PUNJAB ENGINEERING CONGRESS, 1939.

DOMESTIC ENGINEERING

BY MR. F. L. BRAYNE, I.C.S., COMMISSIONER FOR RURAL RECONSTRUCTION.

Outside this hall a few exhibits have been got together representing such improvements in domestic appliances as I have been able to collect. The Irrigation Research Institute have done well by us but for the rest the very crudeness and scantiness of the show will, I hope, stimulate the Engineers to produce something next year which will really be worth calling a Better Homes Exhibition.

There are certain limitations in the work of designing improvements. For the general public the improvement must be made of material fairly easily procurable by village craftsmen and the cost must not be very great; although of course there is no harm in also designing de luxe models for the well-to-do. The availability of cement, iron sheeting, wire gauze and wire-netting can be fairly assumed. When one considers the variety of materials and the craftsmanship which go to the making of many of the hookahs one sees in the village, one realizes how the designing of the more important amenities and necessities of village life has been neglected.

Coming to details, the following are some of the most obvious needs:—

1. Fuel is scarce and smoke is plentiful. We want fuel-saving grates for all kinds of village cooking and efficient chimneys for all kinds of grates. You need not allow for the simmering of milk or the keeping of things hot. The haybox will do that. We have specimens of this but will you exercise your ingenuity in making the maximum use of this village thermos? It should give us hot water at all times of day or night, and be used for all manner of kitchen purposes. While on the subject of village cooking, could not kitchens be made more comfortable and efficient than they are?—Need all the work be done on the floor?

2. The villages are rapidly being turned into swamps by the eternal digging of earth to mend walls. If you can extend the life of the walls by weather-proofing, the digging will automatically be reduced. The Irrigation Research Institute has given us a remedy which is shown outside.

Sodium Silicate, also shown outside, is unfortunately only an outside layer and if damaged, will let in the water. Will pise-enterre walls be an additional economy?

3. Village latrines. We have certainly not reached finality here. The requirements are:—

(*i*) that they shall produce neither flies nor smell.

(*ii*) the contents must not stray into the subsoil water.

(*iii*) if possible, they must be recoverable, both liquids and solids, for use as manure when fully decomposed,

(*iv*) they must require a minimum of servicing to keep clean and sweet.

Septic tank latrines would be useful for better class houses, but for community purposes and small village homes, some kind of hole in the ground is all that is possible.
Squatting boards are exhibited outside and a model of what is called the "Quail-pit" latrines.

4. Water-lifts, for drinking water, that will not get out of order, and can be easily serviced by village artisans.

5. Hygienic well-tops that will keep the water as pure as possible. Neither water nor rubbish nor dust must get in from the top, and water must not stagnate near the well. Models are shown outside.

6. Tanks and pumping arrangements to provide a community supply at the well-top.

7. Drain pipes and drain-bricks of all kinds which can be easily made in villages for waste water disposal.

8. Waste water disposal arrangements for places where trees and garden plots will not soak it all up.

9. Fly traps.

10. Ventilators for walls and roofs (samples outside).

This is not by any means an exhaustive list. The increased efficiency and comfort of the housewife in doing her innumerable home chores, the better health and the greater convenience and comfort of the family are our aims. Will the Engineers kindly look at what we have collected and then after studying village conditions, set to work and invent ways of saving labour drudgery, and inconvenience, and of increasing health, comfort and efficiency for the villager, so that we may have something vastly better to show next year?

More details of the improvements Government is trying to in village life will be found in a book called " BETTER VILLA((Oxford University Press, Rs. 2) which the Punjab Government h commended for general use in its village campaign.

I cannot promise any money for this work, except for the stag the finally designed article. Domestic Engineering must I fear r what Boy Scouts call a spare time activity. Except where the inc is patent royalties, or in the case of a firm the sale of its products, th encouragement I can offer, is the thanks of the villager and the sens social duty successfully performed.

PAPER No. 218.

DIAGRAMS FOR THE DESIGN OF AN A.P.M.

By N. D. Gulhati, I.S.E.

General.

The current practice of distribution of supply among the distributaries of a canal system, in the Punjab, aims at running a channel with full supply or not at all. The proportionality in an outlet, which was the object of Mr. Crump's six-tenth setting in an A.P.M., is no longer considered essential.

To keep channels in good working order, it is also essential that the outlets should take their fair share of silt. The lower the setting of an A.P.M. the more silt it takes. As some of the outlets must of necessity be set high, those that can be set low should be placed as near the bed as possible. There should not be any objection even to placing outlets down to 6" below bed level. This is not unfair to the cultivators. It is generally observed that outlets with large working heads seldom show high silt banks, which clearly indicates that if ample command is available, all the silt is carried right to the fields.

It is clear that an A.P.M. should be set as low as the available working head of the outlet permits. It is therefore necessary that the Minimum Modular head of an A.P.M. should be known with as great accuracy as possible.

Existing formulae.

Mr. Crump's table* of Minimum Modular heads is based on only 15 tests on an A.P.M. of $B=0{\cdot}5'$ and, as such, its application cannot be general.

Mr. K.R. Sharma carried out further experiments on which he based his unwieldy table of varying co-efficients for determining Minimum Modular heads. His experiments (Punjab Engineering Congress Paper No. 176-1934) were also conducted over a limited range, and many A.P.Ms. were found to work non-modularly when designed according to his tables.

This indicated that it was necessary to carry out further observations of the Minimum Modular head of A.P.M's. as fitted on some of the channels, with a view to finding out some general formula for its

* Page vii of Appendix E—1 of Punjab Irrigation Branch Paper No. 26.

determination. Before however, describing these observations, it would be useful to study the problem from theoretical considerations.

Theoretical Minimum Modular head.

An A.P.M. is essentially a pipe (see fig. 1) taking off from a reservoir in which the upstream water level is kept constant.

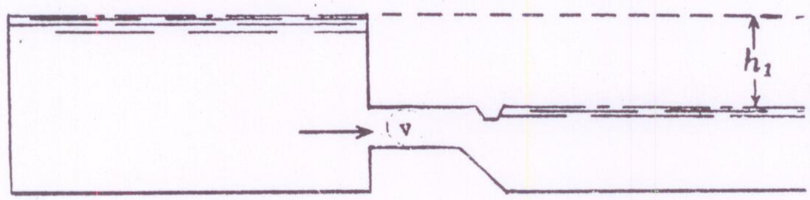

FIG. 1

If v be the velocity through the pipe, and there were no splay or glacis downstream, then the loss of head h_1 through the pipe is equal to

$$\frac{v^2}{2g}+\frac{0{\cdot}2v^2}{2g}+\frac{4flv^2}{2gd}.$$

In the above expression:—

$\frac{v^2}{2g}$ = the head spent in creating the velocity v.

$\frac{0{\cdot}2v^2}{2g}$ is the head lost at entry. (This is equal to $\frac{0{\cdot}08v^2}{2g}$ for a bellmouth entrance and $\frac{0{\cdot}505v^2}{2g}$ for a cylindrical entrance. For the type of approaches generally used in an A.P.M. it would not be far out to consider this loss $=\frac{0{\cdot}2v^2}{2g}$.

$\frac{4flv^2}{2gd}$ is the head lost due to friction in the pipe,

where l is the length of the pipe, d is the diameter of the pipe, and f is an index which for cast iron pipes is of the order of ·005*

Thus, head lost $=h_1=\frac{v^2}{2g}+\frac{0{\cdot}2v^2}{2g}+\frac{4flv^2}{2gd}.$

* "Elementary Hydraulics" by Lea, page 71.

For short pipes the last expression is so small that it can be neglected.

$$h_1 \text{ is therefore } = \frac{1 \cdot 2v^2}{2g}. \qquad (i)$$

Again for **an A.P.M.**, $q = 7 \cdot 3\, By\sqrt{h} = 7 \cdot 3 \times A\sqrt{h}$, if A is the area of the opening; or $q/A = v = 7 \cdot 3\sqrt{h}$ (ii)

Substituting this value of v in equation (*i*), we have

$$h_1 = \frac{1 \cdot 2 \times (7 \cdot 3)^2 \times h}{2g} = 1 \cdot 0h.$$

Mr. Crump's experiments (Irrigation Branch Paper No. 30, by Mr. Fane, page 15) have shown that by the use of a downstream glacis of 1 in 5 and giving splays to downstream wing walls of 1 in 5, the head lost can be reduced from 0·33 *K* to 0·25 *K*, which means that 25% of the head lost is recovered by the use of downstream approaches of the above order.

So if the downstream glacis below an A.P.M. were given a slope of 1 in 5 and a splay of 1 in 5 were adopted for the downstream wings, the M.M.H. (Minimum Modular head) would be

$$= 1 \cdot 0h \times 0 \cdot 75$$
$$= 0 \cdot 75\, h$$

The results of Mr. Crump's experiments, performed on comparatively wide flumes, are perhaps not strictly applicable to A.P.M.s of much narrower throat widths.

The recovery head varies with the loss of energy due to shock at expansion and, as such, outlets with narrower throat widths should have a smaller recovery than that obtained in wider flumes. The M.M.H. for outlets therefore may be expected to be slightly higher than 0·75*h* found above.

It is also reasonable to expect that outlets with wider throats will have greater recovery than those with narrower throats.

To study the effect of this recovery and to compare the theoretical results obtained above with actual, observations of Minimum Modular heads were made on a large number of A.P.M.s.

Method of Observation.

A fairly stiff tin flume of 1·5 ft. width was made to the type design of a meter flume. It was calibrated by actual tank measurements.

During the remodelling of a long distributary, grooves were made in the walls of the flume below the outlet, immediately upstream of the boundary road culvert. *Karries* of section 0·1 ft. × 0·1 ft. were made so as to fit in the grooves. The tin flume was fitted (see fig. 2) in the water-course immediately below the boundary road culvert, so that a standing wave formed both below the outlet, and below the tin flume.

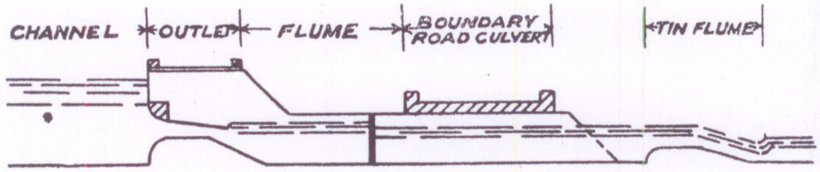

FIG. 2

On those outlets where grooves were not made, a sheet iron trough (fig. 3) about 8 ft. long was made to fit in the bed of the watercourse. Arrangements for heading up were made by fixing two angle irons along its periphery. This trough was fitted in the water-course above the boundary road culvert.

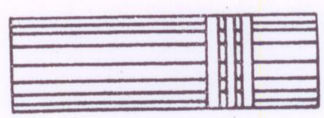

FIG. 3

The *H* of the A.P.M., the gauge in the tin flume and the working head of the outlet were measured, when steady conditions of flow were obtained. The size of the A.P.M. had been previously checked carefully. *Karries* were then put in the grooves, one by one, so as to gradually raise the water level below the outlet, keeping an eye on the gauge in the tin flume After putting in each *Karri*, sufficient time had to be given to let conditions become steady both above the groove and at the tin flume. Just at the time the gauge in the tin flume started to fall, the working head of the outlet was observed by means of a level and this working head was accepted as the Minimum Modular head of the A.P.M. The relevant data of the observations that were made are shown in columns 1 to 3 of the attached statement.

Standing Wave as a Test of Modularity.

During the course of the observations it was noticed that when the guage in the tin flume just started to fall, or in other words the outlet discharge started to decrease, the standing wave did not disappear altogether : but its position on the glacis did not remain steady and it started

to move up and down. So the test for modularity is not that a
wave should form, but that a *steady standing wave should exist*
this point of perfect modularity, it generally required th
level to be raised by 2 to 3 inches, before the standir
disappeared.

Formula for Minimum Modular Head.

It has been explained in the third paragraph that the M
Modular head should be a function of h and also that some variati
head recovered should be expected for different throat width
is fully borne out by the results obtained. On plate I, the M
Modular heads obtained have been plotted against h, sepa
outlets of each throat width. The resulting graph has the same
in each case, viz., M.M.H.$=0{\cdot}82h-B/2$. This gives a general
for determining Minimum Modular head of an A.P.M.

It will be noticed that the relation found between the M
Modular head and h of an A.P.M. is fairly simple.

As previous experimenters tried to connect the Minimum
head with H and Y, with which it had no direct connection, th
not obtain a simple formula.

The 15 tests on an A.P.M. carried out by Mr. Crump on w
based his formulae, and which have been described in Irrigatior
Paper No. 26 have been analysed on the above lines. A perus
graph on plate II shows that the values of Minimum Modular h
were found by Mr. Crump have a direct straight-line-relatior
and the equation of the graph

$$\text{M.M.H.}=0{\cdot}69\,h-0{\cdot}32$$

has the same form, as determined from the observations no
Mr. Crump's values are evidently low, probably because in hi
mental flume he had more gradual downstream expansion than is
adopted in practice. The formula M.M.H.$=0{\cdot}82h-B/2$ is a
to all A.P.M's. which have a minimum slope of glacis of 1 in
minimum splay of the downstream wings of 1 in 5.

In column 9 of the statement attached, the values of the M
Modular head as worked out by the formula, are given. In
10 the differences between the calculated and observed valu
M.M.H. have been worked out. It will be seen that the error is
well within $\frac{1}{10}$th of a foot. Greater agreement is not possib
splays of the downstream wings are different in different ou
therefore some variation in the Minimum Modular head s
expected.

The Design of an A. P. M.

The existing "trial and error method" for the design of an A.P.M. is rather laborious. The diagrams now presented render the design of an A. P. M. so easy that, with a little practice, the average overseer or draftsman can design an outlet with absolute accuracy. These diagrams are based on the following two formulae :—

$$q = 7{\cdot}3\ B\ Y \sqrt{h} \qquad (1)$$

and $$M.M.H. = 0{\cdot}82\ h - B/2 \qquad (2)$$

Enough has already been said about formula (2). As regards the discharge formula (1) this has been standardized for all canals in the Punjab *vide* Chief Engineer's letter No. 1478 dated 20-6-1933. There is no doubt that under actual working conditions the coefficient 7·3 shows a variation of about ±7% but any elaboration of this co-efficient appears to be of only academic interest, when it is kept in view that ordinary irregularities in the construction of an A.P.M. would throw the discharge out by a considerable amount. Long systems of channels are working satisfactorily with A. P. Ms. designed on this co-efficient. A very large number of field observations made with a calibrated tin flume show that the co-efficient 7·3 *is a very fair average* under actual working conditions.

The diagrams are self-explanatory. The two co-ordinates are *H* and *Y*. The firm lines are discharge curves and the dotted lines are lines of Minimum Modular head. An example is given below to illustrate the use of the diagrams.

Example :

To design an A.P.M. for $q = 2{\cdot}0$ cusecs,

F.S.D. = 2·5ft.,

and working head available = 1·4 ft.

On diagram No. II, the line of 2·0 cusecs cuts the line of M.M.H. of 1·4 at the point whose co-ordinates

are $H = 2{\cdot}66$,

and $Y = 0{\cdot}8$.

This completes the design. If it is desired to place the outlet at bed level, refer to the diagram again.

$h = 2{\cdot}5$ cuts the line of 2·0 cusecs where, $Y = 0{\cdot}85$.

So the dimensions are

$B = 0{\cdot}25$,
$H = 2{\cdot}5$,
$Y = 0{\cdot}85$,

and $M.M.H = 1{\cdot}21$ from diagram.

Setting of an A. P. M.

In Irrigation Branch Paper No. 26, Mr. Crump pointed out that A. P. M.s should be designed so that the ratio Y/H is equal to $\frac{1}{2}$ or less. In Irrigation Branch paper No. 26 A, Mr. Colyer laid down the limit that Y should always be less than $2/3\ H$.

The significance of these rules is perhaps not sufficiently realized, and a brief explanation would not be out of place.

On plate III a curve has been drawn showing how the discharge of an A.P.M. varies with H. A perusal of the curve shows that as H decreases, or in other words the ratio Y/H increases, dq/dH (slope of the tangent to the curve) increases. In plain words, for a given percentage variation in H the corresponding percentage variation in discharge increases as Y/H increases. Therefore to reduce to a minimum, the effect of changes in H due to silting, etc., in the channel the ratio Y/H should be kept as small as possible. The ratio Y/H would however be limited by the available working head of the outlet.

To find the point where the percentage increase in discharge is the same as the percentage increase in H, i.e., if $\frac{H_1}{H}=x$, $\frac{q_1}{q}$ is also$=x$.

Now $q=7{\cdot}3\ B\ Y\sqrt{H-Y}$ (1)

and $q_1=7{\cdot}3 B\ Y\sqrt{H_1-Y}$

In this case $H_1=Hx$ and $q_1=qx$,

$\therefore\ xq=7{\cdot}3\ B\ Y\sqrt{xH-Y}$ (2)

Dividing equation (2) by equation (1)

$$x=\frac{\sqrt{xH-Y}}{\sqrt{H-Y}}$$

Squaring, $x^2=\frac{xH-Y}{H-Y}$

or $x^2\ (H-Y)=xH-Y$

or $x^2H-xH\ =x^2Y-Y$

or $Y=\frac{H(x^2-x)}{x^2-1}$

$=\frac{x}{x+1}\times H$

If $x=1{\cdot}05$ then $Y\ \frac{1{\cdot}05H}{2{\cdot}05}=0{\cdot}514H$.

In the limit $x=1$, $Y=\frac{1}{2}H$.

In other words when $Y = \frac{1}{2}H$, the percentage increase in discharge is equal to the percentage increase in H.

If Y is more than $\frac{1}{2}H$ the increase in discharge for any increase in H will be higher.

The line $Y = \frac{1}{2}H$ has been drawn with a large dotted line on all diagrams as the limiting setting. When the dimensions of an A.P.M. fall below this line, it indicates that the higher throat width should be used.

OBSERVATIONS OF MINIMUM MODULAR HEAD OF A.P.Ms.

No.	Name of channels	R. D. of outlet.	Actual date of outlet.				Minimum Modular Head of outlet			Remarks.
			B	H	Y	h	As observed	As calculated M.M.H. $=0{\cdot}82h-B/2$.	Difference Columns 8 and 9.	
1	2	3	4	5	6	7	8	9	10	11
1.	Lalian	123470 R	·25	3·60	·68	2·92	2·19	2·27	·08	
2.	Kirana	126500 R	·25	3·20	1·21	1·99	1·47	1·51	·04	
3.	Lalian	122955 R	·25	3·10	·96	2·14	1·68	1·63	—·05	
4.	Kirana	131950 R	·25	3·04	·86	2·18	1·72	1·66	—·06	
5.	Kirana	61800 L_2	·25	2·52	1·01	1·51	1·26	1·11	—·15	Outlet is situated just above a fall and has bad U/S approaches.
6.	Malke	47230 R	·25	2·44	·86	1·58	1·21	1·17	·04	
7.	Malke	19283 L	·25	2·32	·85	1·47	1·16	1·08	—·08	
8.	Malke	36091 L	·25	2·11	·75	1·36	1·05	·99	—·06	
9.	Lalian	168674 R	·25	2·17	·96	1·21	·94	·87	—·07	
10.	Wasuana	7650 R	·25	2·03	·82	1·21	·84	·87	·03	
11.	Lalian	162915 R	·25	1·81	·83	·98	·68	·68	—	
12.	Tandlian	11240 R	·25	1·78	·50	1·28	·90	·92	·02	
13.	Darya	18106 L	·25	1·78	·55	1·23	·94	·88	—·06	
14.	Darya	19363 L	·25	1.77	·63	1·14	·82	·81	—·05	
15.	Lalian	159360 R	·25	1·50	·71	·79	·48	·52	·04	
1.	Kirana	84000 R	·32	2·92	·70	2·22	1·73	1·66	—·07	
2.	Kalri	8081 R	·32	2·35	·52	1·83	1·30	1·34	·04	
3.	Malke	36113 R	·32	2·10	·95	1·15	·72	·78	·06	
4.	Jalla	2020 L	·32	2·10	·70	1·40	·82	·99	·17	
5.	Rodian	13485 L	·32	1·96	·69	1·27	·93	·88	—·05	
6.	Lalian	154765 L	·32	1·89	·96	·93	·67	·60	—·07	
7.	Malke	41650 R	·32	1·80	·83	·97	·75	·64	—·11	Outlet is situated just above a fall and has bad U/S approaches.
8.	Malke	45970 L	·32	1·63	·66	1·02	·60	·68	·08	
9.	Lalian	159010 L	·32	1·65	·86	·79	·48	·49	·01	
1.	Kalri	15117 R	·4	2·42	·44	1·98	1·33	1·42	·09	
2.	Malkana	7545 R	·4	2·31	·85	1·46	1·05	1·00	—·05	
3.	Darya	19363 R	·4	1·76	·56	1·20	·61	·78	·17	
4.	Jalla	12200 L	·4	1·64	·45	1·19	·63	·78	·15	
5.	Jalla	8920 R	·4	1·54	·73	·81	·52	·46	—·06	
6.	Jalla	13876 R	·4	1·61	·62	·99	·58	·61	·03	
7.	Hadda	6880 L	·4	1·35	·6	·75	·34	·42	·08	
1.	Jalla	13900 R	·5	1·66	·55	1·11	·64	·66	·02	
2.	Rodian	7670 R	·5	1·15	·44	·71	·35	·33	—·02	
1.	Lalian	110420 L	·63	2·78	·61	2·17	1·42	1·46	·04	
2.	Lalian	108264 L	·63	2·11	·96	1·15	·54	·63	·09	
1.	Lalian	123472 L	·2	3·61	·71	2·90	2·24	2·28	·04	
2.	Kirana	40925 L	·2	3·59	·92	2·67	2·00	2·09	09	
3.	Kirana	58500 R	·2	3·37	·46	2·91	2·35	2·29	—·06	
4.	Lalian	116850 L	·2	3·33	·61	2·72	2·26	2·13	—·13	
5.	Kirnana	45800 R	·2	3·32	·57	2·75	2·06	2·16	·10	
6.	Kirana	61135 R	·2	3·17	·78	2·39	1·83	1·86	·03	
7.	Kirana	50000 R	·2	3·01	·71	2·30	1·75	1·79	·04	
8.	Kirana	2950 R	·2	2·93	·65	2·28	1·80	1·77	—·03	
9.	Kirana	49700 L	·2	2·92	·55	2·37	1·78	1·84	·06	
10.	Lalian	118483 R	·2	2·91	·91	2·00	1·61	1·54	—·07	
11.	Kirana	8900 R	·2	2·79	·90	1·89	1·48	1·45	—·03	
12.	Lalian	137032 R	·2	2·78	·56	2·22	1·85	1·72	—·13	
13.	Lalian	136710 R	·2	2·77	·80	1·97	1·54	1·52	—·02	
14.	Kirana	61800 L_1	·2	2·59	·65	1·94	1·52	1·49	—·03	
15.	Lalian	135955 L	·2	2·41	·45	1·96	1·45	1·51	·06	
16.	Lalian	114820 L	·2	2·34	1·10	1·24	0·98	·92	—·06	
17.	Lalian	107257 R	·2	2·25	1·00	1·25	·94	0·93	—·01	
18.	Kirana	18150 R	·2	2·17	·60	1·57	1·14	1·19	·05	
19.	Kirana	9300 R	·2	2·16	·74	1·42	1·05	1·06	·01	
20.	Lalian	119820 L	·2	2·06	·54	1·52	1·16	1·15	—·01	
21.	Kirana	300 R	·2	2·05	·64	1·41	1·05	1·06	·01	
22.	Lalian	118539 R	·2	2·02	·60	1·42	1·12	1·06	—·06	
23.	Lalian	142240 R	·2	·97	·63	1·34	·94	1·00	·06	
24.	Lalian	106061 L	·2	1·90	·61	1·29	·89	·96	·07	
25.	Lalian	142758 L	·2	1·56	·53	11·03	·72	·74	·02	
26.	Lalian	155700 R	·2	1·10	·16	·94	·66	·67	·01	

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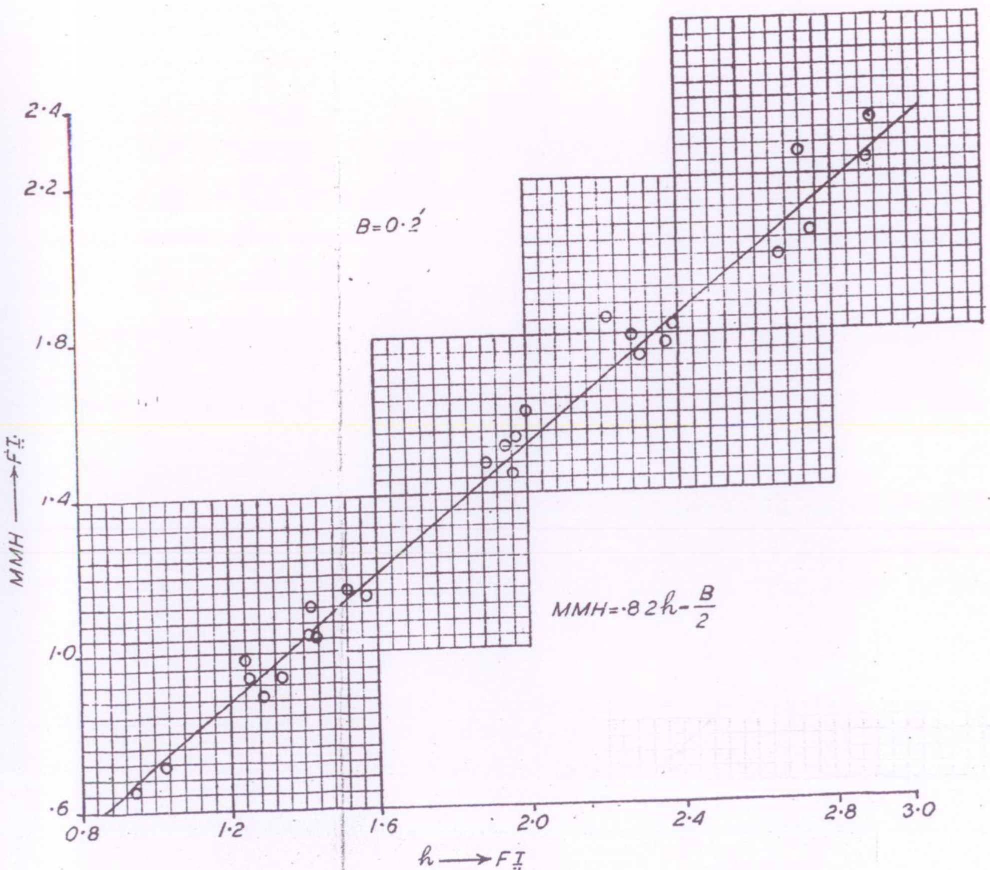

B=0·2'
MMH=·82h-B/2
MMH ⟶ FI
h ⟶ FI
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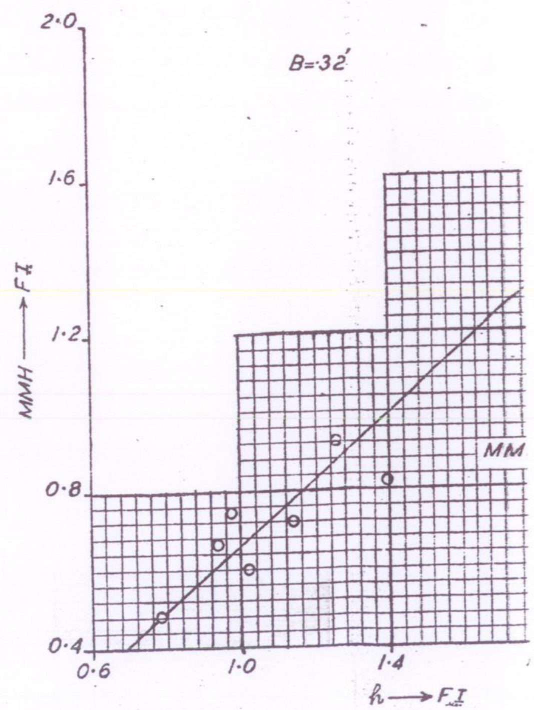

B=·32'
MM
MMH ⟶ FI
h ⟶ FI
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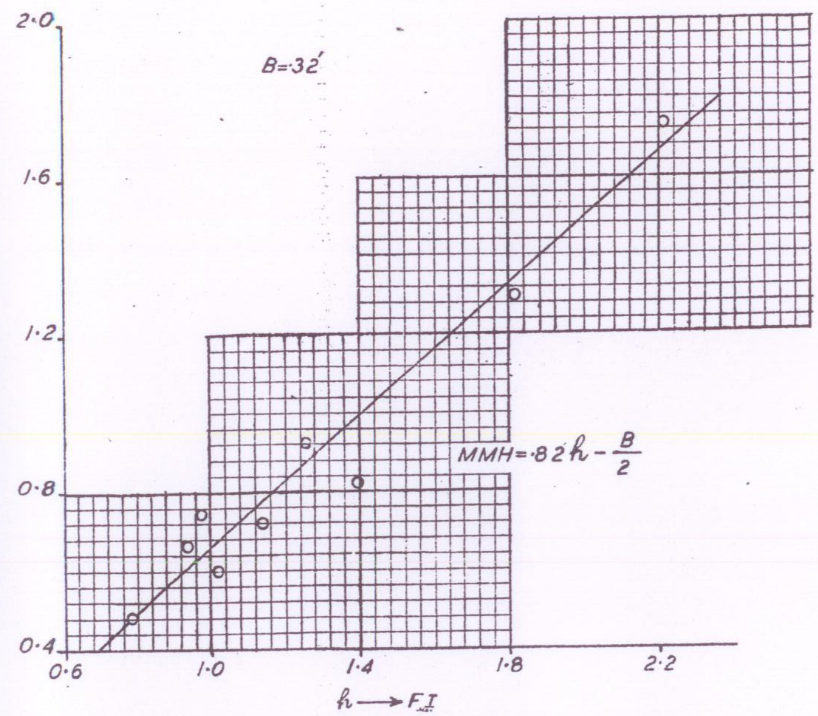
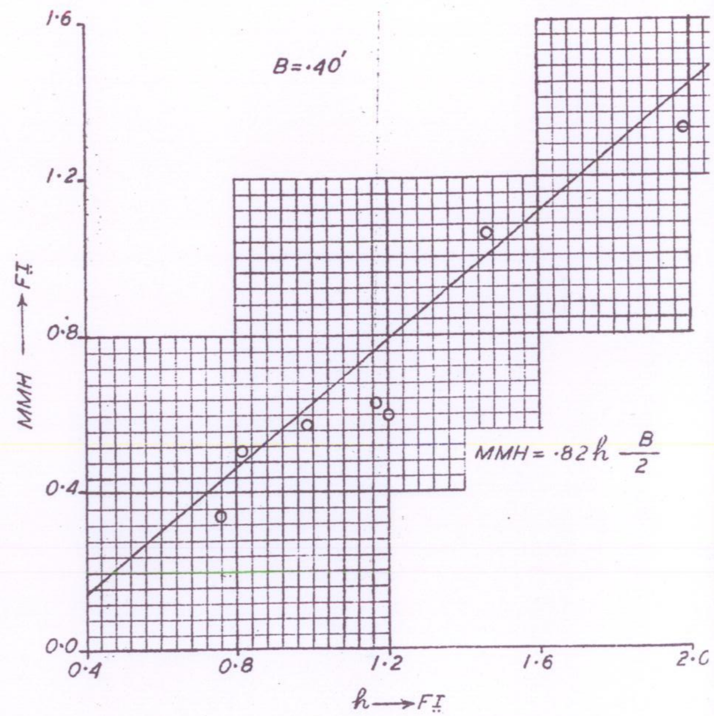
0·4
0·6
1·0
1·4

ADJUSTABLE PROPORTIONAL MODULE
RELATION BETWEEN h AND MINIMUM MODULAR HEAD





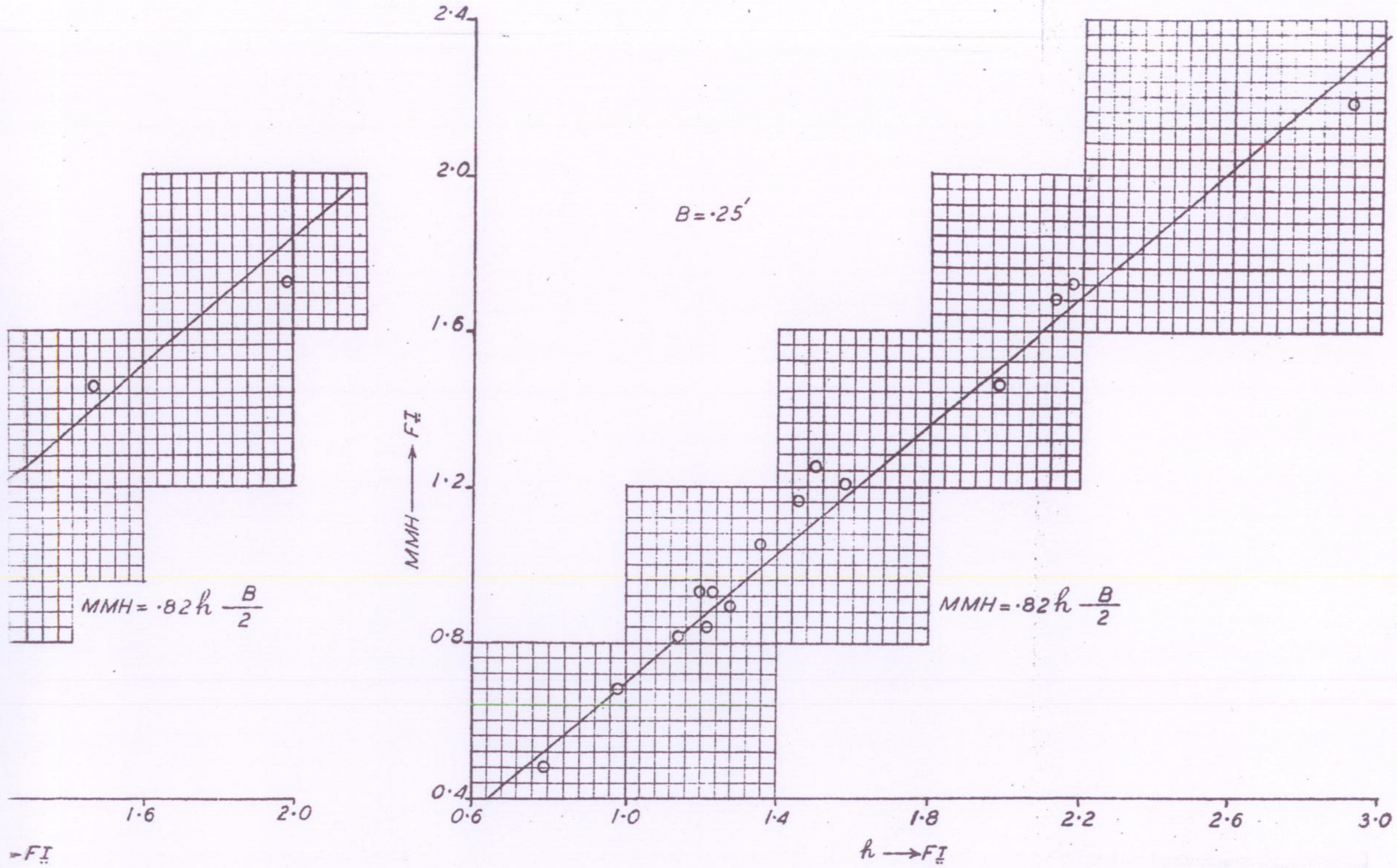
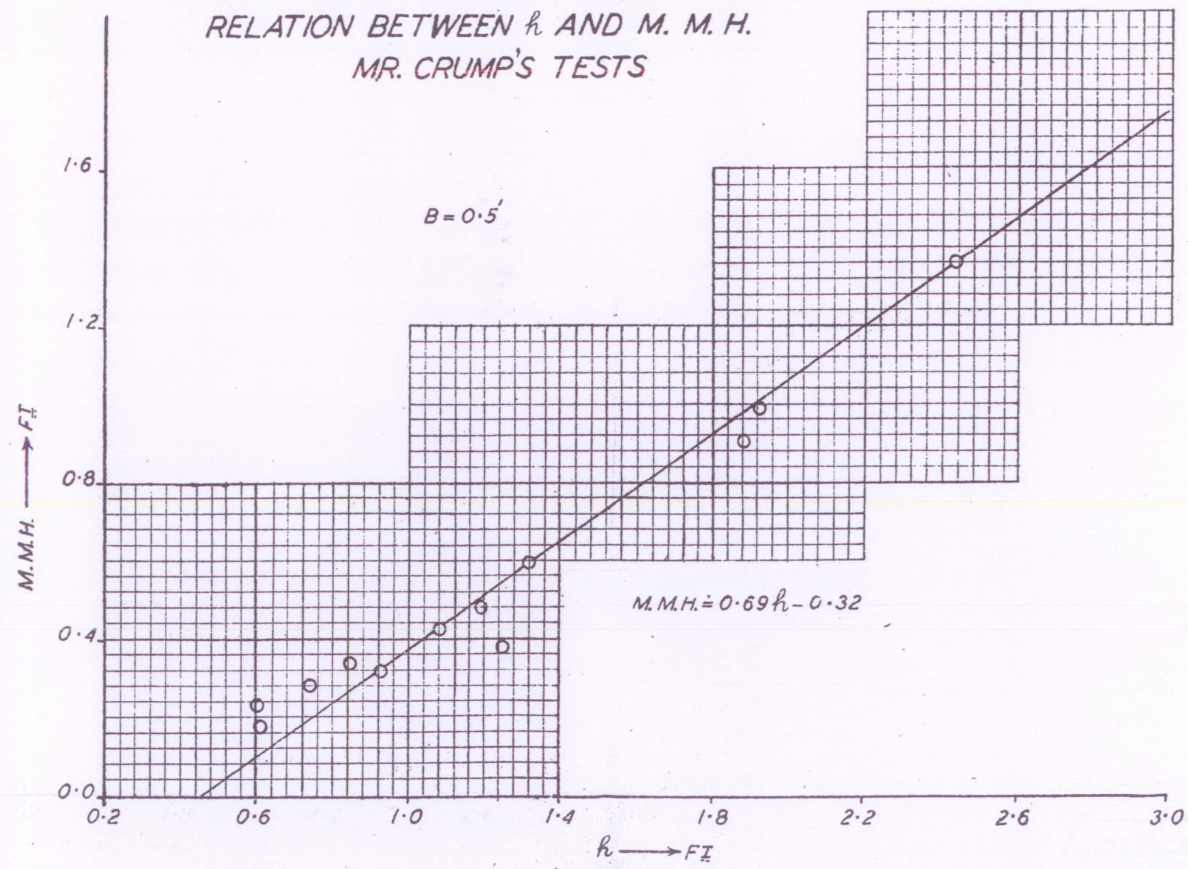

MMH = ·82 h − B/2
1·6
2·0
→ FT.
2·4
2·0
1·6
1·2
0·8
0·4
MMH → FT.
B = ·25′
MMH = ·82 h − B/2
0·6
1·0
1·4
1·8
2·2
2·6
3·0
h → FT.

PLATE II
PAPER NO. 218

ADJUSTABLE PROPORTIONAL MODULE
RELATION BETWEEN h AND M. M. H.
MR. CRUMP'S TESTS

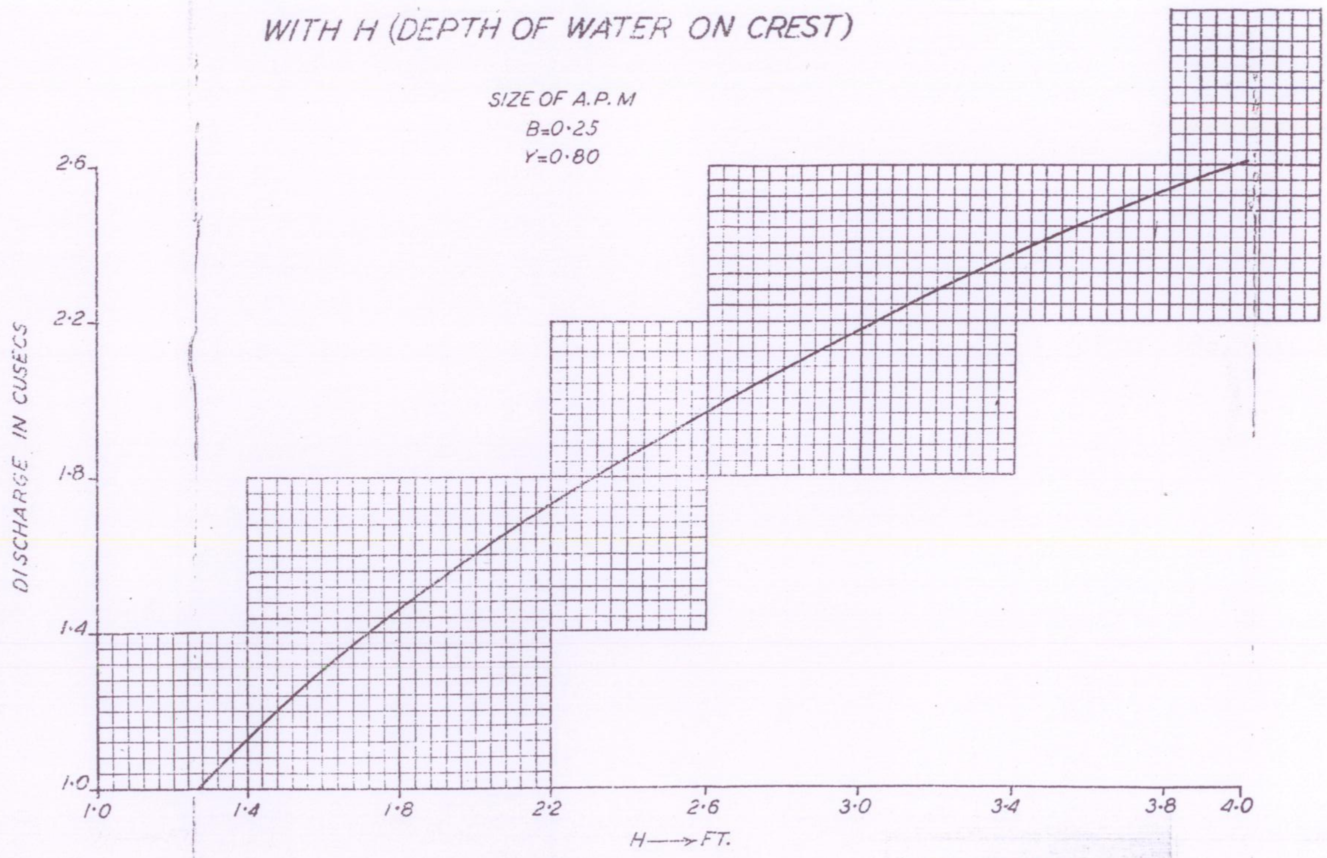


NOTE:—OUT OF THE 15 TESTS MADE BY MR. CRUMP 12 HAVE BEEN PLOTTED ABOVE THE REMAINING THREE HAD $\frac{Y}{H}$ MORE THAN HALF THESE HAVE BEEN LEFT OUT.

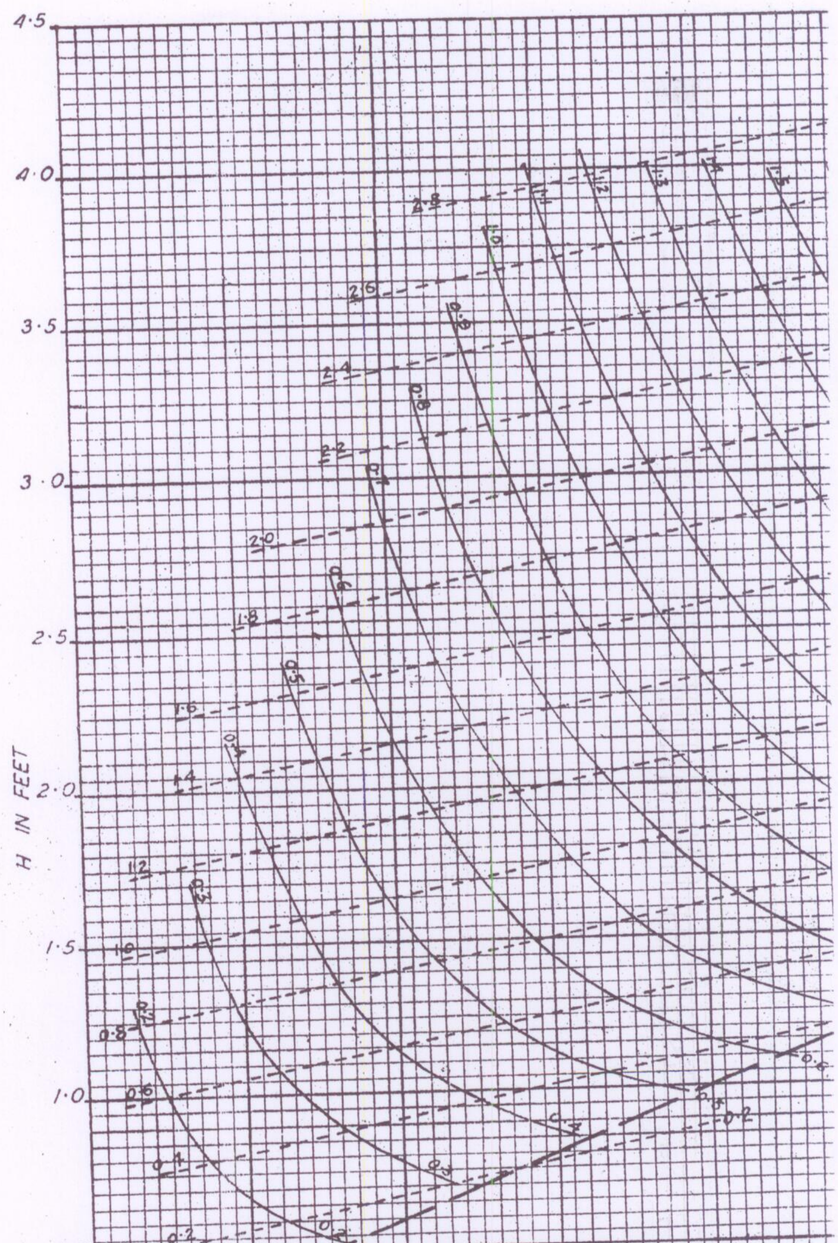
PUNJAB ENGINEERING CONGRES
1939.

PLATE III
PAPER NO. 218

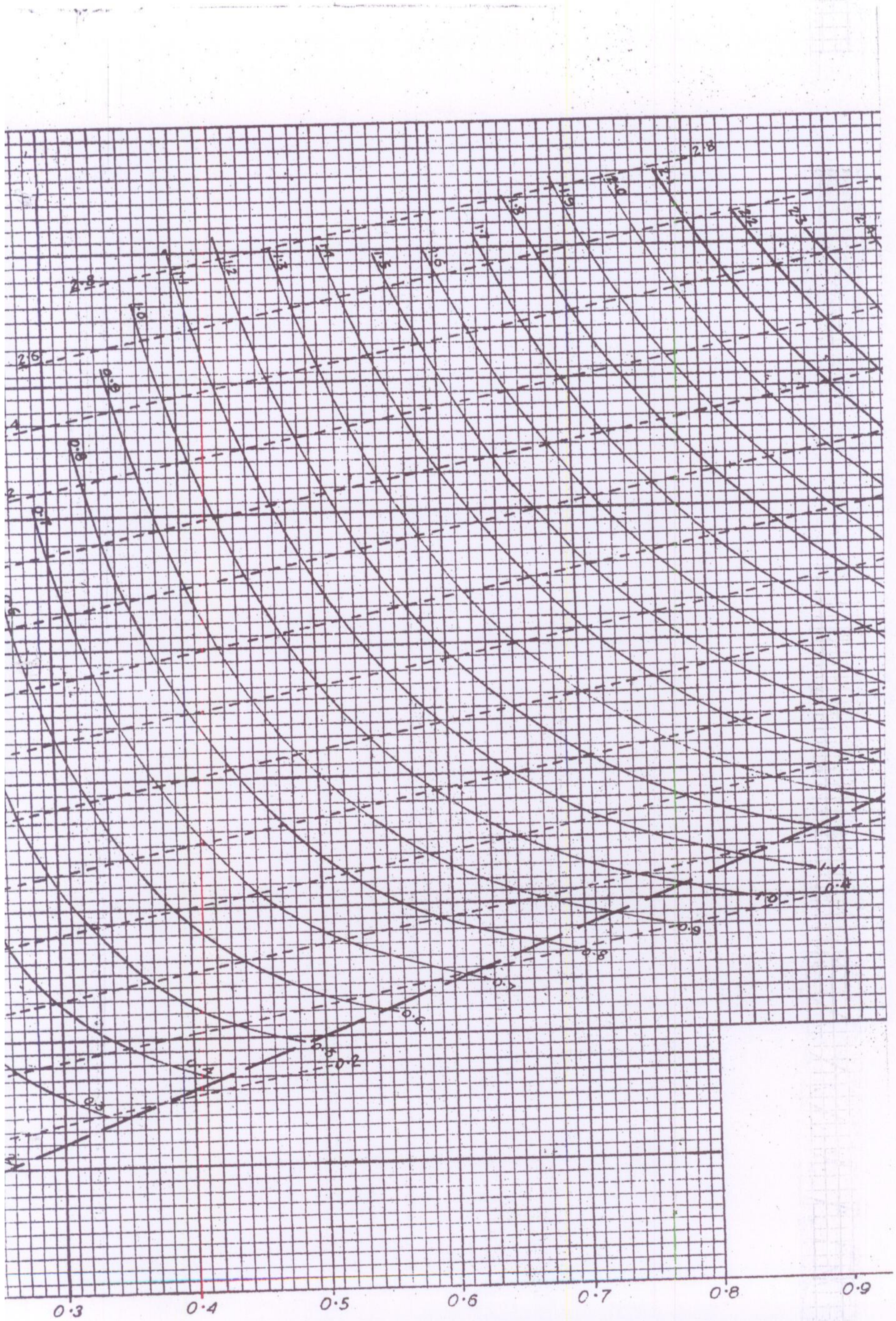
GRAPH
SHOWING VARIATION OF DISCHARGE OF AN A. P. M. WITH H (DEPTH OF WATER ON CREST)



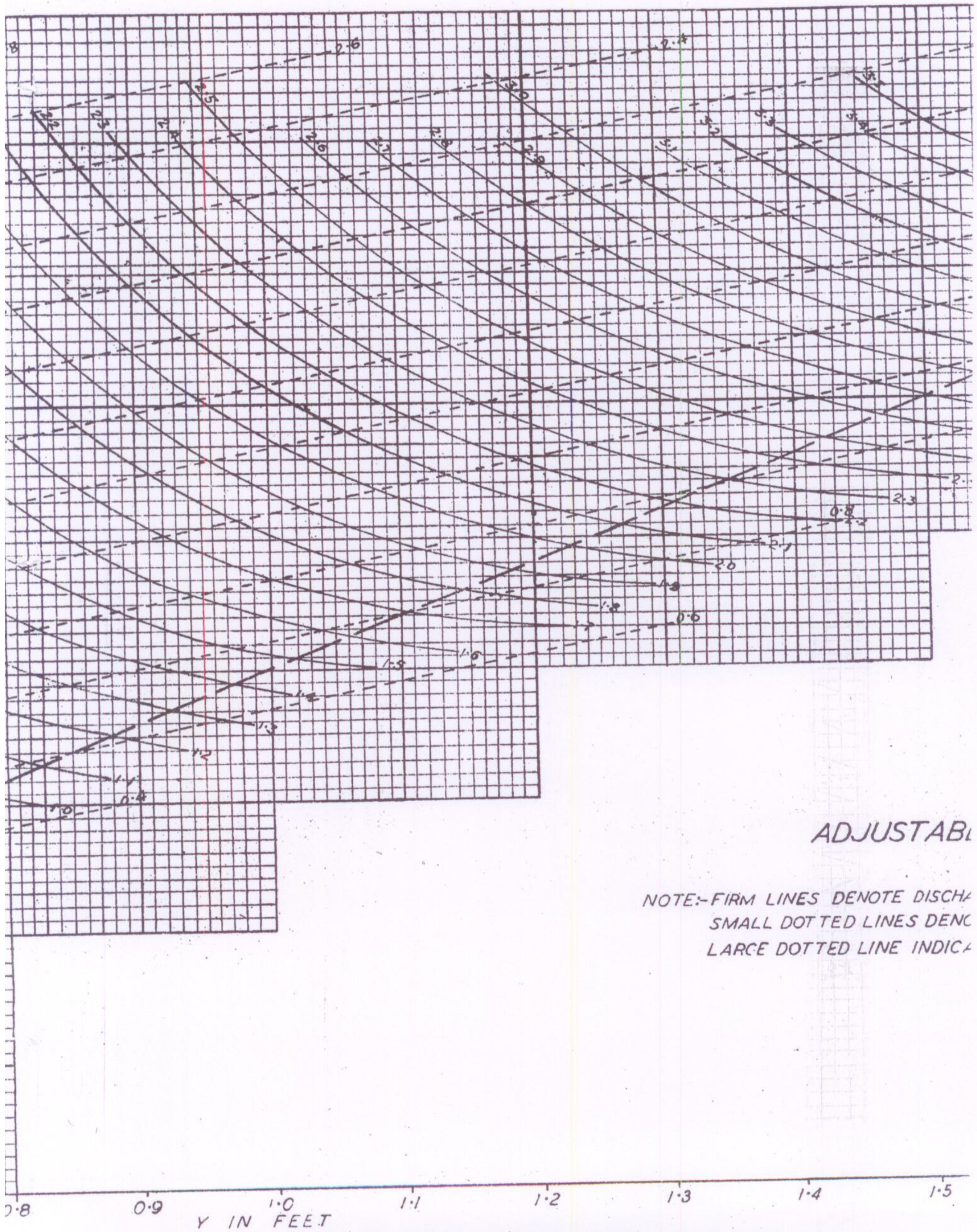
PUNJAB ENGINEERING CONGRESS
1939.



H IN FEET
4·5
4·0
3·5
3·0
2·5
2·0
1·5
1·0
0·5
0·0
0·1
0·2
0·3
0·4
0·5



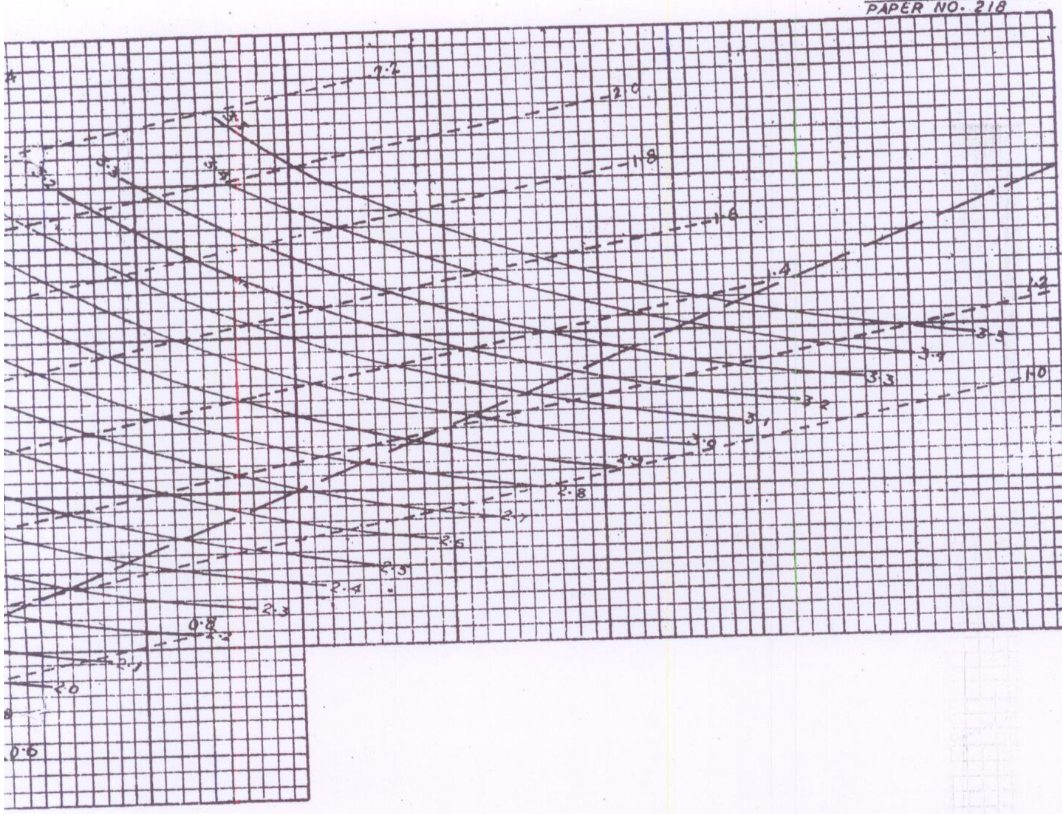
0·3
0·4
0·5
0·6
0·7
0·8
0·9



ADJUSTAB

NOTE:- FIRM LINES DENOTE DISCHA
SMALL DOTTED LINES DENC
LARGE DOTTED LINE INDICA

DIAGRAM NO. I
PAPER NO. 218



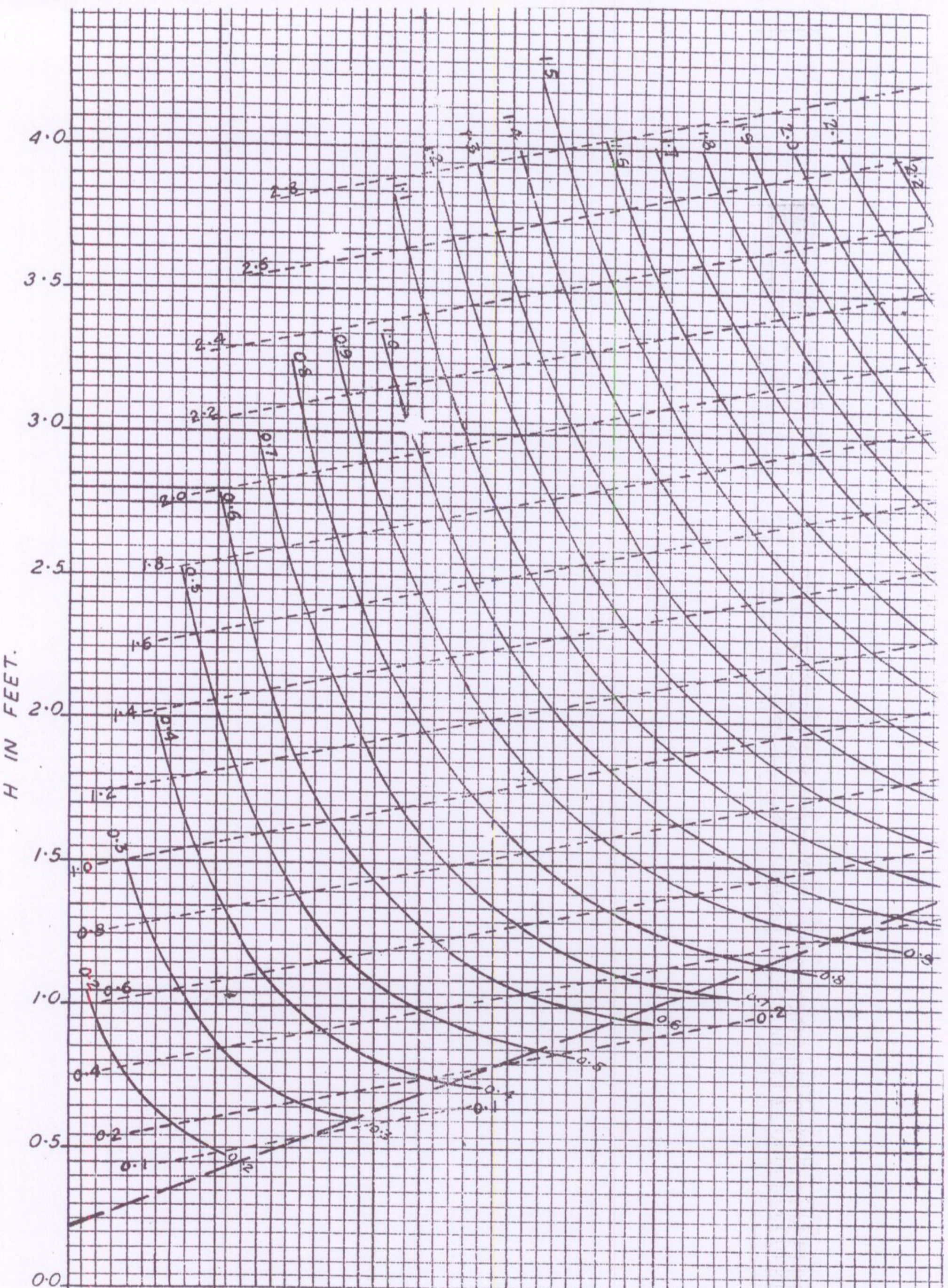
B=0·20

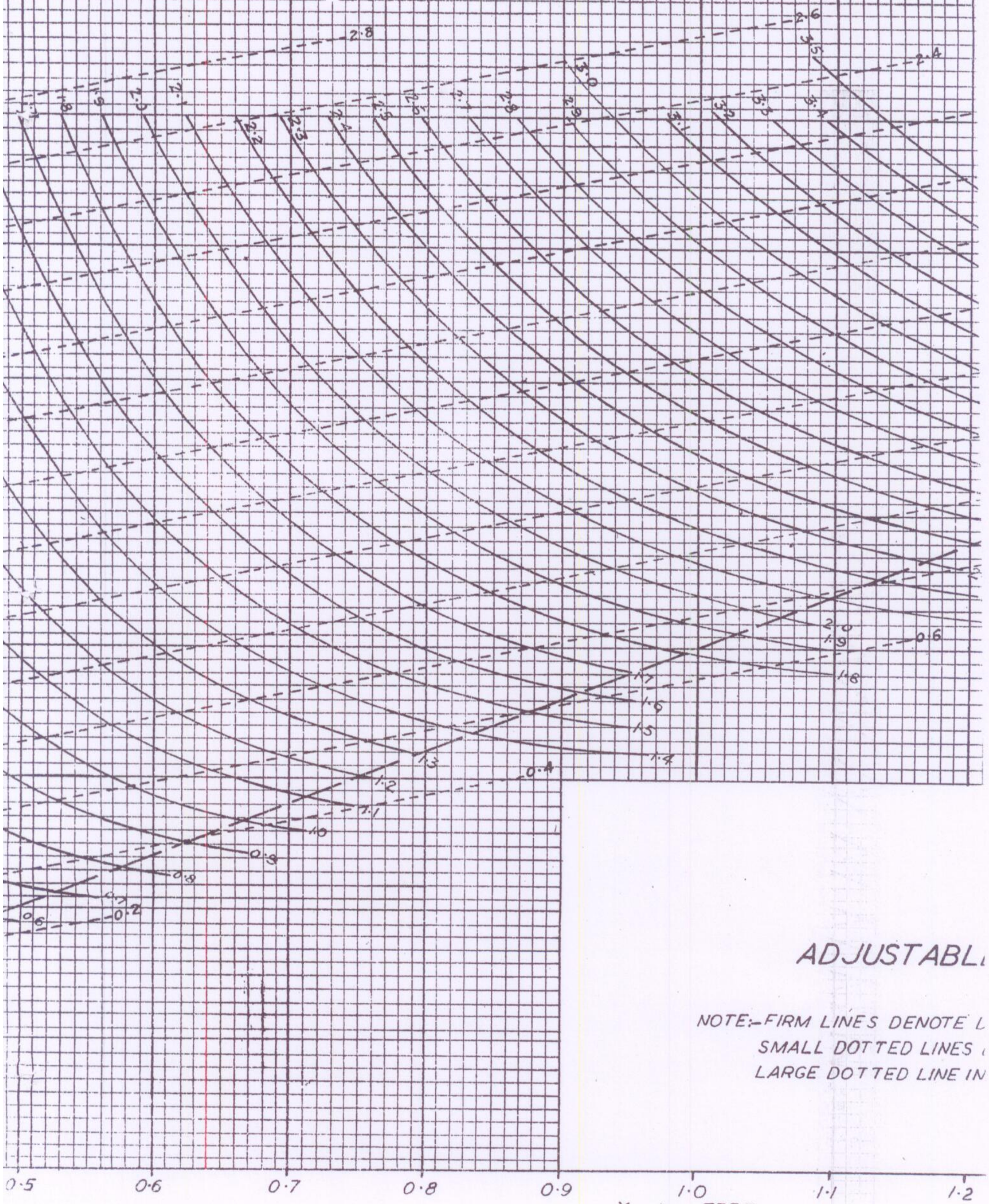
ADJUSTABLE PROPORTIONAL MODULE

TE:- FIRM LINES DENOTE DISCHARGE OF THE OUTLET IN CUSECS.
SMALL DOTTED LINES DENOTE MINIMUM WORKING HEAD REQUIRED FOR MODULARITY.
LARGE DOTTED LINE INDICATES MINIMUM SETTING $Y = \frac{1}{2}H$.

PUNJAB ENGINEERING CONGRESS
1939.

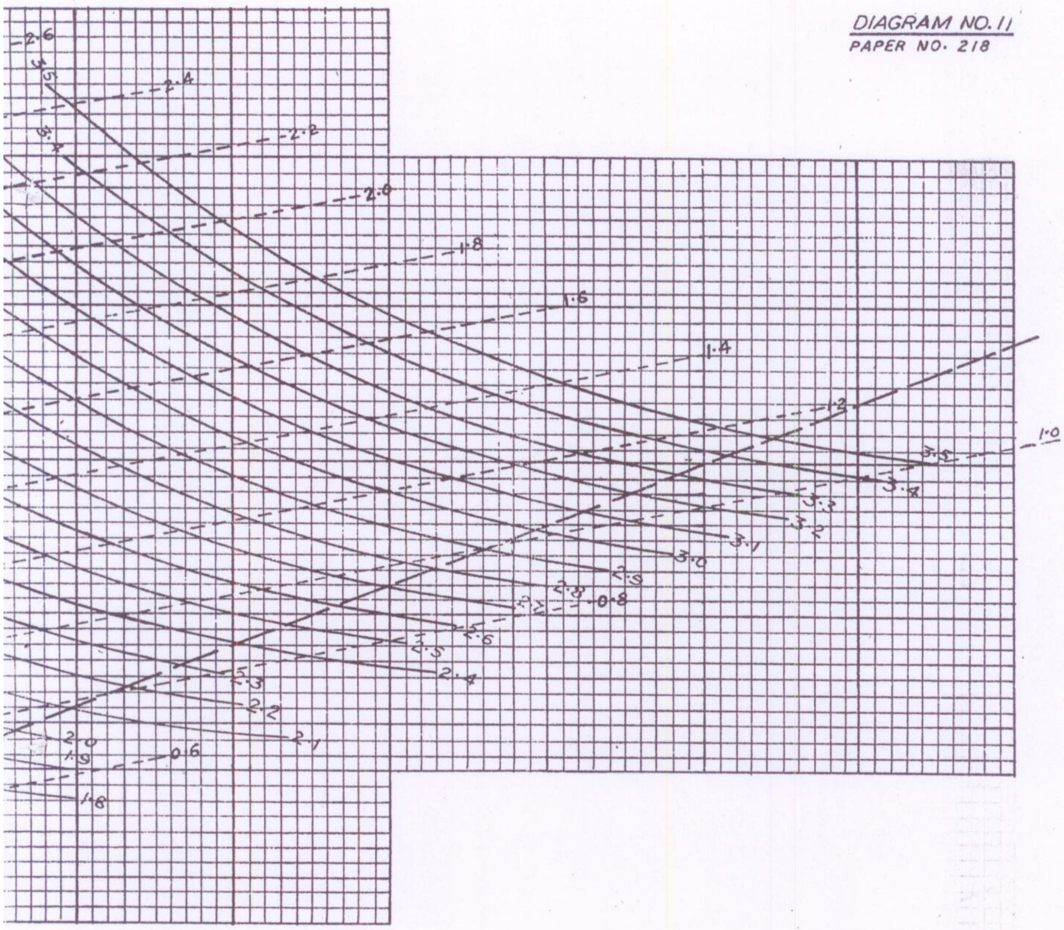
1·3 1·4 1·5 1·6 1·7 1·8 1·9 2·0


H IN FEET.
4·0
3·5
3·0
2·5
2·0
1·5
1·0
0·5
0·0
0·1
0·2
0·3
0·4
0·5
0·6



ADJUSTABL
NOTE:- FIRM LINES DENOTE L
SMALL DOTTED LINES
LARGE DOTTED LINE IN
0·5
0·6
0·7
0·8
0·9
1·0
1·1
1·2
Y IN FEET

DIAGRAM NO. 11
PAPER NO. 218



B=0·25

ADJUSTABLE PROPORTIONAL MODULE

IRM LINES DENOTE DISCHARGE OF THE OUTLET IN CUSECS.
MALL DOTTED LINES DENOTE MINIMUM WORKING HEAD REQUIRED FOR MODULARITY.
ARGE DOTTED LINE INDICATES MINIMUM SETTING Y=½H.

PUNJAB ENGINEERING CONGRESS
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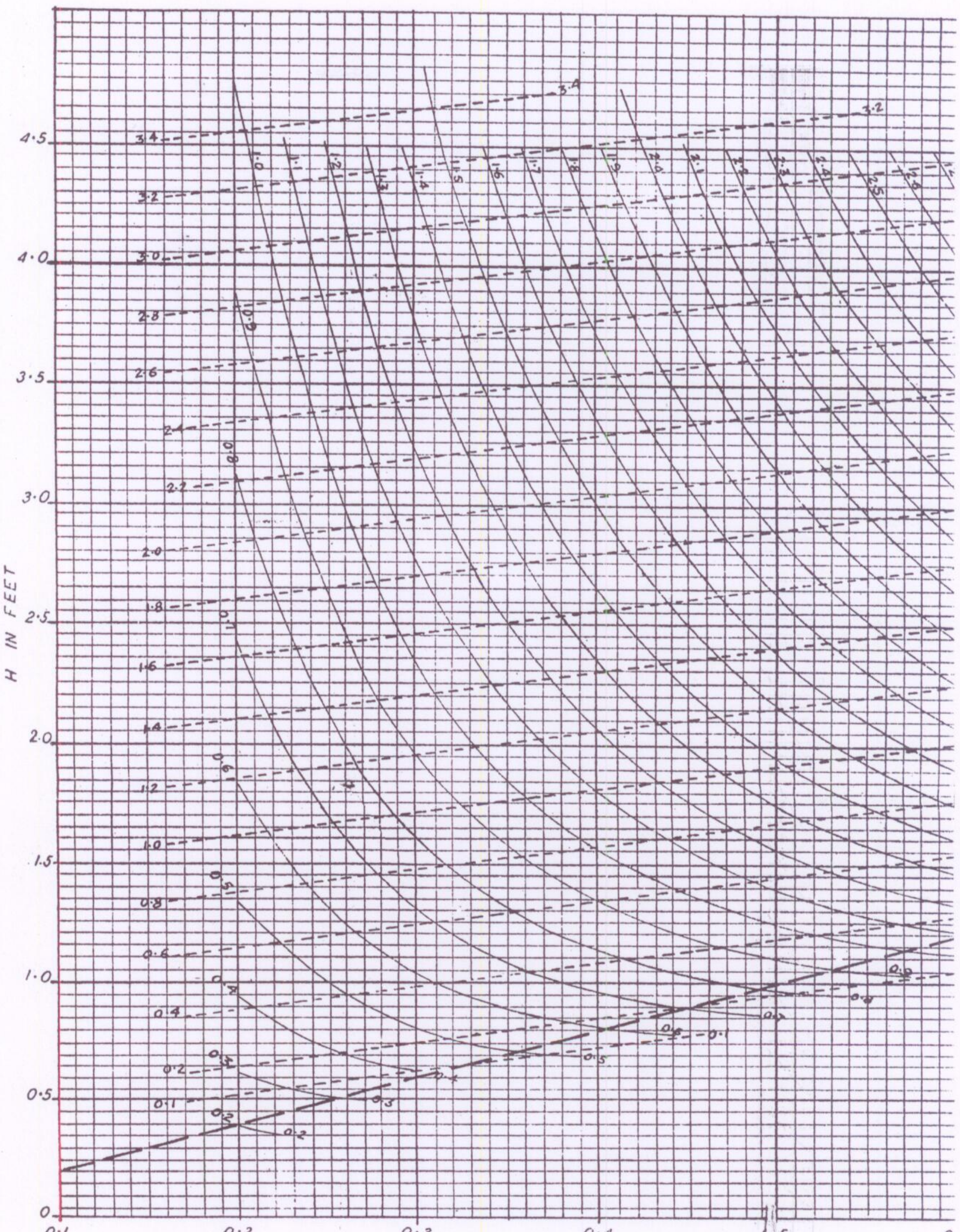
1·1 1·2 1·3 1·4 1·5 1·6 1·7


H IN FEET
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0.1
0.2
0.3
0.4
0.5
0

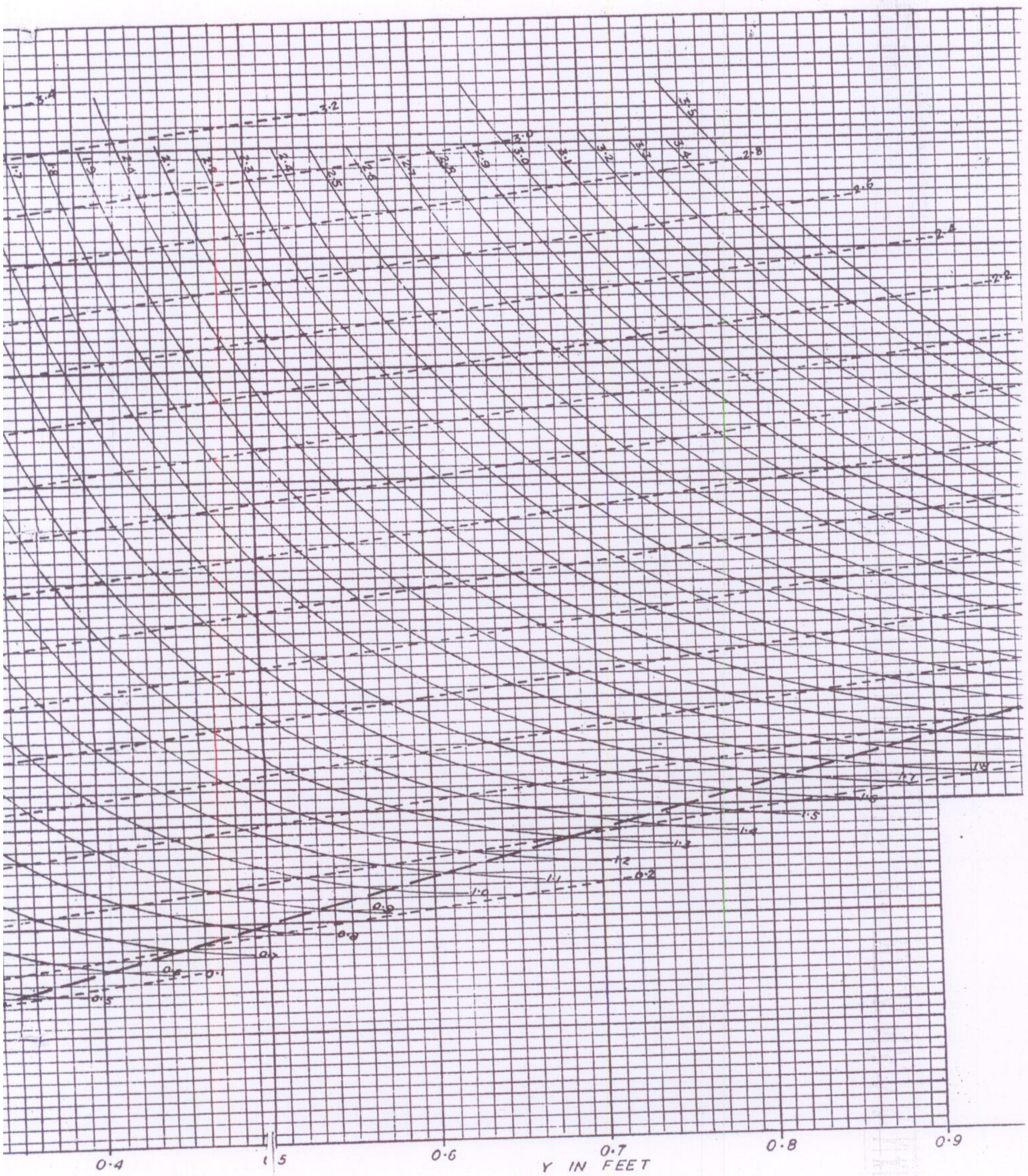
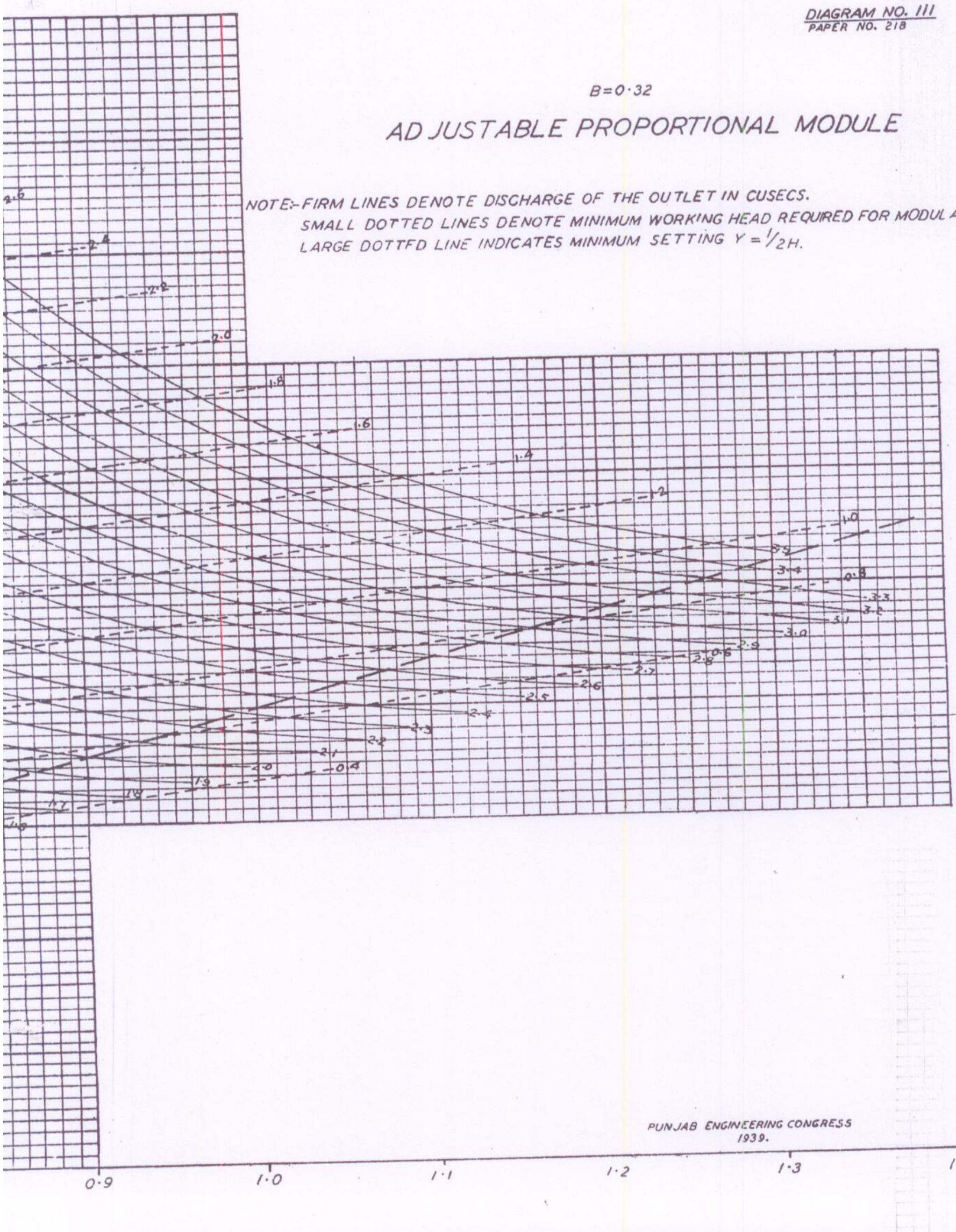

0·4
·5
0·6
0·7
0·8
0·9
Y IN FEET

DIAGRAM NO. 111
PAPER NO. 218

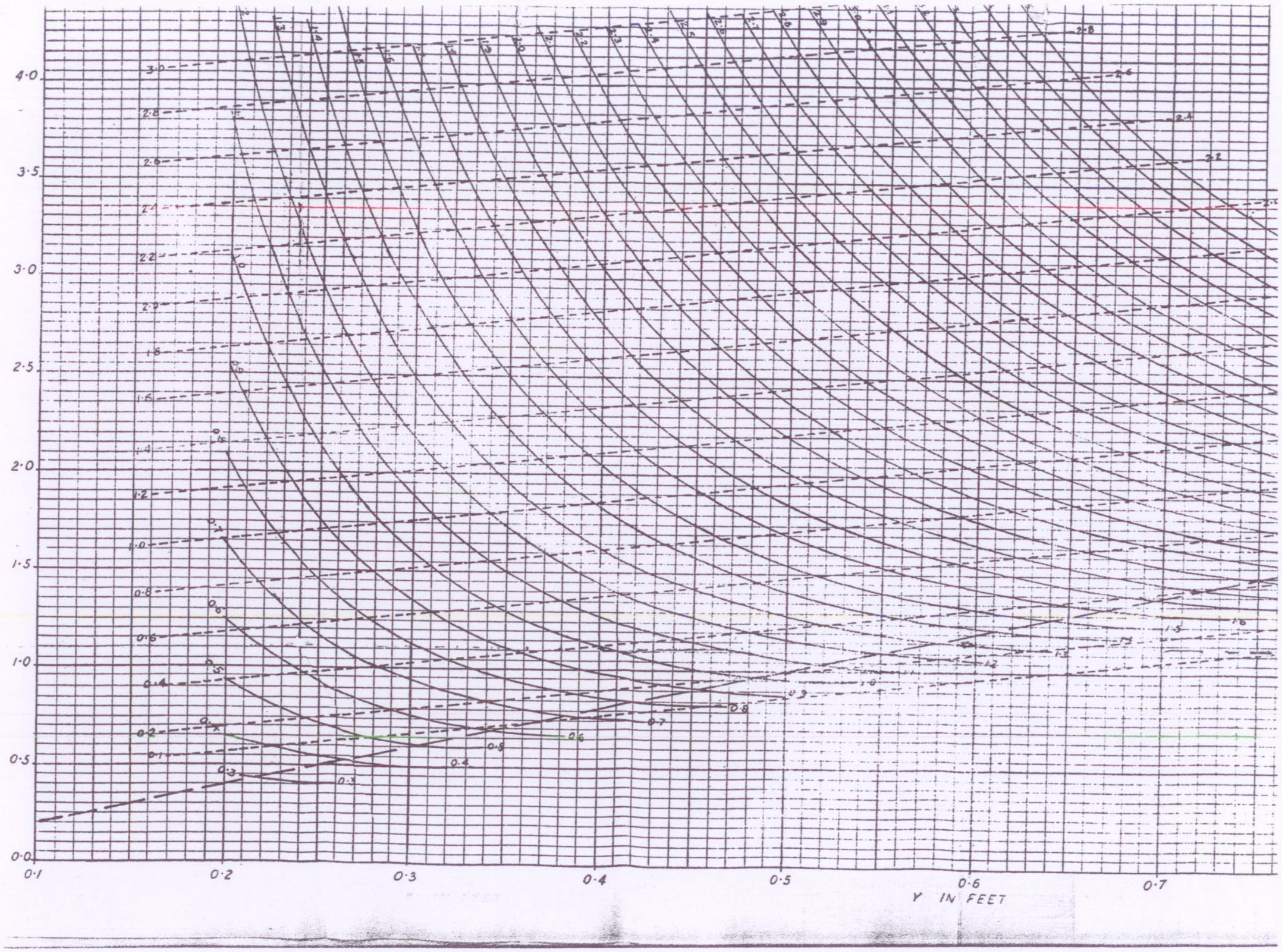
B=0·32

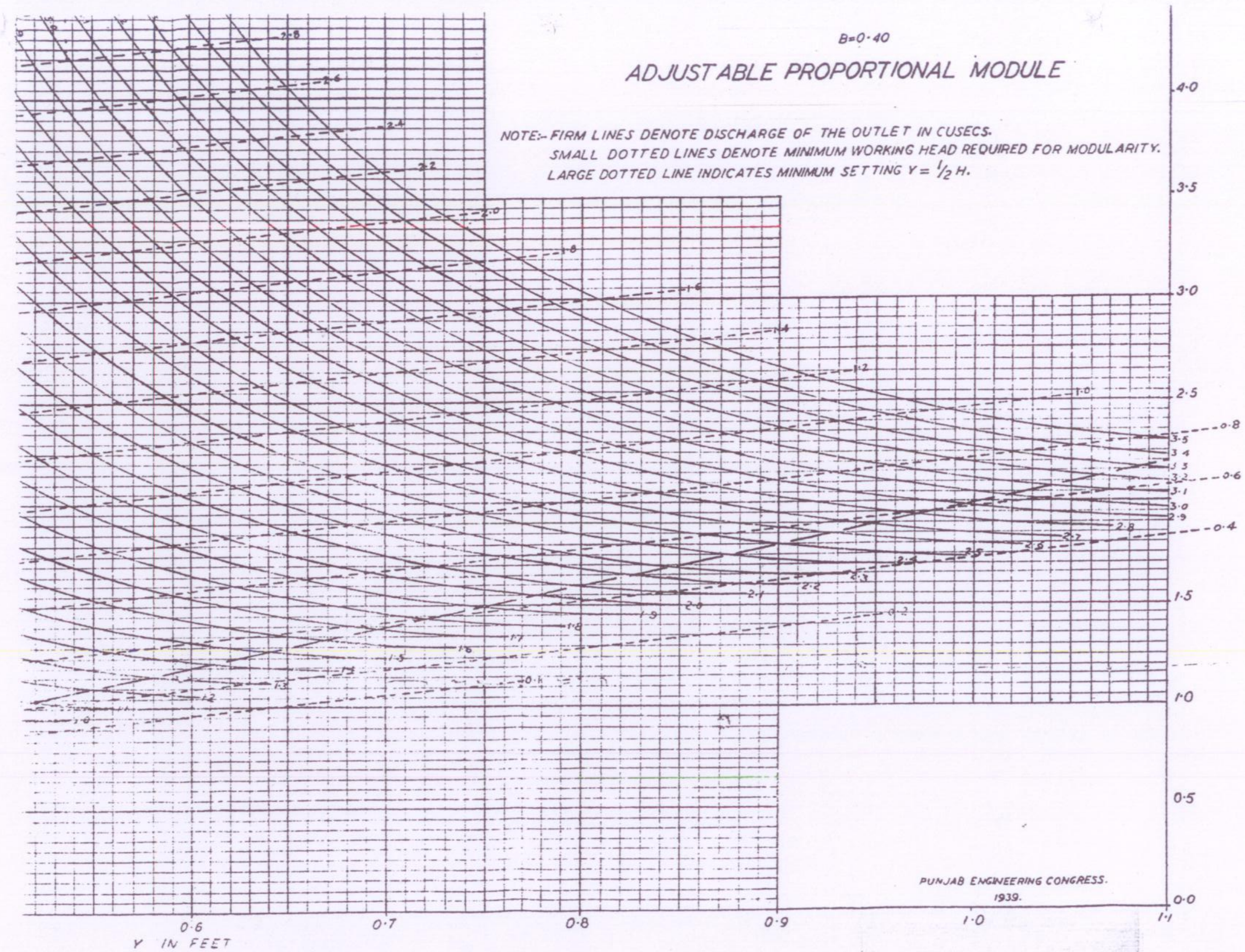
ADJUSTABLE PROPORTIONAL MODULE

NOTE:- FIRM LINES DENOTE DISCHARGE OF THE OUTLET IN CUSECS.
SMALL DOTTED LINES DENOTE MINIMUM WORKING HEAD REQUIRED FOR MODULARITY.
LARGE DOTTED LINE INDICATES MINIMUM SETTING $Y = \frac{1}{2}H$.



PUNJAB ENGINEERING CONGRESS
1939.


4·0
3·5
3·0
2·5
2·0
1·5
1·0
0·5
0·0
0·1
0·2
0·3
0·4
0·5
0·6
0·7
Y IN FEET


B=0·40
ADJUSTABLE PROPORTIONAL MODULE
NOTE:- FIRM LINES DENOTE DISCHARGE OF THE OUTLET IN CUSECS.
SMALL DOTTED LINES DENOTE MINIMUM WORKING HEAD REQUIRED FOR MODULARITY.
LARGE DOTTED LINE INDICATES MINIMUM SETTING Y = 1/2 H.
Y IN FEET
PUNJAB ENGINEERING CONGRESS.
1939.

DISCUSSION

In introducing his paper Mr. **Gulhati**, said that the A.P.M. did not need an introduction. When Mr. Crump evolved the device some 16 years back, he based his formula for discharge of outlets, and his table for determination of their minimum modular head, on 15 tests performed on an A.P.M. of throat width =0·5. In para 5 of Appendix E.I. of Irrigation Branch Paper No. 26, Mr. Crump stated that further tests might show that different formulæ were needed for A.P.Ms. of different throat widths. Many outlets designed according to Mr. Crump's table were found to work non-modularly, and consequently did not draw their due discharge. That in the author's opinion was one of the principal defects in the remodelling of distributaries carried out in the previous 16 years, that was responsible for the zamindar's dread of remodelling.

The three main points brought out in the paper, Mr. Gulhati stated, were :—

(*i*) that Mr. Crump's formula for discharge $q=7{\cdot}3\,By\sqrt{h}$ was a very fair average in actual practice for all sizes of A.P.Ms.

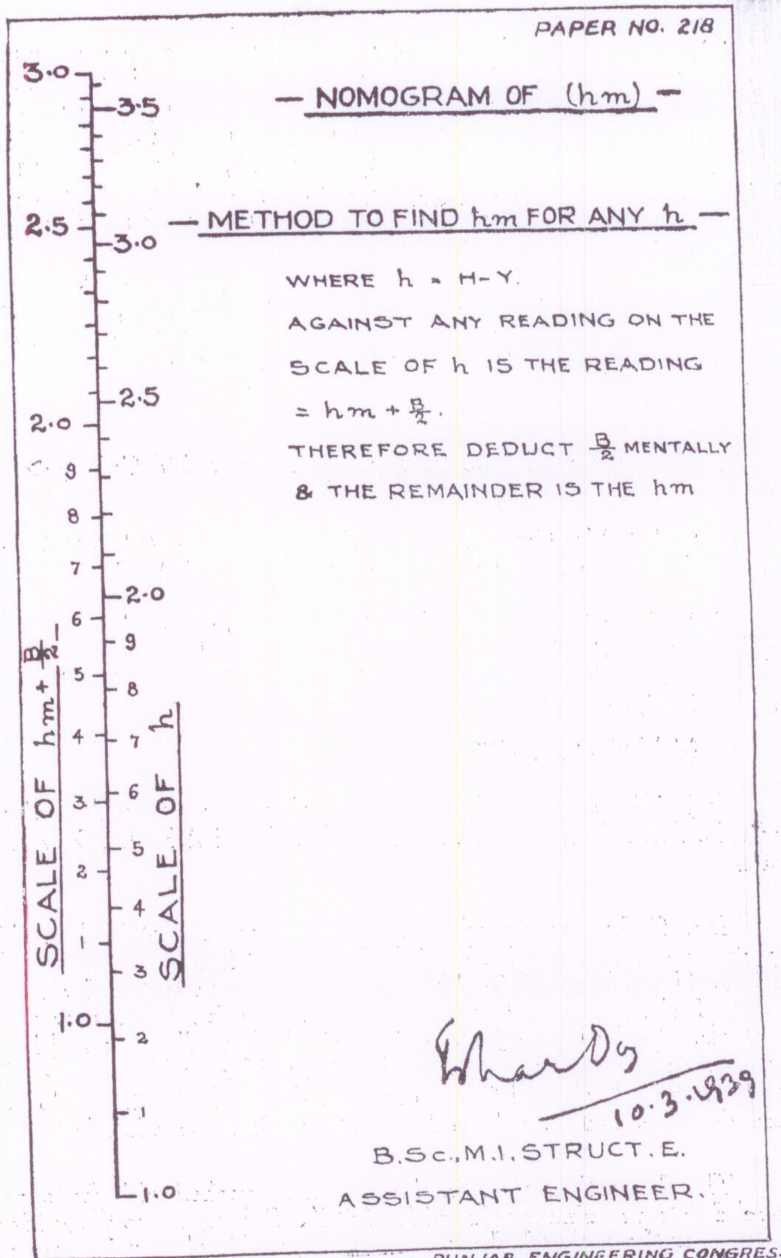
(*ii*) that Mr. Crump's table of minimum modular head was not applicable to all A.P.Ms. A new formula of general application within practical limits had been evolved for determination of minimum modular head, viz,

$$\text{M.M.H}={\cdot}82h-B/2.$$

(*iii*) The diagrams based on the above two formulæ, which made the determination of the most suitable size of A.P.M. a very easy matter.

Mr. Gulhati continued that the experiments contained in this paper were performed in 1934 and during the last four years the formula for M.M.H. as described in this paper had been put to test by many officers of the department and had been found to give results very close to actuals. In the Lower Jhelum Canal Circle these diagrams had been in use ever since these were prepared and enquiries made from the officers of that circle showed that no A.P.M. designed with the help of these diagrams had ever been known to work non-modularly.

The observations given in the statement attached with the paper extended upto a maximum value of H of 3·6'. Subsequent to the writing of the paper the author had a chance to extend his observations up to H=4·5' and the results obtained were found to be in accordance with the formula evolved in this paper.


PAPER NO. 218
— NOMOGRAM OF (hm) —
— METHOD TO FIND hm FOR ANY h —
WHERE h = H-Y.
AGAINST ANY READING ON THE
SCALE OF h IS THE READING
= hm + B/2.
THEREFORE DEDUCT B/2 MENTALLY
& THE REMAINDER IS THE hm
SCALE OF hm + B/2
SCALE OF h
3.0
2.5
2.0
9
8
7
6
5
4
3
2
1
1.0
3.5
3.0
2.5
2.0
9
8
7
6
5
4
3
2
1
1.0
10.3.1939
B.Sc., M.I. STRUCT. E.
ASSISTANT ENGINEER.
PUNJAB ENGINEERING CONGRESS
1939.

The notation employed in this paper should be known to every canal engineer. It was the same as employed by Mr. Crump in Irrigation Branch Paper No. 26, and was in general use in the department. In the final print of proceedings, Mr. Gulhati concluded, the notation would, if possible, be explained for the information of those not conversant with it.

Mr. **Kalha** congratulated the author for setting up easy curves for calculating the size of A.P.Ms. He stated that the recovery of the head lost was a function of the downstream splay and the slope of the glacis. The author had however confined his experiments to a splay of 1 in 5 and a downstream glacis slope of 1 in 5 also. Mr. Kalha asked if the author was content that these were the optimum conditions ; if not, further experiments were required to determine the splay and the glacis slope that would give the maximum recovery and reduce the M.M.H. to a minimum. This was necessary, Mr. Kalha said, as due to the silting of watercourses the working head available was being continuously reduced.

Since the downstream splay had such a bearing on the M.M.H., it should be standardized, and properly checked when outlets were built, as all the care in design could be set at nought by an unscrupulous subordinate by making steep splays and glacis slopes.

As the diagrams were applicable to a particular downstream splay and glacis slope, Mr. Kalha suggested to the author to note this fact on the diagrams so that they may not mislead any one.

Mr. **Ishar Das** stated that for those who had to design outlets this paper was of practical utility. The diagrams were made by Mr. Gulhati about 5 years ago. The speaker was one of those, who had their Blue Print copy since then. He found them very useful. The diagrams were worth being printed and supplied for use in Divisional and Sub Divisional Offices.

The formula $h_m = \cdot 82h - B/2$ fitted in very closely with the data in the field upto $H = 2\cdot 5'$. For deeper setting of A.P.Ms. of $B = 0\cdot 2$ Mr. Ishar Dass found, that for Hs ranging from 2·5 to 3·0 it was safer to use $hm = 0\cdot 82h$ and for Hs ranging from 3·0 to 3·5 feet. $h\,m = 0\cdot 85h$.

Reference had been made in the paper to the trial and error method of design. Of course that was cumbersome business. But the design of A.P.M. could be made very precisely with slide rule. The speaker had been doing this for years and had shown this slide rule method to his friends. It was very simple.

$$q = 7\cdot 3\ BY\sqrt{h}$$

Or,

$$\frac{q}{7\cdot 3 \times B} = Y\sqrt{h}$$

By ordinary slide rule one could find out quotient of $\frac{q}{7{\cdot}3 \times B}$

Keeping the cursor on this quotient on the bottom scale, the slide rule should be moved such that reading on top scale + the reading on cursor = required H.

Design of $Hm = 0{\cdot}82 \; h - B/2$ by slide rule is simple enough, and the setting on value of H could be fixed with no difficulty.

Mr. Ishar Dass quoted an example.

Given Discharge $q = 1{\cdot}49$ cusec.

Observed working head $= 1{\cdot}6$

(h would be near about $2{\cdot}0$

by formula $h_m = 0{\cdot}82h - B/2$)

A. P. M. $B_3 = {\cdot}32$

$$\frac{1{\cdot}49}{7{\cdot}3 \times {\cdot}32} = {\cdot}63.$$

Putting cursor on ·63 on the bottom scale and moving slide, top scale would read 2·05 and ·45 on the slide.

Design thus was :—

q	..1·49
B	.. ·32
H	..2·5
Y	.. ·45
h	..2·05
h_m	..1·52

While checking outlets in the field one needs to calculate sometimes. To facilitate this, Mr. Ishar Dass made 2 monograms of just the size of the Note Book for officers and subordinates. More than 100 blue prints of these diagrams had already been taken by officers and subordinates.

They were very simple.

Reading of h_m for any h could be found at a glance.

The discharge of outlet could be found by putting a straight edge on monogram and then reading the data.

Mr. S. D. Khungar said that he had to do extensive remodelling in Khanewal and Kirana Divisions. He found that many A. P. Ms. were non-modular even though their working heads were more than those required by experiments of Messrs. Crump and Sharma. Such outlets under-drew and naturally there was a howl and he had to raise the crests of all such outlets. This convinced him that more experiments were needed to determine M.M.H. and he was fortunate in persuading Mr. Gulhati to carry out the experiments described in the paper under discussion.

Mr. Khungar continued that he had since built scores of outlets and only in one case he had to alter after construction. On investigation he found that the outlet formed part of a distributor on a minor and the splay of D.S. wings was too sharp—perhaps 1 in 2. M.M.H. of other outlets was usually within 0·1′ of calculated. There was one point however which Mr. Khungar wanted to bring out. Mr. Gulhati had suggested the formula M.M.H. $=0·82h—B/2$ for *all* outlets (see para. 5 of paper). It would be seen from table of observations given in the paper that of the 61 observations, as many as 57 were done on outlets with $B=$or $<0·4$. It was not fair, said Mr. Khungar, to extrapolate these results to cover outlets with $B>0·4$. If an outlet is examined with $Q=2·00$, $H=1·0$, $Y=0·5$, $h=0·5$ $B=0·8$, the formula suggested gave M.M.H. $=0·01$. It was certain that the outlet would not be modular, if only so much working head obtained. This was perhaps an extreme case, but it showed the danger of extrapolating results. More observations were needed on outlets with $B>0·4$. For such outlets the speaker was using the formula M.M.H. $=·82\,h-0·2$. This gave results on the safe side. Mr. Khungar strongly supported the Author's suggestion on page 1 that an outlet should be set as low as the available working head permitted. He had found and it must be the experience of other Irrigation Engineers also, that other conditions remaining the same, channels with deeply set outlets required flatter slopes than channels, which had got high outlets. Cases were not unknown, where a channel which had been steady for a number of years, started silting rapidly when its pipe outlets set low were replaced by A.P.Ms. set at conventional ·6 depth. These channels scoured again when the crests of A.P.Ms. were lowered. Such outlets undoubtedly drew more silt, but it was usually carried to the fields. In a few cases zamindars had to do a little extra silt clearance but it was far better that the zamindar should take a little extra trouble than that the channel should be allowed to have its regime upset by constant silting resulting in serious shortage at tail, inequitable distribution of water, and frequent remodelling. There was likely to be far more agitation if the channel was frequently remodelled than if a few zamindars had to do a bit more of silt clearance. Mr. Khungar also agreed with the Author that Y should not exceed $\frac{1}{2}H$. Theoretically Y could be as much as $\frac{2}{3}\,H$, but he had found that where Y was $>\frac{1}{2}\,H$ and the working head of outlet was good, the A.P.M. worked as an open flume. It would be seen from the analysis given by Mr. Gulhati at page 7 of his paper that the rigidity of an A.P.M. increased as Y decreased, but M.M.H. also increased at the same time. For a given setting M.M.H. would be least where Y equals $\frac{1}{2}H$. Thus outlet could be set lowest where $Y = \frac{1}{2} H$, but at this time rigidity was minimum. The speaker thought that lower setting of outlet and consequent intake of silt is even more important than rigidity and he suggested that B of an A.P.M. should be such that to give the correct discharge Y was roughly equal to 0·4 or 0·45 H. This would permit subsequent increase of discharge without dismantling a large portion of the outlet. This implied that B should be as small as possible.

Mr. **K. R. Sharma** said that there was an attempt in this paper to legislate modular limits of an A.P.M. without giving its design. An A.P.M. was no doubt an orifice as assumed by the author. Mr. Crump devised his outlet as a submerged orifice with a jump. His tables were definitely correct so long as the A.P.M. was a submerged orifice. But the A.P.Ms in practice did not always work as submerged orifices. Often they were partially submerged and sometimes the control sections got fully aerated. Low set A.P.Ms. did often suffer from starvation of the control sections. The author should make specifically clear to what conditions his modular limits apply.

The author had stated in his paper that outlets tested had varying design of outfall. Outfall in an A.P.M. design was a very important feature, because the major portion of the loss was in the outfall. Losses in approaches were only about 15%, about 35% in the jump, and 50% in outfall. The A.P.M. design must have standard outfall to guarantee certainty of modular limits and to keep the modular head low.

Mr. **Mithal** congratulated the author for bringing the excellent data collected from the field to the notice of the Congress. Mr. Mithal used the formula suggested by the author in designing the working heads of outlets for more than a dozen channels on the Lower Jhelum Canal in 1936 and 37. On three channels that were actually constructed before he left all the outlets worked modularly, which showed that the formula recommended could be relied on.

Mr. Mithal wanted to emphasize that the outlets could be made more rigid than those recommended by the author by having as great a value of B as possible. He suggested as an example that instead of having $B = 0{\cdot}2$ and $Y = 0{\cdot}8$ it would be much better to have $B = 0{\cdot}8$ and $Y = 0{\cdot}2$ for ensuring greater rigidity, provided the working heads were available.

Replying to the discussion Mr. Gulhati thanked the members who had taken part in it. He informed Mr. Kalha that more gradual splays and glacis would certainly reduce the modular head, but it would make the outlets very expensive. It was for this reason that the author limited the splays to 1 : 5. The author agreed with Mr. Kalha that the D/S splays should be standardized and that outlets when built should be carefully checked by the Sub Divisional Officers in full detail.

Replying to Mr. Ishar Das's statement that with deep set outlets the modular head required was more than that given by the formula, the author thought that the fault must lie with the D/S approaches.

2. The author referred Mr. Khungar to his introductory remarks in which he had stated that the formula evolved was of general application within practical limits. There were very few outlets constructed with B more than 0·4. That was the reason why the author had not prepared diagrams of A.P.Ms. with throat width of more than 0·4.

3. Replying to Mr. Sharma the author stated that Mr. Crump's experiments were confined to A.P.Ms. of B=0·5 and Mr. Crump himself had accepted the necessity of making further tests on A.P.Ms. of different throat widths.

4. The author referred Mr. Mithal to the remarks made by Mr. Khungar regarding the selection of a suitable B with which the author was in full agreement.

NOTATION.

A.P.M.	=Adjustable proportional Module.
B	=Throat width of the A.P.M.
q	=Discharge of the A.P.M.
y	=Height of the opening of the A.P.M.
H	=Depth of crest of outlet below the Full Supply level in the distributary.
h	$=H-y$.
M.M.H.	=Minimum Modular head.