C.1

HYDRAULICS RESEARCH DIVISION

Technical Note

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TITLE: "Errors in Velocity Measurements made with a 622AA Price Current Meter from a Boat"

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CORRESPONDENCE FILE NO:
4885

ERRORS IN VELOCITY MEASUREMENTS MADE WITH A 622AA PRICE CURRENT METER FROM A BOAT

Purpose:

1. To investigate the magnitude and location of flow disturbance in the immediate proximity of an inflated boat.
2. To assess the influence of the flow disturbance on current meter velocity observations.

Equipment:

1. The boat is an Avon Sportboat supplied by WSC. This is an inflatable boat 3.81 meters in length with a 1.68 meter beam. The boat also has a reinforced wooden transom, suitable for a small outboard engine (see Figure 1).
2. The Mooring Apparatus was manufactured by HRD staff using a 6.096 meter long steel "I" beam and two specially made right angle towing brackets (see Figure 1).
3. Attachment materials - eye bolts, "C" clamps, ¼ inch poly line, plywood meter mounting platform and base.
4. Weight to simulate observers normally aboard the boat was obtained with seven lead bars weighing 50 lbs. each.
5. The current meter was of the 622AA type with serial number 1-61, and the tail section removed for rod mounting.
6. The meter was suspended using a standard, carriage mounting, HRD calibration rod.
7. Towing device - Kempf & Remmers Modified C102 carriage operating on the towing tank of the HRD laboratory. Accuracy of the carriage is $\pm$1% of mean speed at all speeds.

Procedure:

1. Two separate series of observations were carried out.
   (a) Straight towing - with the boat parallel to the tow tank walls (see Figure 1 and 3).
   (b) Angle towing - with the boat at an angle of approximately 45^{o} to the tow tank walls (see Figure 2 and 4).

2. The test apparatus was set up in the following manner:
   - The "I" beam was clamped to the deck of the towing carriage with approximately ½ of its length extending out over the rear edge. During the straight towing mode, the beam was positioned so that it was parallel with the tank walls and approximately 2 meters in from the port wall (see Figures 1 and 3). For the angle towing series, the beam was placed on an angle to accommodate the requested ~45° boat angle (see Figures 2 and 4).
   - The meter mounting platform base was put in place on top of the starboard pontoon of the boat and then tied down (see Figure 2).
   - The craft was placed in the water at the rear of the carriage and the observer simulation weights distributed in it so that the boat remained on an even keel.
   - The towing brackets were clamped to the "I" beam far enough apart to allow the boat to be moored between them, fore and aft, with short lengths of poly line (see Figure 1).
   - The meter mounting platform (see Figure 2) was clamped onto its base at the selected towing positions starting at position "A" (see Figures 3, 4 and 6). Position "B" is shown in Figures 2, 3 and 4 and position "C" in Figures 1, 3, 4 and 5.
   - The suspension rod was inserted and then clamped into the mounting platform and the meter fastened to the bottom end of the rod (see Figure 5).
   - The meter was lowered to a selected towing depth, starting at 15.24 cm below the water surface, and clamped in place.
   - The rod and mounting platform were adjusted so that the meter was level horizontally and faced into the water flow parallel to the flow direction and was held 25 cm out from the side of the boat.
3. Data collection runs were commenced towing the boat, with the meter attached, through the full range of positions, depths and speeds. At least three runs were made for each position, depth, speed and towing arrangement to eliminate any false readings. The positions were "A", "B" and "C" as shown in Figures 6, 2 and 1 respectively, plus 3 and 4, the depths varied from 15.24 cm to 121.92 cm in 15.24 cm increments,

the speeds were 30, 60, 90, 120, 150, 180, 210 and 250 cm/s, and the towing arrangements were with the boat parallel to the flow direction and at an angle of $\sim 45^{\circ}$ to it as shown in Figures 1 and 2 respectively.

4. Velocity data, in revolutions per second, was collected for each run and then plotted in two ways in relation to standard calibration for this meter.

Calculations and Data Representation:

1. The first relationship is revolutions per second versus a correction coefficient. This shows the direct amount of difference between the test data and the standard calibration data. See straight towing plots 1 through 7 and angle towing plots 1 through 8.
The correction coefficient is defined as

$$K_c = \frac{R_s}{R_t}$$

where R_t = test run meter revolutions per second.
R_s = standard calibration meter revolutions per second.
K_c = correction coefficient.

2. The second relationship is revolutions per second versus a percentage error. This shows the difference between the test data and the standard calibration data expressed as a percentage. See straight towing plots 1A through 7A and angle towing plots 1A through 8A.
The percentage error is given by:

$$(1) \quad E = \frac{R_t - R_s}{R_s} \times 100$$

From equation (1)

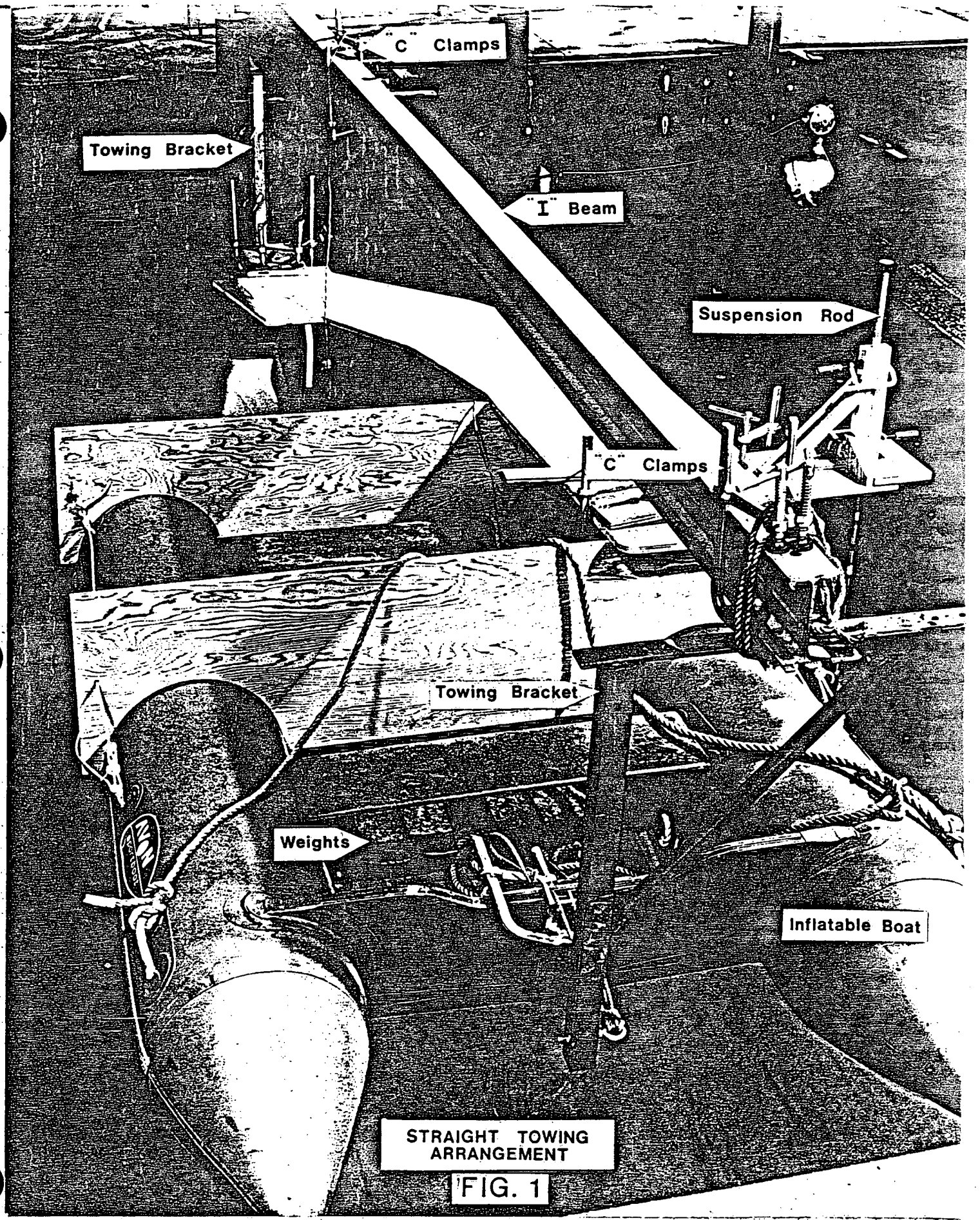
$$(2) \quad E = \left(\frac{R_t}{R_s} - 1\right) \times 100$$

Where E = percentage error as related to standard calibration.

Summary:

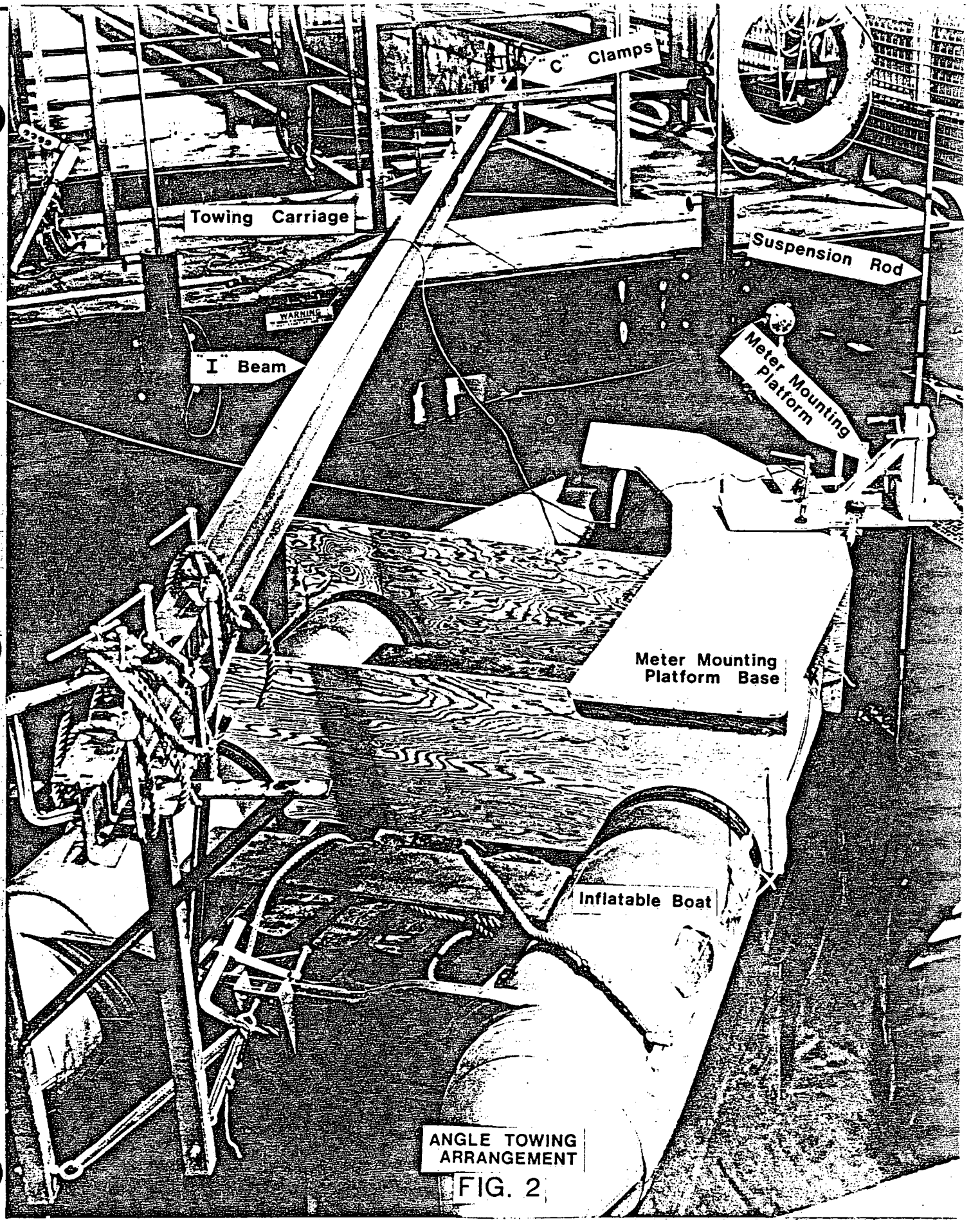
Interference created by the boat does appear to change the velocity of the current meter. The amount of change is dependent on the meter position relative to the boat and its relationship to the water flow direction. Throughout the tested speed and depth range and the two towing arrangements used, a change of 2% or less occurred at position "A". The maximum change of 6.8% occurred at position "C" with the boat being towed parallel to the water flow and the meter set at a depth of 15.24 cm.

Details of the flow disturbance effect are shown in the percentage error graphs included in this report. It should be noted that positive percentage error values show meter velocities faster than those obtained during standard calibration while negative values show a slower velocity.



STRAIGHT TOWING ARRANGEMENT

FIG. 1



ANGLE TOWING ARRANGEMENT

FIG. 2

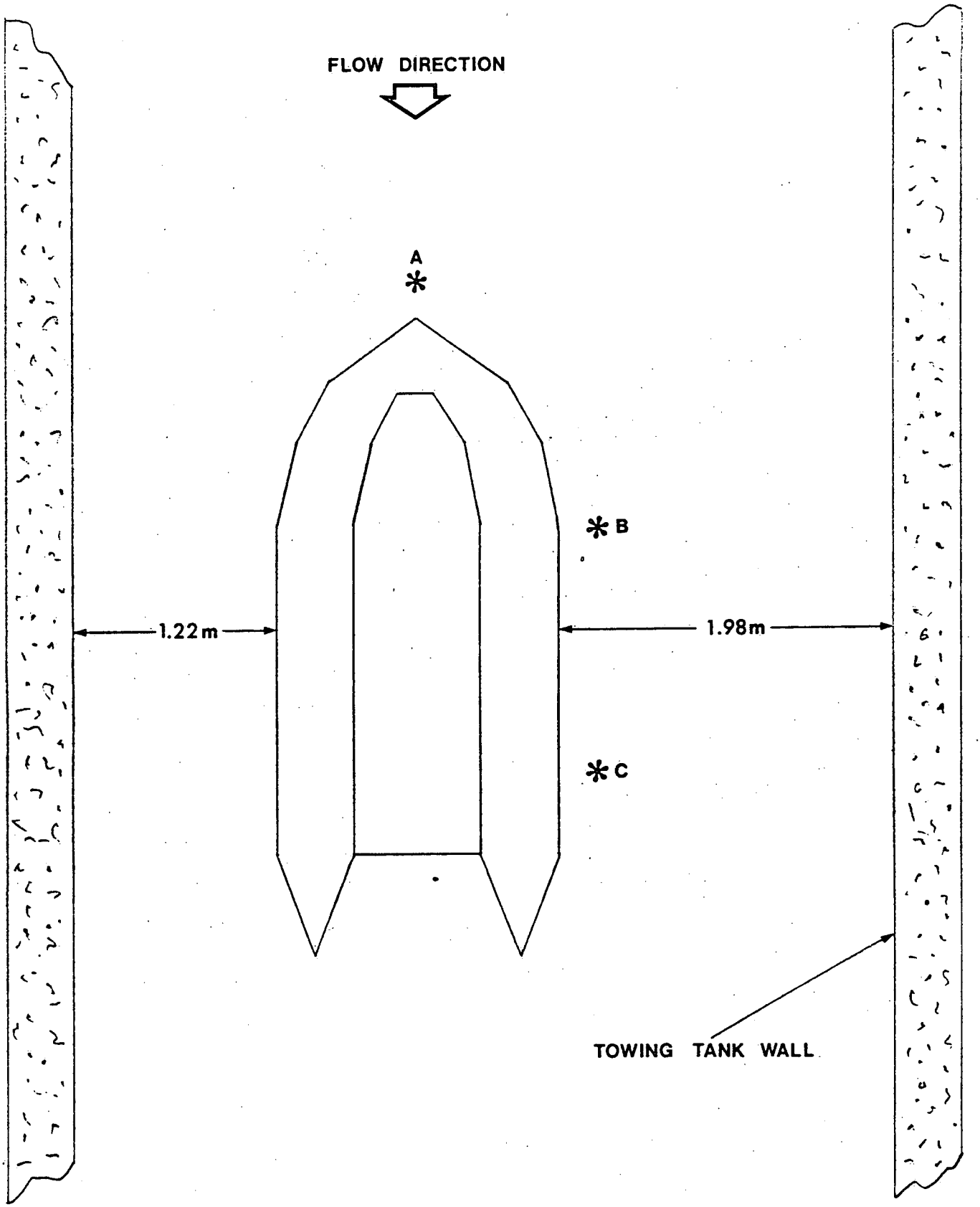


FIG. 3

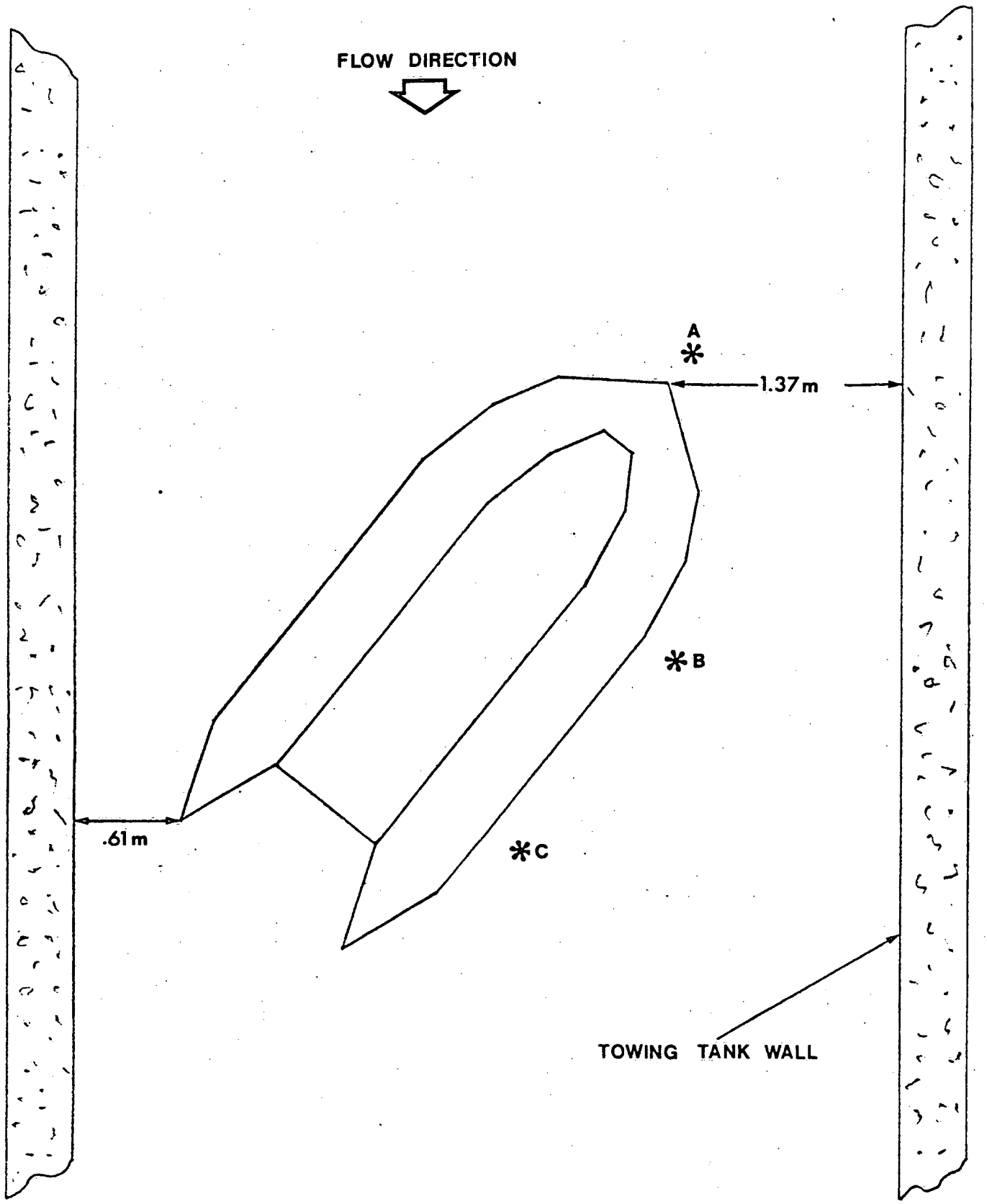


FIG. 4

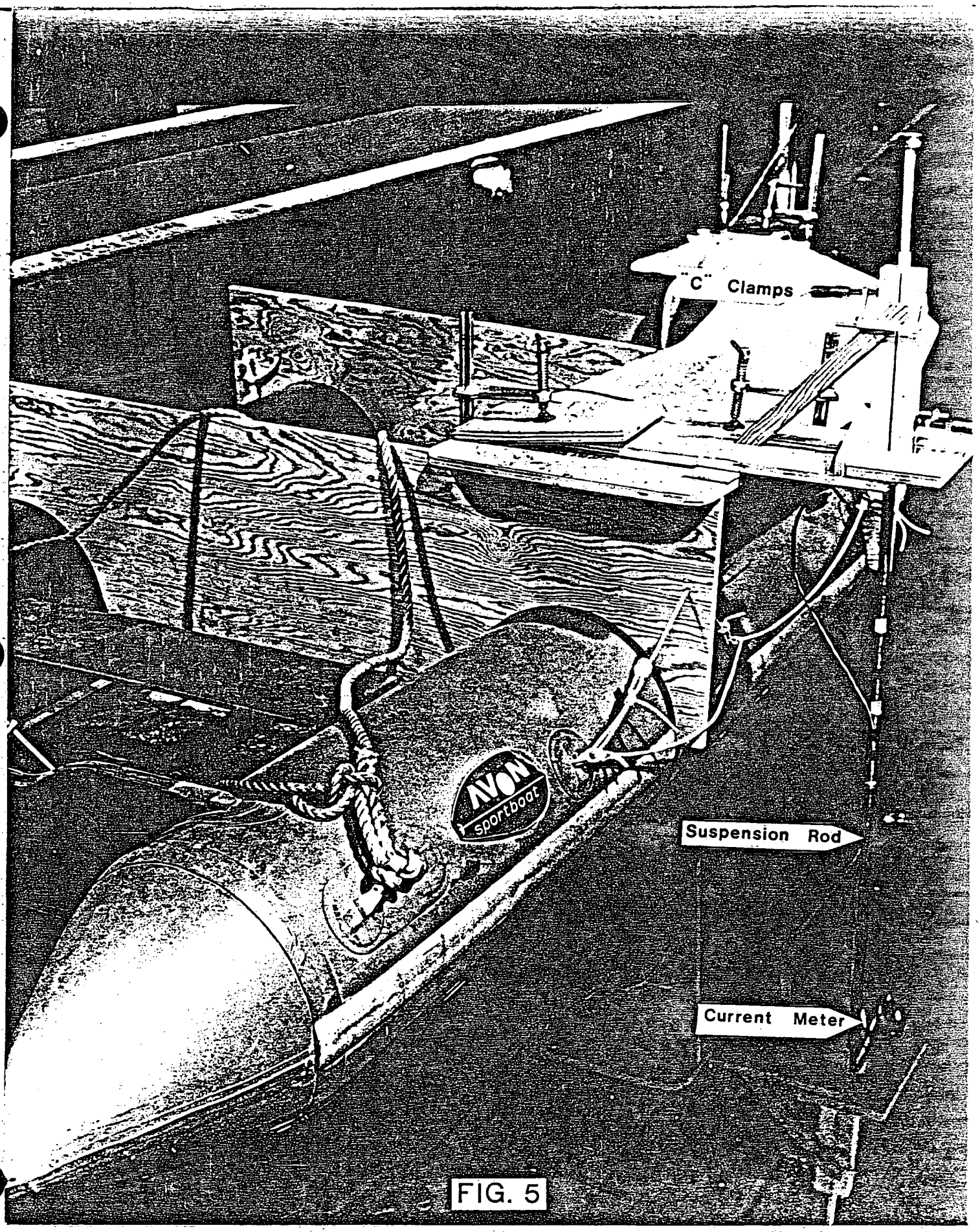


FIG. 5

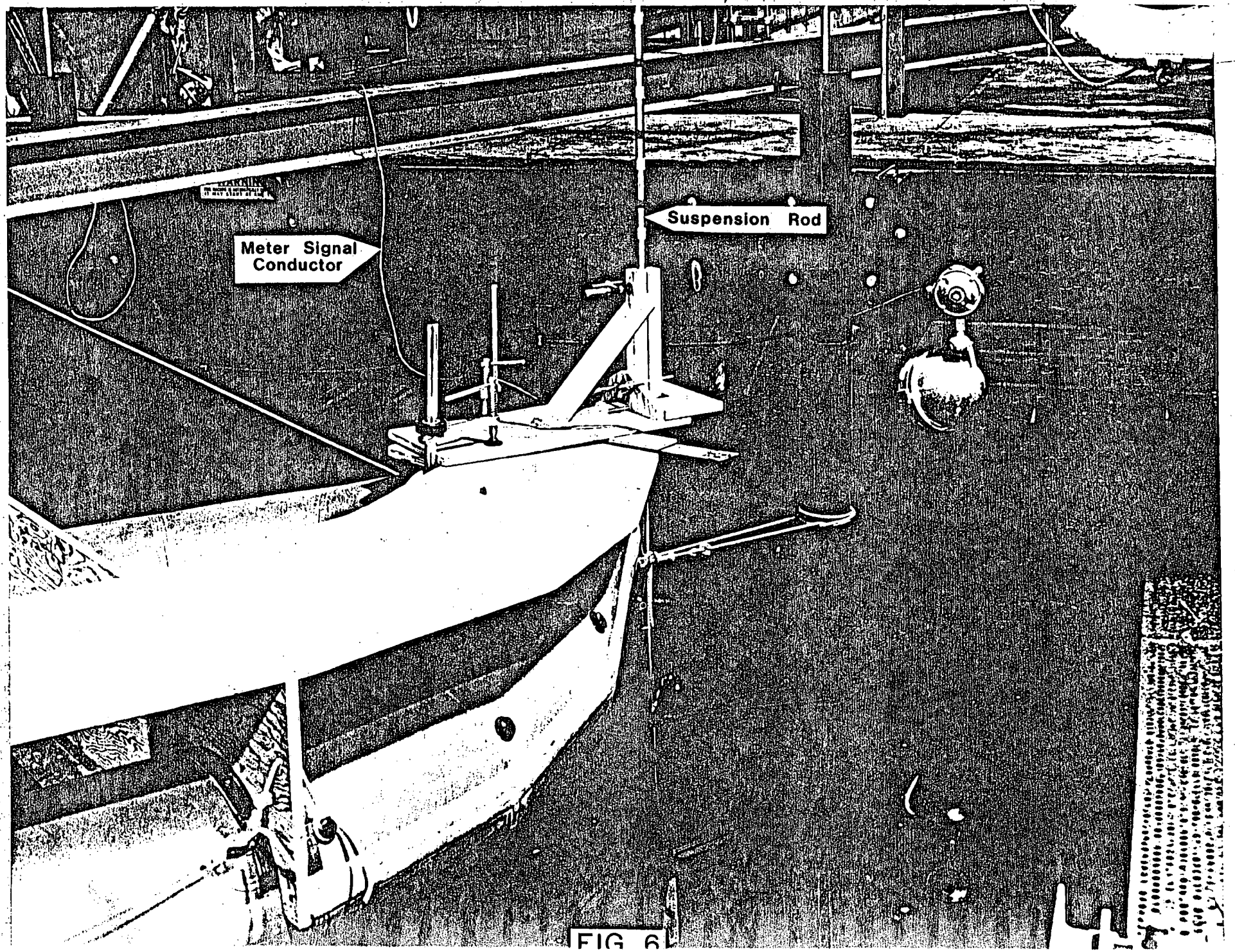
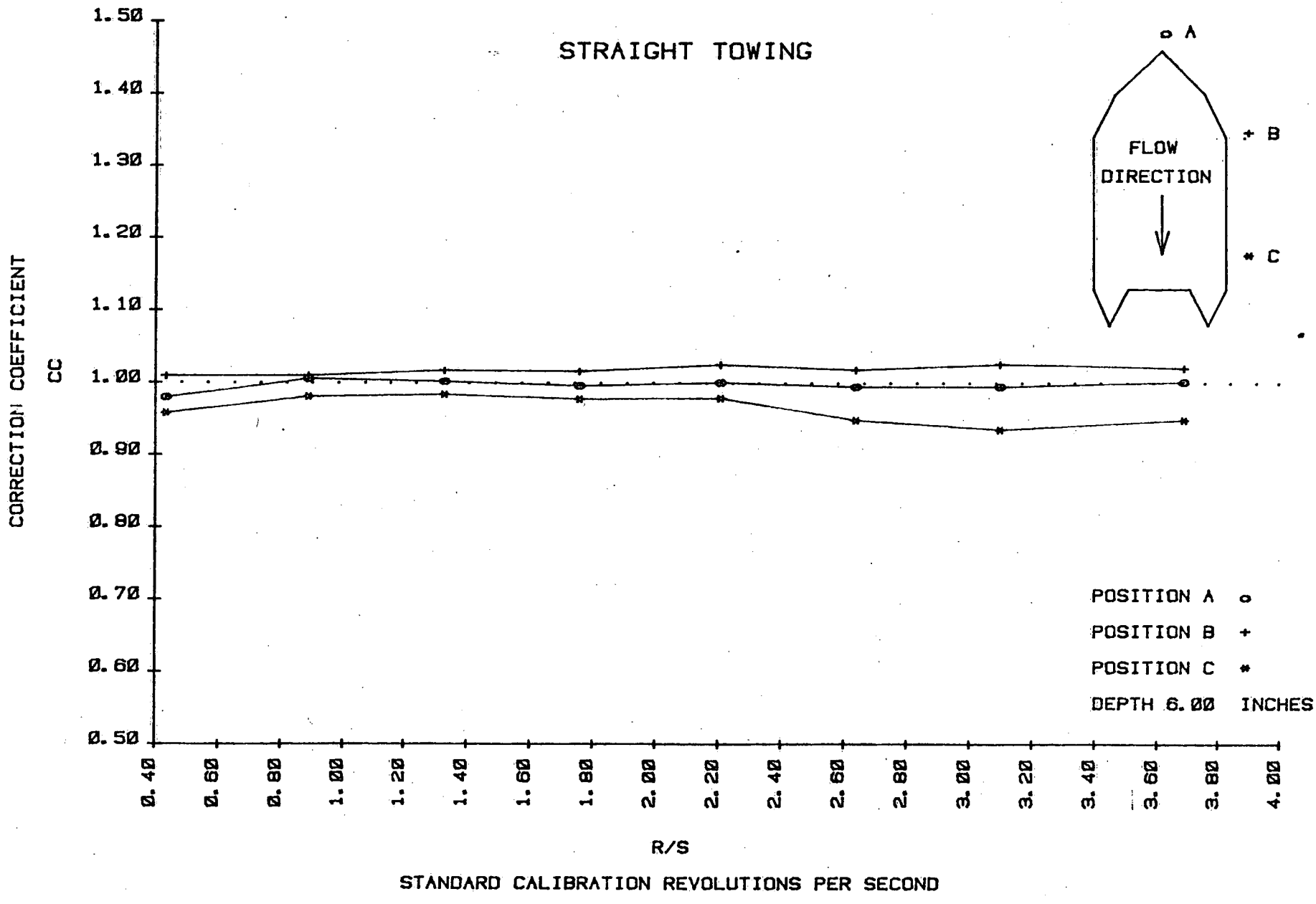


FIG. 6

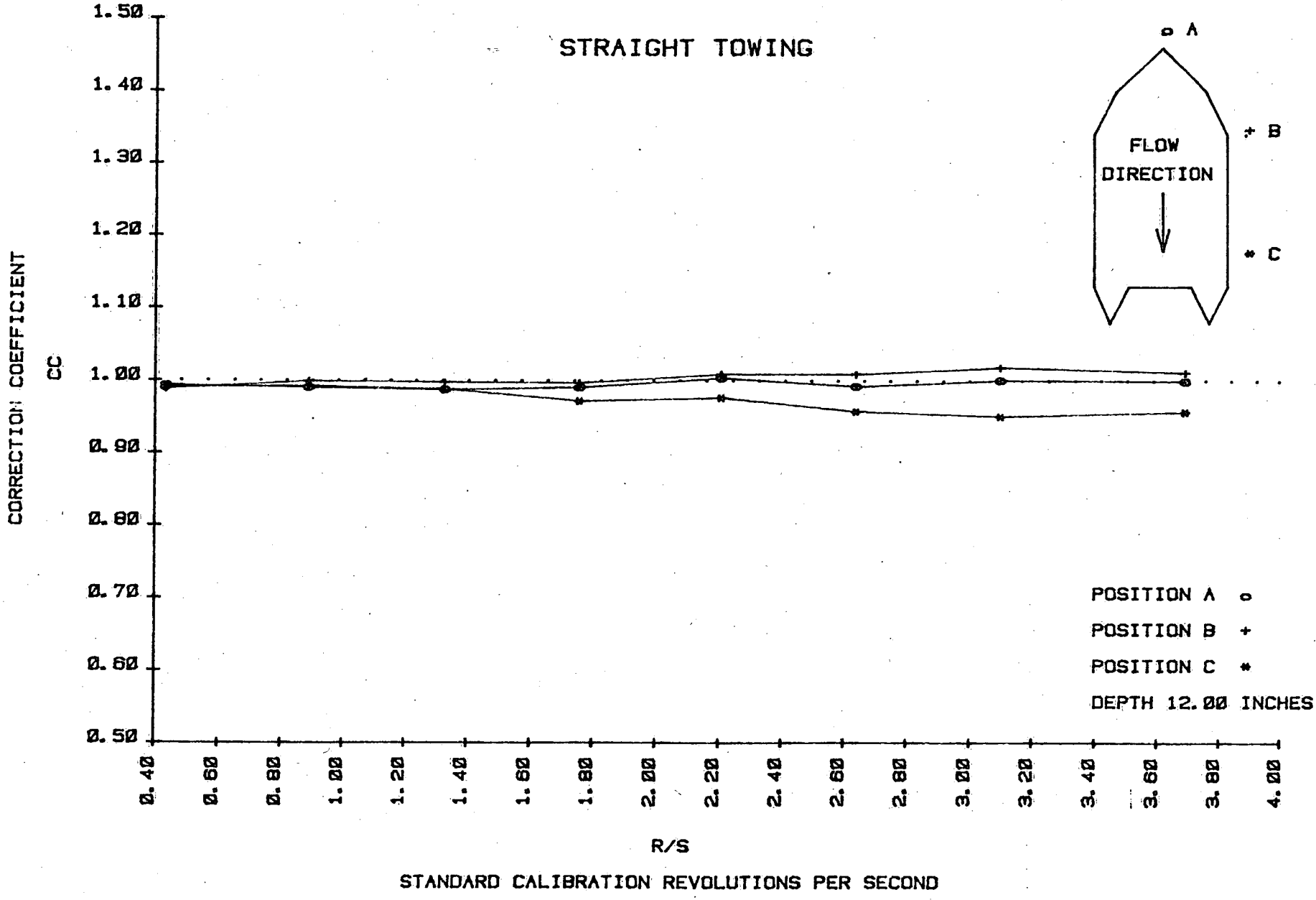
FLOW DISTURBANCE EFFECT ON PRICE 622AA METER



PLOT 1

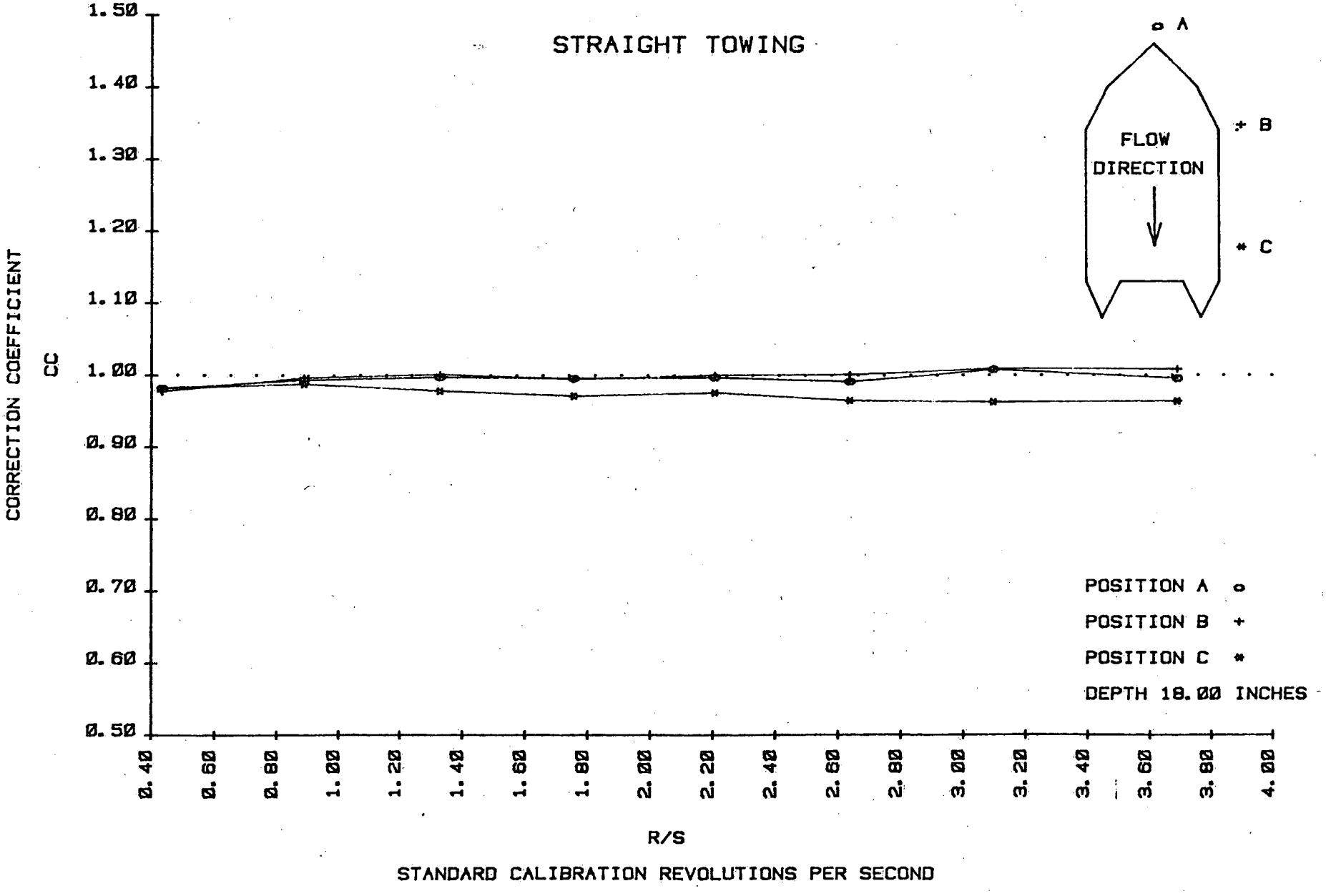
PLOT 2

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER



PLOT 3

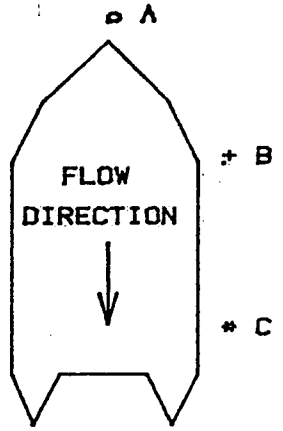
FLOW DISTURBANCE EFFECT ON PRICE 622AA METER



PLOT 4

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

STRAIGHT TOWING



CORRECTION COEFFICIENT
CC

1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50

0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.20 2.40 2.60 2.80 3.00 3.20 3.40 3.60 3.80 4.00

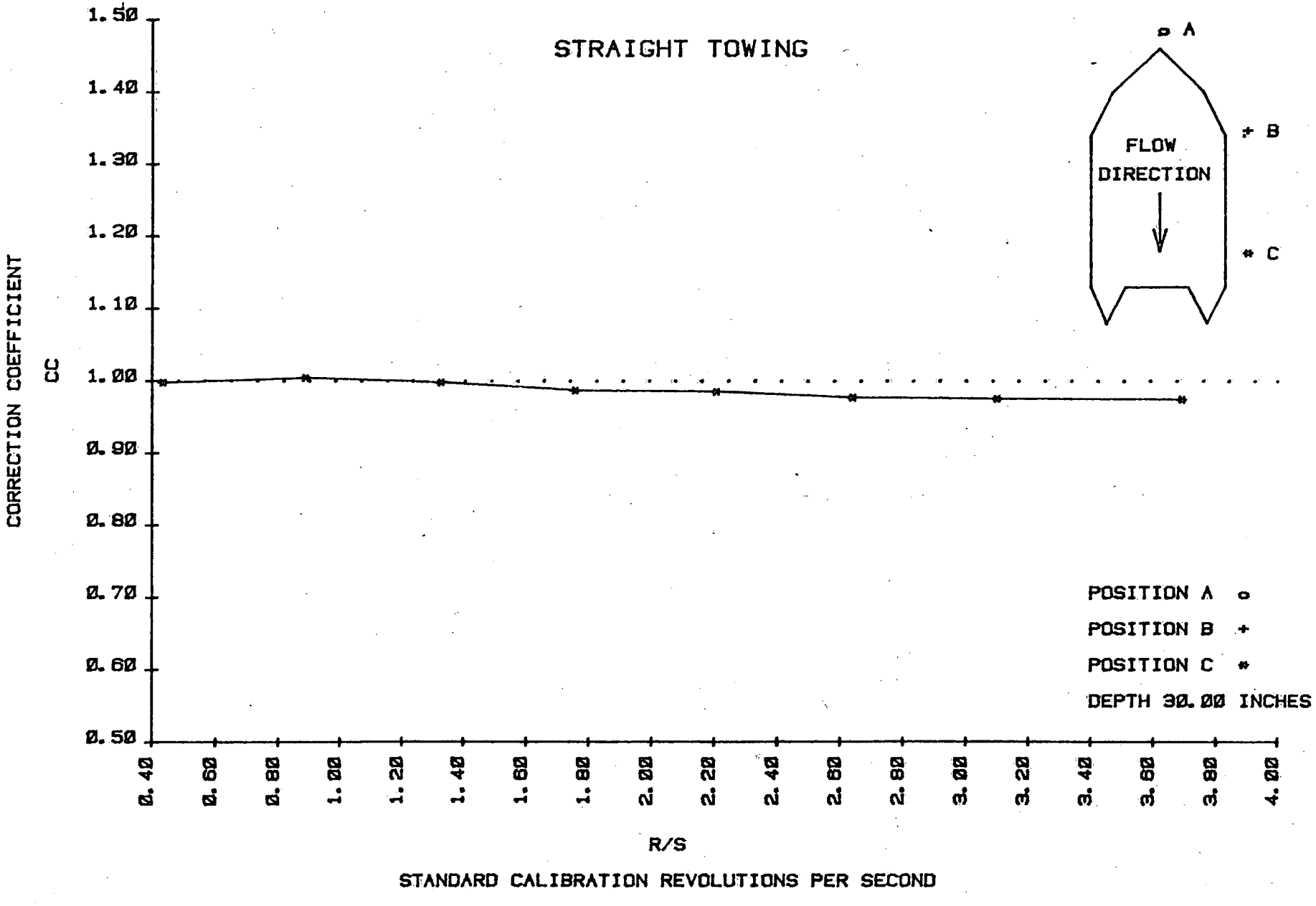
R/S

STANDARD CALIBRATION REVOLUTIONS PER SECOND

POSITION A o
POSITION B +
POSITION C *
DEPTH 24.00 INCHES

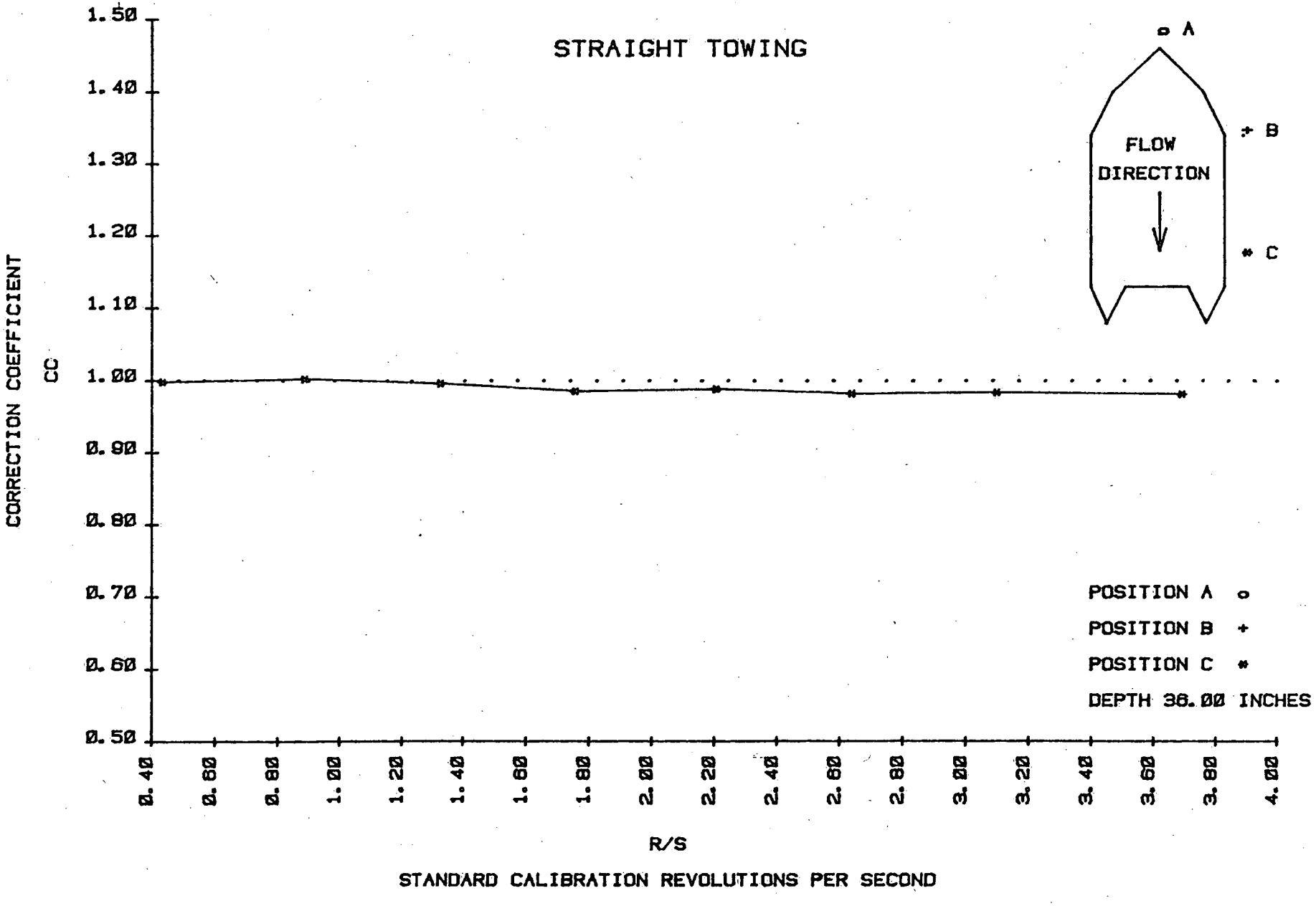
PLOT 5

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER



PLOT 6

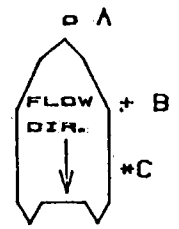
FLOW DISTURBANCE EFFECT ON PRICE 622AA METER



PLOT 1A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

STRAIGHT TOWING



PERCENTAGE ERROR

%

10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0

0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0 220.0 230.0 240.0 250.0

cm/s

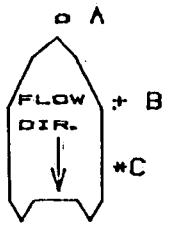
METER VELOCITY

POSITION A o
POSITION B +
POSITION C *
DEPTH 6.0 INCHES

PLOT 2A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

STRAIGHT TOWING



PERCENTAGE ERROR

%

10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0

0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0 220.0 230.0 240.0 250.0

cm/s

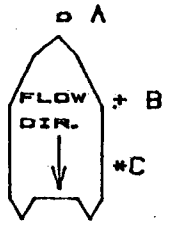
METER VELOCITY

POSITION A o
POSITION B +
POSITION C *
DEPTH 12.0 INCHES

PLOT 3A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

STRAIGHT TOWING



PERCENTAGE ERROR

%

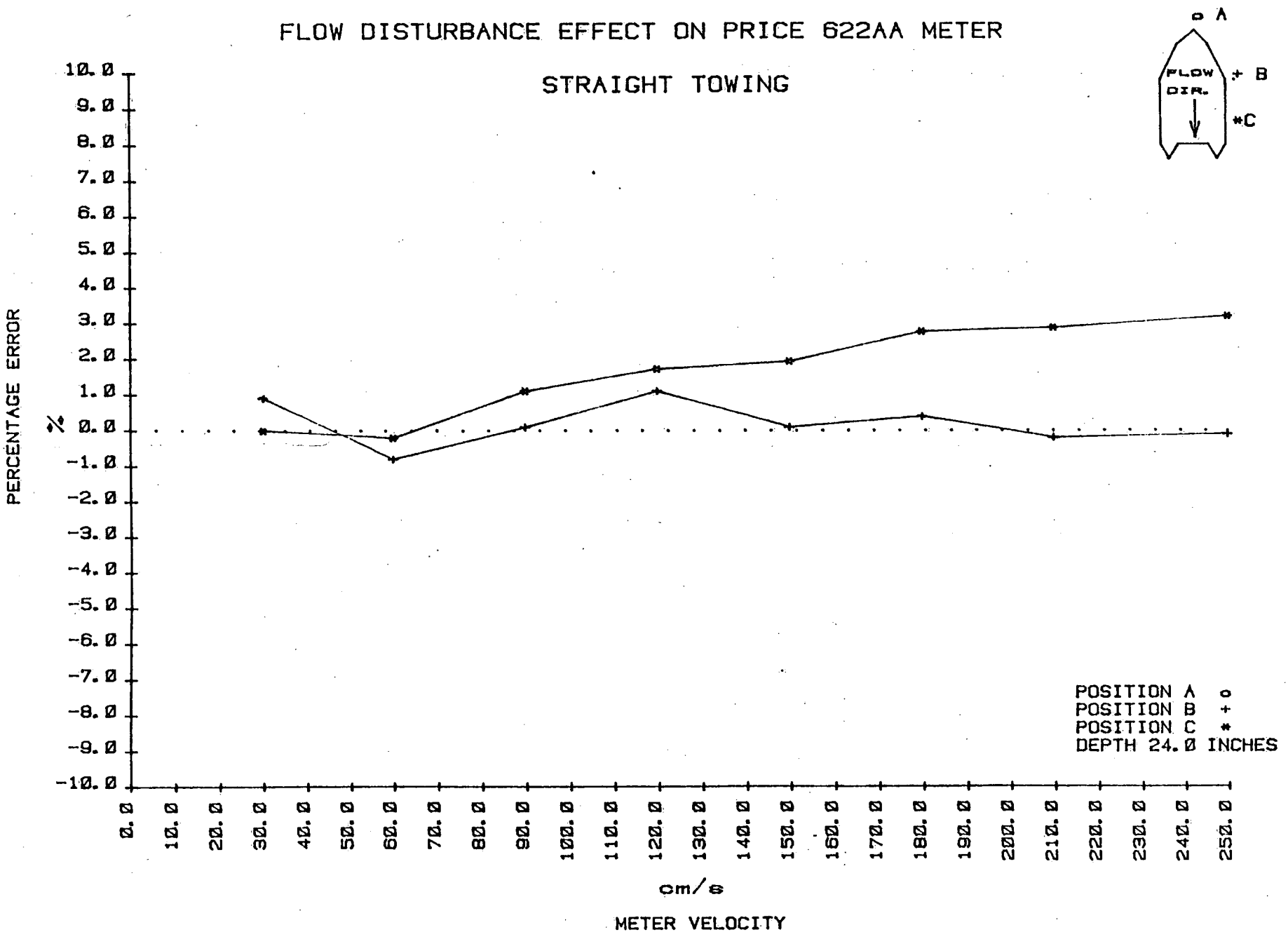
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0

0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0 220.0 230.0 240.0 250.0

cm/s

METER VELOCITY

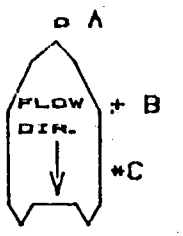
POSITION A o
POSITION B +
POSITION C *
DEPTH 18.0 INCHES


FLOW DISTURBANCE EFFECT ON PRICE 622AA METER
STRAIGHT TOWING
o A
+ B
*C
FLOW DIR.
PERCENTAGE ERROR
%
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
230.0
240.0
250.0
cm/s
METER VELOCITY
POSITION A o
POSITION B +
POSITION C *
DEPTH 24.0 INCHES

PLOT 4A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

STRAIGHT TOWING

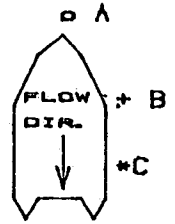


PLOT 5A

PLOT 6A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

STRAIGHT TOWING



PERCENTAGE ERROR

%

10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0

0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0 220.0 230.0 240.0 250.0

cm/s

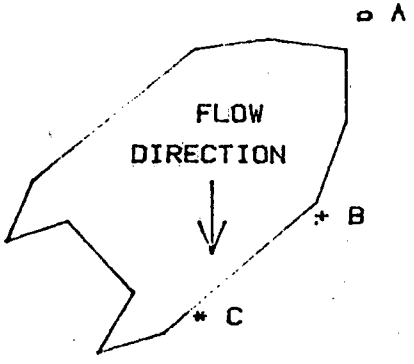
METER VELOCITY

POSITION A o
POSITION B +
POSITION C *
DEPTH 42.0 INCHES

PLOT 1

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



CORRECTION COEFFICIENT
CC

1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50

0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.20 2.40 2.60 2.80 3.00 3.20 3.40 3.60 3.80 4.00

R/S

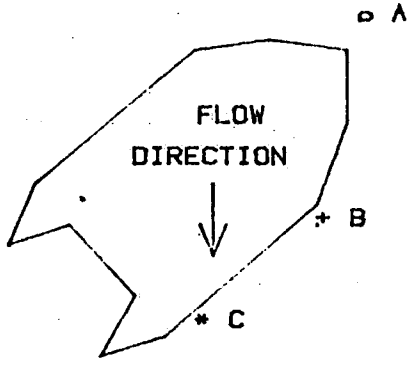
STANDARD CALIBRATION REVOLUTIONS PER SECOND

POSITION A o
POSITION B +
POSITION C *
DEPTH 6.00 INCHES

PLOT 2

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



CORRECTION COEFFICIENT
CC

1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50

0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.20 2.40 2.60 2.80 3.00 3.20 3.40 3.60 3.80 4.00

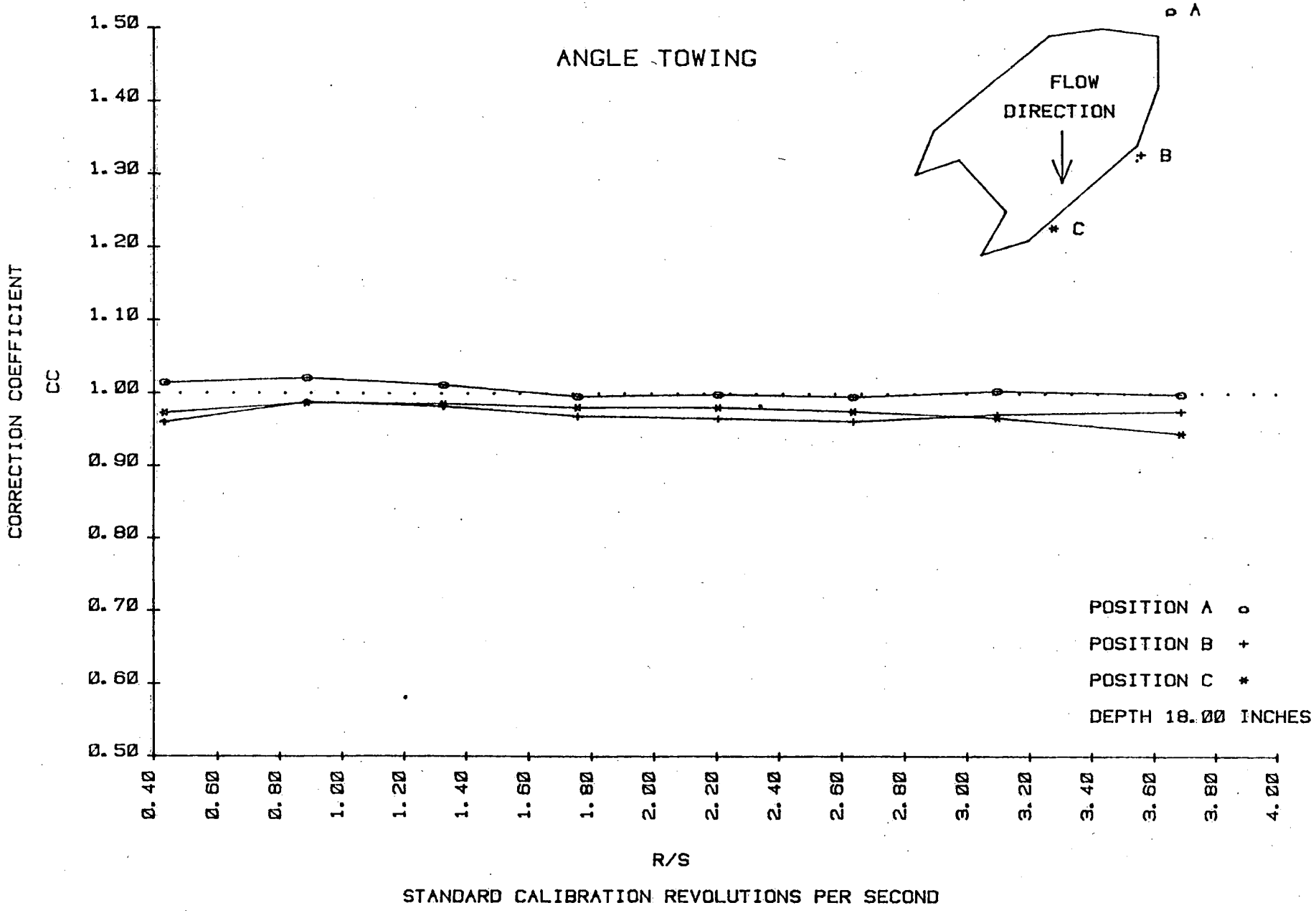
R/S

STANDARD CALIBRATION REVOLUTIONS PER SECOND

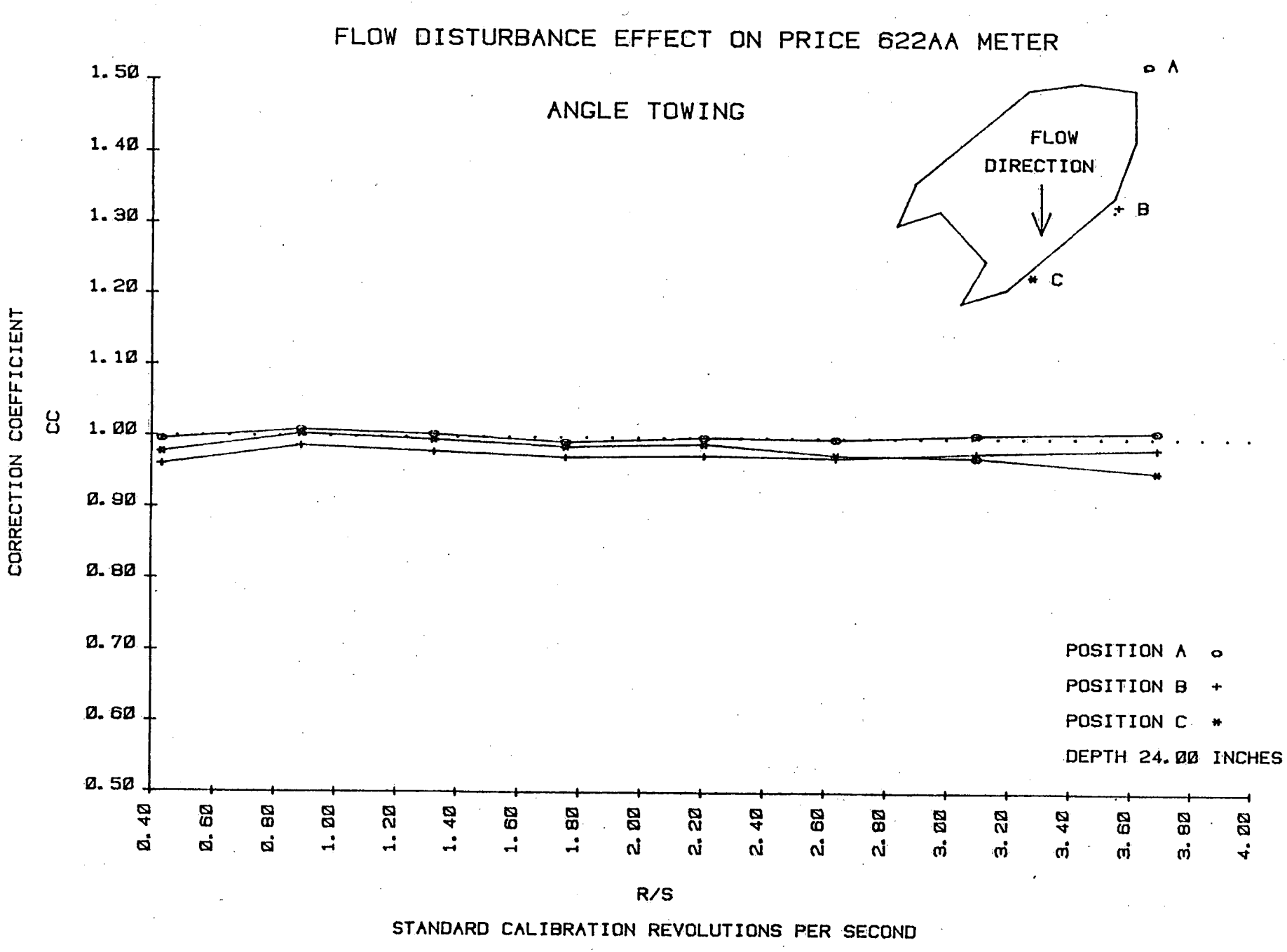
POSITION A o
POSITION B +
POSITION C *
DEPTH 12.00 INCHES

PLOT 3

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER



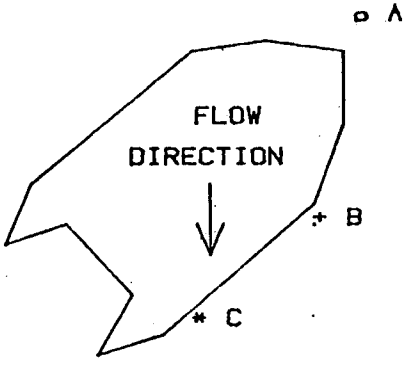
PLOT 4


FLOW DISTURBANCE EFFECT ON PRICE 622AA METER
ANGLE TOWING
FLOW DIRECTION
A
B
C
CORRECTION COEFFICIENT
CC
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
3.20
3.40
3.60
3.80
4.00
R/S
STANDARD CALIBRATION REVOLUTIONS PER SECOND
POSITION A o
POSITION B +
POSITION C *
DEPTH 24.00 INCHES

PLOT 5

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



CORRECTION COEFFICIENT
CC

1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50

0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.20 2.40 2.60 2.80 3.00 3.20 3.40 3.60 3.80 4.00

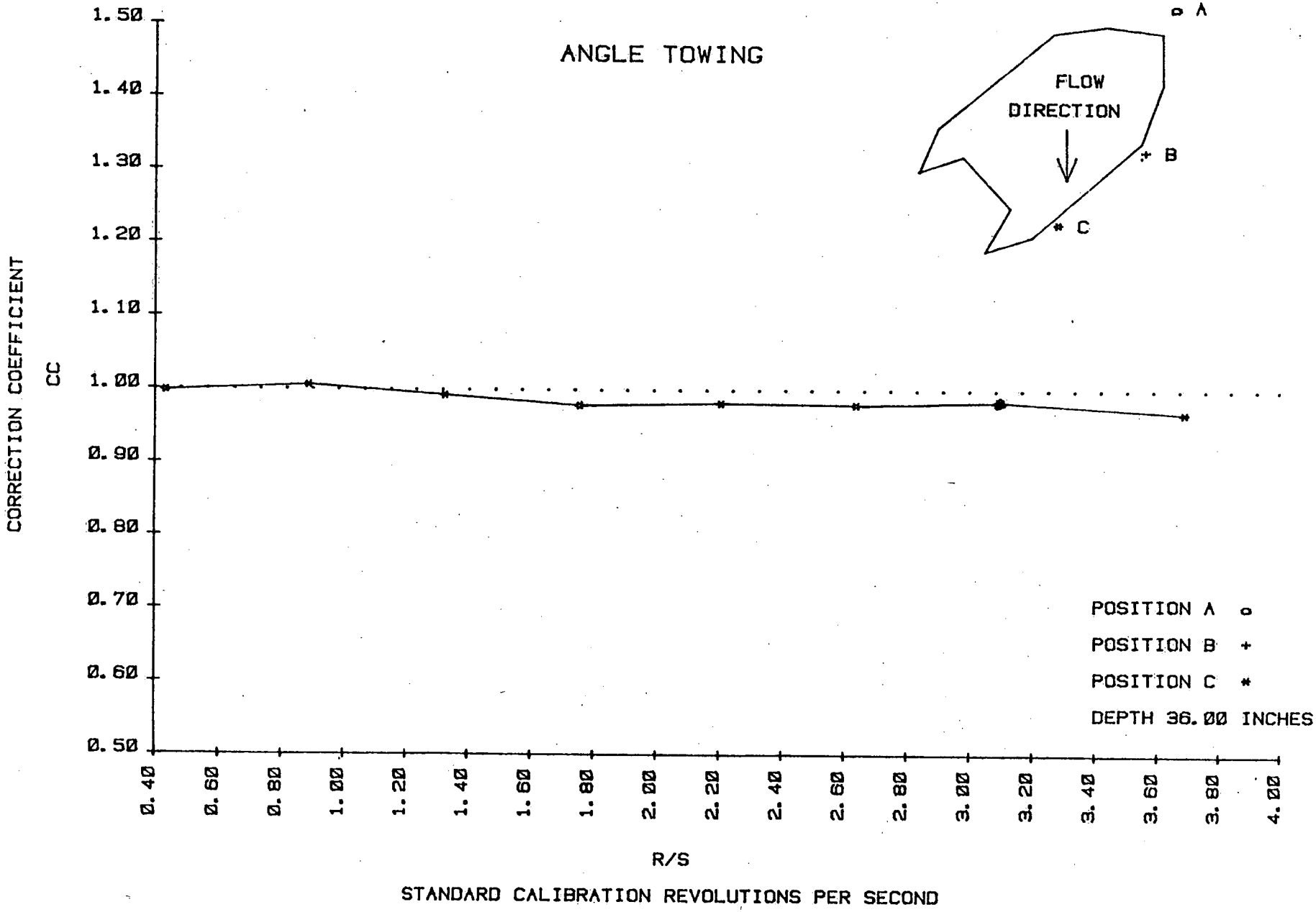
R/S

STANDARD CALIBRATION REVOLUTIONS PER SECOND

POSITION A o
POSITION B +
POSITION C *
DEPTH 30.00 INCHES

PLOT 6

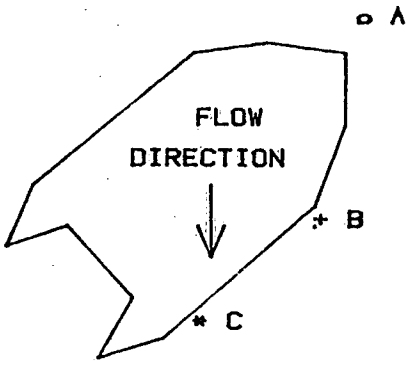
FLOW DISTURBANCE EFFECT ON PRICE 622AA METER



PLOT 7

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



CORRECTION COEFFICIENT
CC

1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50

0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.20 2.40 2.60 2.80 3.00 3.20 3.40 3.60 3.80 4.00

R/S

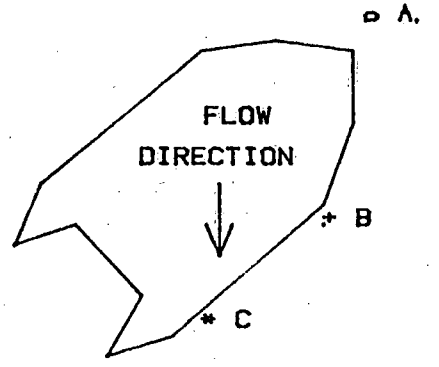
STANDARD CALIBRATION REVOLUTIONS PER SECOND

POSITION A o
POSITION B +
POSITION C *
DEPTH 42.00 INCHES

PLOT 8

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



CORRECTION COEFFICIENT
CC

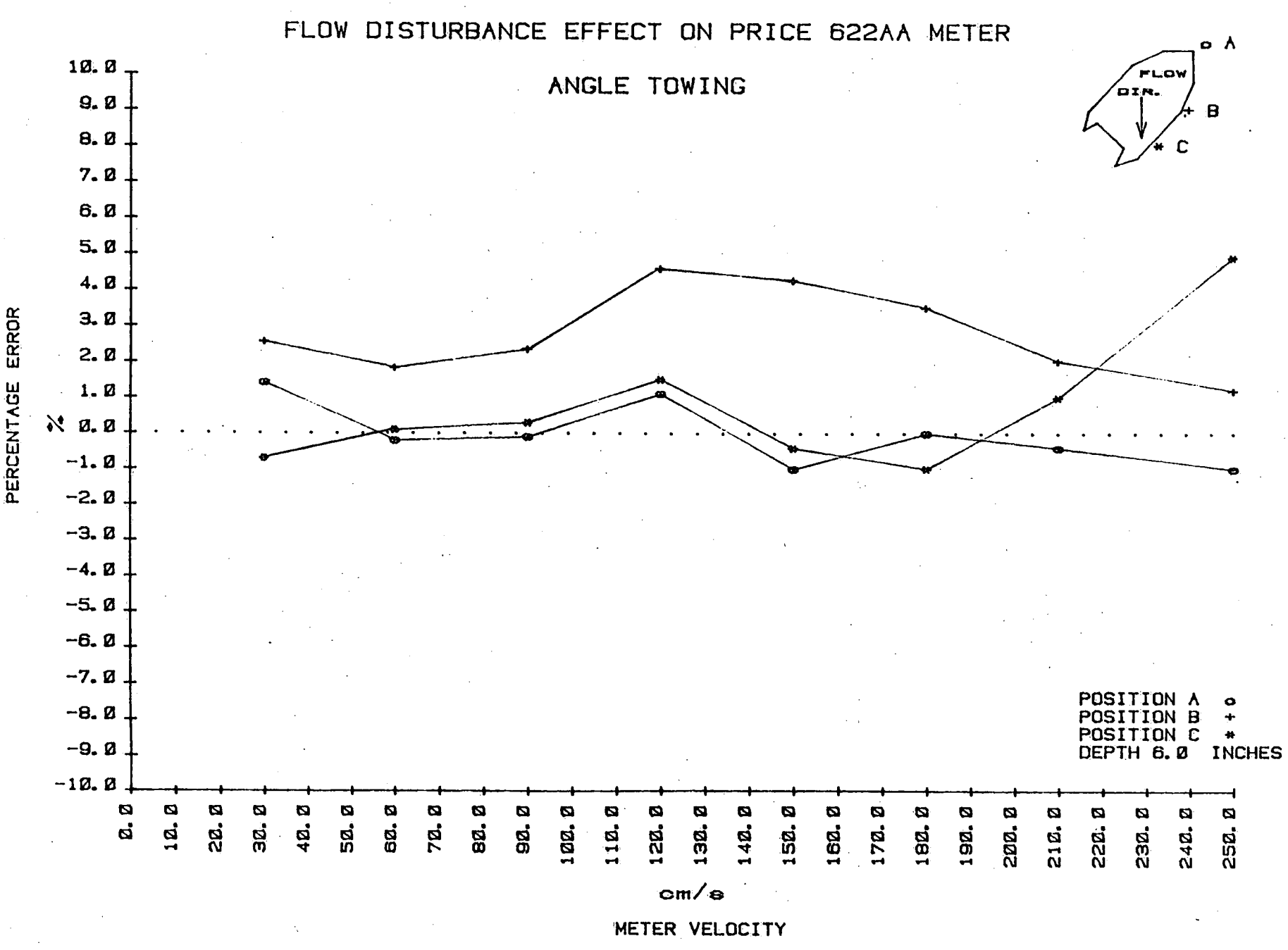
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50

0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.20 2.40 2.60 2.80 3.00 3.20 3.40 3.60 3.80 4.00

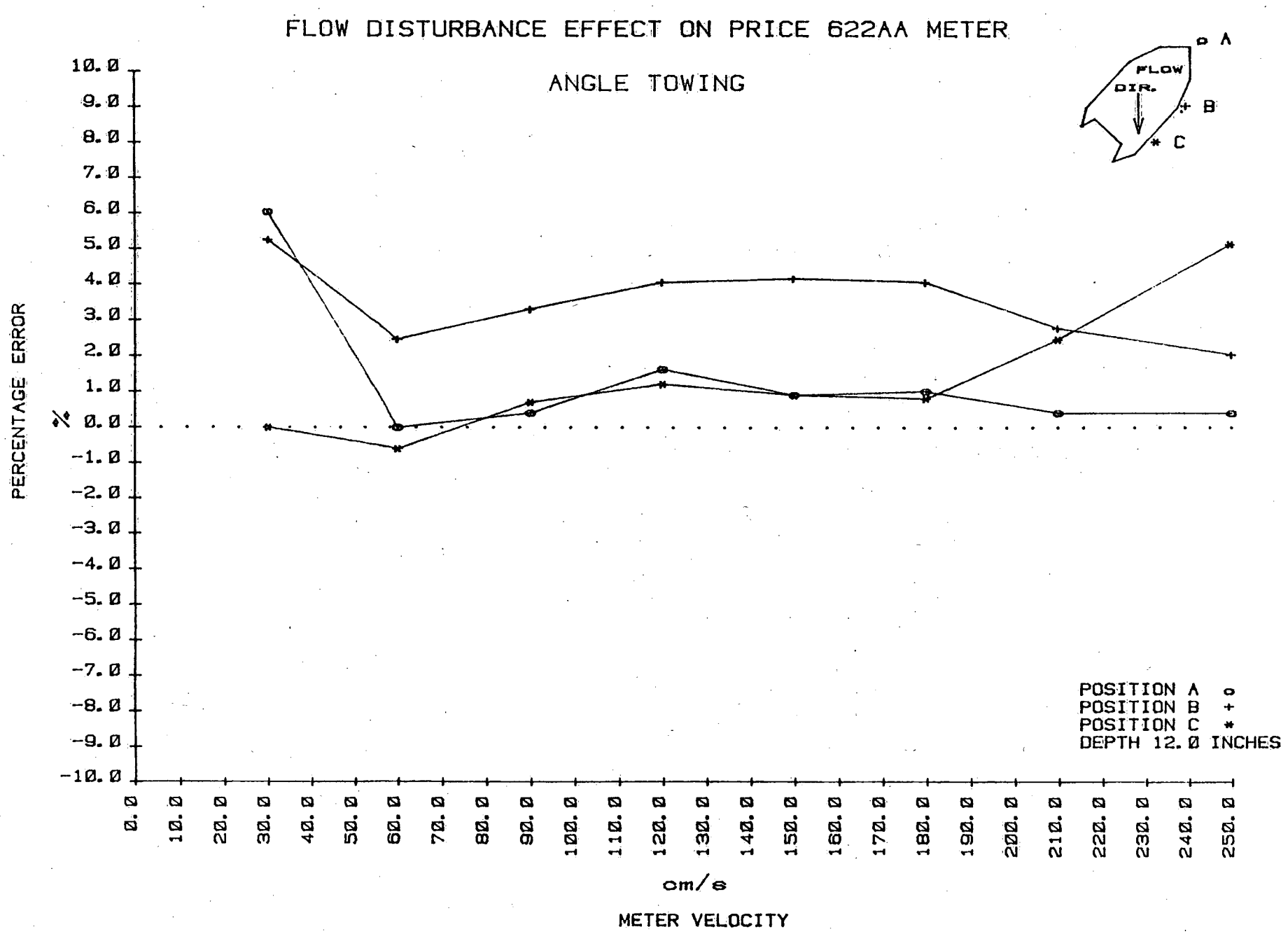
R/S

STANDARD CALIBRATION REVOLUTIONS PER SECOND

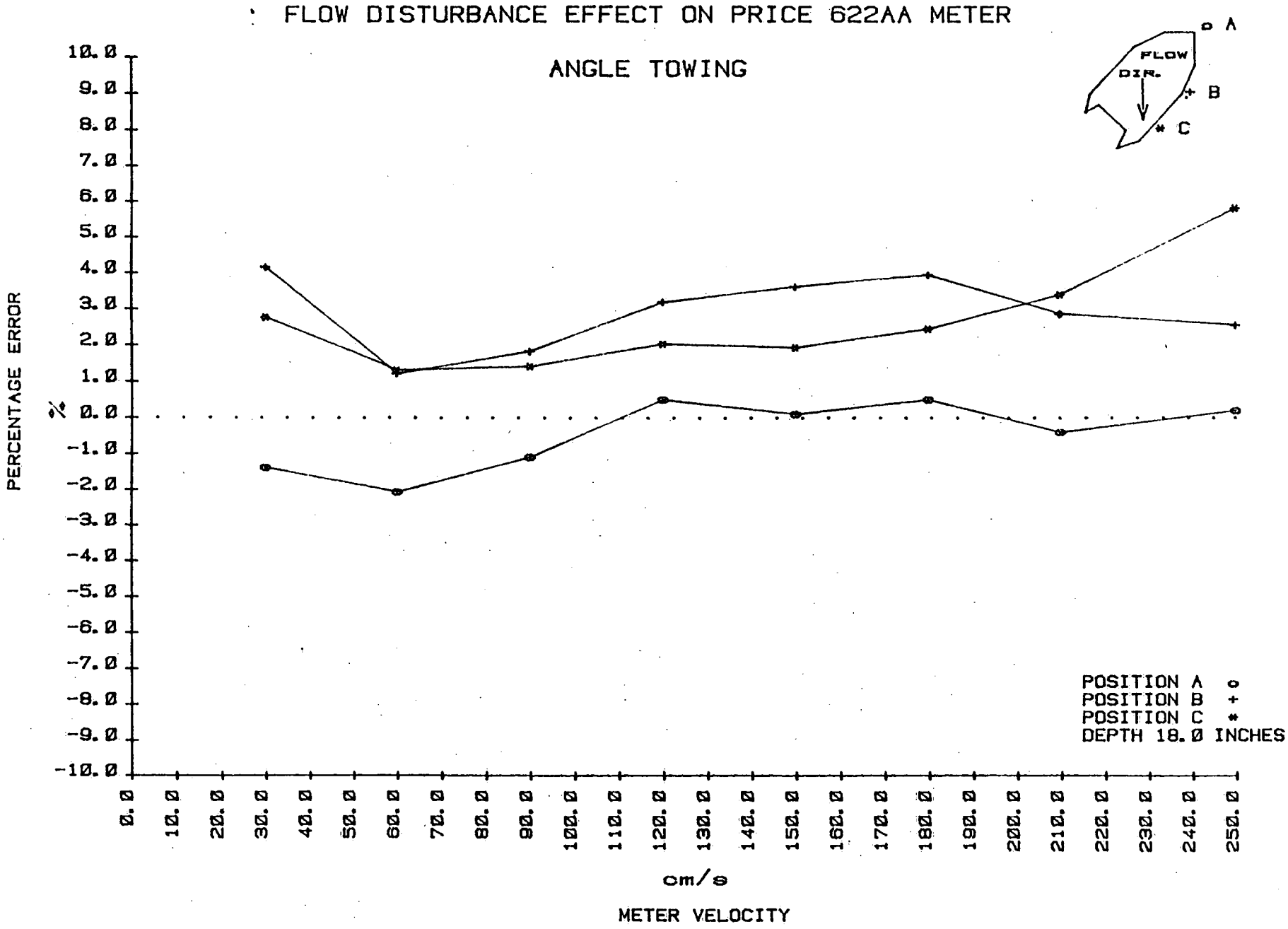
POSITION A o
POSITION B +
POSITION C *
DEPTH 48.00 INCHES


FLOW DISTURBANCE EFFECT ON PRICE 622AA METER
ANGLE TOWING
FLOW DIR.
A
B
C
PERCENTAGE ERROR
%
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
230.0
240.0
250.0
cm/s
METER VELOCITY
POSITION A o
POSITION B +
POSITION C *
DEPTH 6.0 INCHES

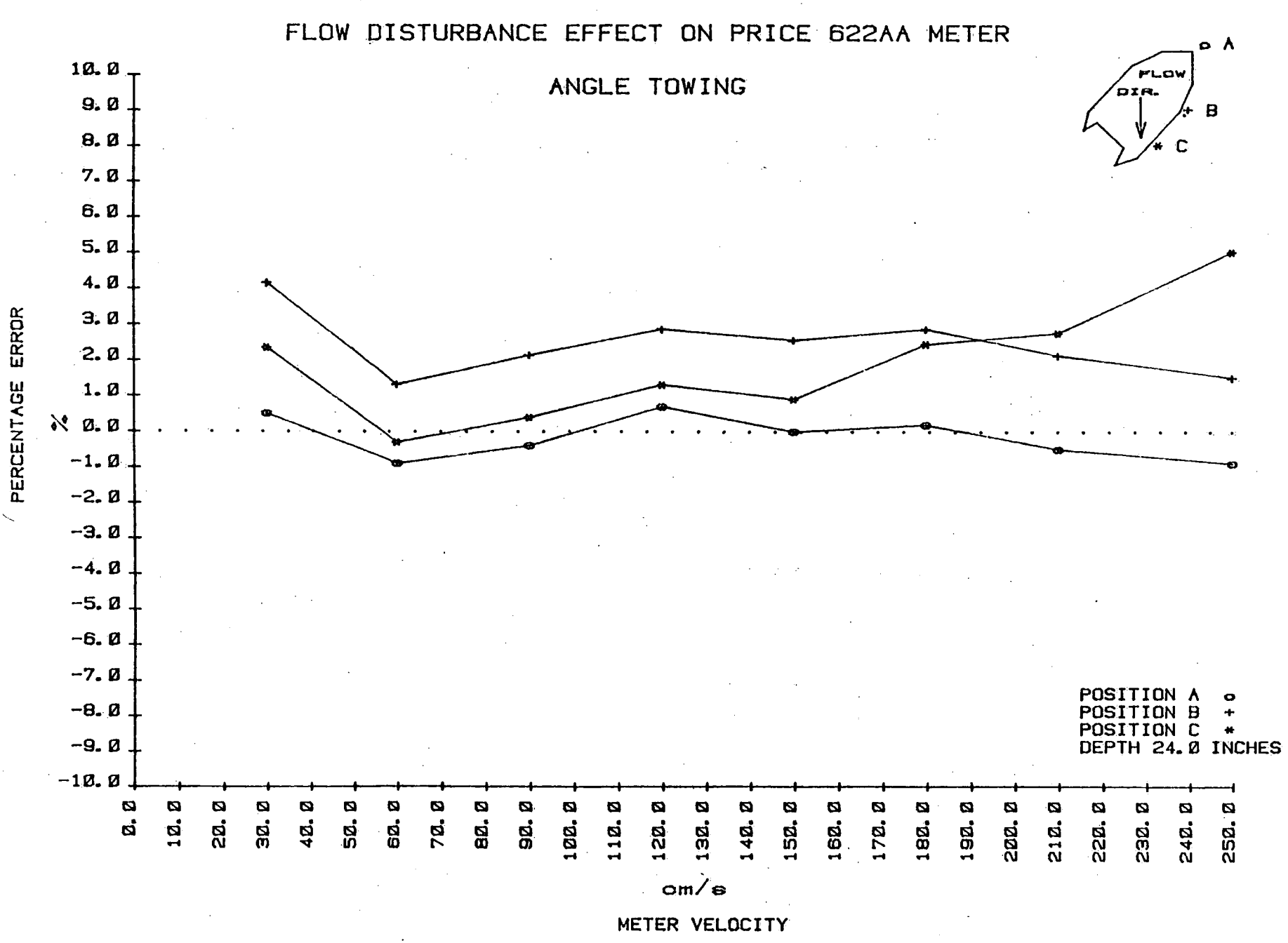
PLOT 1A


FLOW DISTURBANCE EFFECT ON PRICE 622AA METER
ANGLE TOWING
FLOW DIR.
A
B
C
PERCENTAGE ERROR
%
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
230.0
240.0
250.0
cm/s
METER VELOCITY
POSITION A o
POSITION B +
POSITION C *
DEPTH 12.0 INCHES

PLOT 2A


FLOW DISTURBANCE EFFECT ON PRICE 622AA METER
ANGLE TOWING
FLOW DIR.
A
B
C
PERCENTAGE ERROR
%
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
230.0
240.0
250.0
cm/s
METER VELOCITY
POSITION A o
POSITION B +
POSITION C *
DEPTH 18.0 INCHES

PLOT 3A

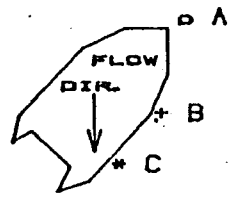

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER
ANGLE TOWING
FLOW DIR.
A
B
C
PERCENTAGE ERROR
%
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0
200.0
210.0
220.0
230.0
240.0
250.0
cm/s
METER VELOCITY
POSITION A o
POSITION B +
POSITION C *
DEPTH 24.0 INCHES

PLOT 4A

PLOT 5A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



PERCENTAGE ERROR

%

10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0

0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0 220.0 230.0 240.0 250.0

cm/s

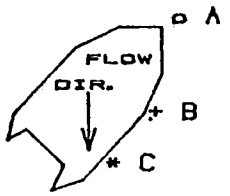
METER VELOCITY

POSITION A o
POSITION B +
POSITION C *
DEPTH 30.0 INCHES

PLOT 6A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



PERCENTAGE ERROR

%

10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0

0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0 220.0 230.0 240.0 250.0

cm/s

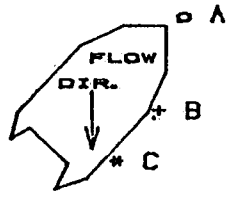
METER VELOCITY

POSITION A o
POSITION B +
POSITION C *
DEPTH 36.0 INCHES

PLOT 7A

FLOW DISTURBANCE EFFECT ON PRICE 622AA METER

ANGLE TOWING



PERCENTAGE ERROR

%

10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
-9.0
-10.0

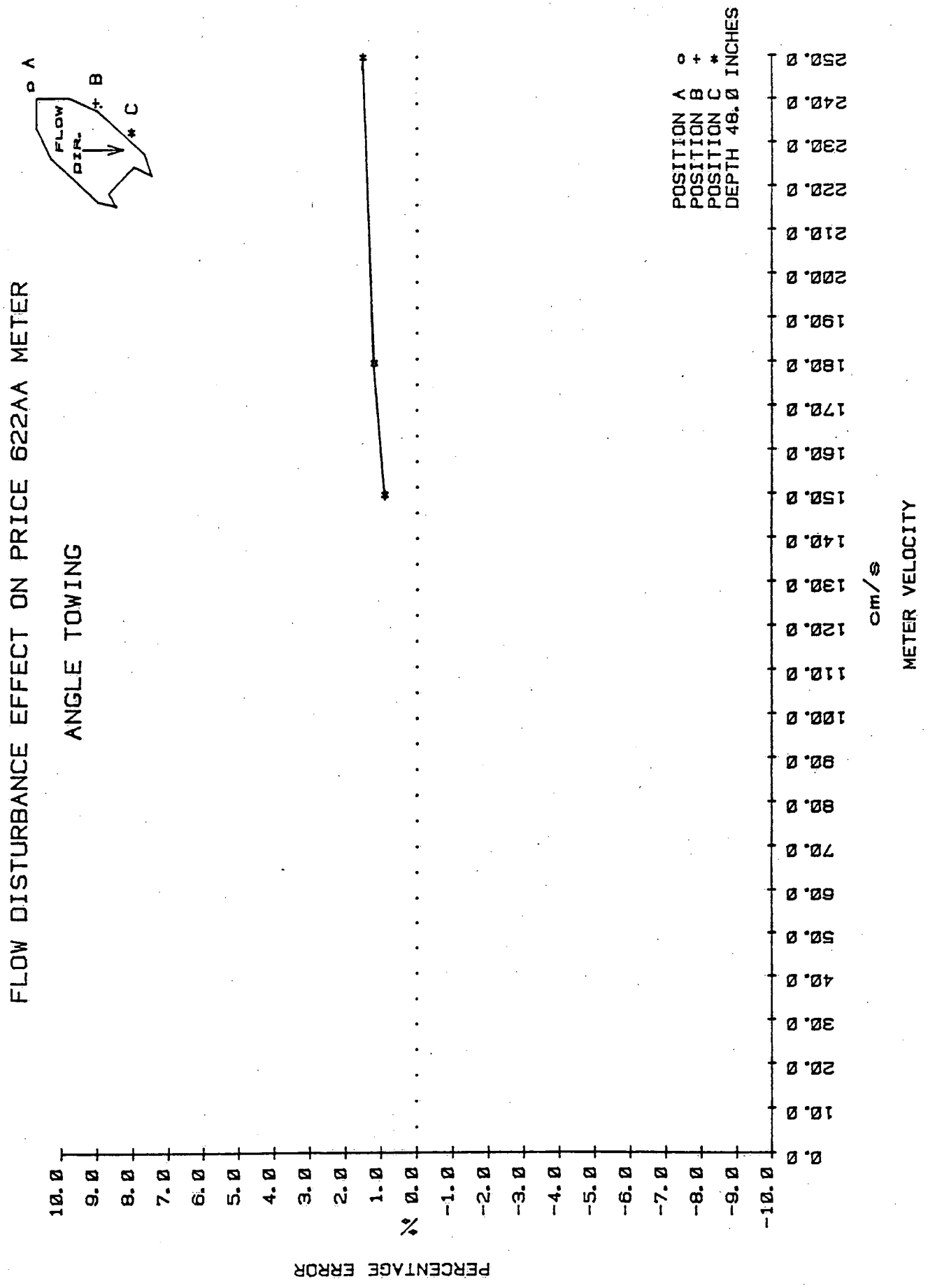
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 110.0 120.0 130.0 140.0 150.0 160.0 170.0 180.0 190.0 200.0 210.0 220.0 230.0 240.0 250.0

cm/s

METER VELOCITY

POSITION A o
POSITION B +
POSITION C *
DEPTH 42.0 INCHES

23730



PLOT 8A