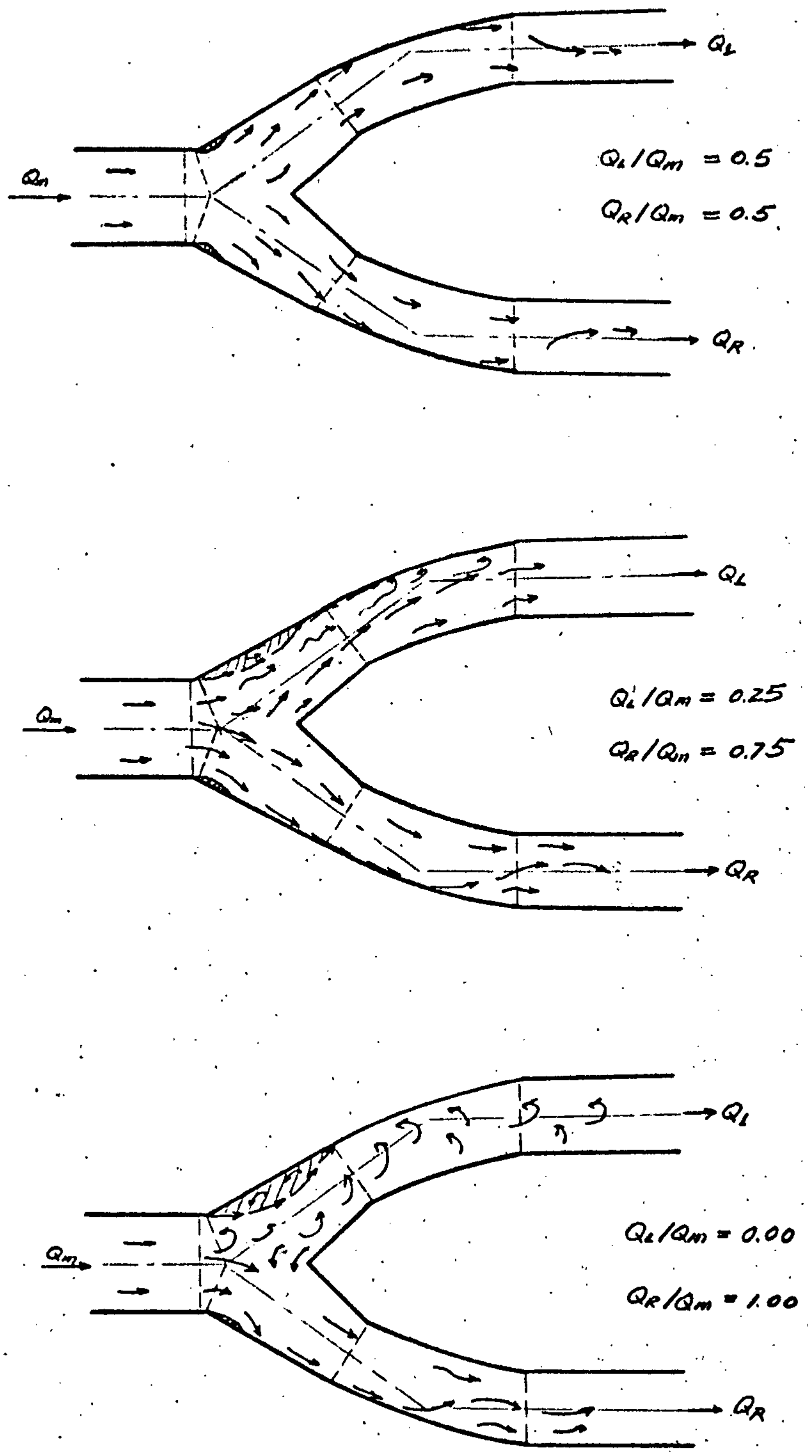


FIGURE III-1 Flow Patterns in Manifold without Tie-rod

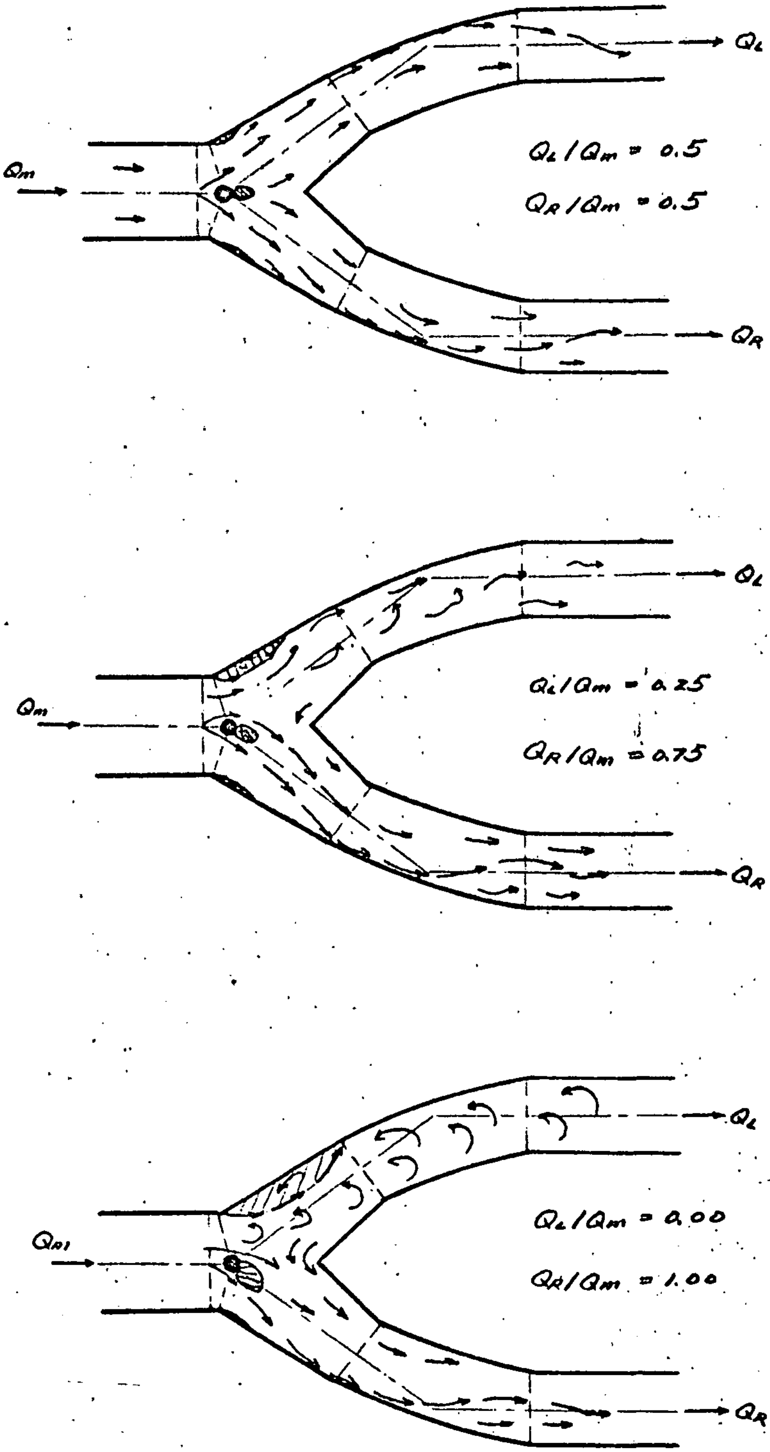


FIGURE III-2 Flow Patterns in Manifold with Tie-rod

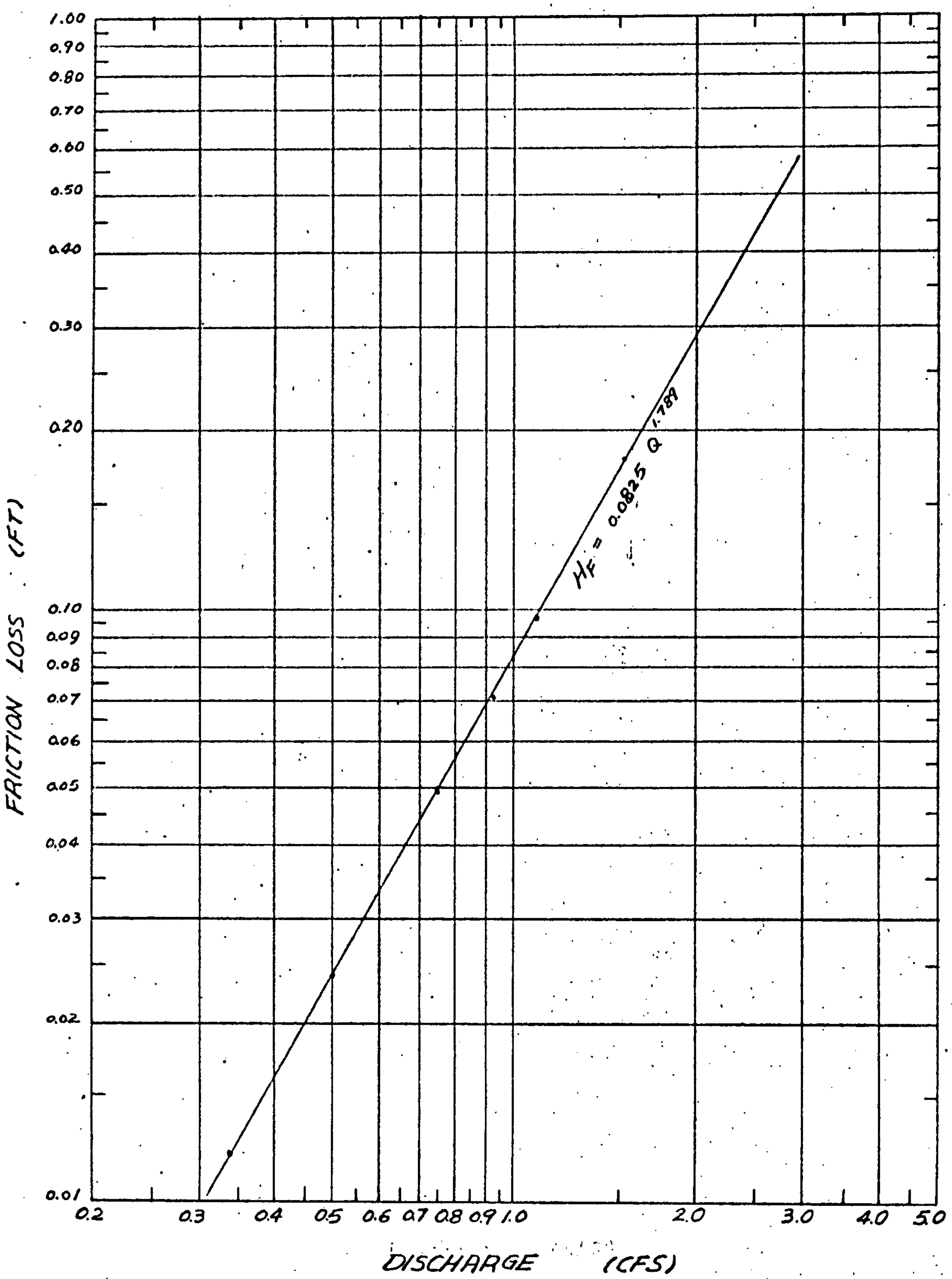


FIGURE IV-1 Skin Friction Loss in Main Pipe

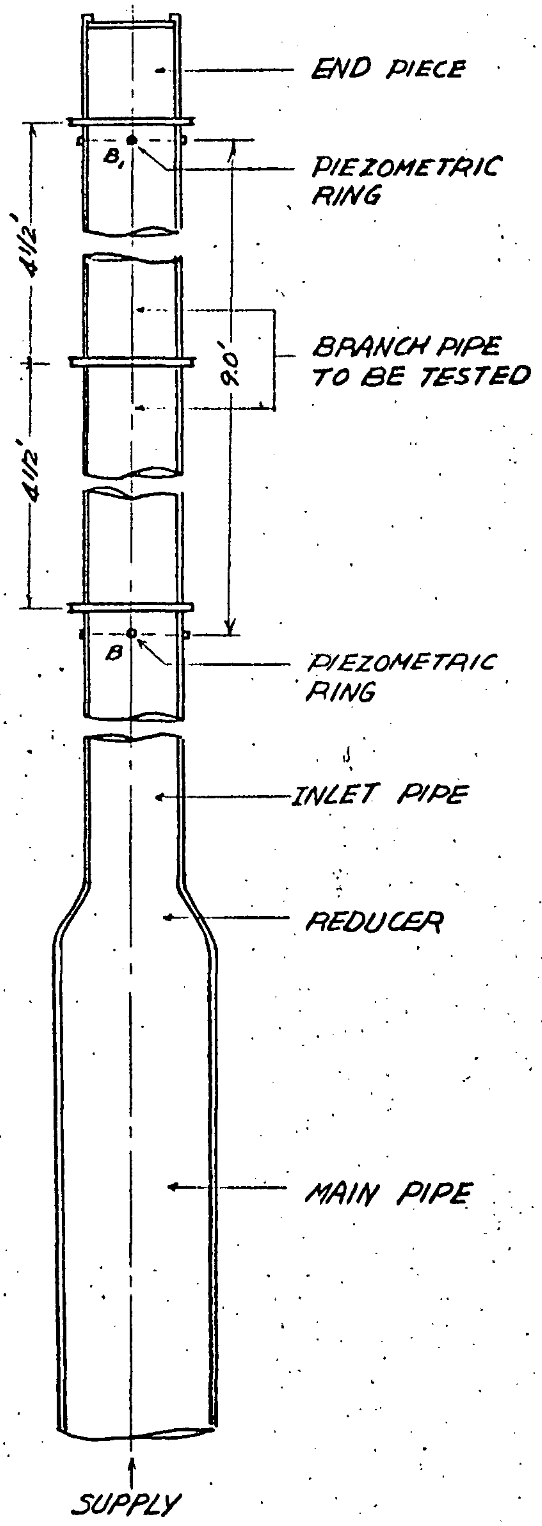


FIGURE IV-2 Experimental Set-up for Measuring Skin Friction Losses in Branch Pipes

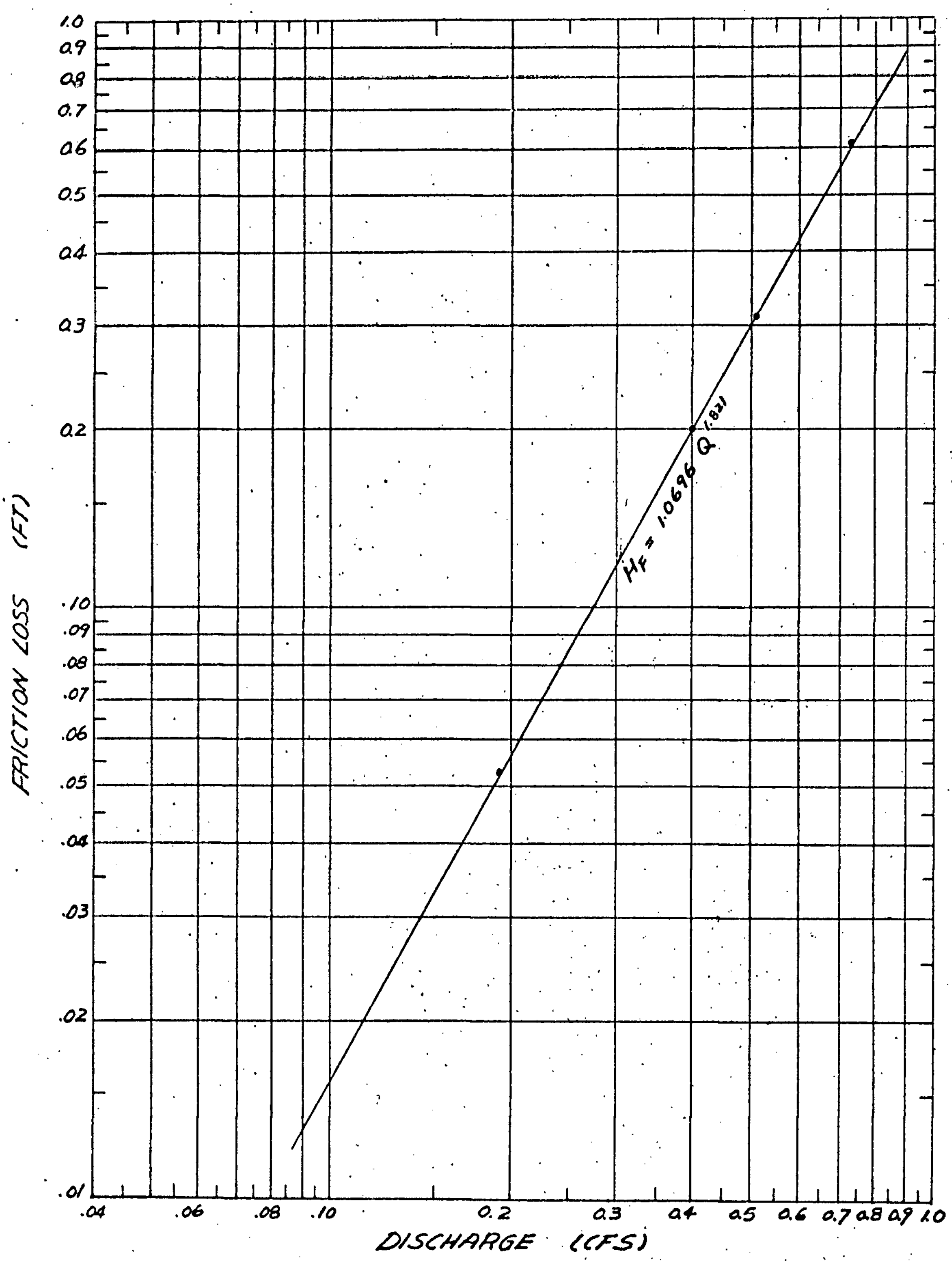


FIGURE IV-3 Skin Friction Loss in Right Branch Pipe

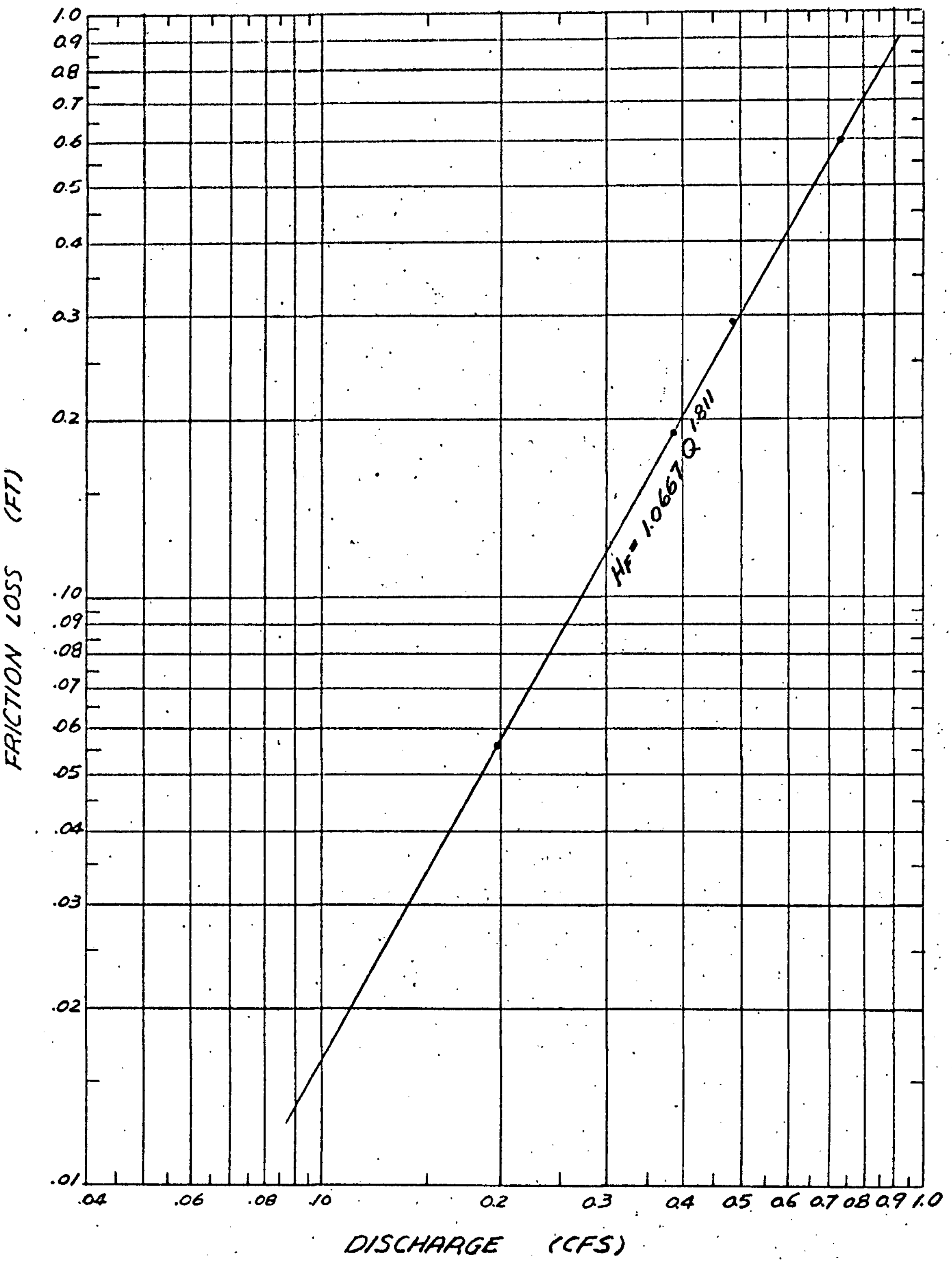


FIGURE IV-4 Skin Friction Loss in Left Branch Pipe

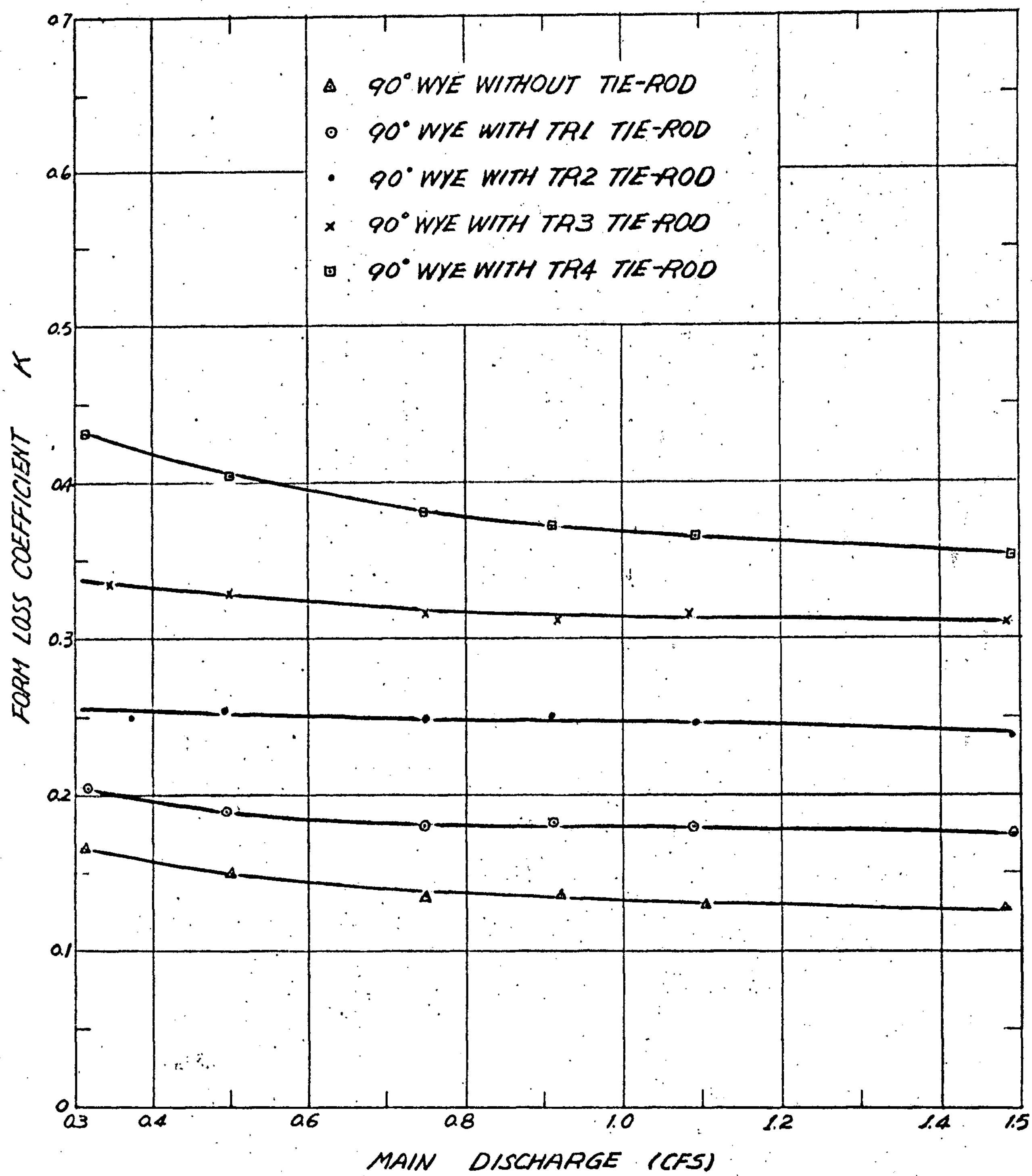


FIGURE V-1 Form Loss Coefficients for 90° Wye (Symmetrical Flow)

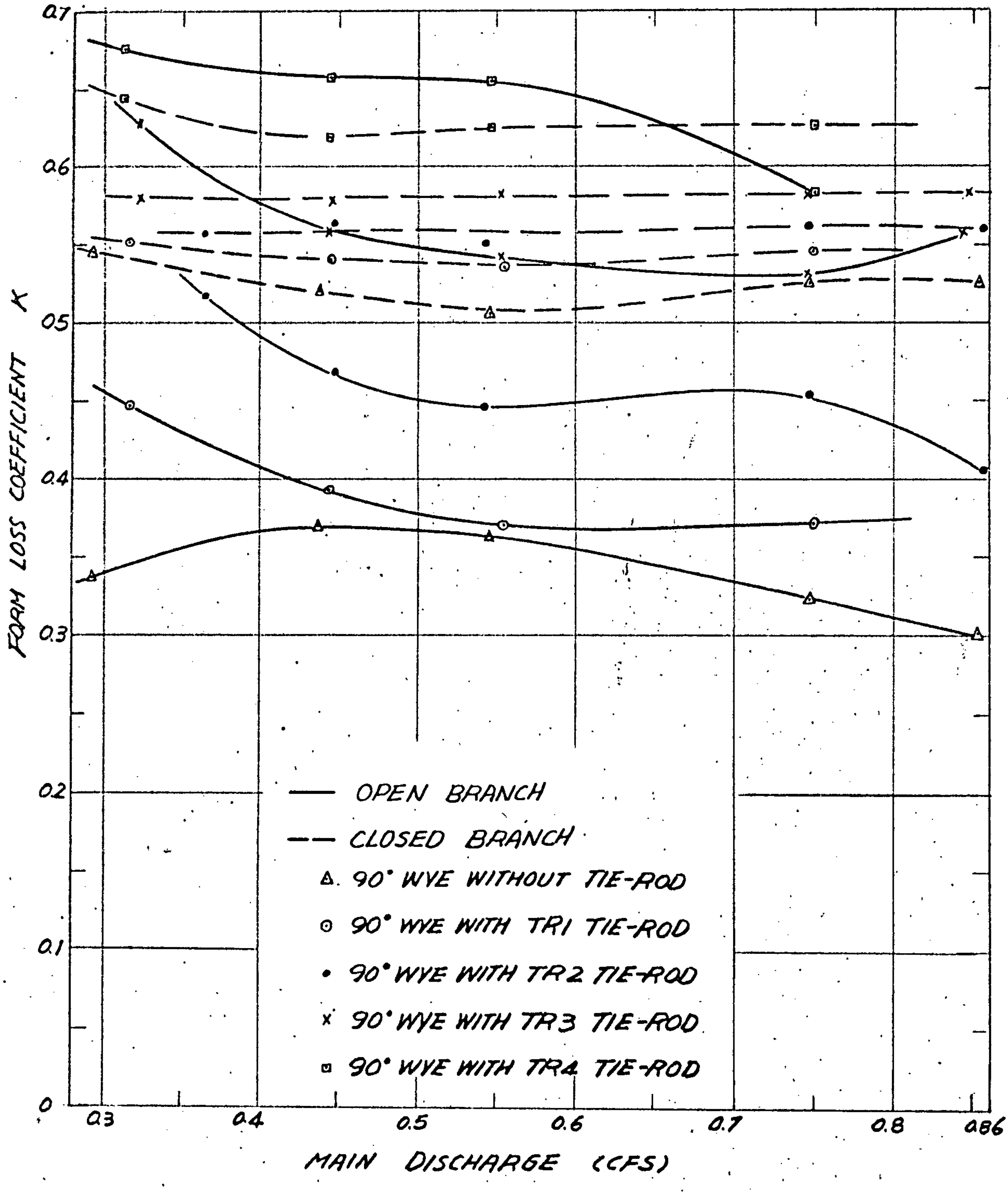


FIGURE V-2 Form Loss Coefficients for 90° Wye (One-leg Flow)

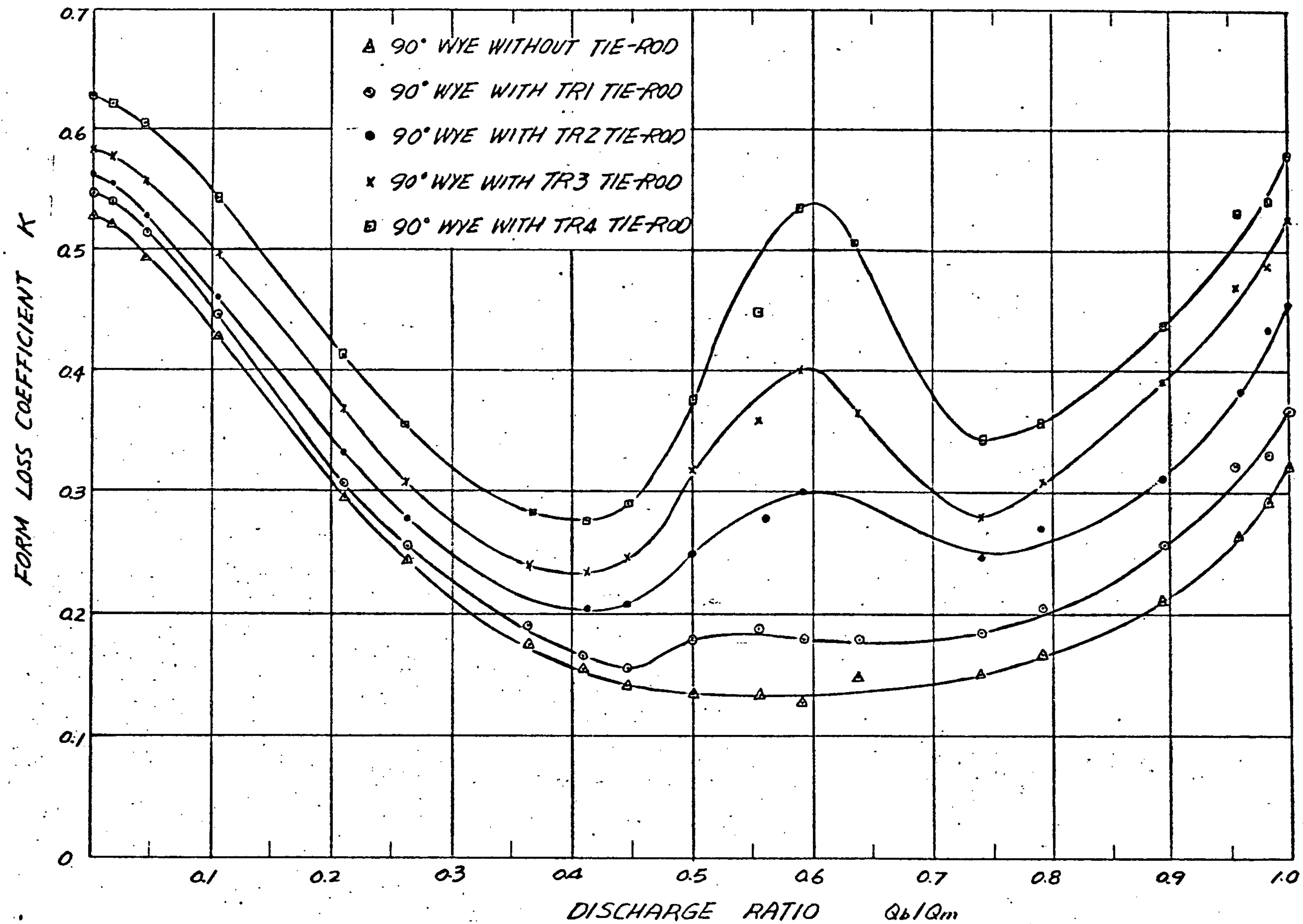


FIGURE V-3 Form Loss Coefficients for 90° Wye (Unsymmetrical Flow)

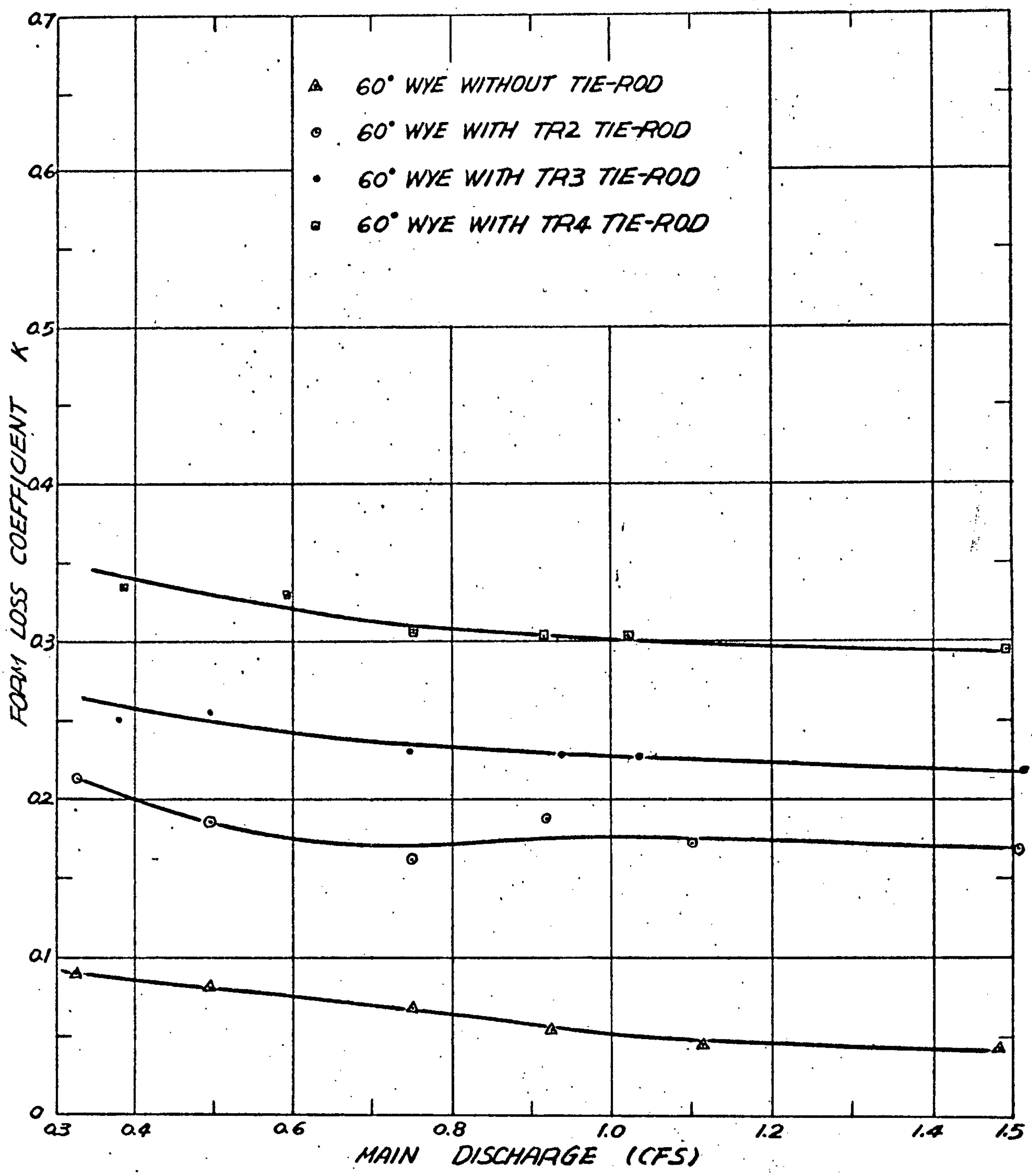


FIGURE V-4 Form Loss Coefficients for 60° Wye (Symmetrical Flow)

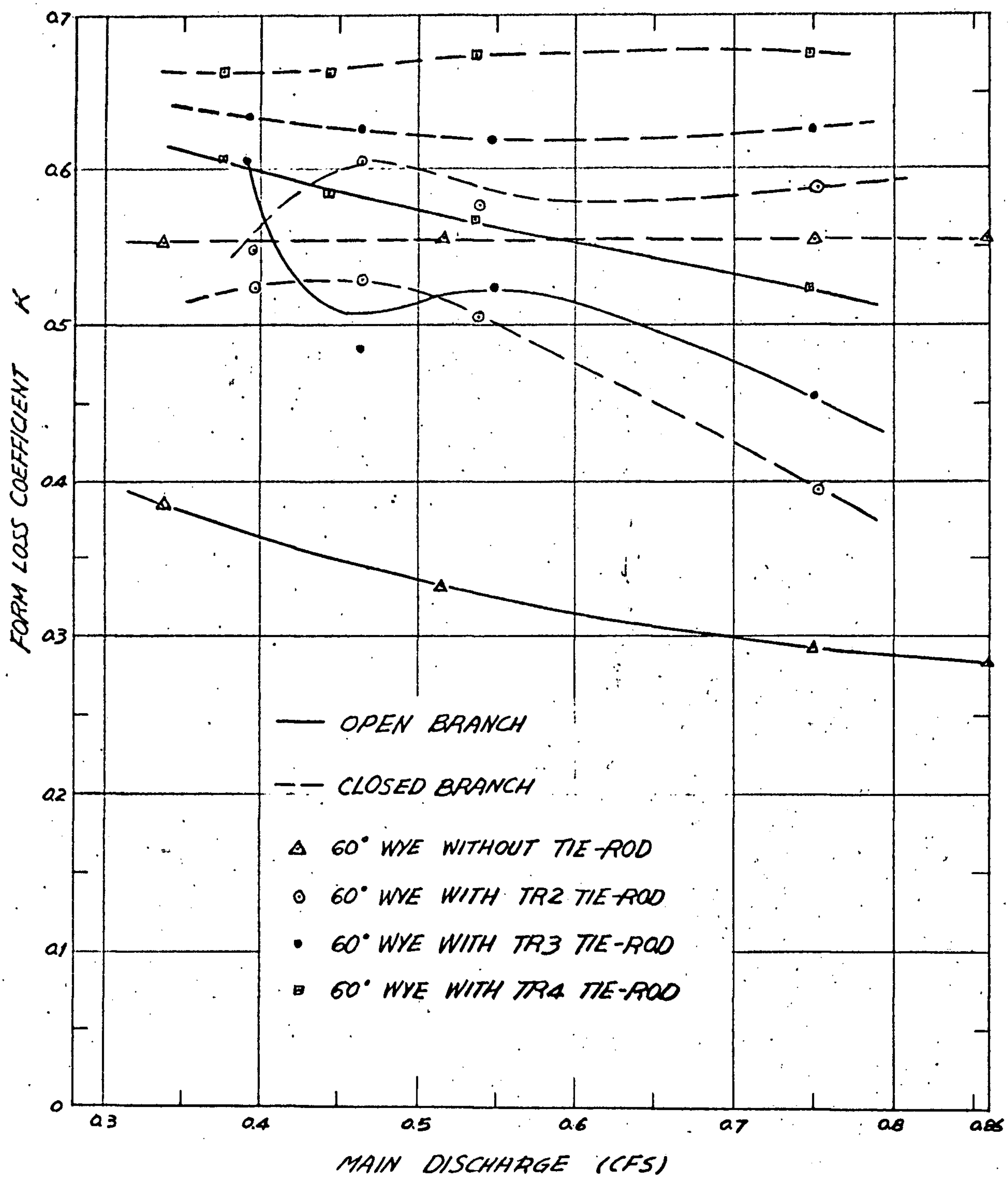


FIGURE V-5 Form Loss Coefficients for 60° Wye (One-leg Flow)

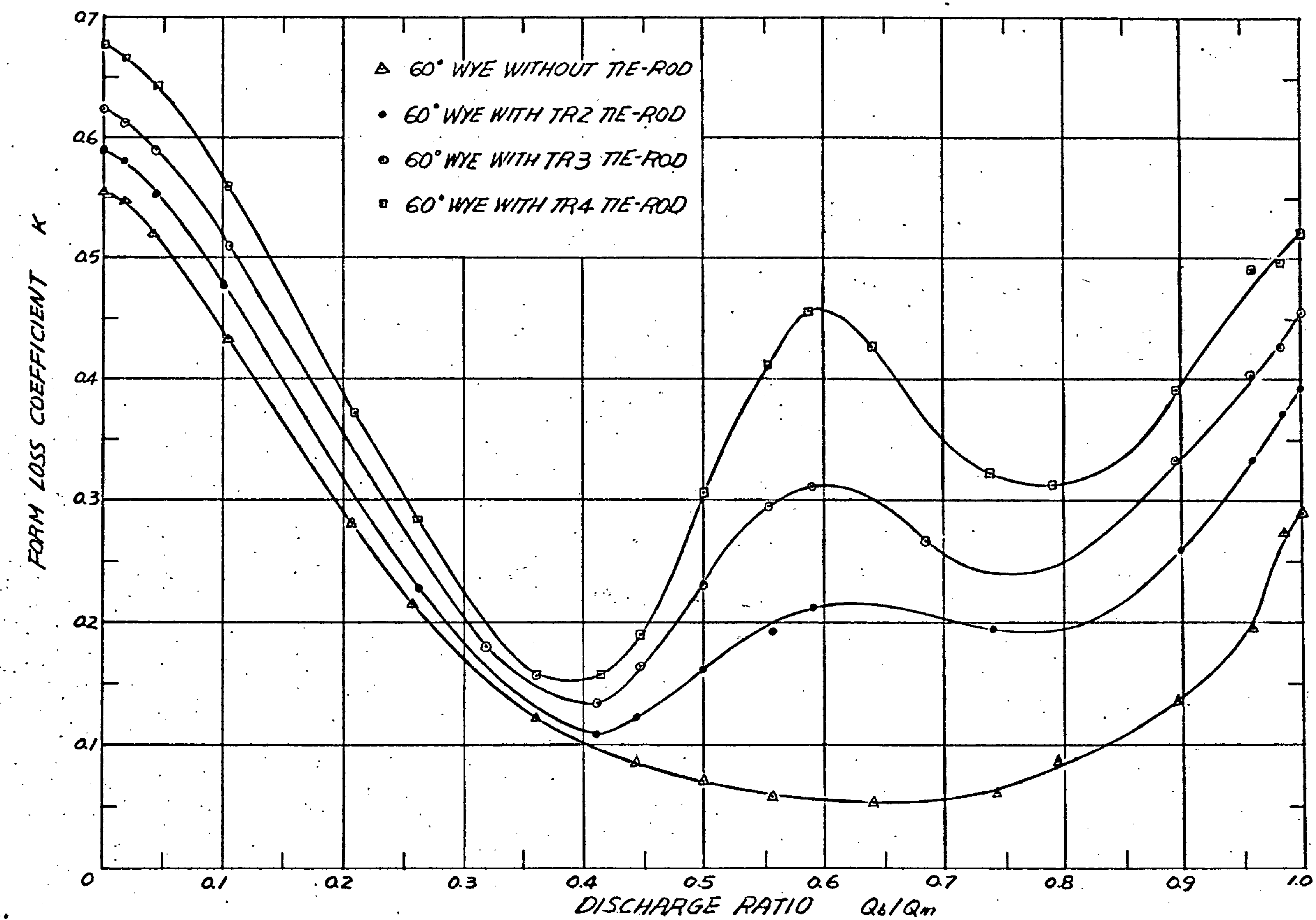


FIGURE V-6 Form Loss Coefficients for 60° Wye (Unsymmetrical Flow)

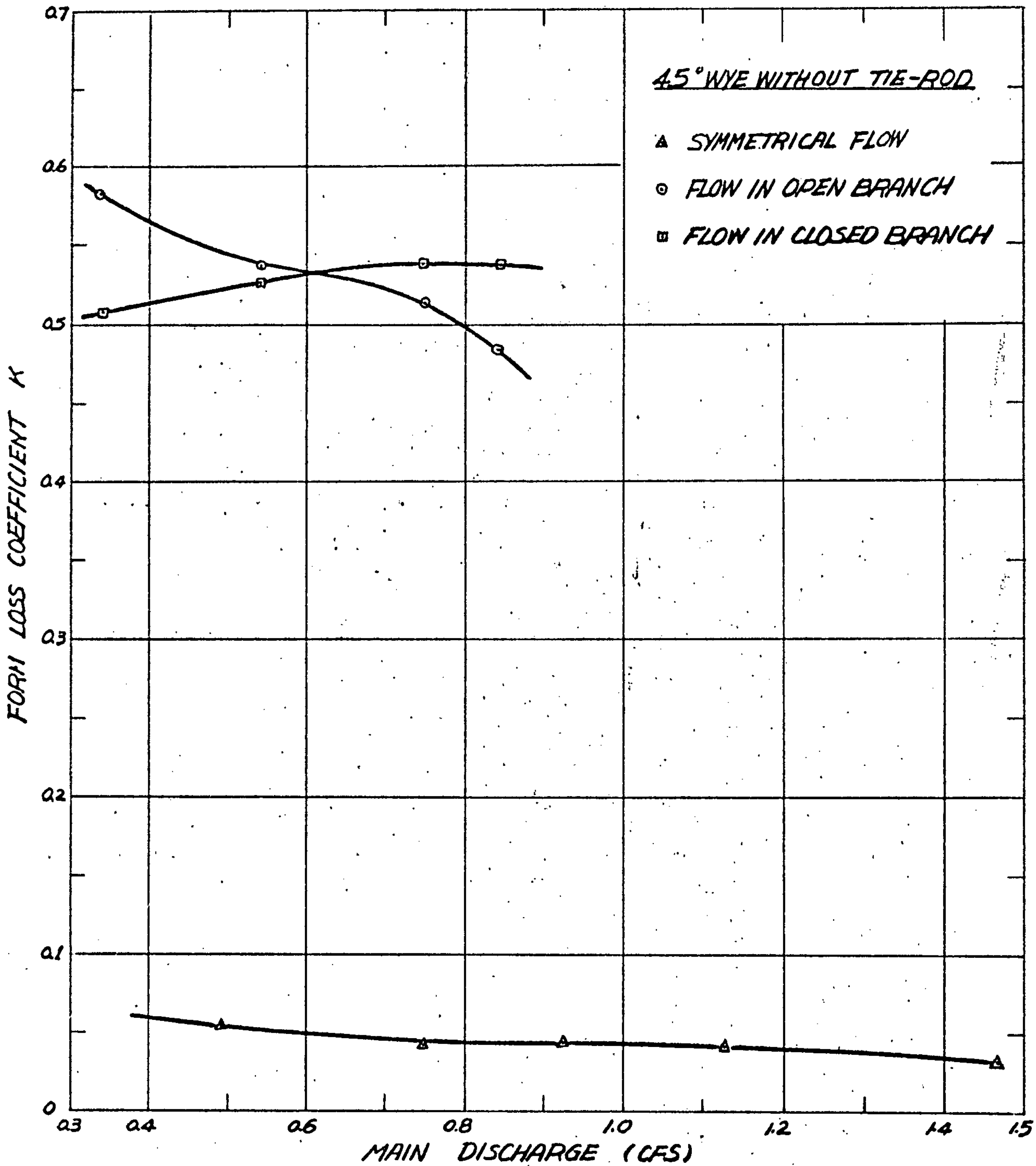


FIGURE V-7 Form Loss Coefficients for 45° Wye (Symmetrical & One-leg Flows)

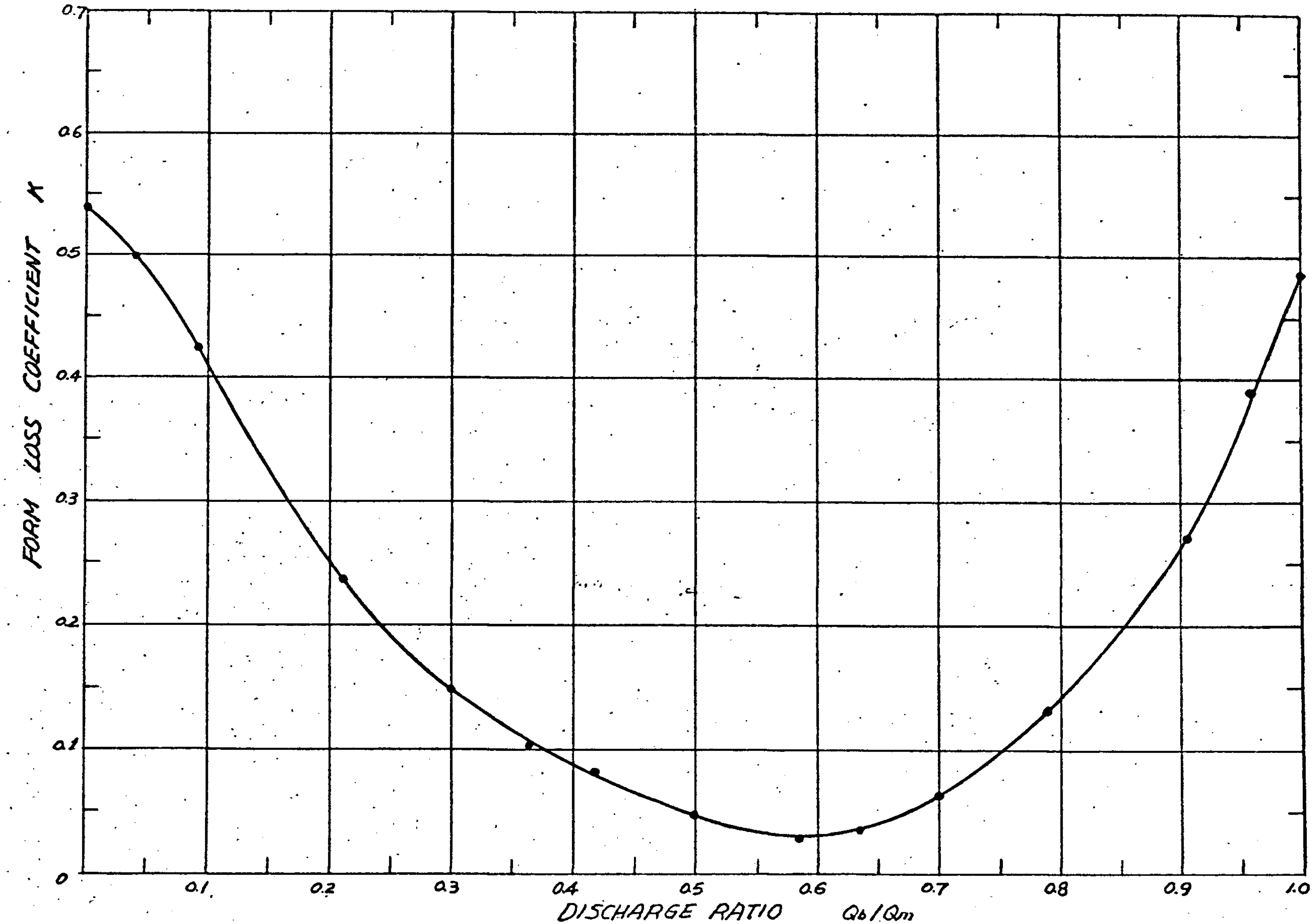


FIGURE V-8 Form Loss Coefficients for 45° Wye (Unsymmetrical Flow)

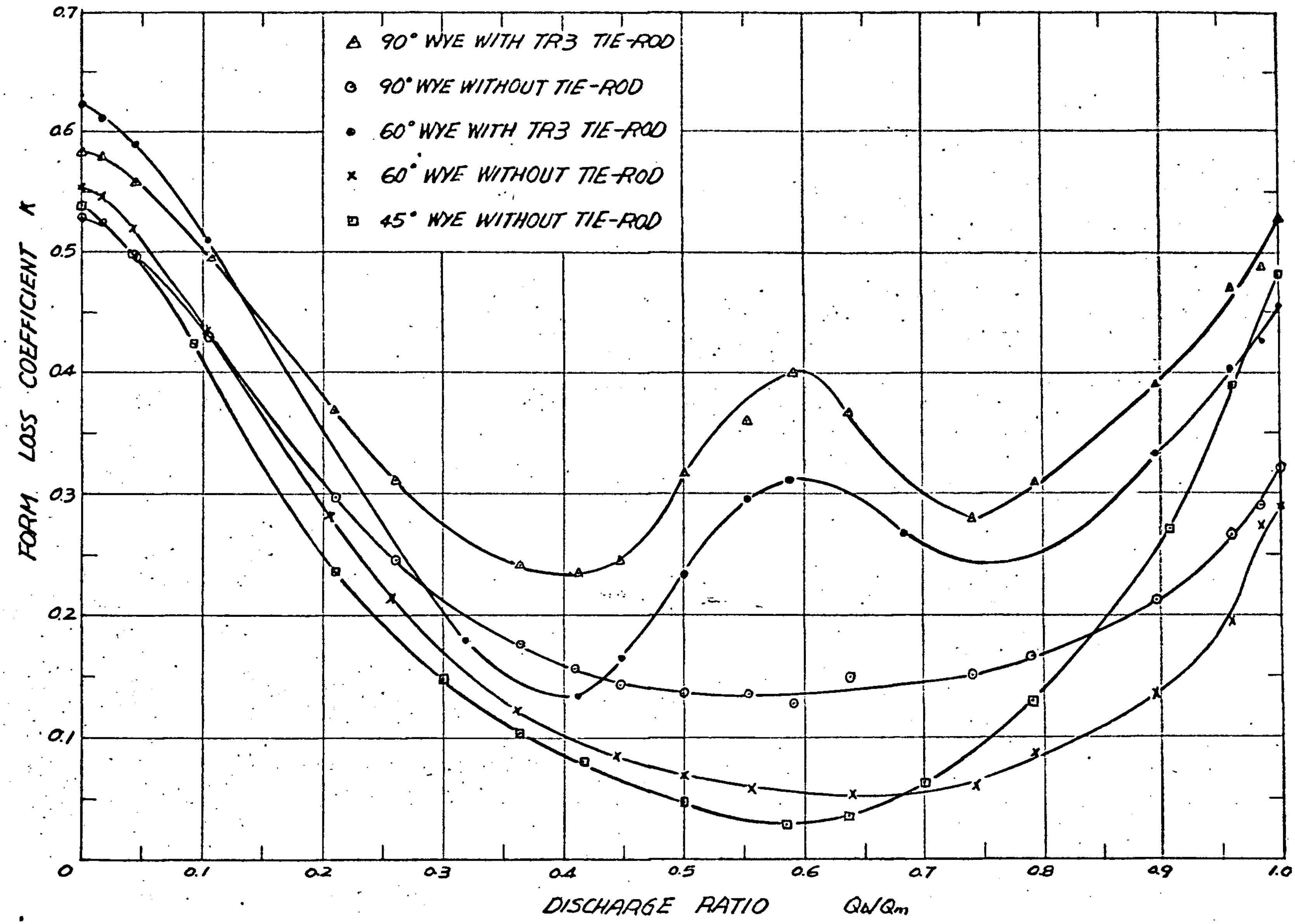


FIGURE V-9 Comparison of Form Loss Coefficients for Wyes (Unsymmetrical Flow)

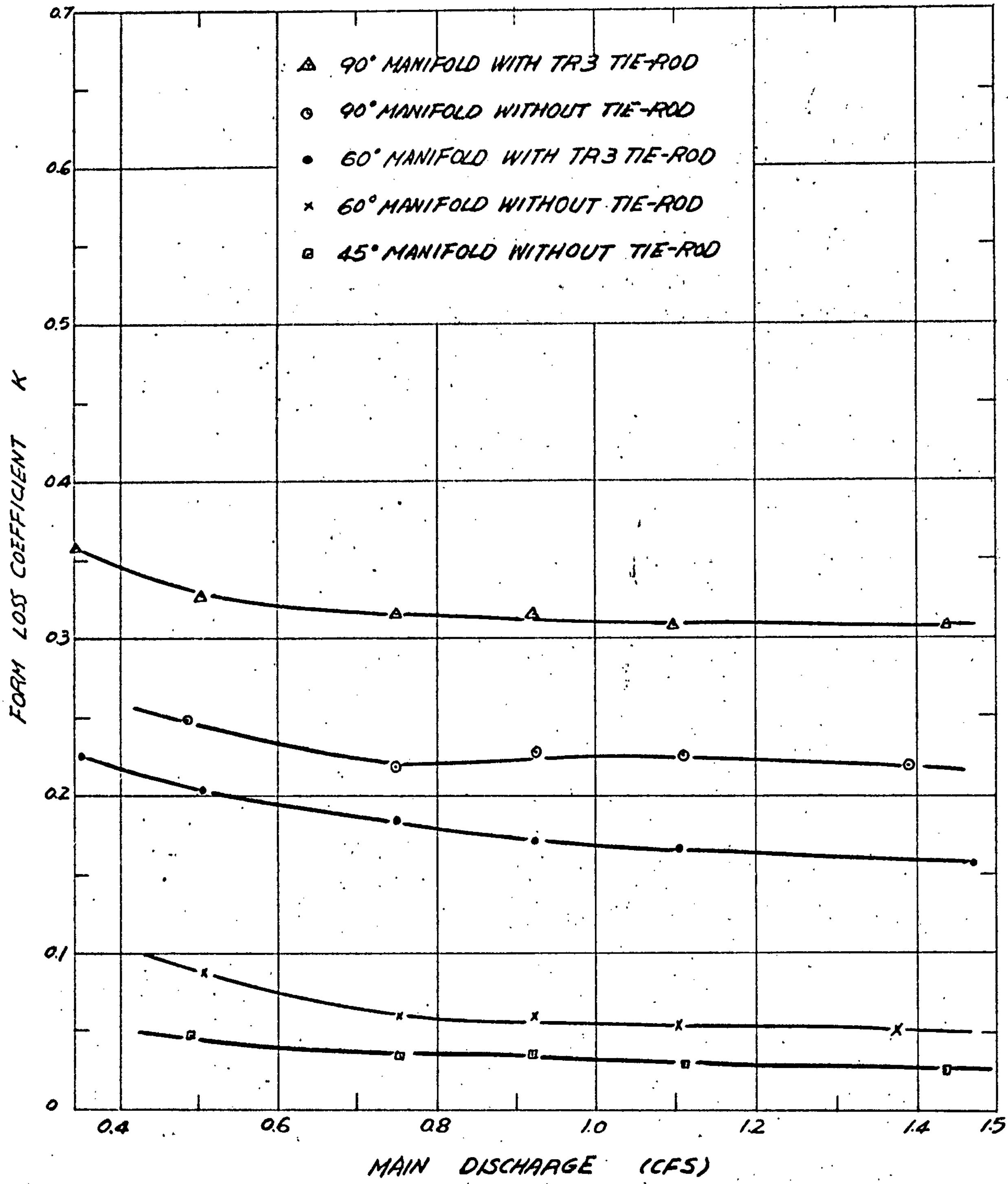
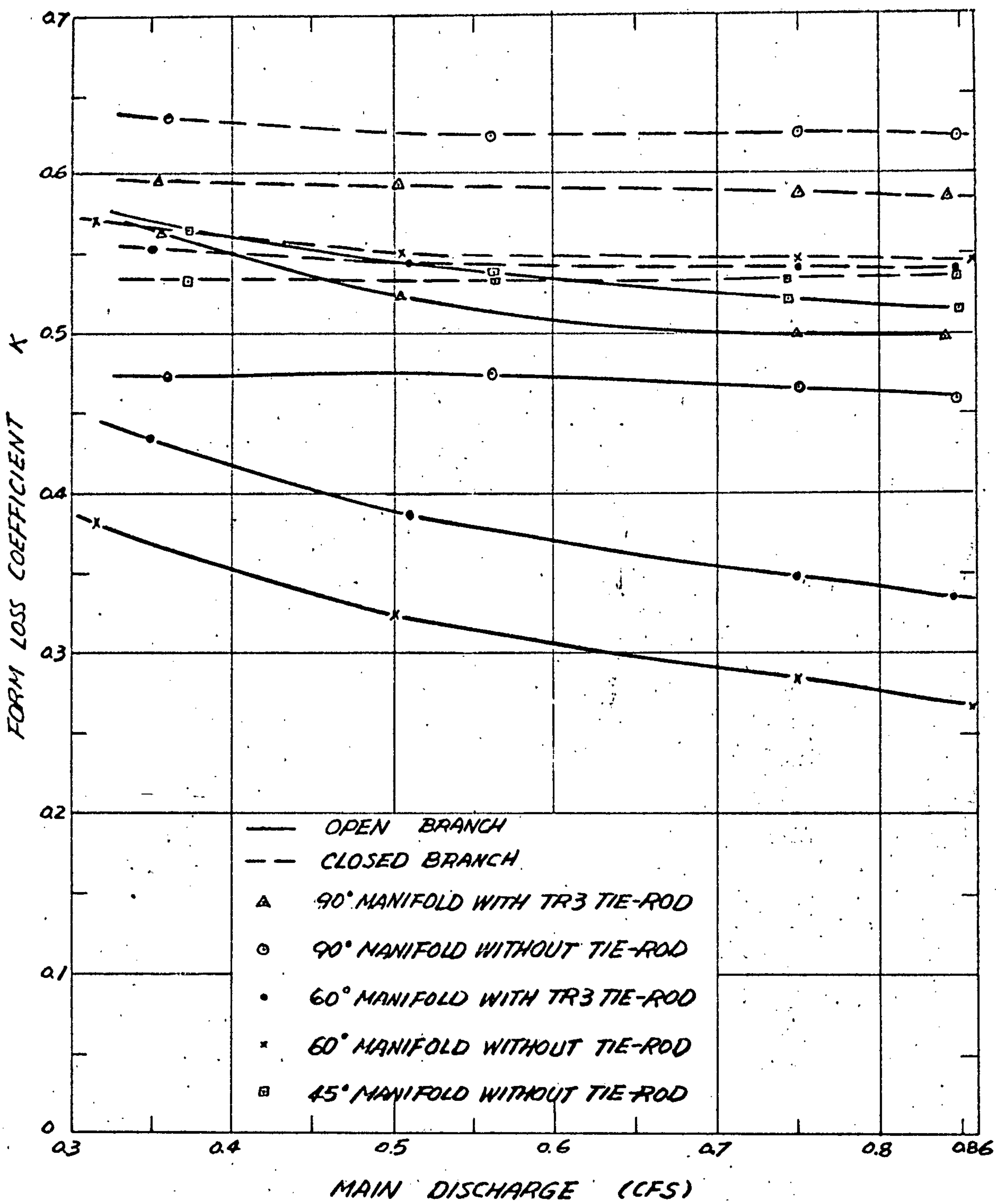


FIGURE V-10 Form Loss Coefficients for Manifolds (Symmetrical Flow)



<u>FIGURE V-11</u> Form Loss Coefficients for Manifolds (One-leg Flow)

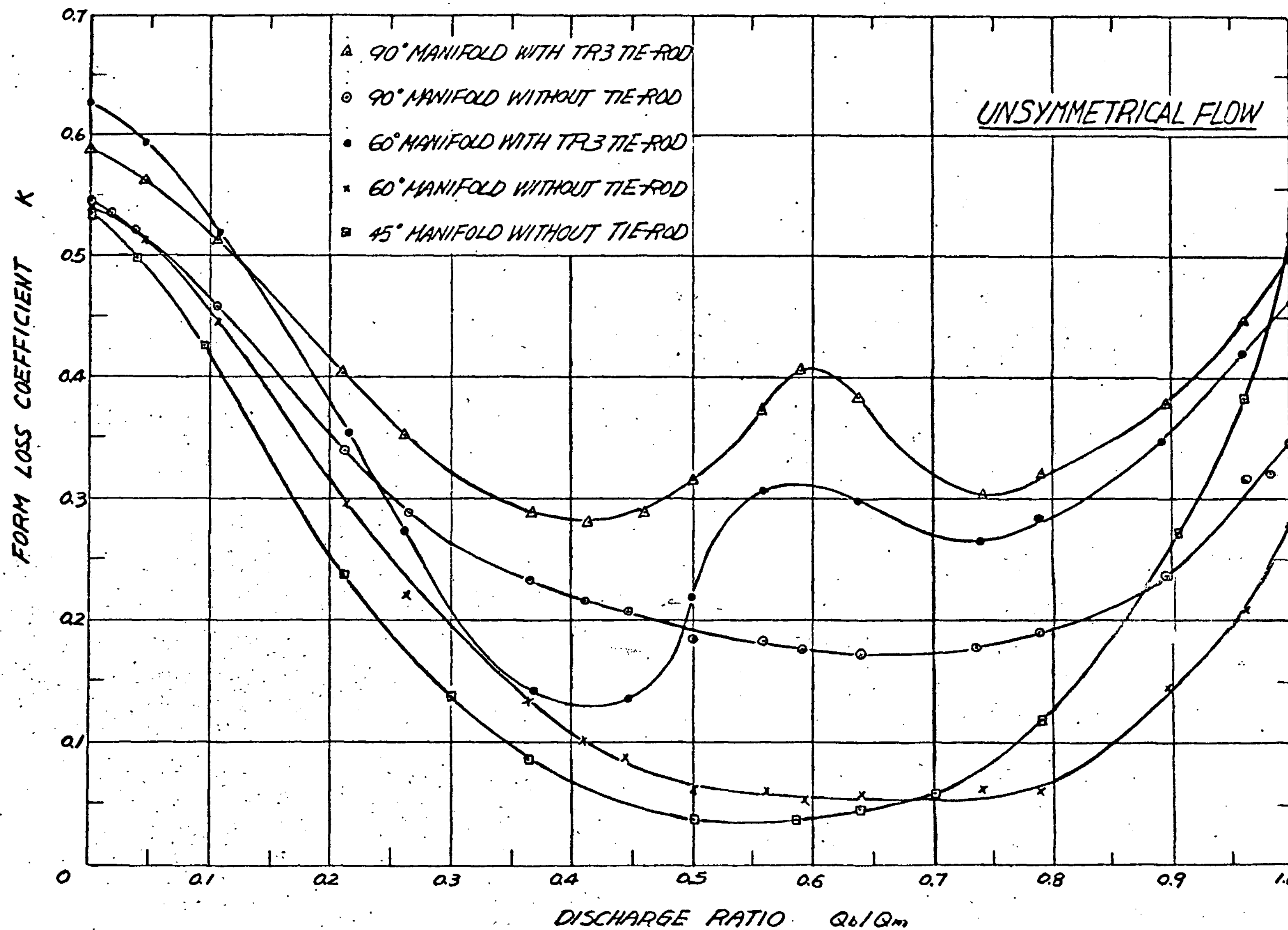


FIGURE V-12 Form Loss Coefficients for Manifolds (Unsymmetrical Flow)

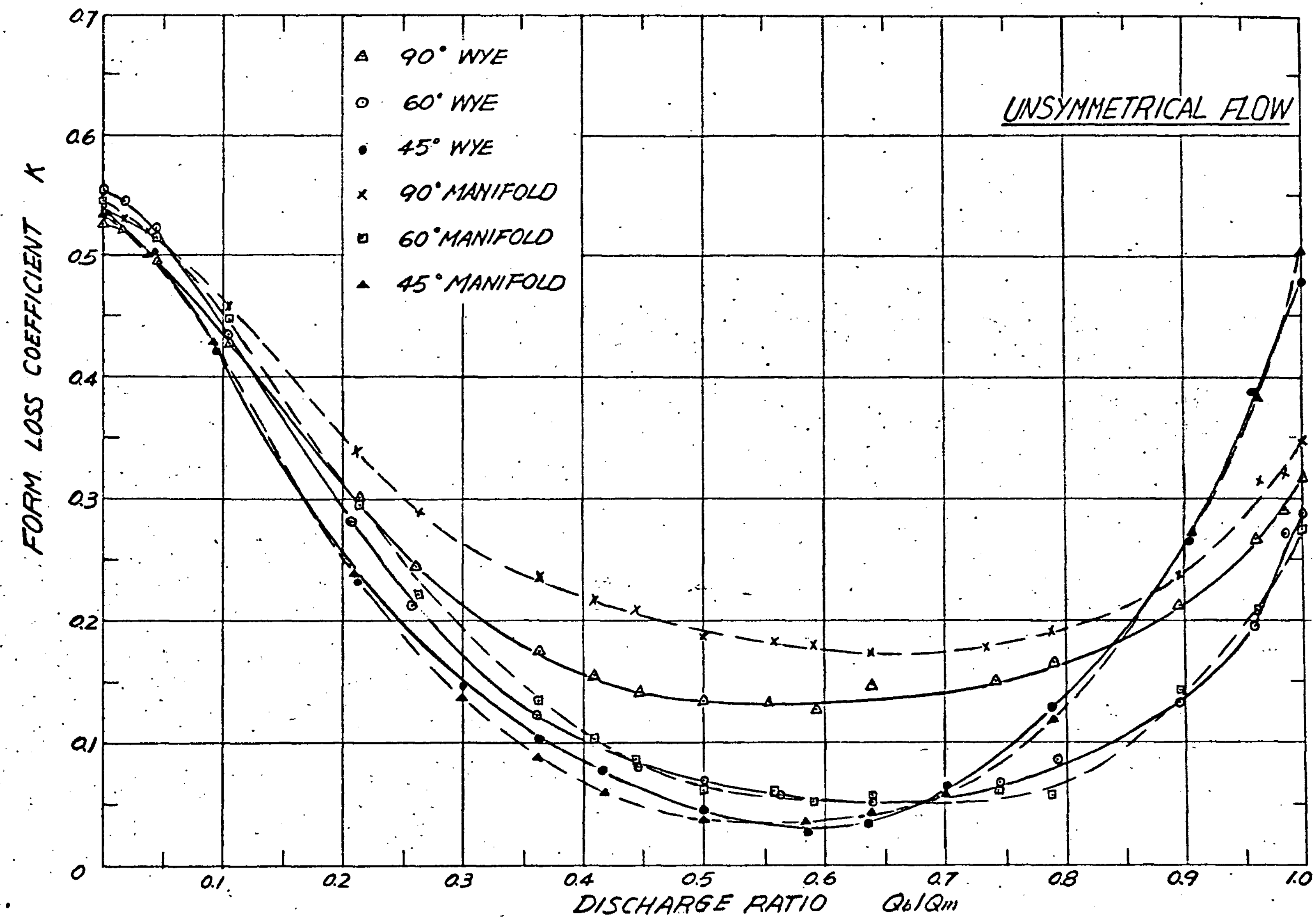


FIGURE V-13 Comparison of Form Loss Coefficients for Wyes & Manifolds without Tie-rod

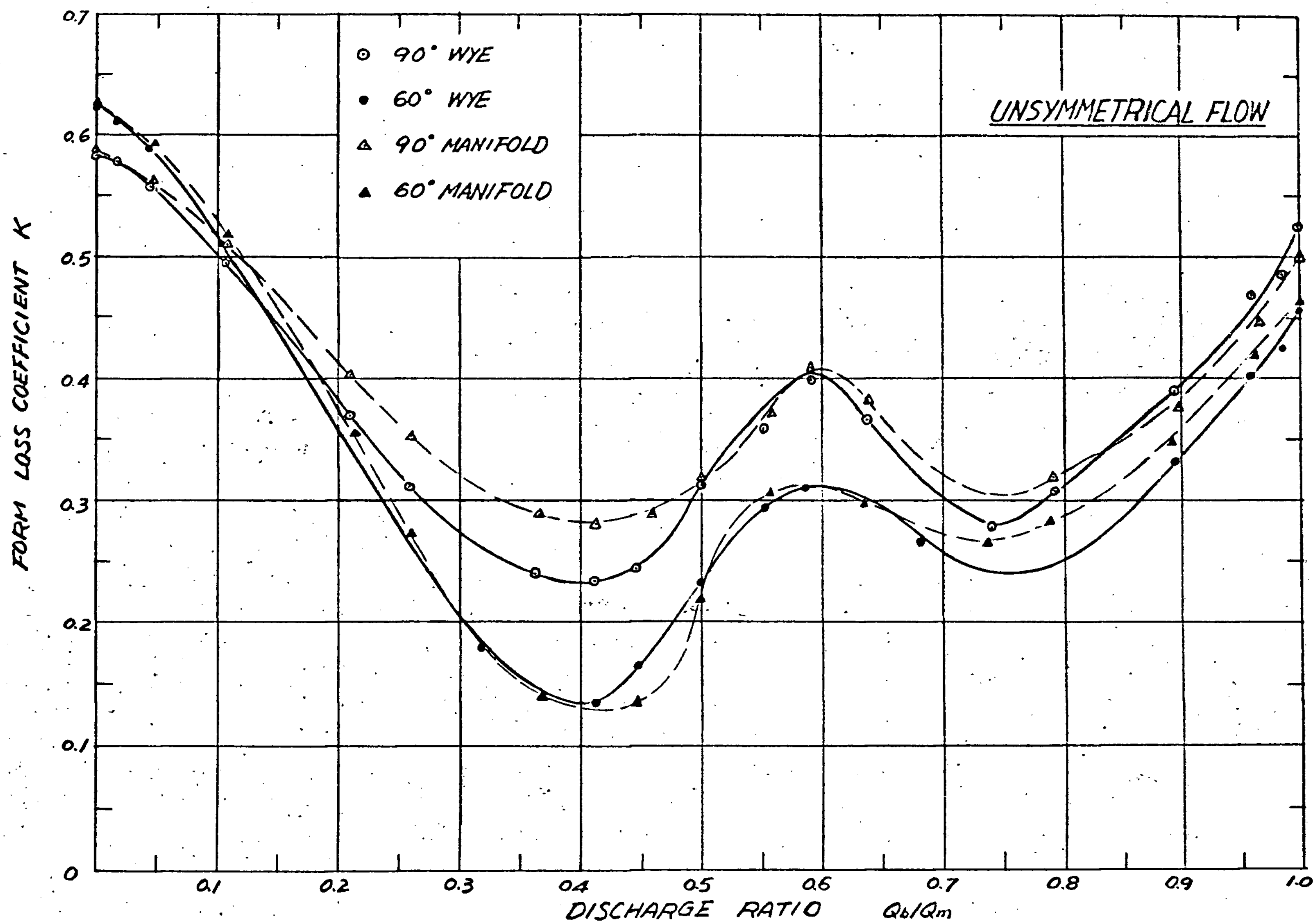


FIGURE V-14 Comparison of Form Loss Coefficients for Wyes & Manifolds with TR3 Tie-rod

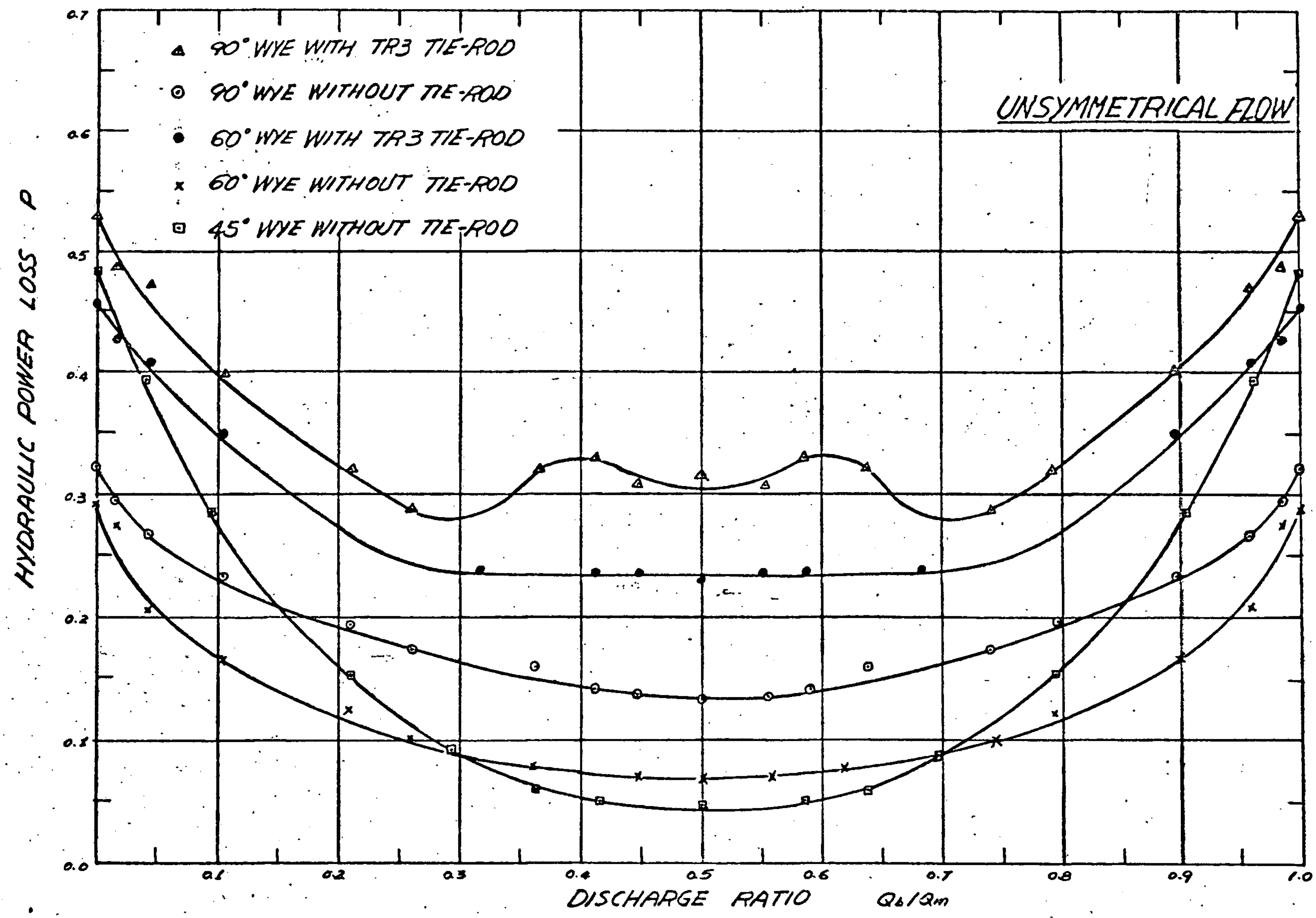


FIGURE V-15 Hydraulic Power Losses in Wye Arrangements

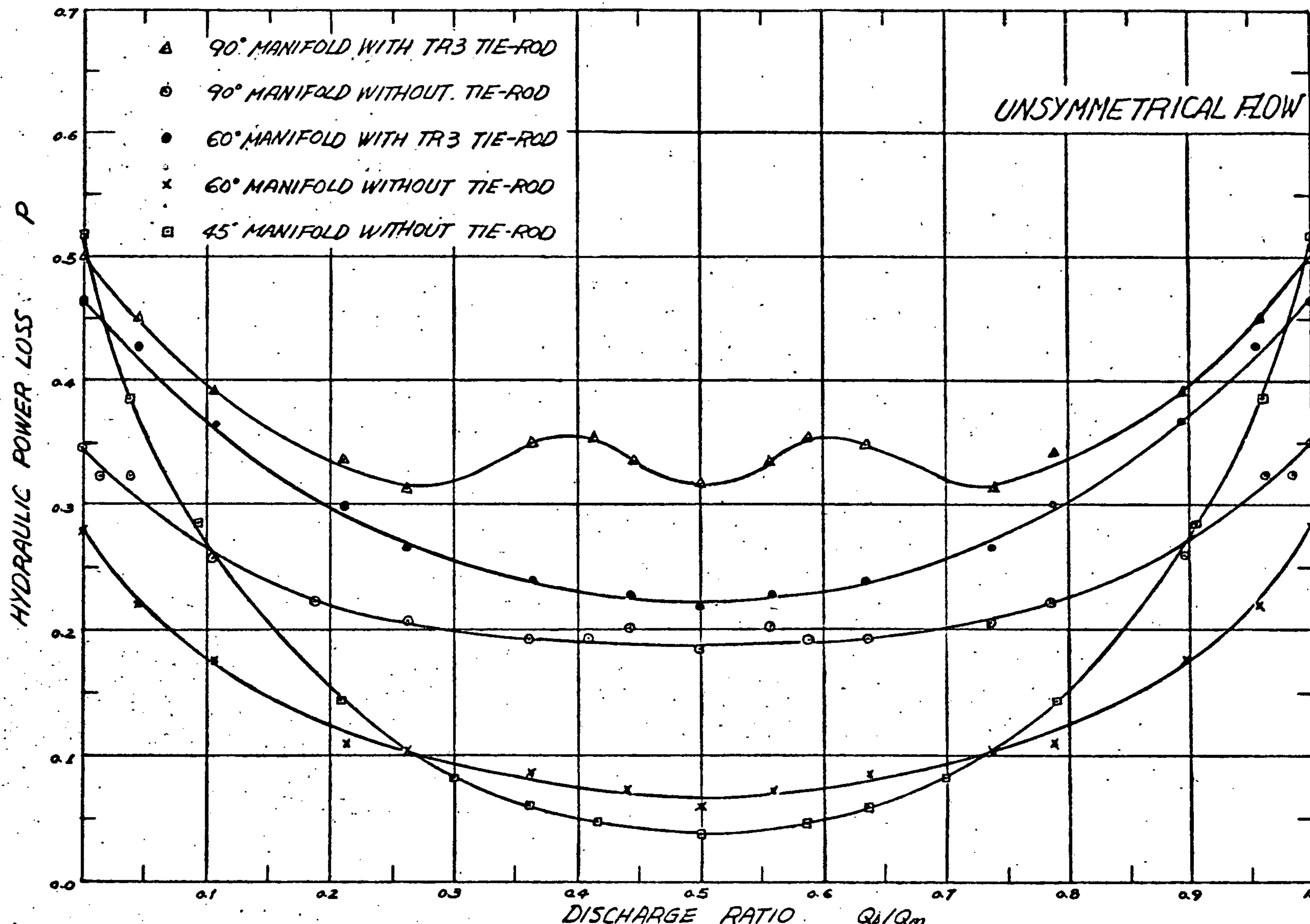


FIGURE V-16 Hydraulic Power Losses in Manifold Arrangements

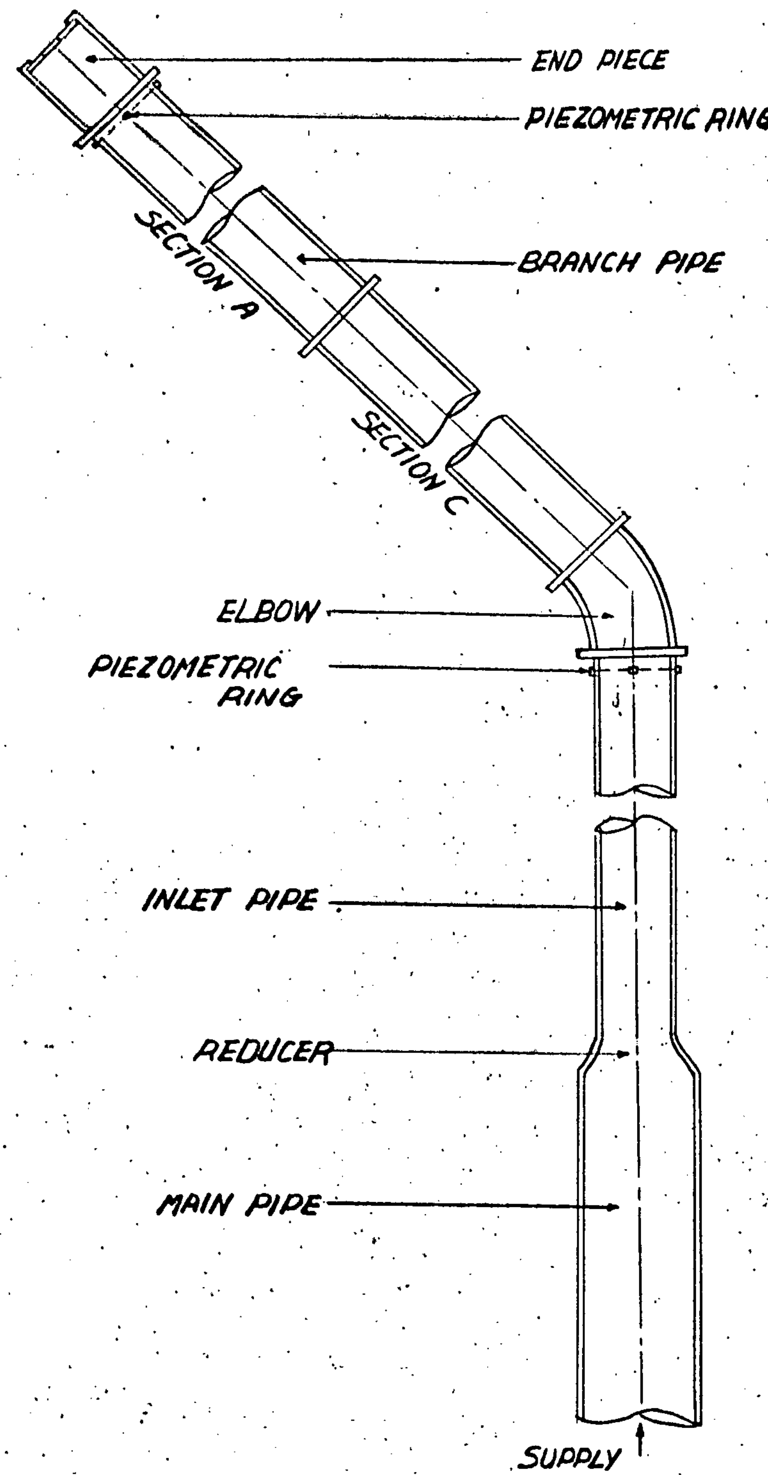


FIGURE A-1 Experimental Set-up for Measuring Head Losses in Elbows

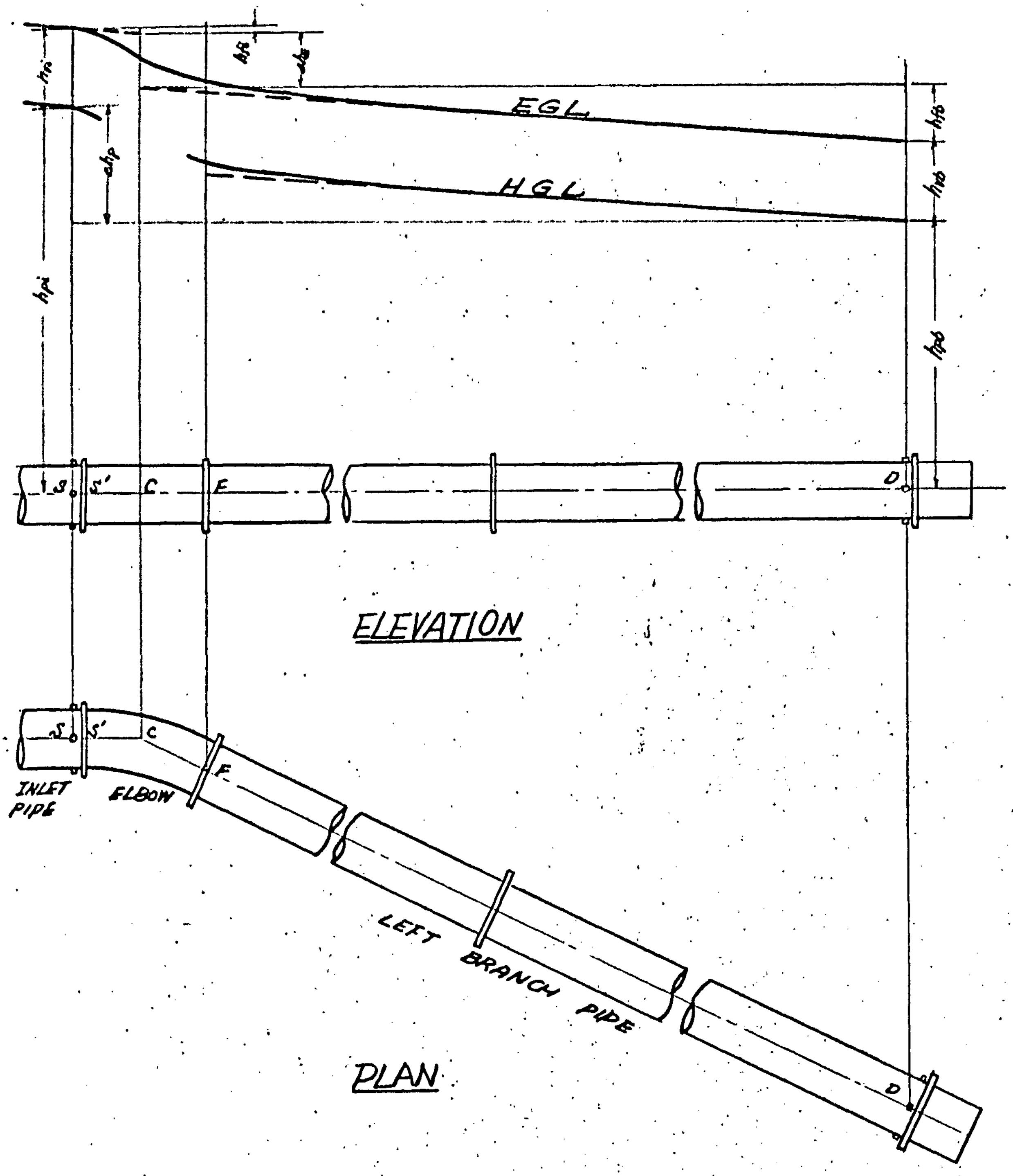


FIGURE A-2 Hydraulic & Energy Gradient Lines for Elbow Testing Set-up

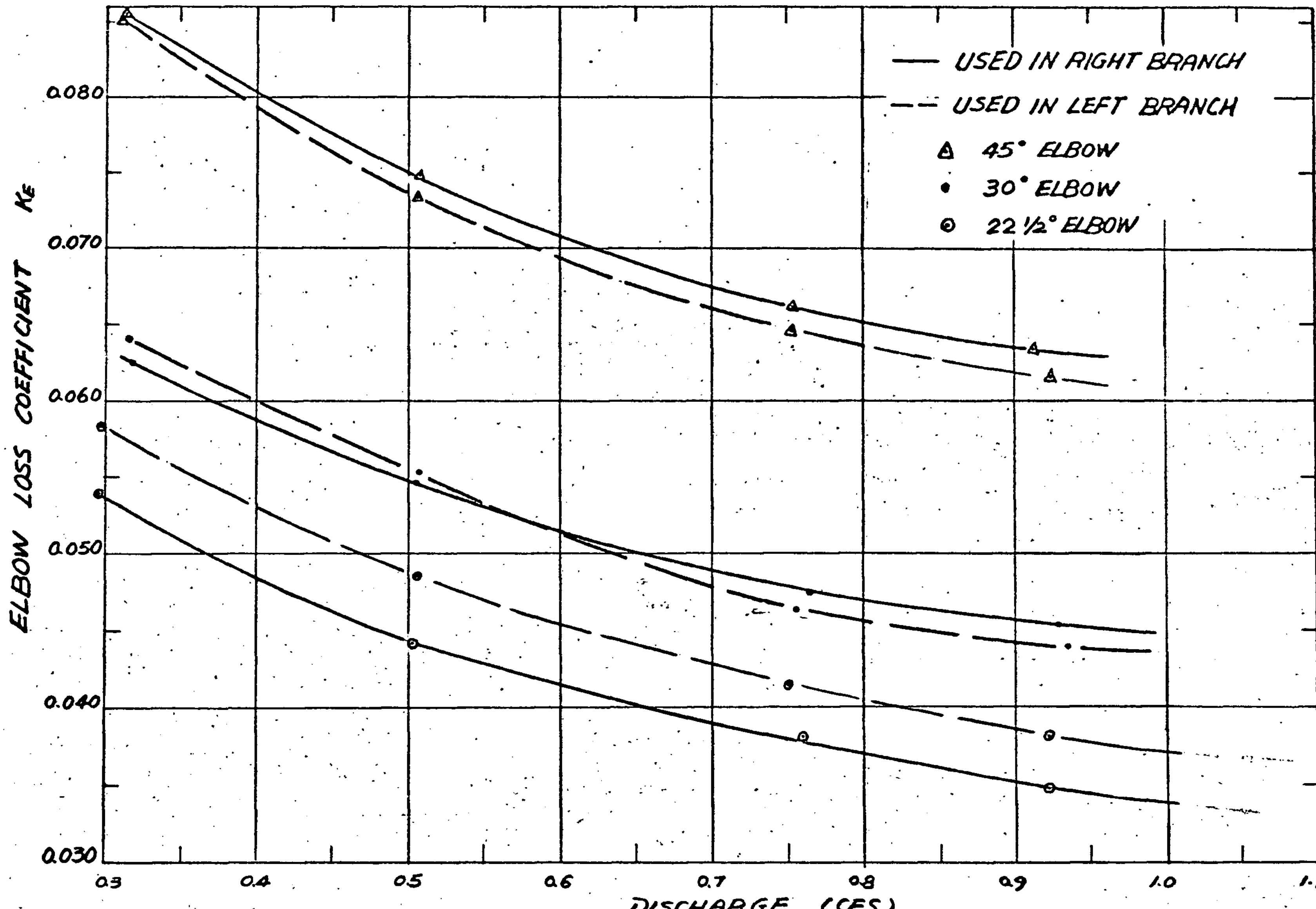


FIGURE A-3 Elbow Loss Coefficients