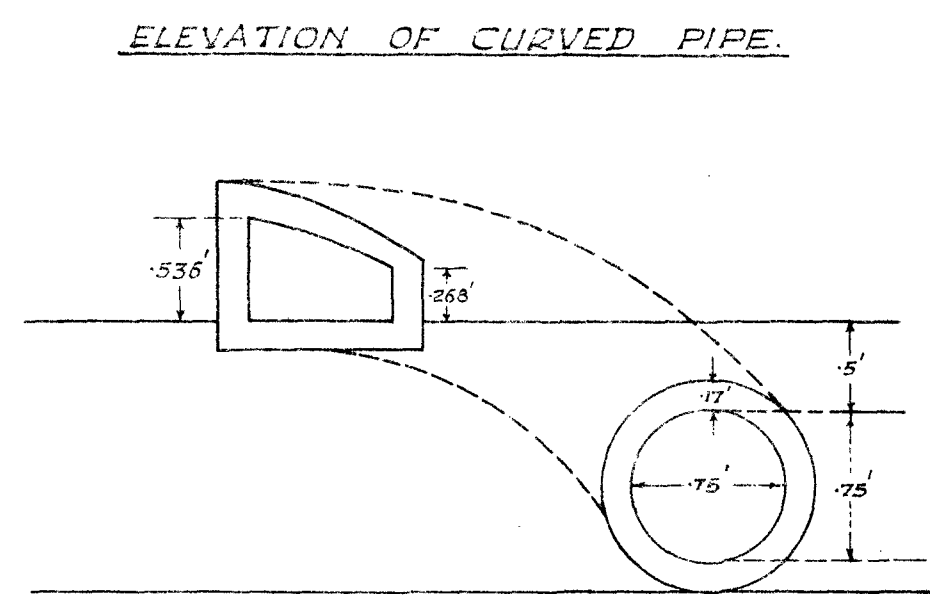
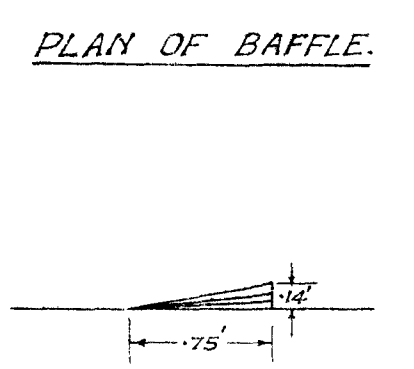
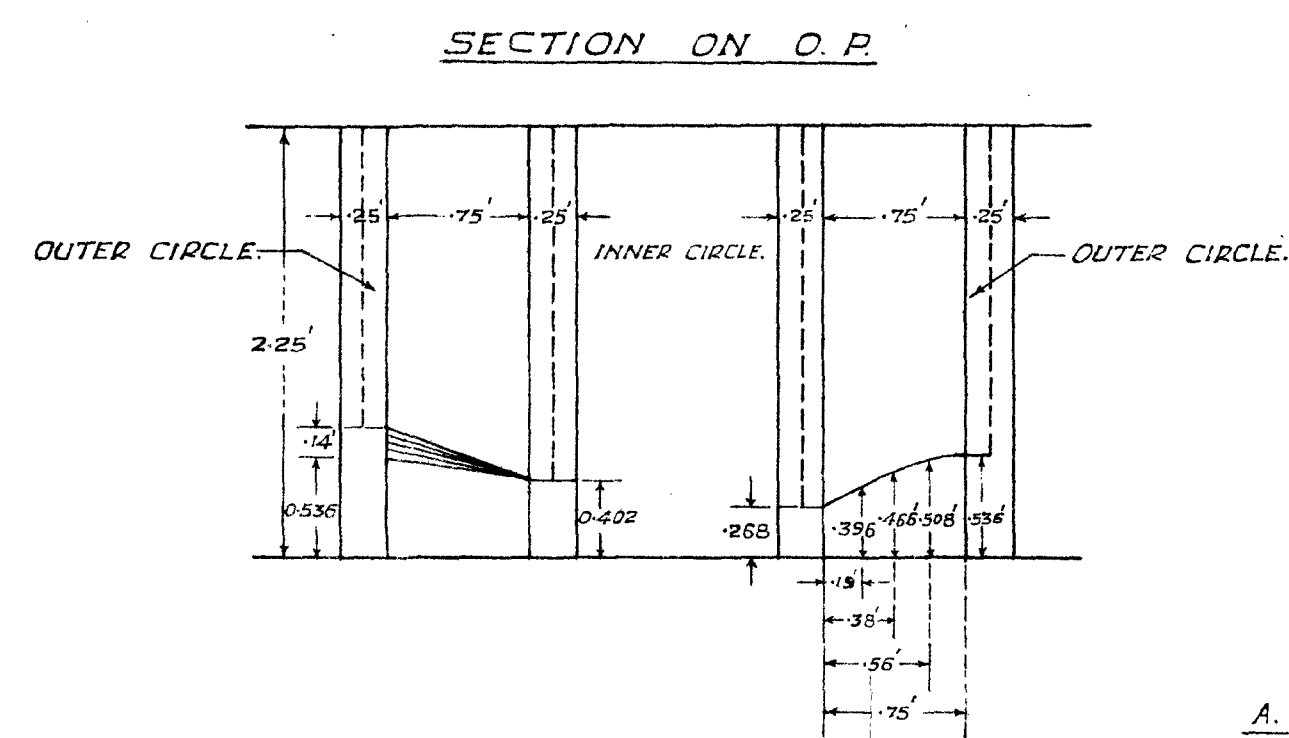
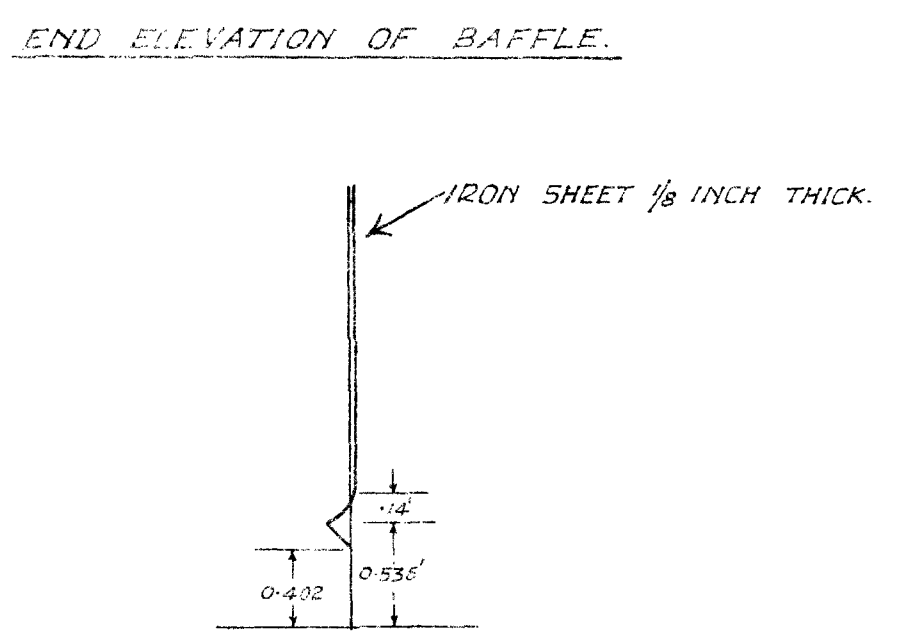
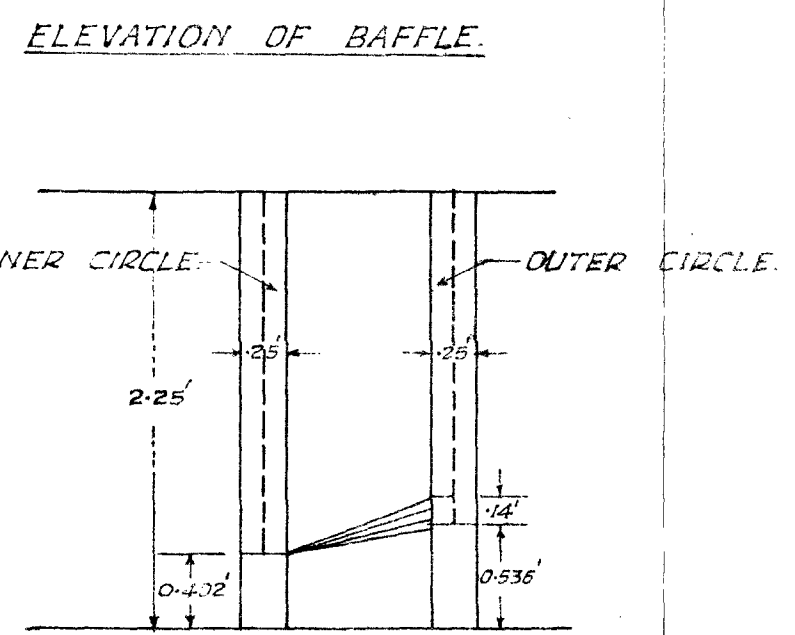
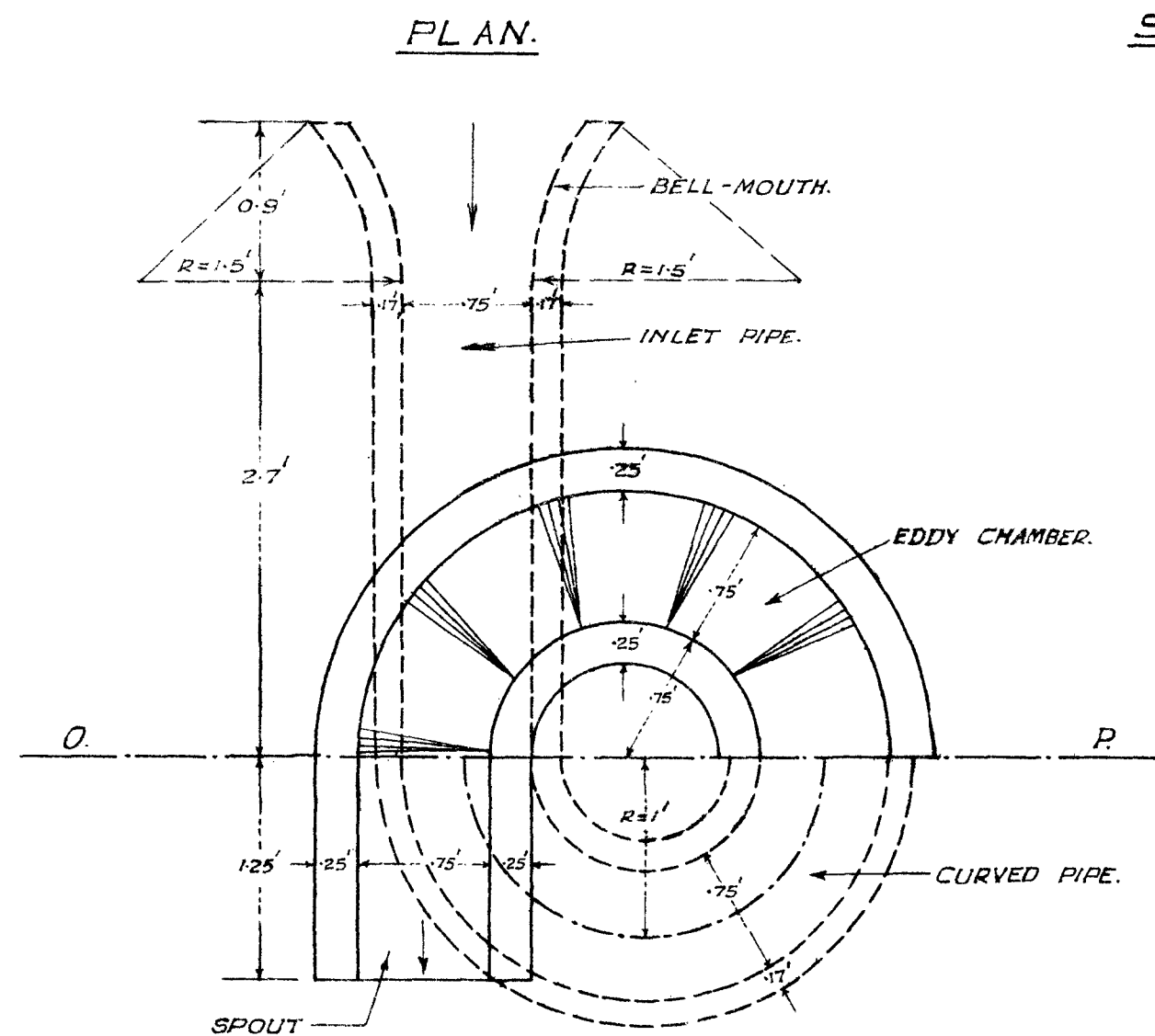


**1 CUSEC GIBB MODULE.**  
SCALE:- 1 INCH = 1 FOOT.



SECTIONS IN CURVED PIPE ON

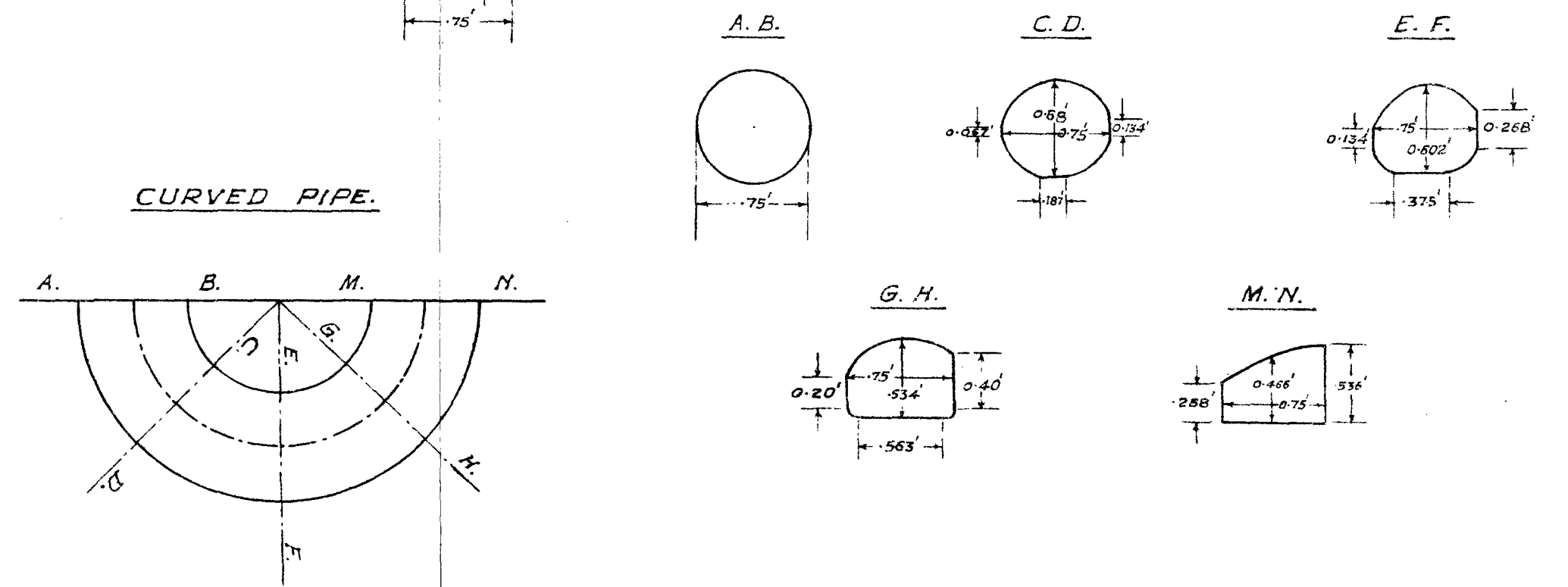
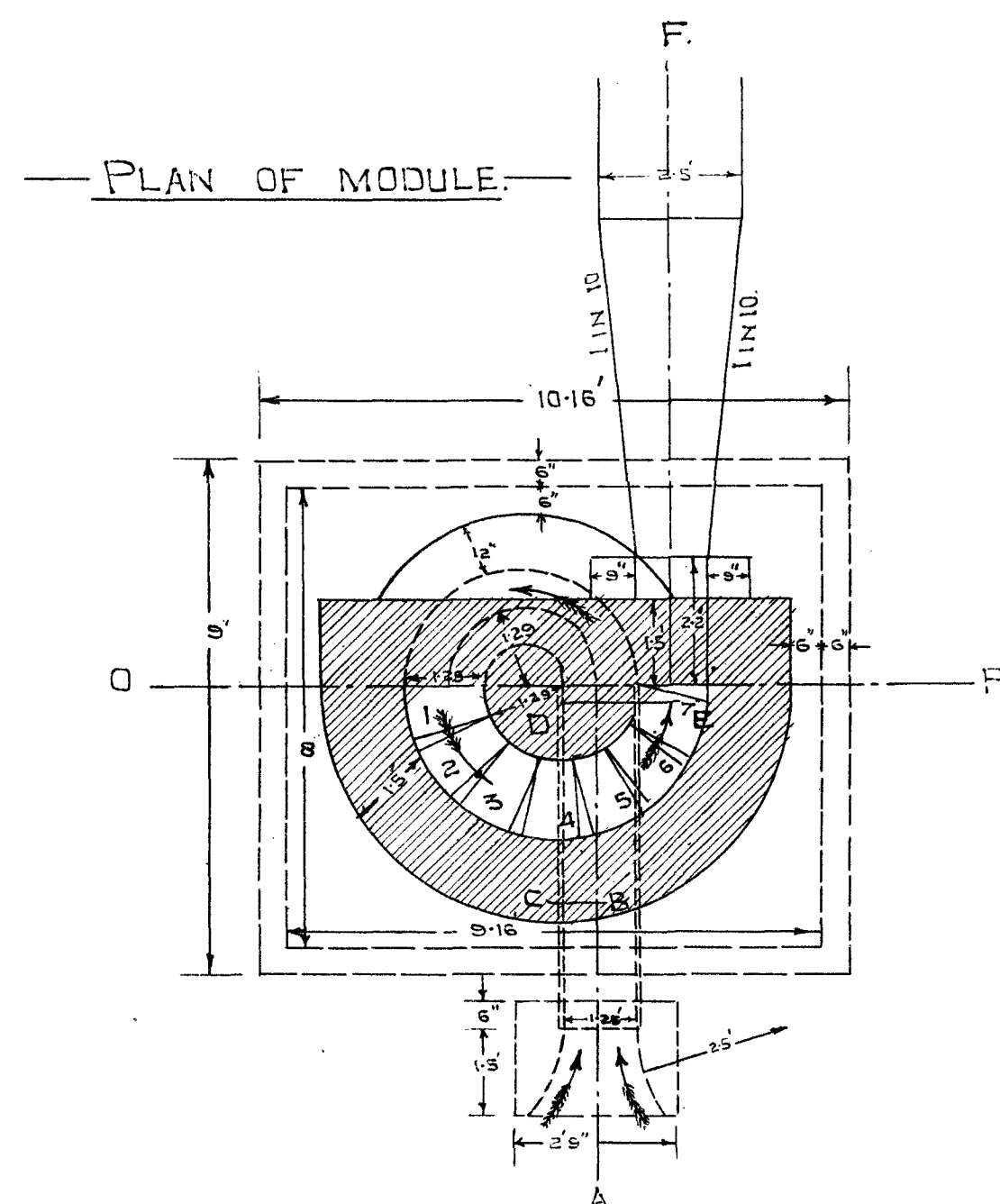


TABLE SHOWING DIMENSIONS OF 1, 2 & 3 CUSECS R.C.C. GIBB MODULES.  
(ALL DIMENSIONS ARE IN FEET.)

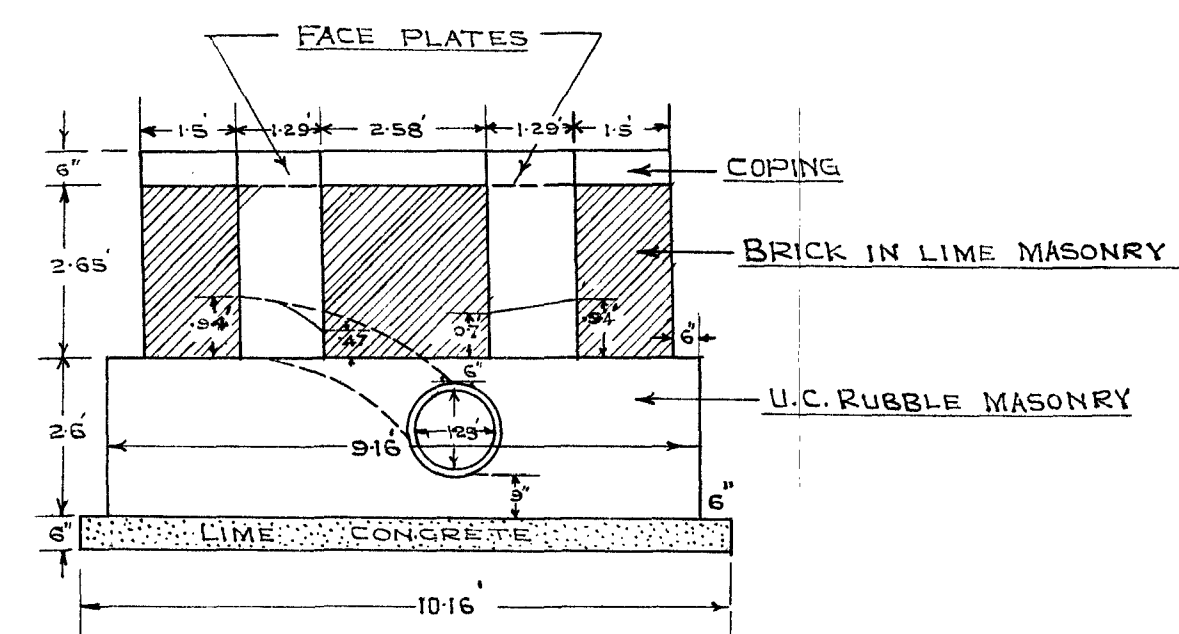
|   | 1 CUSEC MODULE.  | 2 CUSECS MODULE.  | 3 CUSECS MODULE.   |
|---|--|---|--|
| <b>BELL-MOUTH.</b>  |  |   |  |
| (1) LENGTH OF BELL-MOUTH.   | 0.9  | 1.0   | 1.2  |
| (2) RADIUS OF BELL-MOUTH.   | 1.5  | 1.66  | 2.0  |
| <b>INLET PIPE.</b>  |  |   |  |
| (3) DIAMETER OF INLET PIPE.   | 0.75   | 0.83  | 1.0  |
| (4) LENGTH OF INLET PIPE.   | 2.7  | 3.0   | 3.6  |
| <b>CURVED PIPE.</b>   |  |   |  |
| (5) RADIUS OF CENTRE LINE OF CURVED PIPE.                               | 1.0  | 1.0   | 1.5  |
| (6) DISTANCE BETWEEN TOP OF CURVED PIPE & FLOOR OF MODULE.              | 0.5  | 0.5   | 0.5  |
| <b>EDDY CHAMBER.</b>  |  |   |  |
| (7) $r_o$ = RADIUS OF OUTER SEMI-CIRCLE.                                | 1.5  | 1.916   | 2.75   |
| (8) $r_i$ = RADIUS OF INNER SEMI-CIRCLE.                                | 0.75   | 0.958   | 1.375  |
| (9) B = WIDTH OF EDDY CHAMBER.  | 0.75   | 0.958   | 1.375  |
| (10) HEIGHT OF EDDY CHAMBER.  | 2.25   | 2.56  | 2.6  |
| (11) LENGTH OF SPOUT.   | 1.25   | 1.68  | 1.75   |
| <b>BAFFLES.</b>   |  |   |  |
| (12) NUMBER OF BAFFLES.   | 5  | 5   | 6  |
| (13) HEIGHT OF LOWER EDGE OF BAFFLES FROM MODULE FLOOR AT OUTER CIRCLE. | 0.536  | 0.72  | 0.75   |
| (13) HEIGHT OF LOWER EDGE OF BAFFLES FROM MODULE FLOOR AT INNER CIRCLE. | 0.402  | 0.54  | 0.562  |
| (14) RADIUS OF LOWER EDGE OF BAFFLES AT OUTER CIRCLE.                   | 0.14   | 0.18  | 0.22   |
| (15) CROSS SECTIONS AT JUNCTION OF CURVED PIPE & EDDY CHAMBER.          |  |   |  |
| $d_o$ = DEPTH OF WATER AT OUTER CIRCUMFERENCE.                          | 0.536 AT 0.75 FROM INNER CIRCLE.   | 0.72 AT 0.958 FROM INNER CIRCLE.  | 0.75 AT 1.375 FROM INNER CIRCLE.   |
| $d_i$ = DEPTH OF WATER AT INNER CIRCUMFERENCE.                          | 0.508 AT 0.56 FROM INNER CIRCLE.<br>0.466 AT 0.38 FROM INNER CIRCLE.<br>0.396 AT 0.19 FROM INNER CIRCLE.<br>0.268 AT INNER CIRCLE. | 0.69 AT 0.718 FROM INNER CIRCLE.<br>0.63 AT 0.479 FROM INNER CIRCLE.<br>0.54 AT 0.239 FROM INNER CIRCLE.<br>0.36 AT INNER CIRCLE. | 0.72 AT 1.031 FROM INNER CIRCLE.<br>0.653 AT 0.687 FROM INNER CIRCLE.<br>0.555 AT 0.344 FROM INNER CIRCLE.<br>0.375 AT INNER CIRCLE. |
| (16) DEVELOPMENT OF CURVED PIPE.  |  |   |  |
| CROSS SECTION A. B.   | 0.75   | 0.83  | 1.0  |
| CROSS SECTION C. D.   | 0.067, 0.187, 0.134, 0.75, 0.68.   | 0.09, 0.24, 0.18, 0.86, 0.78.   | 0.094, 0.34, 0.10, 1.09, 0.914.  |
| CROSS SECTION E. F.   | 0.134, 0.375, 0.268, 0.75, 0.602.  | 0.18, 0.48, 0.36, 0.89, 0.73.   | 0.187, 0.68, 0.374, 1.18, 0.826.   |
| CROSS SECTION G. H.   | 0.20, 0.563, 0.40, 0.75, 0.534.  | 0.27, 0.71, 0.54, 0.92, 0.68.   | 0.282, 1.02, 0.564, 1.27, 0.74.  |
| CROSS SECTION M. N.   | SEE ITEM (15)  | SEE ITEM (15)   | SEE ITEM (15)  |

4 CUSECS GIBB MODULE.

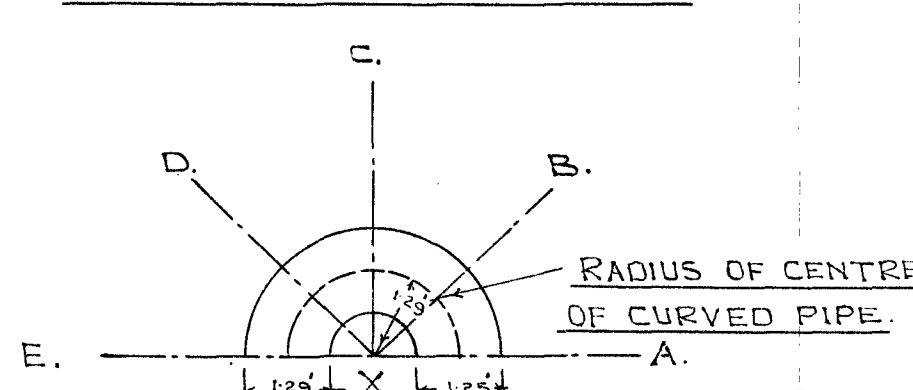
SCALE:- 3 FEET = 1"



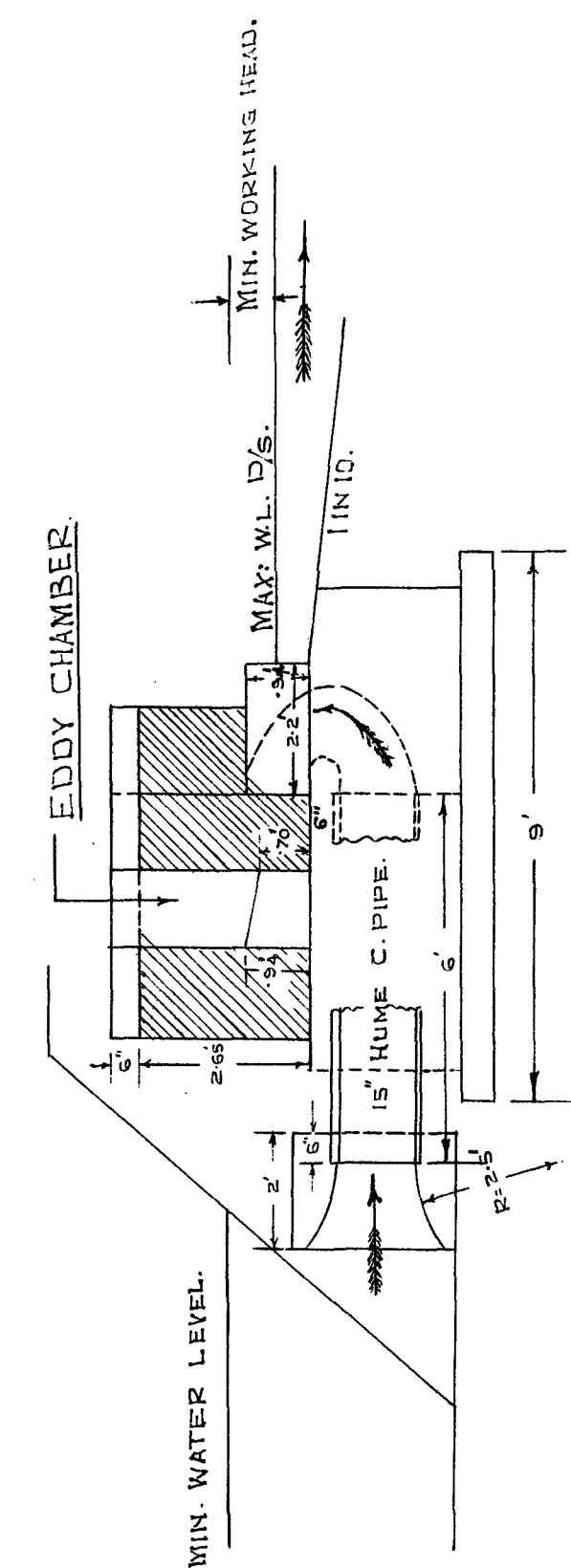
SECTION ALONG O.P.



PLAN OF CURVED PIPE

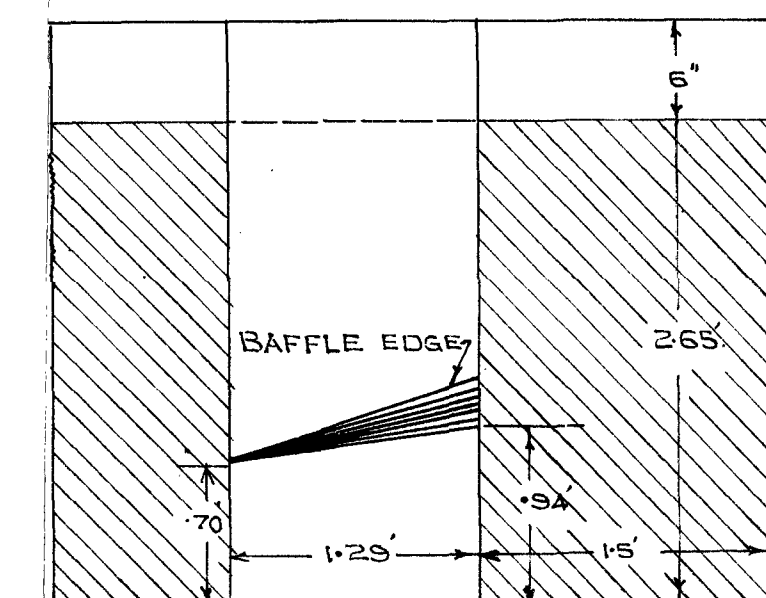


SECTION ALONG A.B.C.D.E.F.

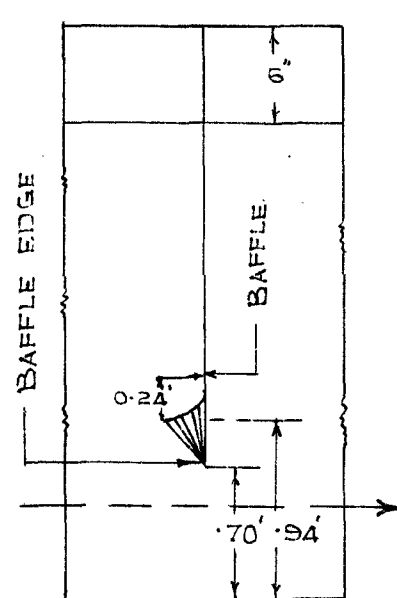


ENLARGED VIEW OF BAFFLE

SCALE:- 1" = 1 INCH.



FRONT VIEW



SIDE VIEW

ENLARGED SECTIONS OF CURVED PIPE

SCALE:- 1" = 1 INCH.

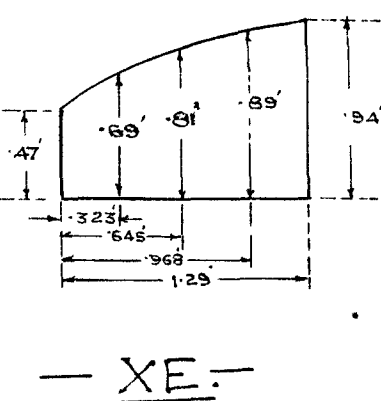
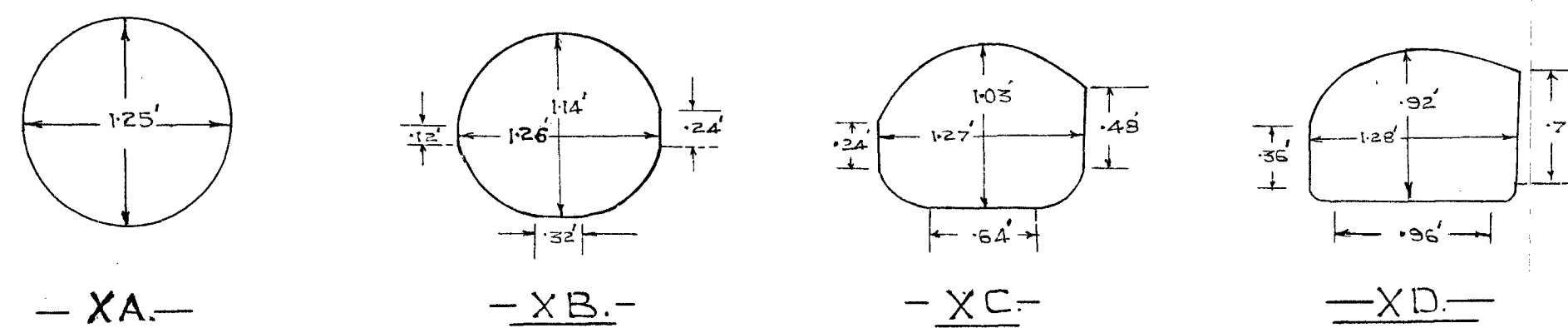


TABLE SHOWING DIMENSIONS OF 4, 5, 8, 10 & 16 CUSECS GIBB MODULES.

(IN BRICK MASONRY WITH CEMENT PLASTER ON THE INSIDE & CEMENT POINTING ON THE OUTSIDE.)

ALL DIMENSIONS ARE IN FEET.

|  | 4 CUSECS MODULE                  | 5 CUSECS MODULE.                 | 8 CUSECS MODULE.                | 10 CUSECS MODULE.                | 16 CUSECS MODULE.               |
|--|----------------------------------|----------------------------------|---------------------------------|----------------------------------|---------------------------------|
| <b>BELL MOUTH</b>  |                                  |                                  |                                 |                                  |                                 |
| 1 LENGTH OF BELL MOUTH   | 1.5                              | 1.5                              | 1.8                             | 2.1                              | 2.4                             |
| 2 RADIUS OF BELL MOUTH   | 2.5                              | 2.5                              | 3.0                             | 3.5                              | 4.0                             |
| <b>INLET PIPE</b>  |                                  |                                  |                                 |                                  |                                 |
| 3 DIAMETER OF INLET PIPE   | 1.25                             | 1.25                             | 1.5                             | 1.75                             | 2.0                             |
| 4 LENGTH OF INLET PIPE   | 6.0                              | 6.0                              | 6.0                             | 8.0                              | 8.0                             |
| <b>CURVED PIPE</b>   |                                  |                                  |                                 |                                  |                                 |
| 5 RADIUS OF CENTRE LINE OF CURVED PIPE                                 | 1.29                             | 1.375                            | 1.625                           | 1.832                            | 2.5                             |
| 6 DISTANCE BETWEEN TOP OF CURVED PIPE AND FLOOR OF MODULE.             | 0.5                              | 0.5                              | 0.5                             | 0.5                              | 0.5                             |
| <b>EDDY CHAMBER</b>  |                                  |                                  |                                 |                                  |                                 |
| 7 $R_0$ = RADIUS OF OUTER SEMI-CIRCLE.                                 | 2.58                             | 2.75                             | 3.25                            | 3.64                             | 5.0                             |
| 8 $R_1$ = RADIUS OF INNER SEMI-CIRCLE                                  | 1.29                             | 1.375                            | 1.625                           | 1.832                            | 2.5                             |
| 9 B = WIDTH OF EDDY CHAMBER  | 1.29                             | 1.375                            | 1.625                           | 1.832                            | 2.5                             |
| 10 HEIGHT OF EDDY CHAMBER INCLUDING 6" COPING.                         | 3.15                             | 3.58                             | 4.25                            | 4.3                              | 5.0                             |
| 11 LENGTH OF SPOUT   | 2.2                              | 2.44                             | 3.15                            | 3.19                             | 3.5                             |
| <b>BAFFLES</b>   |                                  |                                  |                                 |                                  |                                 |
| 12 NUMBER OF BAFFLES   | 7                                | 7                                | 7                               | 8                                | 10                              |
| 13 HEIGHT OF LOWER EDGE OF BAFFLES FROM MODULE FLOOR. AT OUTER CIRCLE. | 0.94                             | 1.04                             | 1.34                            | 1.366                            | 1.519                           |
| AT INNER CIRCLE.   | 0.70                             | 0.78                             | 1.0                             | 1.025                            | 1.14                            |
| 14 RADIUS OF LOWER EDGE OF BAFFLES AT OUTER CIRCLE.                    | 0.24                             | 0.26                             | 0.33                            | 0.34                             | 0.38                            |
| 15 CROSS SECTION AT JUNCTION OF CURVED PIPE & EDDY CHAMBER.            |                                  |                                  |                                 |                                  |                                 |
| $d_0$ = DEPTH OF WATER AT OUTER CIRCUMFERENCE                          | 0.94 AT 1.29 FROM INNER CIRCLE   | 1.04 AT 1.375 FROM INNER CIRCLE. | 1.34 AT 1.625 FROM INNER CIRCLE | 1.366 AT 1.832 FROM INNER CIRCLE | 1.519 AT 2.5 FROM INNER CIRCLE. |
|  | 0.89 AT 0.968 FROM INNER CIRCLE. | 0.905 AT 1.032 " " "             | 1.27 AT 1.22 " " "              | 1.298 AT 1.374 " " "             | 1.442 AT 1.875 " " "            |
|  | 0.81 AT 0.645 FROM INNER CIRCLE. | 0.77 AT 0.544 " " "              | 1.0 AT 0.407 " " "              | 1.014 AT 0.458 " " "             | 1.322 AT 1.25 " " "             |
|  | 0.69 AT 0.323 FROM INNER CIRCLE. | 0.52 AT INNER CIRCLE             | 0.67 AT INNER CIRCLE.           | 0.69 AT INNER CIRCLE.            | 1.32 AT 0.625 " " "             |
| $d_i$ = DEPTH OF WATER AT INNER CIRCUMFERENCE.                         | 0.47 AT INNER CIRCLE.            |                                  |                                 |                                  | 0.76 AT INNER CIRCLE.           |
| 16 DEVELOPMENT OF CURVED PIPE  |                                  |                                  |                                 |                                  |                                 |
| C.S. XA.   | 1.25                             | 1.25                             | 1.5                             | 1.75                             | 2.0                             |
| XB.  | 0.12; 0.52; 0.24; 1.26; 1.14.    | 0.13; 0.54; 0.26; 1.25; 1.17.    | 0.17; 0.40; 0.34; 1.53; 1.42.   | 0.17; 0.46; 0.34; 1.77; 1.61.    | 0.19; 0.61; 0.38; 2.125; 1.87.  |
| XC.  | 0.24; 0.64; 0.48; 1.27 1.03      | 0.26; 0.69; 0.52; 1.312; 1.09.   | 0.34; 0.80; 0.67; 1.56; 1.34.   | 0.34; 0.92; 0.68; 1.79; 1.47.    | 0.38; 1.25; 0.76; 2.25; 1.66.   |
| XD.  | 0.36; 0.96; 0.71; 1.28; 0.92     | 0.39; 1.03; 0.75; 1.343; 1.08.   | 0.51; 0.80; 1.0; 1.59; 1.26.    | 0.51; 1.38; 1.02; 1.8; 1.35.     | 0.57; 1.87; 1.14; 2.375; 1.49.  |
| XE.  | SEE ITEM (15)                    | SEE ITEM (15).                   | SEE ITEM (15).                  | SEE ITEM (15)                    | SEE ITEM (15)                   |

MIDDLE PORTION OF THE EDDY CHAMBER.

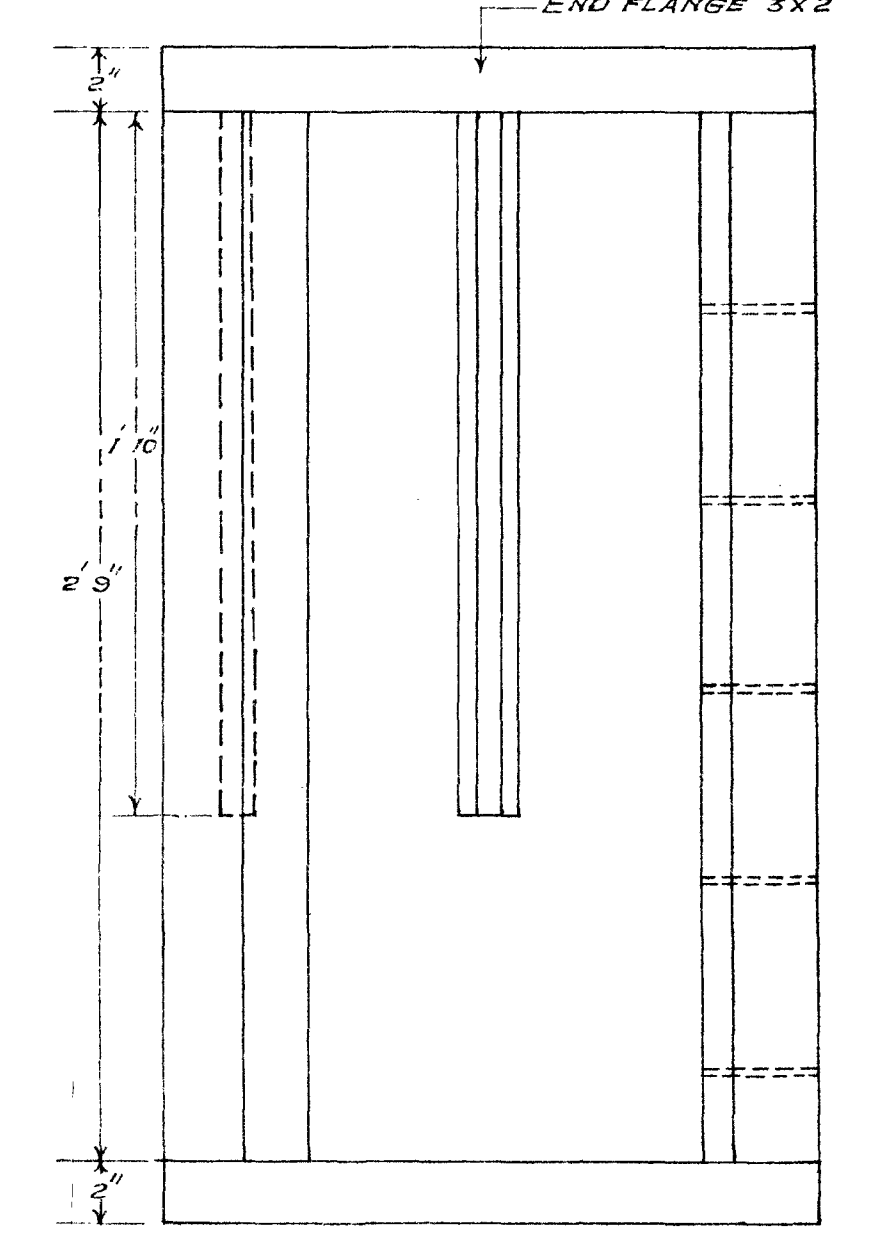
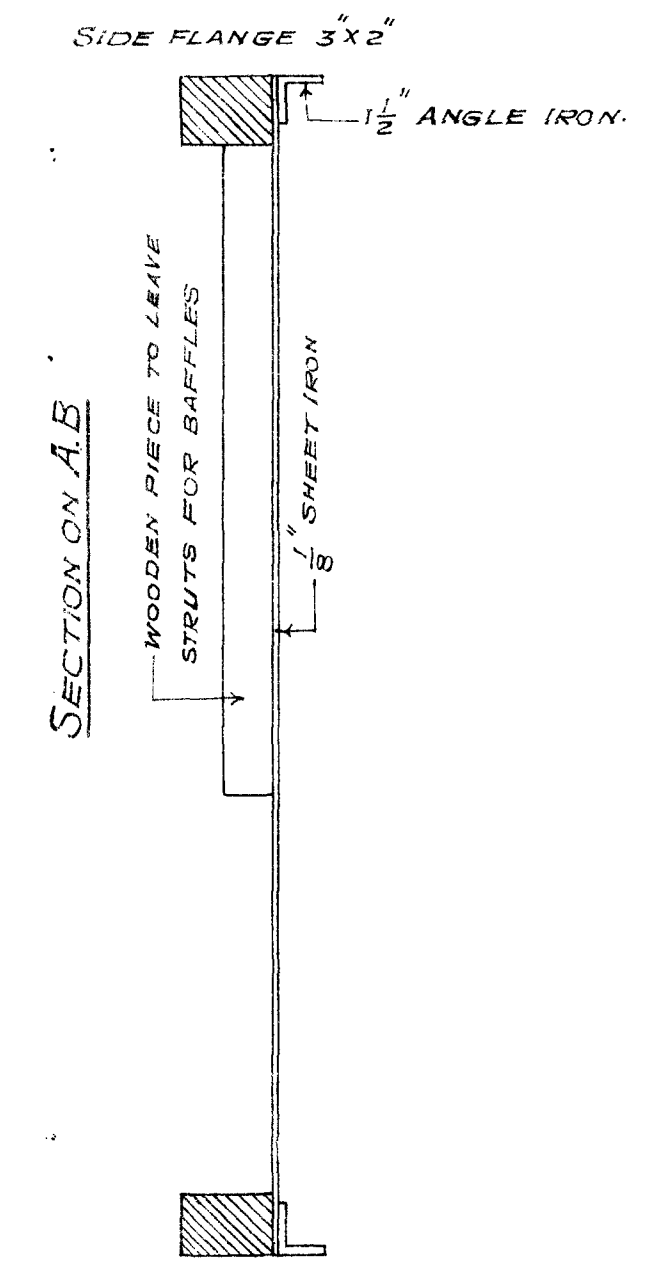
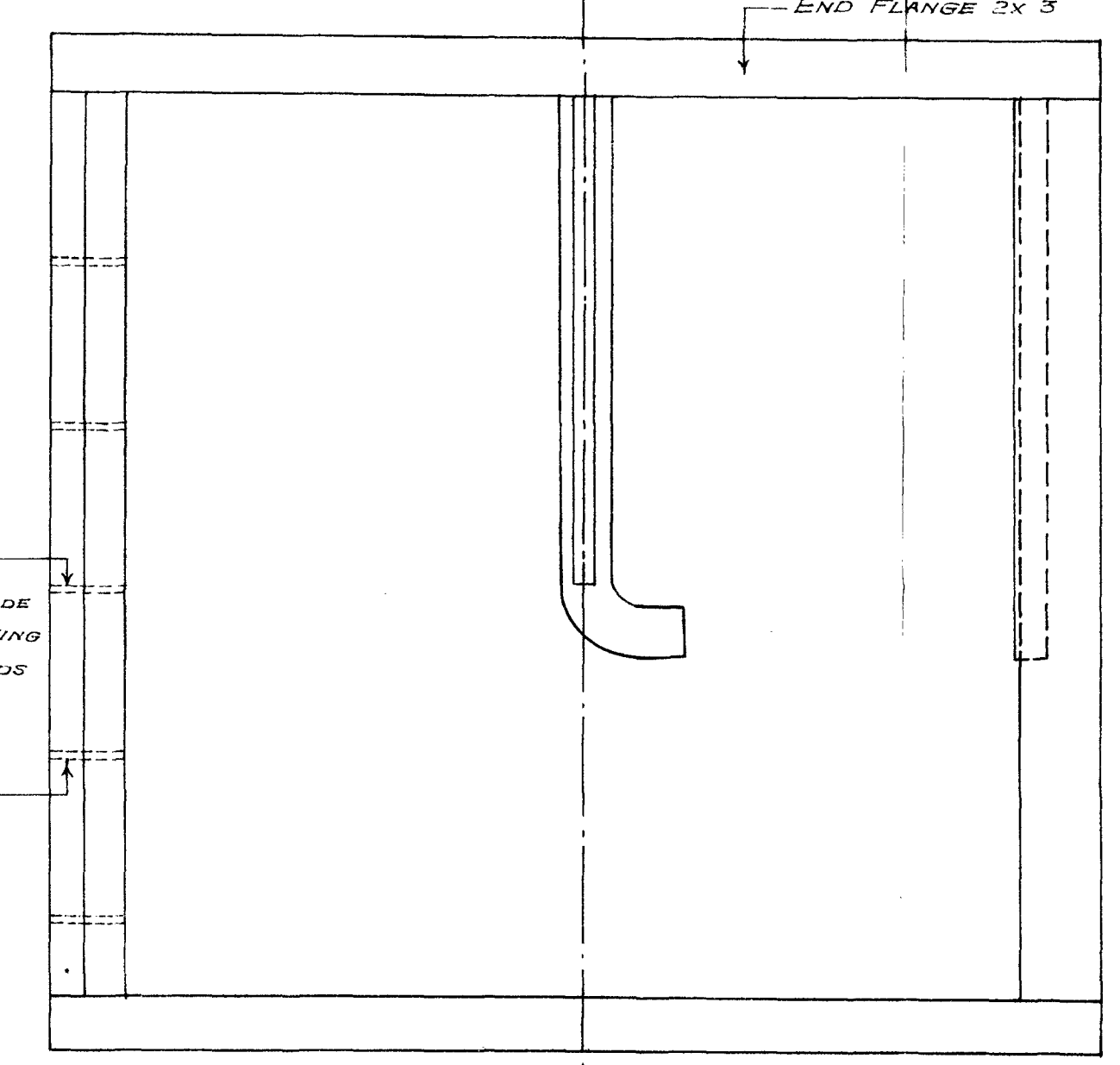
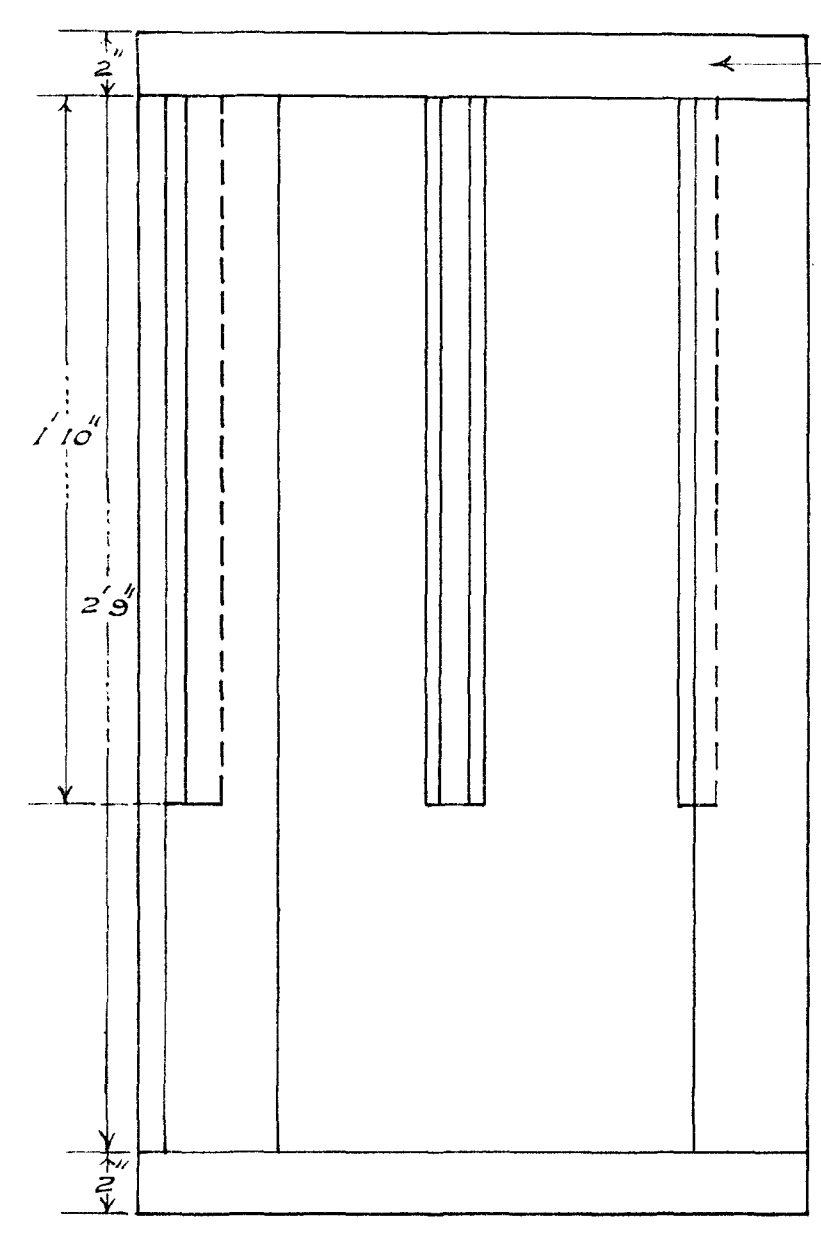
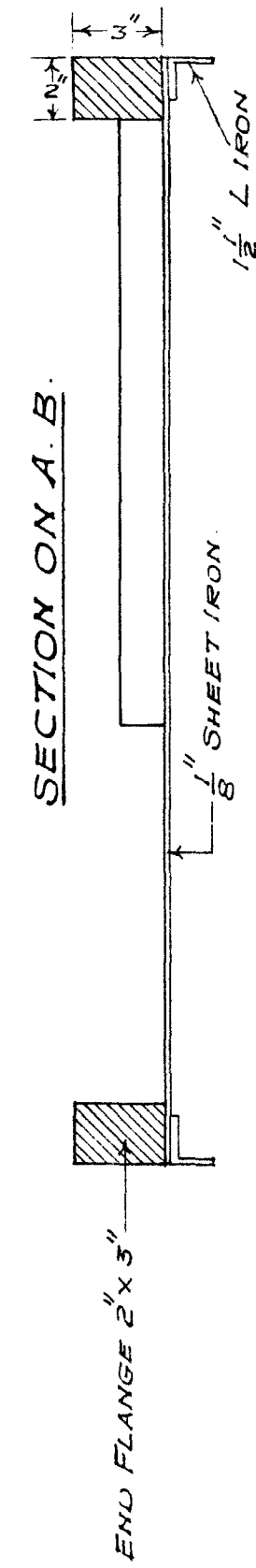
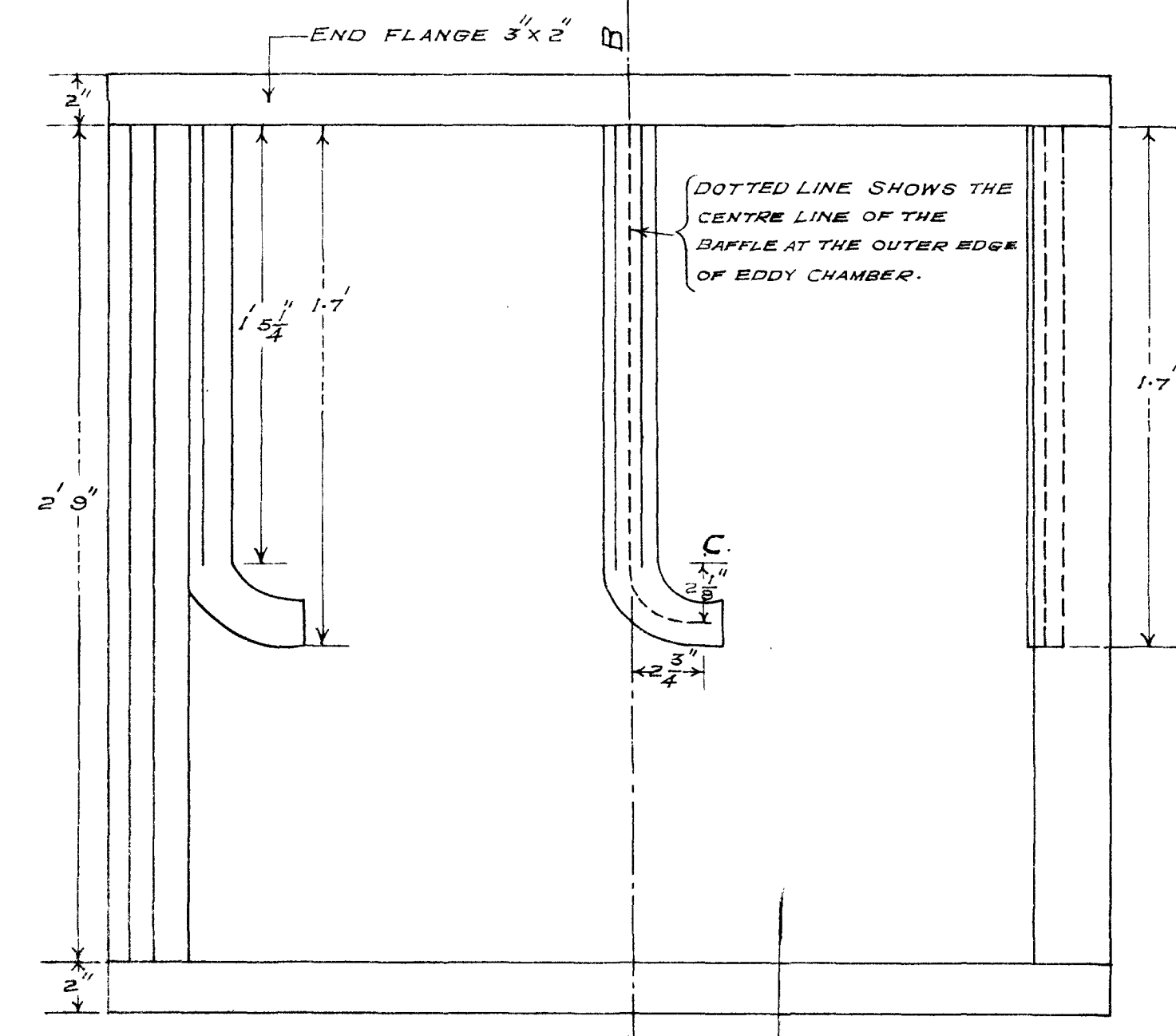
LEFT HAND PORTION OF THE EDDY CHAMBER.

OUTER SIDE PLAN FIG. I

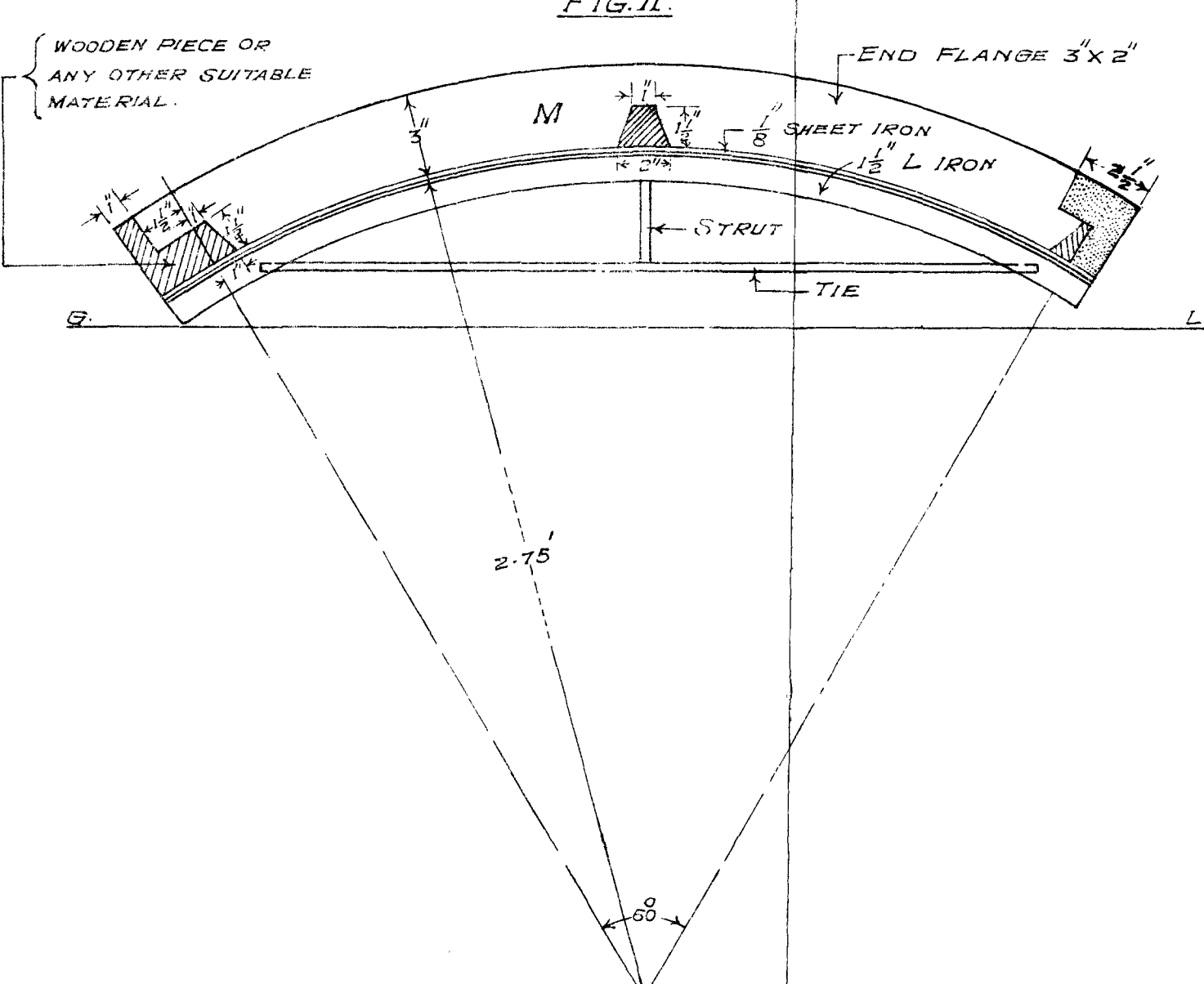
INNER SIDE PLAN FIG. III

OUTER SIDE PLAN FIG. V

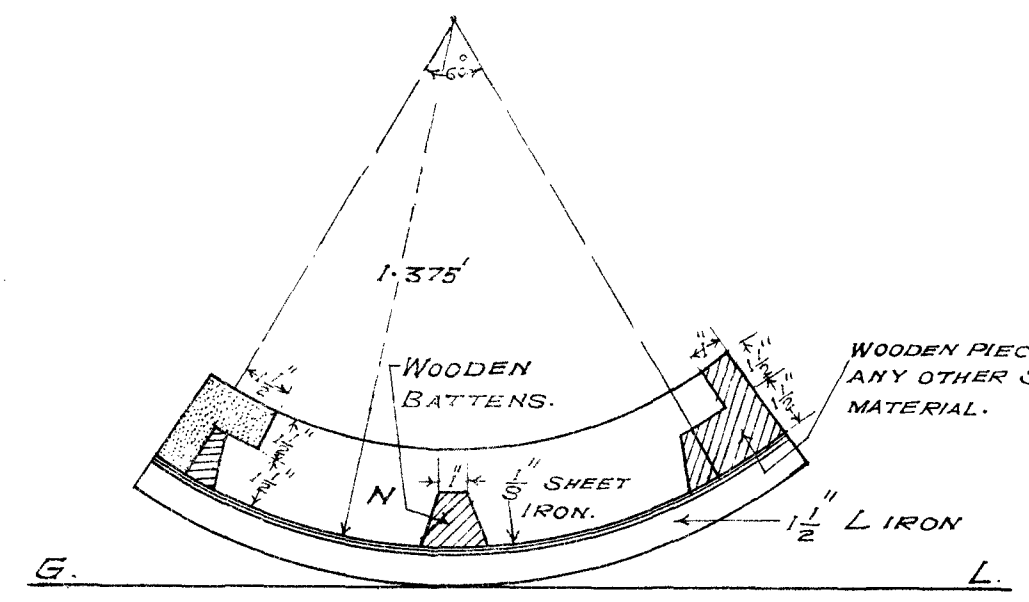
INNER SIDE PLAN FIG. VII



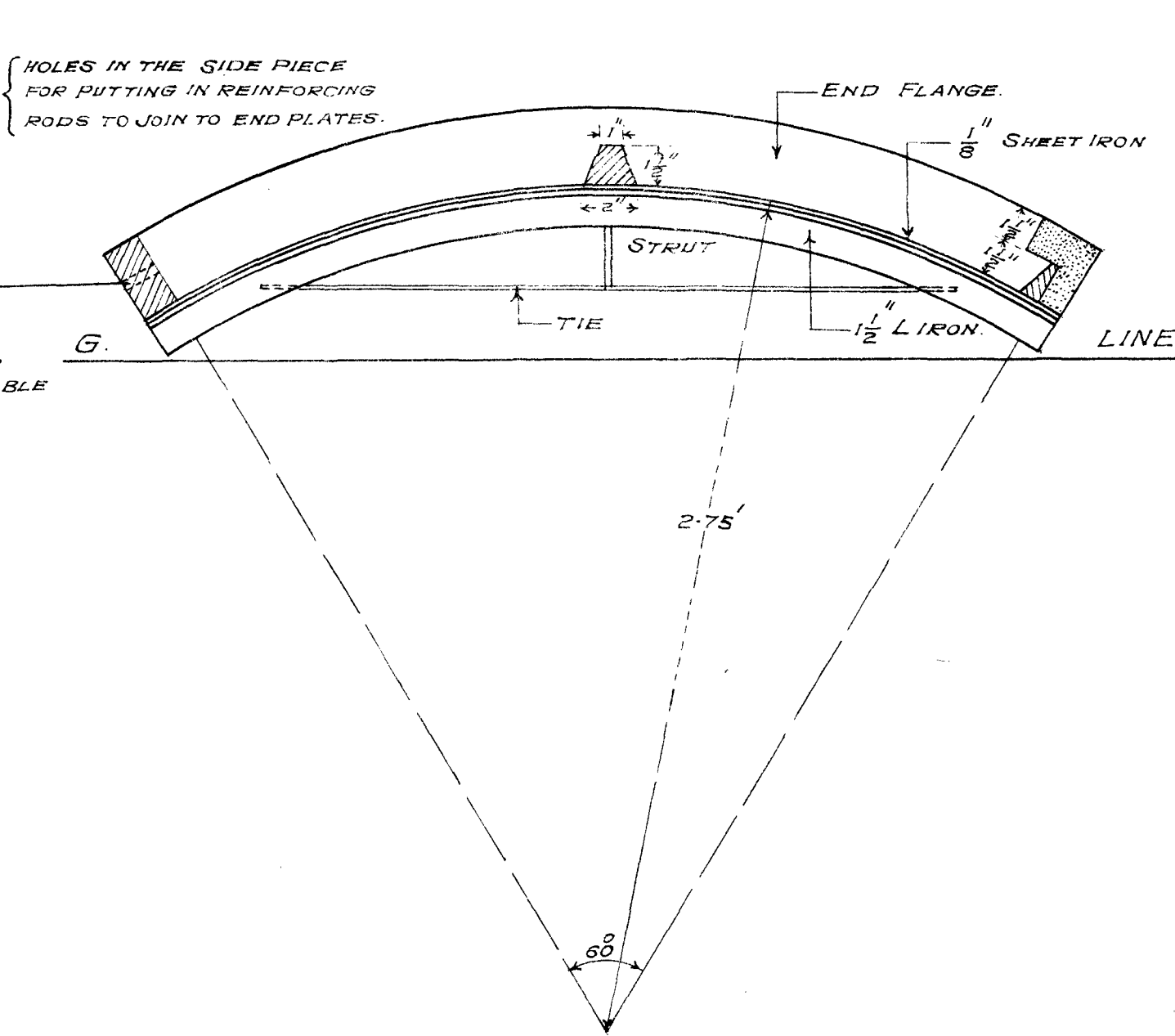
SECTION FIG. II



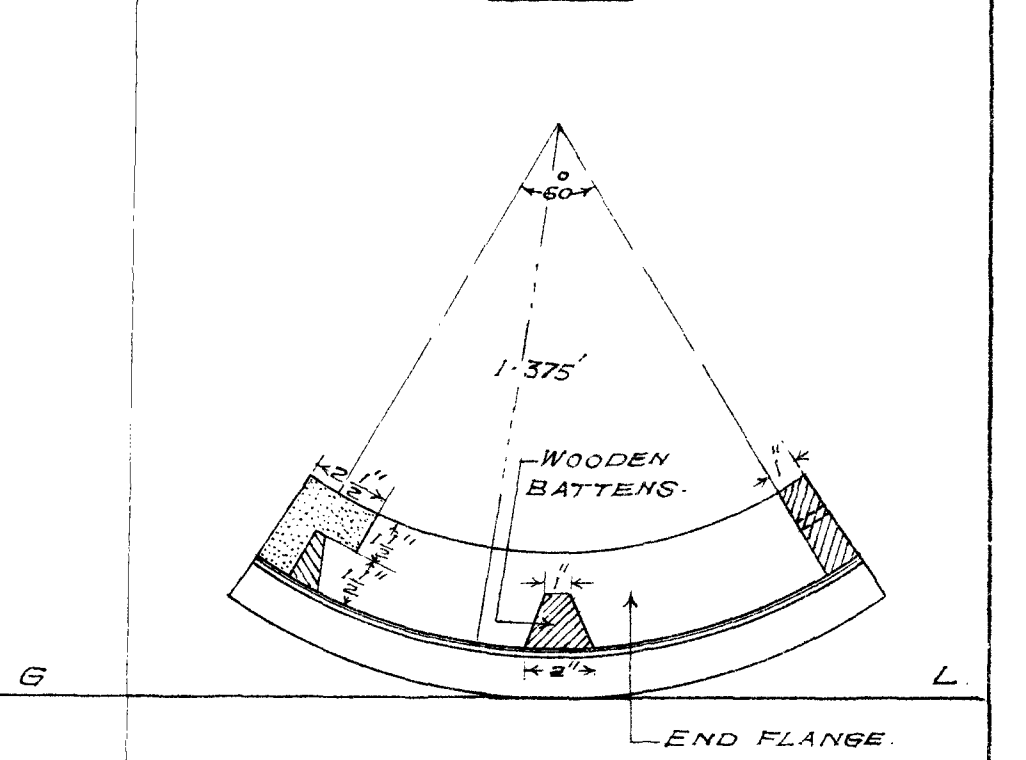
SECTION FIG. IV



SECTION FIG. VI



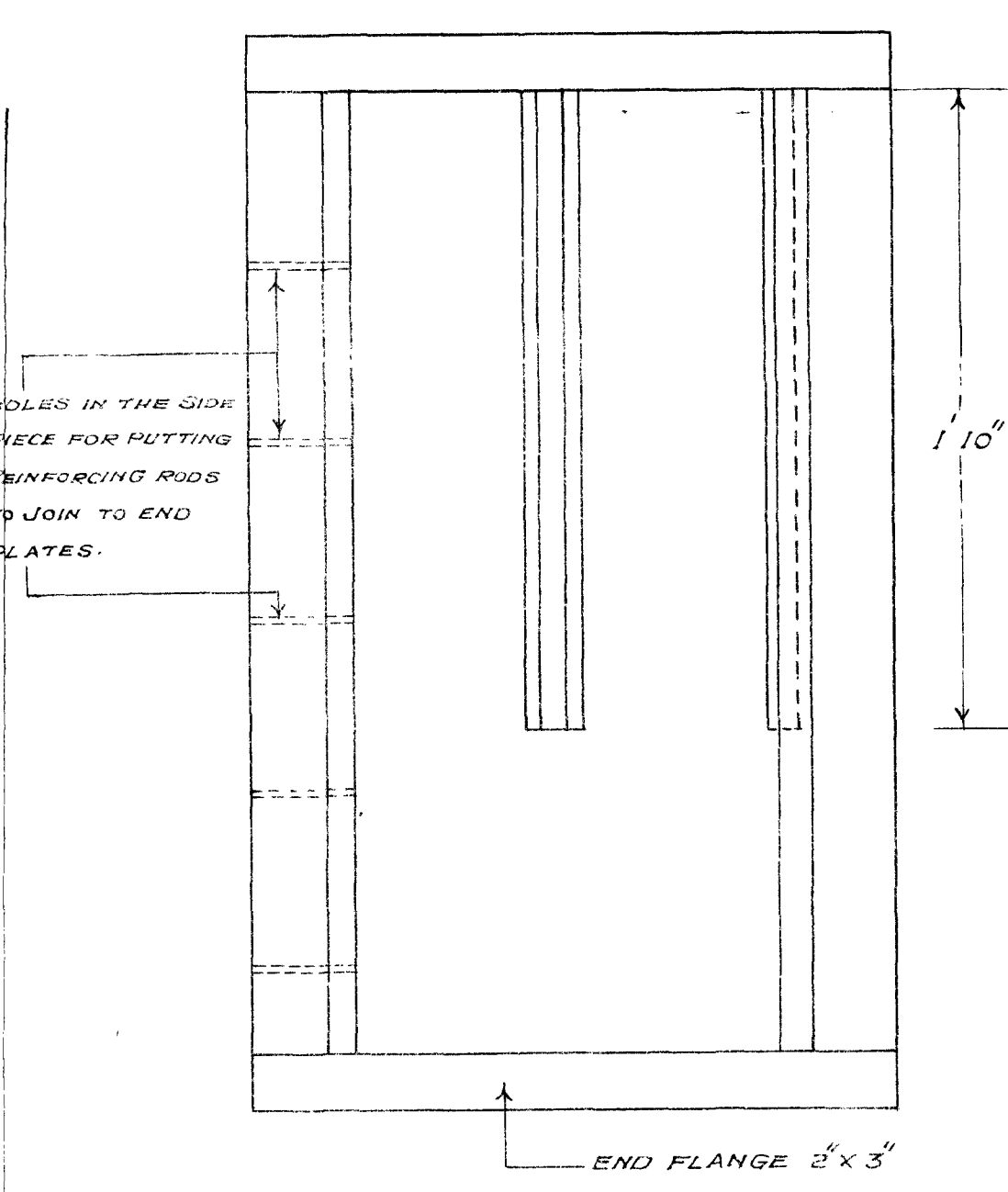
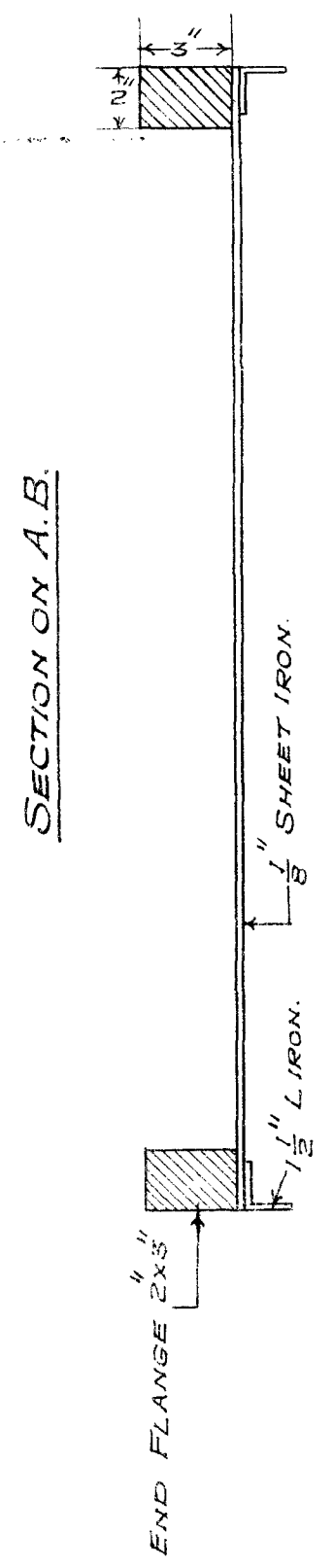
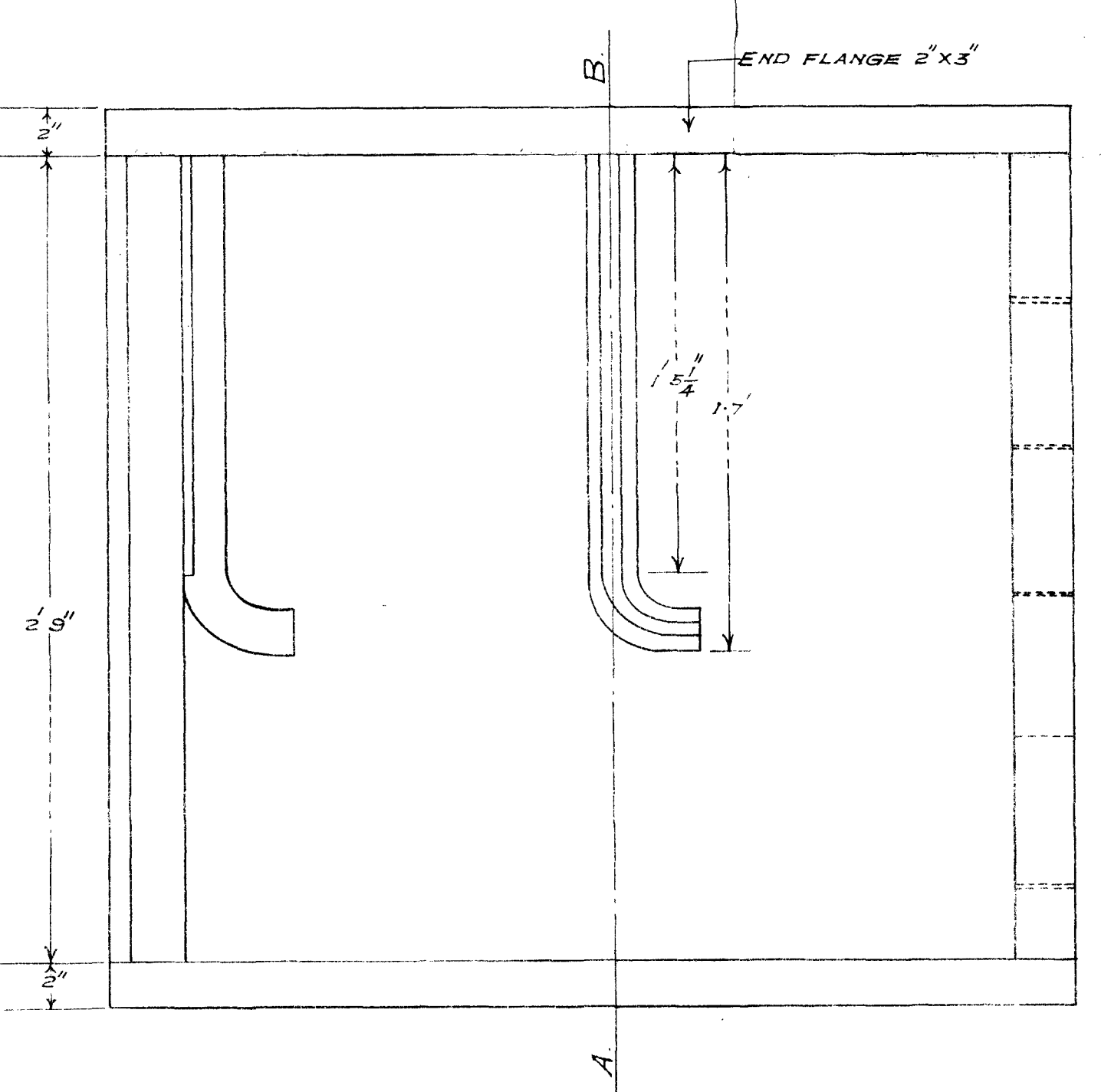
SECTION FIG. VIII



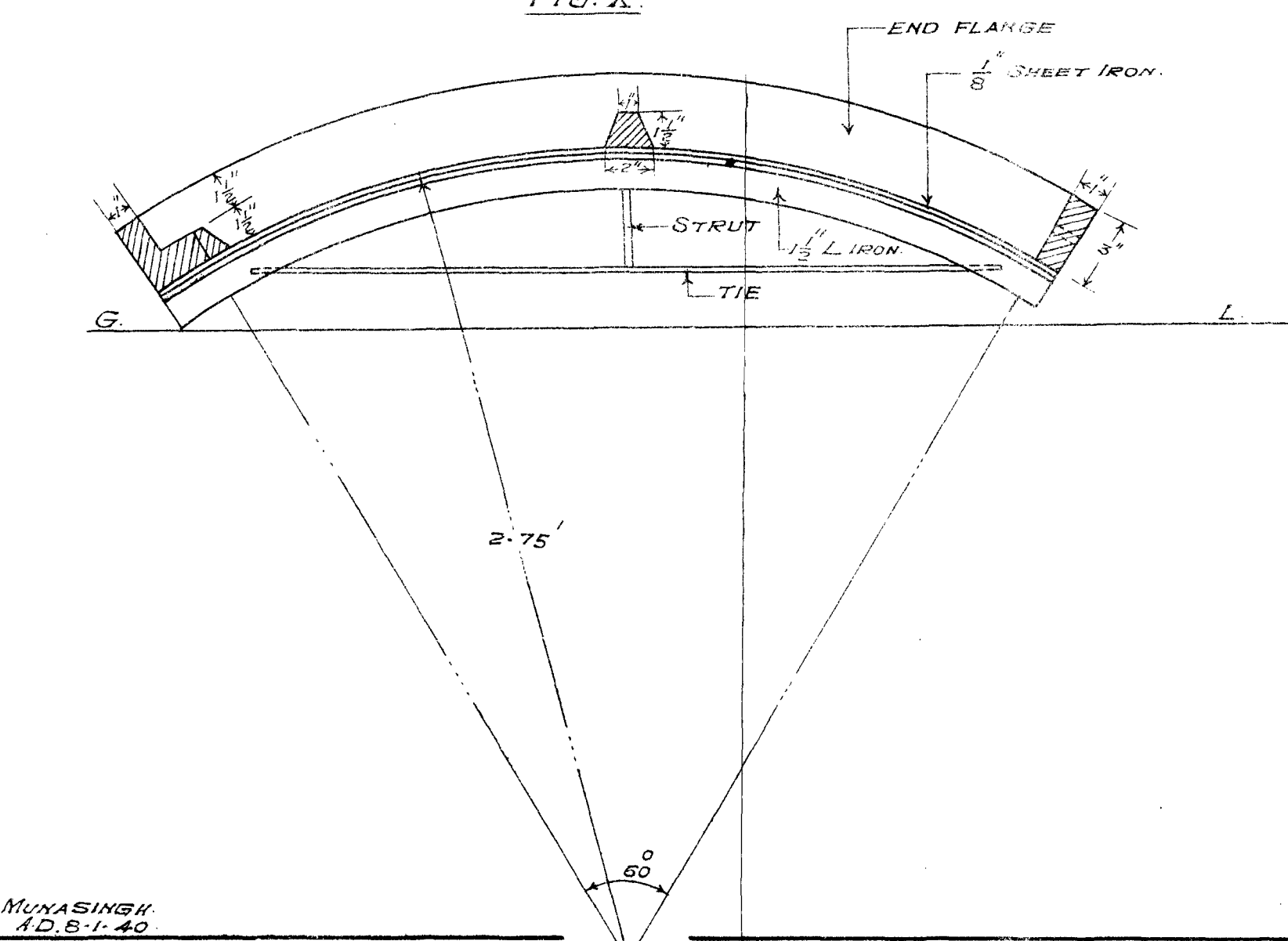
RIGHT HAND PORTION OF THE EDDY CHAMBER.

OUTER SIDE PLAN FIG. IX

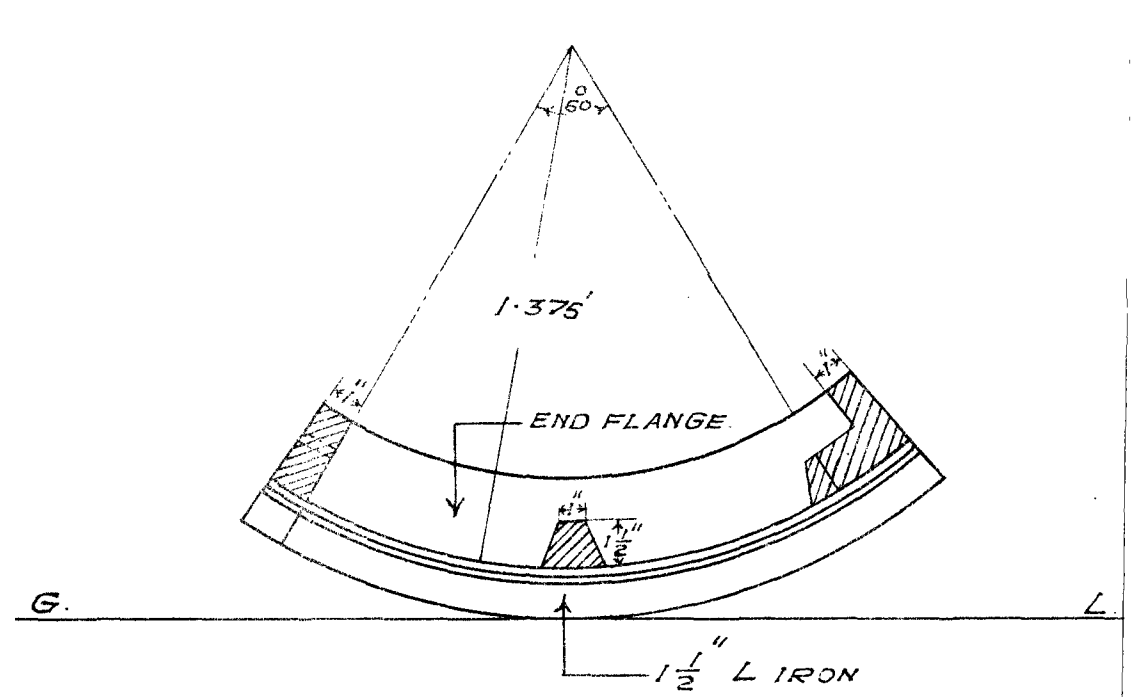
INNER SIDE PLAN FIG. XI



SECTION FIG. X

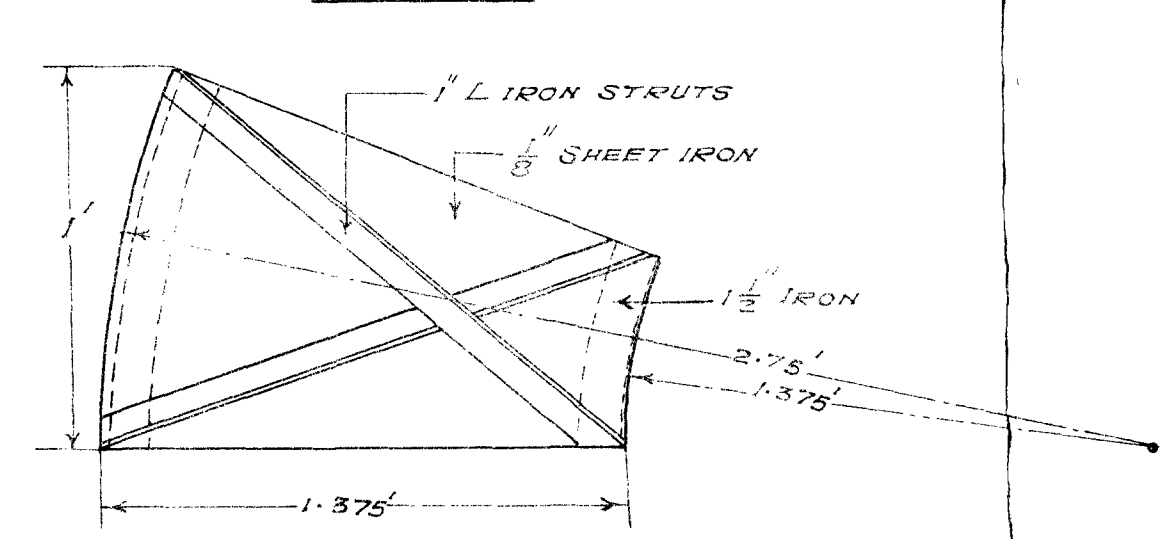


SECTION FIG. XII

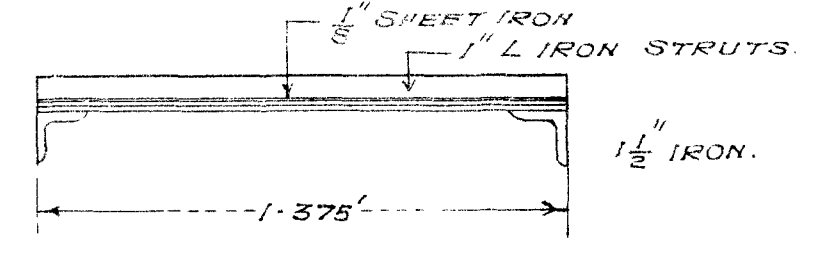


DETAILS OF THE DISTANCE PIECE

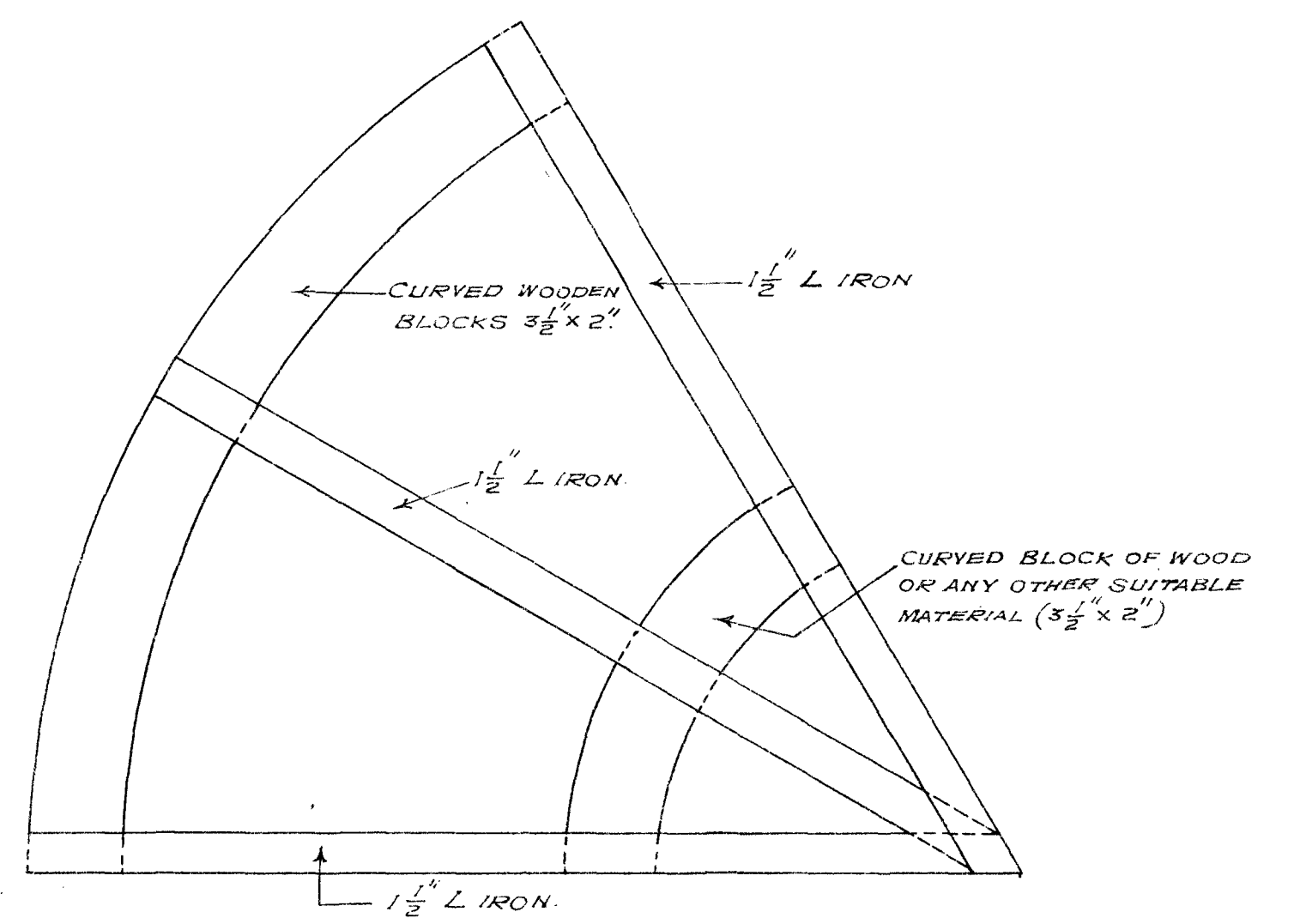
PLAN FIG. XIII



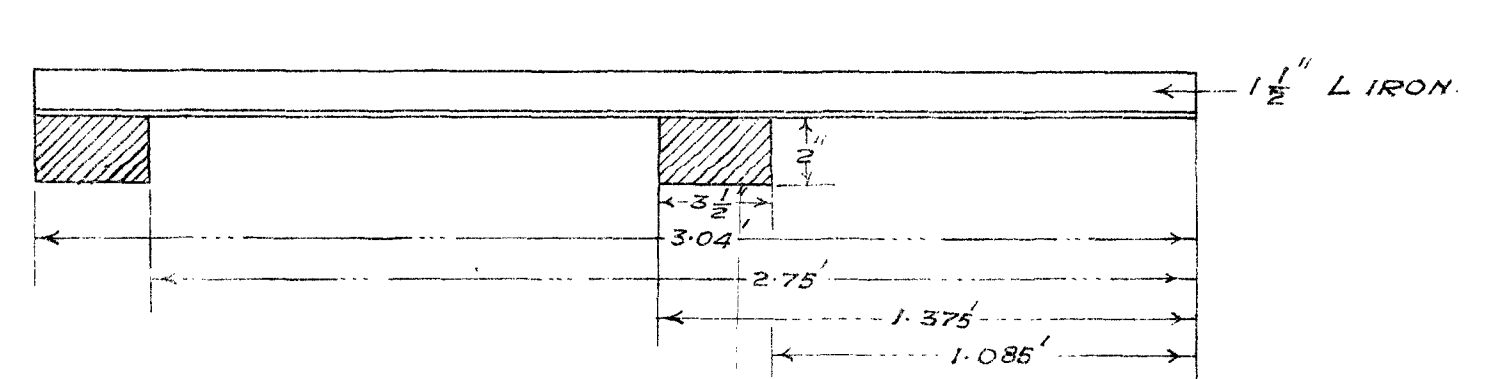
SECTION FIG. XIV



PLAN FIG. XV



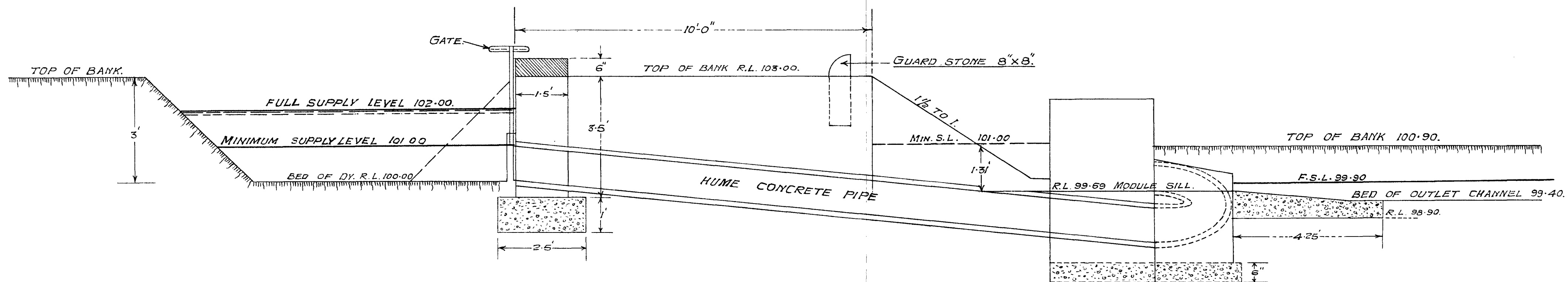
SECTION FIG. XVI



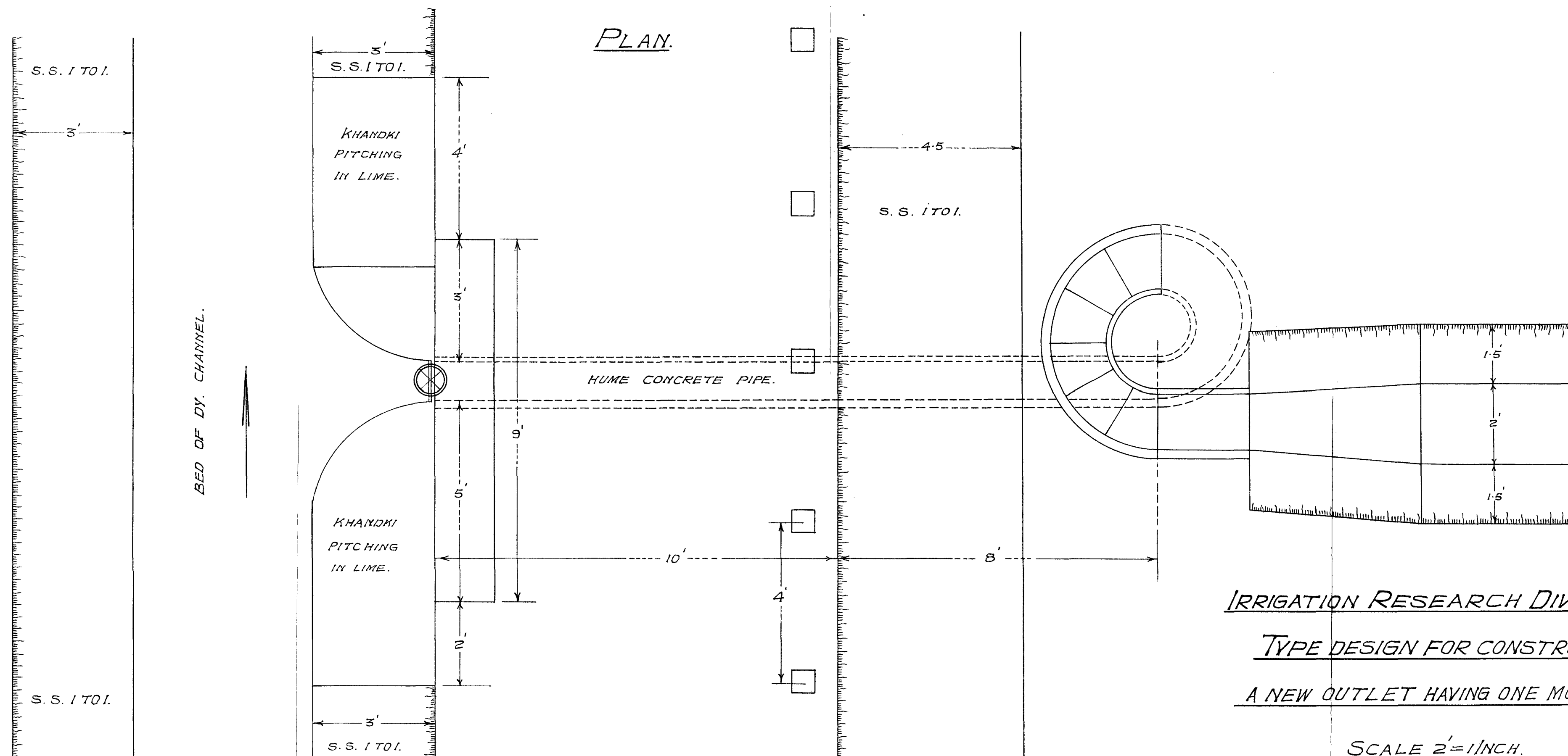
REMOVABLE PIECES SHOWN THUS [diagonal lines]
NONREMOVABLE PIECES SHOWN THUS [cross-hatch]



LONGITUDINAL SECTION.



PLAN.



IRRIGATION RESEARCH DIVISION  
 TYPE DESIGN FOR CONSTRUCTING  
 A NEW OUTLET HAVING ONE MODULE.

SCALE 2" = 1' INCH.

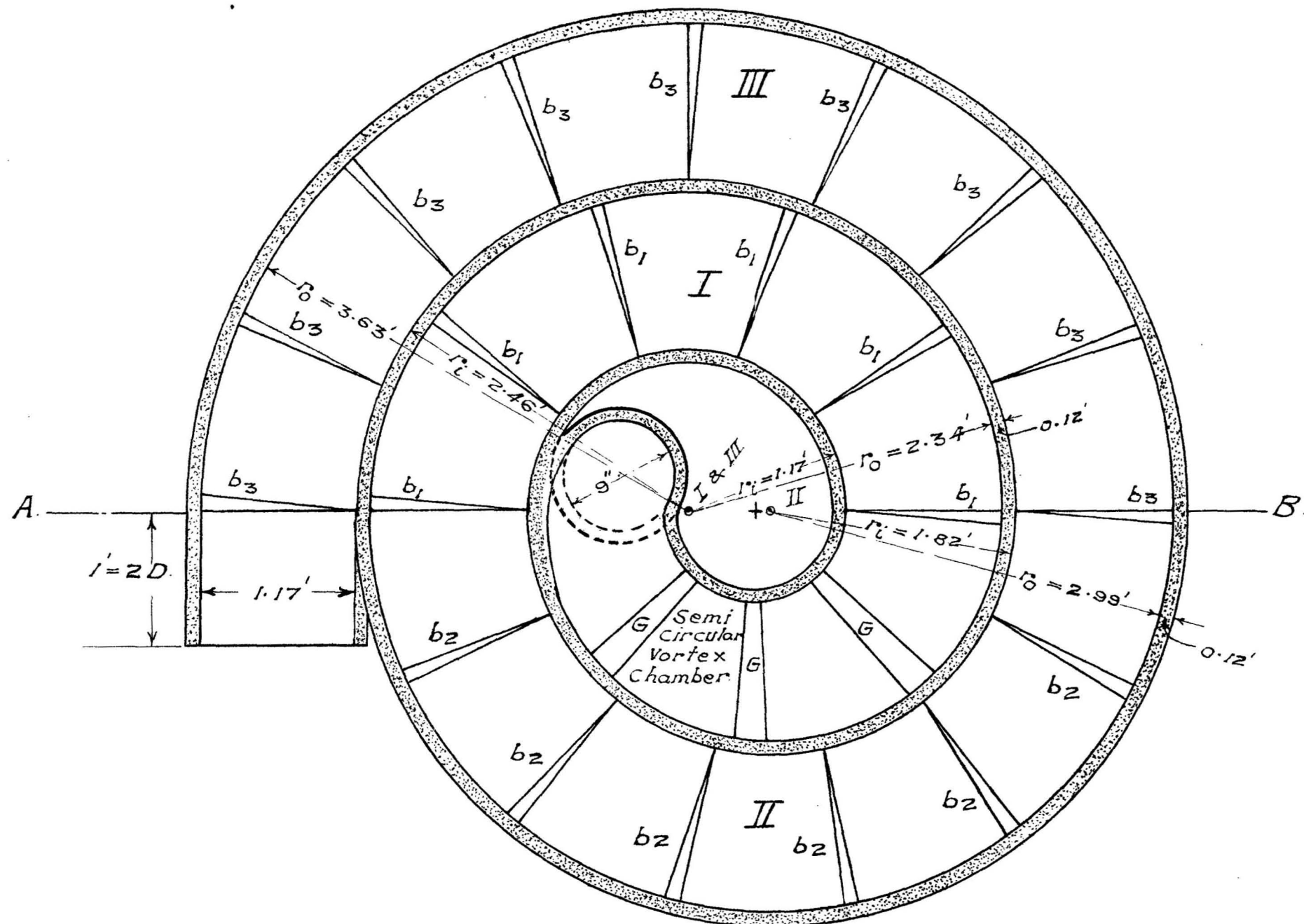
IRRIGATION RESEARCH DIVISION.  
1 Cusec Spiral Gibb module (in R.C. concrete)

$$Q = c \sqrt{2g} r_0 \left[ D \sqrt{h_0} \log_e m - \frac{h_0^{1.5}}{2} (m^2 - 1) \right]$$

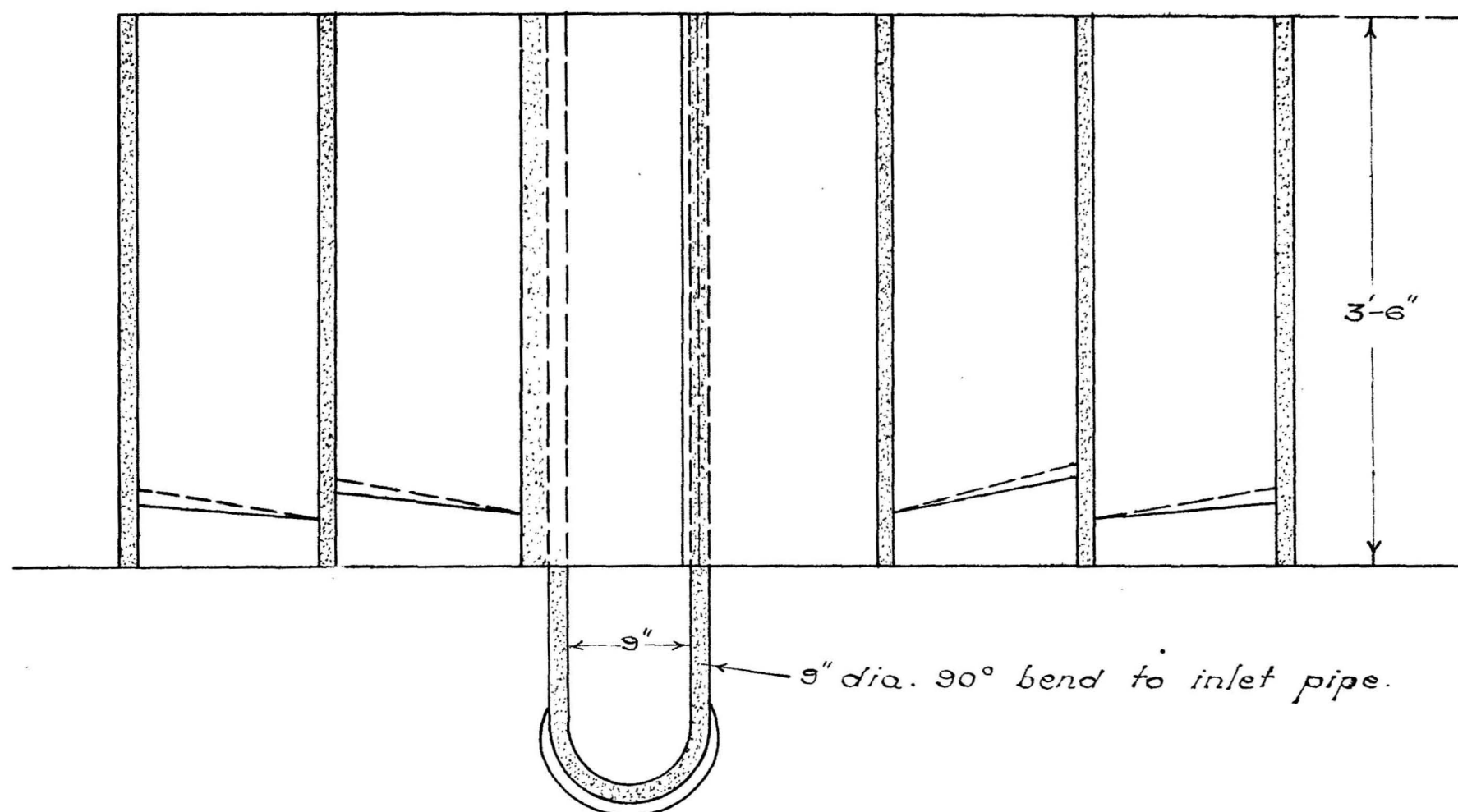
$$h_0 = \frac{D}{7}; m = \frac{r_0}{r_i}$$

scale: - 1" = 1"

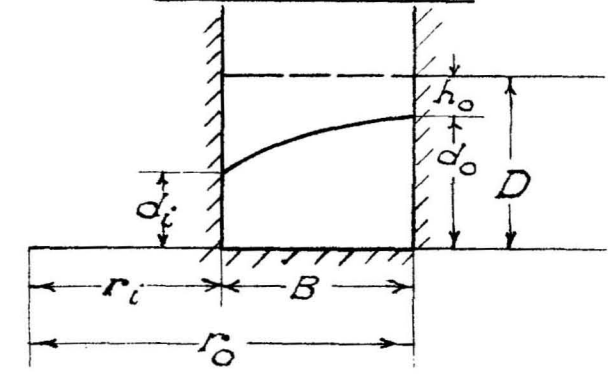
PLAN



SECTION ON A. B.



NOTATION

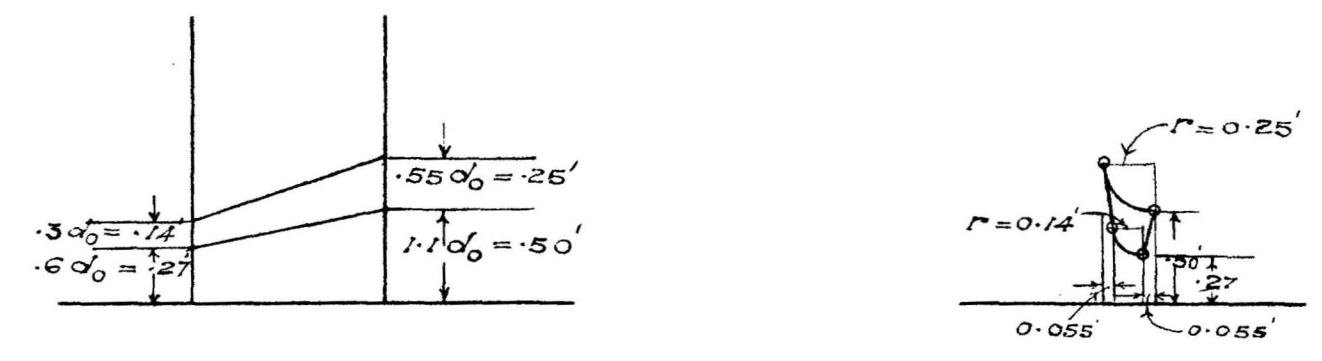


DETAILS.

FRONT ELEVATION.

GUIDES.

END VIEW.



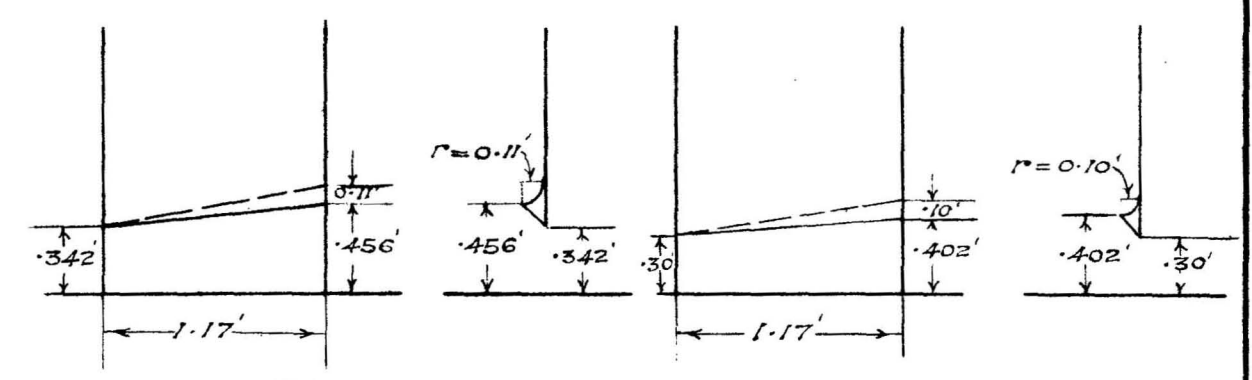
BAFFLES.

FRONT ELEVATION.

END VIEW.

FRONT ELEVATION.

END VIEW.



| Semi-circle. | C coefficient of Q | r <sub>0</sub> | r <sub>i</sub> | B = r <sub>0</sub> - r <sub>i</sub> | m = r <sub>0</sub> /r <sub>i</sub> | h <sub>0</sub> | d <sub>0</sub> | D    | Distances between baffles along outer Circle. | No. of Baffles |
|--------------|--------------------|----------------|----------------|-------------------------------------|------------------------------------|----------------|----------------|------|---|----------------|
| I            | 0.758              | 2.34           | 1.17           | 1.17                                | 2.0                                | .076           | .456           | .532 | 1.47  | 6              |
| II           | 0.850              | 2.99           | 1.82           | 1.17                                | 1.66                               | .067           | .402           | .469 | 1.34  | 7              |
| III          | 0.935              | 3.63           | 2.46           | 1.17                                | 1.48                               | .067           | .402           | .469 | 1.43  | 8              |

NOTE (PLAN)

- I & III is the centre of 1st & 3rd. Semi-circles.
- II is the centre of 2nd. Semi-circle.
- + is the centre of the inner circle of Vortex chamber.

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|--|---|
| <p>Advani &amp; Co., The Mall, Cawnpore.<br/>                 Aero Stores, Karachi.*<br/>                 Army Musketry Stores, Moga (Punjab).†<br/>                 Banthiya &amp; Co., Ltd., Station Road, Ajmer.<br/>                 Bengal Flying Club, Dum Dum Cantt.*<br/>                 Bhawnani &amp; Sons, New Delhi.<br/>                 Bombay Book Depot, Charni Road, Girgaon, Bombay.<br/>                 Book Company, Calcutta.<br/>                 Booklover's Resort, Taikad, Trivandrum, South India.<br/>                 British Book Depot, Lucknow.<br/>                 British Book Depot, Risalpure.<br/>                 British Stationery Mart, Booksellers, Peshawar Cantt.<br/>                 Buckingham &amp; Co., Booksellers and Stationers, Greenwood Street, Sialkot City.<br/>                 Burma Book Club, Ltd., Rangoon.<br/>                 Cambridge Book Co., Booksellers, New Dak Bungalow Road, Patna.<br/>                 Chandrakant Chimanlal Vora, Ahmedabad.<br/>                 Chatterjee &amp; Co., 3, Bacharam Chatterjee Lane, Calcutta.<br/>                 Chiny &amp; Sons, Booksellers, etc., Dhantoli, Nagpur, C. 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(1933), Ltd., Calcutta.<br/>                 Tripathi &amp; Co., Booksellers, Princess Street, Kalbadevi Road, Bombay, Messrs. N. M.<br/>                 Uberoy, J. C., Journalist, Printer and Publisher, Jaycee House, Alexandra Road, Ambala.<br/>                 University Book Agency, Kacheri Road, Lahore.<br/>                 Upper India Publishing House, Ltd., Literature Palace, Amnudaula Park, Lucknow.<br/>                 Varadaachary &amp; Co., Madras, Messrs. P.<br/>                 Venkatasubban, A., Law Bookseller, Vellore.<br/>                 Wheeler &amp; Co., Allahabad, Calcutta and Bombay, Messrs. A. H.<br/>                 Young Man &amp; Co. (Regd.), Egerton Road, Delhi.</p> |
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\* Agents for publications on Aviation only.

† Agent for Army Publications only.

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EXPERIMENTS WITH GIBB MODULES.



356.—3 cusecs Gibb module being tested in the Measuring Tank (Gibb's standard design).



929.—One cusec Spiral module with 3 semi-circles.



EXPERIMENTS WITH GIBB MODULES.



←  $m = \frac{r_o}{r_i} = 2.0$   
 (Gibb standard design)

m=1.5

m=3.0

459.—0.3 cusec Gibb Modules : different designs.



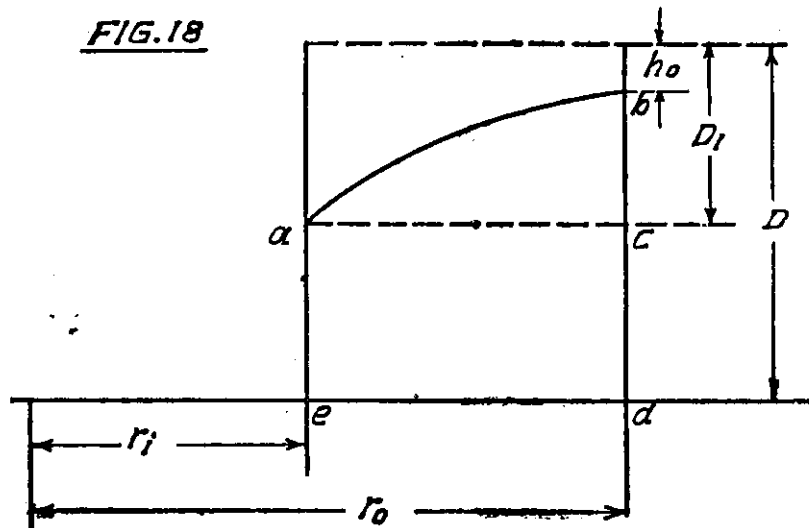
16 Cusecs →  
 module

3 Cusecs →  
 module

1366.—8 and 16 cusecs Gibb modules (standard design) at the head of Distributary 8, Nira Left Bank Canal.

APPENDIX I.

COMPARISON OF ORIGINAL GIBB FORMULA AND THE NEW GENERAL FORMULA.



Gibb's formula (with standard notation) for

$$q_{abc} = r_0 D_1^{3/2} \sqrt{2g} \left( \frac{1}{m} \log_e m - \frac{m^2 - 1}{2m^3} \right) \quad (1)$$

General formula is :-

$$q_{abc} = \int_{r_1}^{r_0} \sqrt{2gh_0 \frac{r_0^2}{r^2} \left( (D_1 - h_0) \frac{r_0^2}{r^2} \right)} dr$$

putting  $h_0 = k D_1$

$$q_{abc} = r_0 \sqrt{2g} D_1^{3/2} \left[ \sqrt{k} \log_e m + \frac{k^{3/2}}{2} (1 - m^2) \right] \quad (2)$$

∴ for the two formulae to agree

$$\sqrt{k} = \frac{1}{m} \text{ or } k = \frac{1}{m^2}$$

$$\text{and } \frac{k^{3/2} (1 - m^2)}{2} = \frac{1 - m^2}{2m^3}$$

$$\text{or } k^{3/2} = \frac{1}{m^3} \text{ or } k = \frac{1}{m^2} \text{ i.e., } h_0 = \frac{D_1}{m^2}$$

For part a c d e, Gibb says

$$q_{acde} = r_0 \sqrt{2g} D_1^{3/2} \times \frac{m^2 - 1}{m^3} \log_e m \quad (3)$$

and the general formula gives

$$\begin{aligned} q_{acde} &= \int_{r_1}^{r_0} \sqrt{2gh_0} \frac{r_0^2}{r^2} dr = \sqrt{2gh_0} \int_{r_1}^{r_0} \frac{r_0^2}{r^2} dr \\ &= \sqrt{2gh_0} \int_{r_1}^{r_0} \frac{1}{r^2} dr \\ &= \sqrt{2gh_0} \left[ -\frac{1}{r} \right]_{r_1}^{r_0} \\ &= \sqrt{2gh_0} \left( \frac{1}{r_1} - \frac{1}{r_0} \right) \\ &= \sqrt{2gh_0} \frac{r_0 - r_1}{r_1 r_0} \end{aligned} \quad (4)$$

For the two formulae 3 and 4 to agree,

$$D_1^{3/2} \times \frac{m^2 - 1}{m^3} = \sqrt{h_0} \frac{r_0 - r_1}{r_1 r_0}$$

but  $h_0 = \frac{D_1}{m^2}$  as shown above

$$\therefore D_1^{3/2} \frac{(m^2 - 1)}{m^3} = \sqrt{\frac{D_1}{m}} \times \frac{r_0 - r_1}{r_1 r_0}$$

Gibb's results will agree with those for the general formula therefore, so long as

$$\begin{aligned}
 k &= \frac{1}{m^2} \text{ and } d_1 = \frac{D_1 (m^2 - 1)}{m^2} \text{ or } D = d_1 + D_1 \\
 &= \frac{h_o (m^2 - 1)}{k \frac{m^2}{m^2}} = D_1 \left( 1 + \frac{m^2 - 1}{m^2} \right) \\
 &= h_o (2 m^2 - 1) \\
 \text{or } \frac{h_o}{D} &= K = \frac{1}{2m^2 - 1} \quad (5)
 \end{aligned}$$

This shows that Gibb's formula in terms of  $D_1$  was not restricted to  $m=2$ , as he seems to have thought; but was nevertheless restricted to one shape.

COMPARISON OF NEW DESIGNS AND GIBB'S STANDARD DESIGN FOR A 3 CUSEC MODULE.

(a) Gibb's formulas are :-

$$Q = r_o \sqrt{2gh} H_1^{3/2} \left[ \frac{1}{m} \log_e m - \frac{m^2 - 1}{2 m^3} + \frac{m^2 - 1}{m^3} \log_e m \right] \quad (6)$$

$$= r_o \sqrt{2g} H_1^{3/2} \left[ \frac{2m^2 - 1}{m^3} \log_e m - \frac{m^2 - 1}{2 m^3} \right] \quad (7)$$

Gibb assumed that  $H_1 = \frac{H}{2}$ , where  $H = D + h$  (i.e., head lost in inlet pipe).

$$\text{then } Q = \frac{r_o \sqrt{2g} H^{3/2}}{2\sqrt{2}} \left[ \frac{2m^2 - 1}{m^3} \log_e m - \frac{m^2 - 1}{2 m^3} \right] \quad (8)$$

The general formula gives

$$Q = r_o \sqrt{2g} [D_1]^{3/2} \left\{ \sqrt{k} \log_e m + \frac{k^{3/2}}{2} (1 - m^2) \right\} + \sqrt{k} D_1 d_1 \log_e m \quad (9)$$

$$\begin{aligned}
 &= r_o \sqrt{2g} D_1^{1/2} \left[ \sqrt{k} \log_e m (D_1 + d_1) + \frac{D_1 k^{3/2}}{2} (1 - m^2) \right] \\
 &= r_o \sqrt{2g} D_1^{1/2} \left[ D \sqrt{k} \log_e m + \frac{D_1 k^{3/2}}{2} (1 - m^2) \right] \quad (10)
 \end{aligned}$$

Now  $k D_1 = K D$

$$\text{or } D_1 = \frac{K}{k} D$$

$$\text{So } Q = r_o \sqrt{2g} D^{3/2} \left[ \sqrt{K} \log_e m + \frac{K^{3/2}}{2} (1 - m^2) \right] \quad (11)$$

For the formulas 8 and 11 to agree,

$$\frac{H^{3/2}}{2\sqrt{2}} \left[ \frac{2m^2 - 1}{m^3} \right] = D^{3/2} \sqrt{K}$$

$$\text{Now } K = \frac{1}{2m^2 - 1} = \frac{1}{7} \text{ when } m=2$$

$$\therefore \frac{H^{3/2}}{\sqrt{8}} \frac{7}{8} = D^{3/2} \times \frac{1}{\sqrt{7}}$$

$$\text{or } \frac{D}{H} = \frac{7\sqrt{7}}{8\sqrt{8}} \text{ or } \frac{D}{H} = \frac{7}{8}$$

The calculated discharge according to Gibb's formula for his three cusec standard design is equal to 3.21 cusecs, which shows that the actual discharge is 7 per cent less than the theoretical.

Q according to the general formula is

$$Q = r_o \sqrt{2g} D^{3/2} \left\{ \sqrt{K} \log_e m + \frac{K^{3/2}}{2} (1 - m^2) \right\}$$

28 NOTE ON THE THEORY, DESIGN AND CONSTRUCTION OF GIBB MODULES.

$r_0=2.75$  ft. ;  $m=2$  ;  $D=\frac{3}{8}$  when  $H=1$  ; and

$$K = \frac{1}{2m^2 - 1} = \frac{1}{7}$$

$$\begin{aligned} \therefore Q &= 2.75 \times 8 \left\{ \frac{7\sqrt{7}}{8\sqrt{8}} \times \sqrt{\frac{1}{7}} \times 0.693 - \frac{3}{2} \times \frac{7\sqrt{7}}{8\sqrt{8}} \times \frac{1}{7\sqrt{7}} \right\} \\ &= 21.76 (0.2144 - 0.0663) \\ &= 3.22 \text{ cusecs.} \end{aligned}$$

Thus the two formulas agree, so long as

$$K = \frac{1}{2m^2 - 1}, \text{ etc.}$$



## APPENDIX II.

AREA OF FLOW IN THE GENERAL FORMULA AND DIAMETER OF THE INLET PIPE.

$$\text{Area} = \int_{r_1}^{r_0} d \, dr; \text{ But } d = D - h_0 \frac{r_0^2}{r^2}$$

$$\begin{aligned} \therefore \text{Area} &= \int_{r_1}^{r_0} \left( D - h_0 \frac{r_0^2}{r^2} \right) dr \\ &= D (r_0 - r_1) - h_0 r_0^2 \left[ \frac{1}{r_1} - \frac{1}{r_0} \right] \\ &= (r_0 - r_1) (D - h_0 m) \end{aligned}$$

$$\text{But } r_0 - r_1 = B \therefore \text{Area} = B (D - h_0 m)$$

Area of the inlet pipe should be equal to the area of flow in the eddy chamber, or  $\pi \frac{d^2}{4} = B (D - h_0 m)$

$$\therefore d = \sqrt{\frac{4}{\pi} B (D - h_0 m)} = 1.13 \sqrt{B (D - h_0 m)}$$

d being diameter of pipe.

## APPENDIX III.

## CALCULATION SHEET OF TABLE 15.

Loss of head was calculated by observing pressure heads in the inlet and rising pipes of the standard 3 cusec module at D.5. They were found to be as under for the upstream depth = 1.0' over module sill at which the module began to work.

|   |         |
|---|---------|
| (i) Loss at bell-mouth entrance of inlet pipe | = 0.09' |
| (ii) Loss in inlet pipe 5 ft. long            | = 0.03' |
| (iii) Loss in rising curved pipe              | = 0.06' |
|   | = 0.18' |

As  $h_o + d_o = 0.125 + 0.75 = 0.875'$

the actual loss of head =  $1.10' - 0.875' = 0.225'$ .

The difference between 0.225 and 0.18 = 0.045 is most probably due to a greater loss than observed in the rising pipe due to the changing section of the pipe and due to change of flow from parallel into free vortex. The loss in the rising curved pipe may therefore be taken = 0.11' against 0.06' observed. The total losses will then be

|             |
|-------------|
| (i) 0.09'   |
| (ii) 0.03'  |
| (iii) 0.11' |
| 0.23'       |

2. Loss of head in the case of 0.3, 1.0 and 2.0 cusec modules can be approximately found out as under :

(i) Loss at Bell-mouth entrance of inlet pipe :

$$v = c/2 \sqrt{\frac{dh}{l}} \text{ or loss } \propto \frac{v^2 l}{d}$$

As  $l$  is the same in all cases, loss  $\propto v^2/d$

2 cusec module.

$$v = 3.7 \text{ f/s}; d = 0.83 \text{ ft. } \therefore v^2/d = 16.5$$

$$v^2/d \text{ for 3 cusec module} = \frac{(3.82)^2}{1.0} = 14.6$$

$$\therefore \text{loss at bell mouth entrance} = \frac{16.5}{14.6} \times 0.09' = 0.10'$$

Let it be the same as in 3 cusec module, i.e., 0.09'

1 cusec module.

$$v = 2.27 \text{ f/s}; d = 0.75' \quad v^2/d = 6.9$$

$$\therefore \text{loss} = \frac{6.9}{14.6} \times 0.09 = 0.04'$$

0.3 cusec module.

$$v = 1.53 \text{ f/s}; d = 0.5'; v^2/d = 4.7$$

$$\text{Loss} = \frac{4.7}{14.6} \times 0.09 = 0.03'$$

(ii) Loss in leading pipe 5 ft. long :  $v = c/2 \sqrt{dh/l}$ ;  $c = 106$ .

By substituting values we get loss for 2 cusecs module = 0.03'

1 cusec module = 0.01'

0.3 cusecs module = 0.01'

(iii) Loss in the rising pipe can be approximately calculated on the assumption that loss

$$\propto \frac{v^2 l}{d}$$

1 i.e., the length of rising pipe of

3 cusec module=4.0'

2 cusec module=3.25'

1 cusec module=2.75'

0.3 cusec module=1.75'

Calculating in a similar way as in (i), we get for

3.0 cusec module, loss =0.06' observed

2.0 " " " =0.06'

1.0 " " " =0.02'

0.3 " " " =0.01'

As stated above, actual loss is greater and may be taken to be 0.11'; 0.09' and 0.09' respectively. Table 17 shows the calculated results.

TABLE 17.

|   | 0.3 cusec module | 1.0  | 2.0  | 3.0  |
|---|------------------|------|------|------|
| $D=h_o+d_o$ (ft.) . . . . .                                 | 0.37             | 0.62 | 0.84 | 0.87 |
| Loss in bell-mouth entrance of leading pipe (ft.) . . . . . | 0.03             | 0.04 | 0.09 | 0.09 |
| Loss in friction in leading pipe 5 ft. long (ft.) . . . . . | 0.01             | 0.01 | 0.03 | 0.03 |
| Loss in rising pipe (ft.) . . . . .                         | 0.09             | 0.09 | 0.10 | 0.11 |
| Total loss (ft.) . . . . .                                  | 0.13             | 0.14 | 0.22 | 0.23 |
| Minimum level u/s over module sill . . . . .                | 0.50             | 0.76 | 1.06 | 1.10 |
| These figures are shown in item 1 of Tables 15 and 16.      |                  |      |      |      |

## CALCULATION SHEET 2 OF TABLE 15.

*Loss of head in chamber at exit of the Standard Pipe outlet.*

$$\text{Loss of head} = h = \left( \frac{v_2 - v_3}{2g} \right)^2$$

where  $v_2$  is the velocity in the pipe outlet.

and  $v_3$  is the velocity in chamber

*3 cusec module.*

$Q=3$  cusecs : diameter of pipe=12"

$\therefore v_2=3.85$  f/s

$v_3=0.91$  f/s, as width of chamber=5 ft.

and depth=1.10 ft.

$$\therefore h = \frac{(3.85 - 0.91)^2}{64} = 0.13 \text{ ft.}$$

*2 cusec module.*

$$v_2=3.70 \text{ f/s}; v_3 = \frac{2.0}{2.5 \times 1.06} = 0.75 \text{ f/s}$$

$$\therefore h = \frac{(3.70 - 0.75)^2}{2g} = 0.13'$$

*1 cusec module.*

$$v_2=2.27 \text{ f/s}; v_3 = \frac{1.0}{2 \times 0.76} = 0.66 \text{ f/s}$$

$$\therefore h=0.04'$$

0.3 cusec module.

$$v_2 = 1.53 \text{ f/s and } v_3 = \frac{0.30}{2 \times 0.5} \text{ f/s}$$

$$h = \frac{(1.53 - 0.3)^2}{2g} = 0.02'$$

These figures are shown in item 5 (iii) of Table 15.

CALCULATION SHEET 3 OF TABLE 16.

*Loss of head in outlet channel and chamber.*

$$v = \frac{1.346}{N_s} R^{3/4} (h/l)^{1/2}$$

Where  $h$  = loss of head in friction

$N_s = 0.017$  for good masonry work

$l$  = length of outlet channel = 15 ft.

3 cusec module.

Size of channel = 1.5' x 1'

$$V_2 = 2.0 = \frac{1.346}{0.017} \times (0.3)^{3/4} (h/15)^{1/2}$$

i.e., loss in outlet channel = 0.06 ft.

$$\begin{aligned} \text{loss in chamber} &= \frac{(v_2 - v_3)^2}{2g} \\ &= \frac{(2.0 - 0.91)^2}{2g} = 0.02' \end{aligned}$$

2 cusec module.

$v_2 = 2.0$  and  $v_3 = 0.75$  f/s

loss in outlet channel = 0.08 ft.

loss in chamber = 0.02 ft.

Similarly in the case of 1 cusec and 0.3 cusec modules loss in outlet channel = 0.03' and 0.01' respectively and loss in chamber = 0.01' and 0.01' respectively.

These figures are shown in item 5 (ii) and (iii) of Table 16.



## APPENDIX IV.

## DESIGN OF ONE CUSEC SPIRAL GIBB MODULE.

1. The range of one cusec 'single semi-circle' module is 0.93'; and according to Gibb the range of spiral module of 3 semi-circles is 2.25 ft.

2. In the case of spiral modules, the water is led vertically upwards by a standard 90° bend connecting with the leading pipe. From this point, the water flows round in what is an upstream continuation of the module trough in which a series of guides (*vide* G in Plate V) are constructed to establish a free vortex flow.

3. In order to make an allowance for retardation in the spiral modules, Gibb assumed the following coefficients of discharge.

In the case of modules having two semi-circles

C for the 1st (upstream) semi-circle=0.85 and  $m=r_0/r_1=2.0$

C for the 2nd (downstream) semi-circle=0.935 and  $m=1.66$

In the case of modules having 3 semi-circles,

C for the 1st (upstream) semi-circle=0.758 and  $m=2.0$

C for the 2nd (middle) semi-circle=0.85 and  $m=1.66$

& C for the 3rd (downstream) semi-circle=0.935 and  $m=1.5$

4. Let us first consider a spiral module of 3 semi-circles built of say 3/32" iron sheets.

*1st (upstream) semi-circle.*

Let  $h_0 = 0.089'$  (*i.e.*, the same as in single semi-circle module)

$D = 7 h_0 = 0.623'$  and  $m = 2.0$

$$Q = C \sqrt{2g} r_0 \left[ D \sqrt{h_0} \log_e m - \frac{h_0^{1.5}}{2} (m^2 - 1) \right]$$

$$1.0 = 0.758 \times 8 \times r_0 \times (0.089)^{1.5} [7 \times 0.6931 - 1.5]$$

$$r_0 = 1.85 \text{ ft.}$$

$$r_1 = 0.92' \text{ and } B = \text{the width of eddy chamber} = 0.93'$$

*2nd (middle) semi-circle.*

$$r_0 = 2.5 \text{ } B = 2.32'$$

$$r_1 = 2.32 - B = 1.39' \text{ and } m = 1.66$$

$$1.0 = 0.85 \times 8 \times 2.32 \times h_0^{1.5} \left[ 7 \times \log_e 1.66 - \frac{m^2 - 1}{2} \right]$$

$$h_0 = 0.089' \text{ and } D = 7 h_0 = 0.623'$$

*3rd (downstream) semi-circle.*

$$r_0 = 3 \text{ } B = 2.79'$$

$$r_1 = 3 \text{ } B - B = 1.86'$$

and  $m = 1.5$

$$1.0 = 0.935 \times 8 \times 2.79 \times h_0^{1.5} [7 \times 0.4055 - 0.625]$$

$$h_0 = 0.078' \text{ and } D = 7 h_0 = 0.546'$$

Diameter of the leading pipe

$$d = 1.13 \sqrt{B (D - h_0 m)}$$

$$= 1.13 \sqrt{0.93 (0.625 - 2 \times 0.089)}$$

$$= 0.73' \text{ or say } 9''$$

5. When considering the case of R. C. concrete modules, we have to increase  $r_0$  and  $r_1$  to make an allowance for the thickness of concrete walls.

Let the walls be 0.12' thick.

*1st semi-circle.*

Let  $r_1 = 1.17'$  and  $r_0 = 2.34'$ ;  $m = 2.0$

$$1.0 = 0.758 \times 8 \times 2.94 \times h_0^{1.5} \left[ 7 \log_e 2 - \frac{m^2 - 1}{2} \right]$$

$$h_0 = 0.076'$$

*2nd semi-circle,*

$$2 r_1 = 2 B + 0.12 = 3.63'$$

$$\text{or } r_1 = 1.82'$$

$$2 r_o = 5 B + 0.12 \text{ and } r_o = 2.99$$

$$m = r_o / r_1 = 1.66$$

$$1.0 = 0.85 \times 8 \times 2.99 \times h_o^{1.5} [7 \times .5068 - 0.889]$$

$$h_o = .067 \text{ ft.}$$

*3rd semi-circle.*

$$2 r_1 = 4 B + 0.24$$

$$\text{or } r_1 = 2.46'$$

$$2 r_o = 6 B + 0.24$$

$$\text{or } r_o = 3.63'$$

$$m = 1.48$$

$$1.0 = 935 \times 8 \times 3.63 \times h_o^{1.5} \left[ 7 \times \log_e 1.48 - \frac{(1.48)^2 - 1}{2} \right]$$

$$h_o = 0.067'$$

Diameter of the leading pipe.

$$= 1.13 \sqrt{B (D - h_o m)}$$

$$= 1.13 \sqrt{1.17 (0.532 - 0.152)}$$

$$= 0.75'$$