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Transportation of chert in launders

Louis Joseph Porri

John Lyle Pickering

Department: Mining Engineering

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TRANSPORTATION
OF
CHERT IN LAUNDERS.

BY L.J.PORRI AND J.L.PICKERING.

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INTRODUCTION.

Water is often carried from place to place in artificial channels, such as troughs, aqueducts, ditches and canals. A launder is, specifically speaking, a trough, and it is with this that this article will treat.

It is the purpose of this investigation to discover, if possible, first, the maximum carrying power of water when transporting chert; second, to find the relation existing between the velocities of different sized chert.

The experiments of different men have been consulted, and a brief account of their results is given. It was deemed advisable to put their work first, following with our results.

Owing to the lack of data, we cannot give a very extensive account of the early life of launders, so will concentrate our efforts, from the standpoint of history, to the experiments of the last few years.

Our conclusions are summarized at the end, but each test has its conclusion following it.

All drawings and tables are with the test to which they are connected.

HISTORY.

Hydraulic transportation has been known since Solomon's time,but the investigating of the power that allowed the transporting, was not studied until the last century or two.

In designing an open rectangular trough or launder, there is a certain ratio of breadth to depth which is most advantageous, because that thereby either the discharge is the greatest, or the least amount of material is required for its construction. This advantageous proportion, is the one which offers the least frictional resistance to the flow, and may be applied to ore and water as well as to water alone. In a very wide and shallow trough the friction is great, and the same is true for one of small width and large depth. It is now a question as to the best proportions for least friction.

The head lost in friction is directly proportional to the wetted perimeter, and inversely to the water cross-section. In order that this may be the least possible, the wetted perimeter should be a minimum for a given area, or the area should be a maximum for a given wetted perimeter. But the area divided by the wetted perimeter is the hydraulic radius or $R=\frac{a}{p}$, which, therefor is to be a maximum, subject to the other conditions of the problem. This is a general rule, appliable to all kinds of channals. (Merriman)

The following, concerning launders, is taken from the Engineering and Mining Journal of April 10, 1910, under the heading" Ore Dressing in the Coeur de'Alene District". The launders in this district are rectangular wooden boxes, and with the exception of sand and slime boxes, are lined with steel and iron. It was found that the wear in the flat bottomed launder was greatest in the center, regardless of slope. This was probalby due to the sides throwing the bulk of the ore to the center. It was also found that the greater th the velocity of water, the greater the rotation and consequent impacts of coarse pieces of ore and tailing. The experiments with different slopes tended to show that a maximum carrying power of the water could be reached, and that on a small slope the ore would tend to dam up, always starting at the point where the bottom was worn the most.

F.K. Blue in 1906, (E. and M.J. Vol. 84), conducted a series of experiments to determine the conditions as to grade and velocity under which sand, in a mixture of sand and water, would fall to the bottom, naturally, of the launder and fill up so that the material would run over. He also desired to know what effect sand in suspension would have on the coefficient of fluid friction. The apparatus he employed, consisted essentially of a small launder in which a continuous and constant flow of material could be maintained. This was done by means of a centrifugal pump, which returned the material from the lower end of the launder to a supply tank above the upper end. The amount of material was regulated by a gate in the bottom of the delivering tank. The apparatus was arranged with a deflector at the discharge end of the launder, by which the material could be suddenly deflected into a measuring tank, and then deflected into the receiving tank whenever desirable. The quanity of flow was determined by noting the time required to fill the receiving tank up to a certain mark. By experimenting with the results of his observations he discovered that the quanity with which the proportion of sand in suspension bears the most well-defined relation, is the slope of the launder. Plotting the proportion of sand to the velocity, indicates an aparent relationship of the proportion of sand, of about the sixth power of the velocity, but with a very probable error. But plotting a quanity of sand in suspension, as a function of the slope, a well defined relationship is noted. From this he found that the equation between S, the grade of the launder, and Q the proportional quanity of sand, may be written $S=KQ^m$ where K and m are coefficients depending on the experiment. In experimenting with slime and sand, he found a curve similar to sand alone but some distance from it; showing that the presence of sand in large quanities and slime in small, produced a marked reduction in the fluid resistance occurring in the launder.

Phillip Argall, in the Report of the Canadian Zinc Commission, stated that the practice of British Columbia mill men was to use excessive amounts of water, while on the other hand the Mexicans used as little as possible. The latter is considered the best by most experienced mill men.

It has been shown by mathimatical analysis, that the conditions for securing the maximum amount of power through a conduit of constant diameter, without economy of water, is that the draught from the pipe should be such that the frictional loss will be one third of the static head.(Eng. News.May 4,1903).

TRANSPORTATION OF CHERT IN LAUNDERS.

Using the statements in the introduction as a basis to work from, we come to the investigation proper.

The first problem was the building of the necessary apparatus. A launder was constructed and the hopper, feed box, sump tank, supply tank and the measuring tank were put in as shown in the accompaning drawings. Since a small amount of water was used for the measurement of quanity, a tank of known capacity was used to catch the water during the time desired. This tank had a water gauge attachment, that permitted the reading the height of water direct. The tank was also on a pair of scales by which the weight could be obtained.

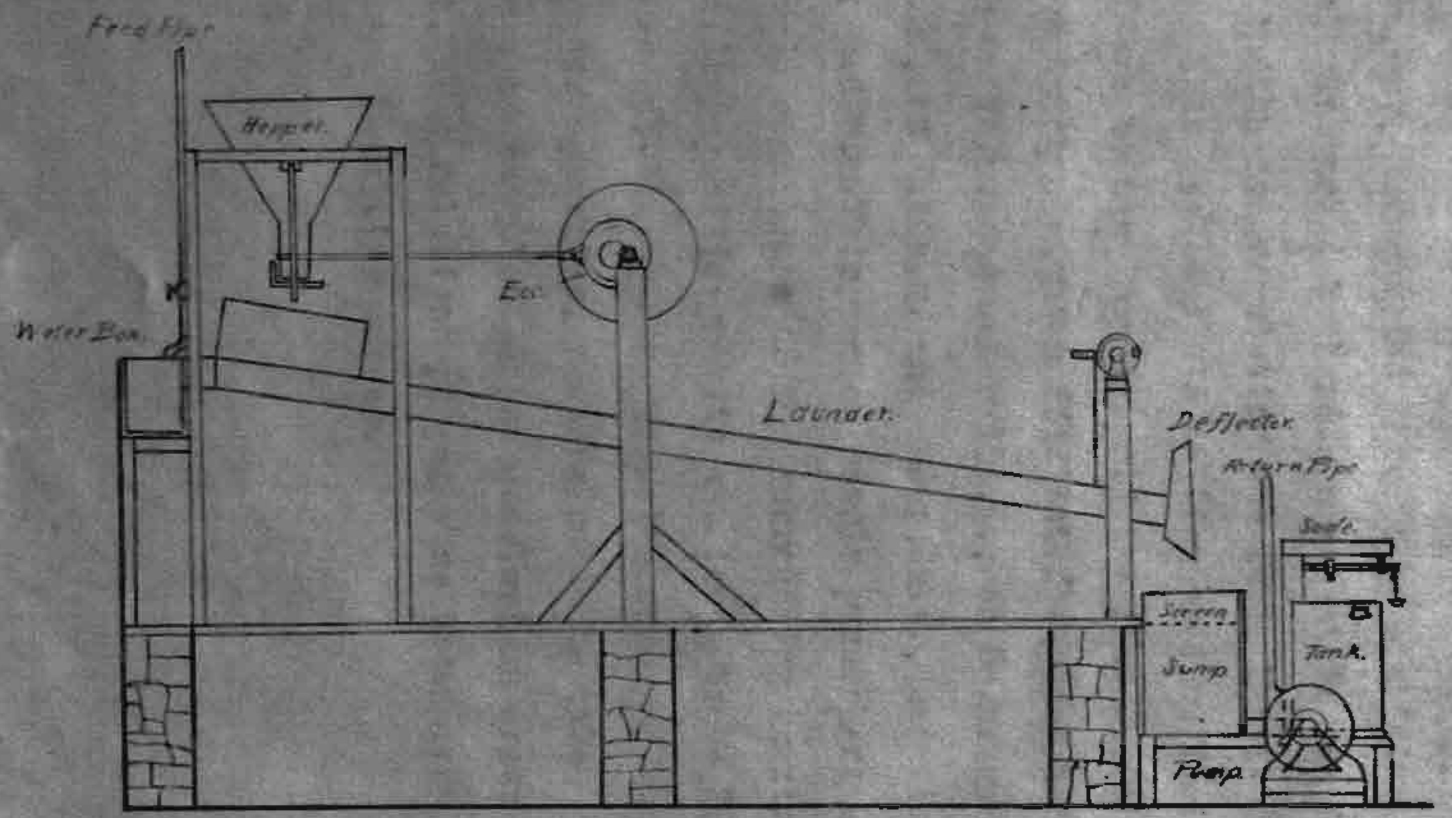
At the beginning of the experiment, the water gauge was made to read zero; and the water then allowed to flow in, the time between the beginning and the end of the experiment determined by the use of a watch. The time was always of sufficient length to over-come any possible errors in reading the watch for a short time. At the close of the test, and after the surface of the water has become quiet, the gauge is read, giving the depth that has flowed in during the observed time. This result multiplied by the area of the cross-section gives the volume. and the last result divided by the number of seconds will give the discharge per second. Knowing the specific gravity of the ore used, the amount of ore can be calculated, having obtained the weight by means of the scales.

¶ In obtaining the cross-section of the water flowing in launders, the following method was used. Drive a nail in the bottom of a meter stick and read the centimeters from the bottom of the launder to a stick nailed across the top. When water is flowing through the launder, find the number of centimeters between the stick and the surface of the water. Subtracting this from the distance to the bottom of the launder, will give you the depth of water flowing. The width can be measured direct. This meathod enables you to obtain the cross-section to a very accurate point. In this manner, by varying the water supply, a series of observations could be obtained for different cross-sections as well as different slopes. The width of the launder can easily be changed by nailing boards on the inside of the launder.

The feed came from a hopper above the upper end of the launder, and was fed into it by a sliding plate that was worked by hand. An eccentric was first attached to the rod regulating the feed, but it was found that this method would deliver an insufficient amount of ore to the launder. All the feed was sized, four sizes being thought sufficient.The sizes used were; ore on 7m.m. and under 10m.m., on 5m.m. and under 7m.m., on 2.62m.m. and under 5m.m., and finally all under 2.62m.m.This was as nearly pure chert as the geologic conditions of the surrounding country permitted.Its specific gravity was found to be 2.62.

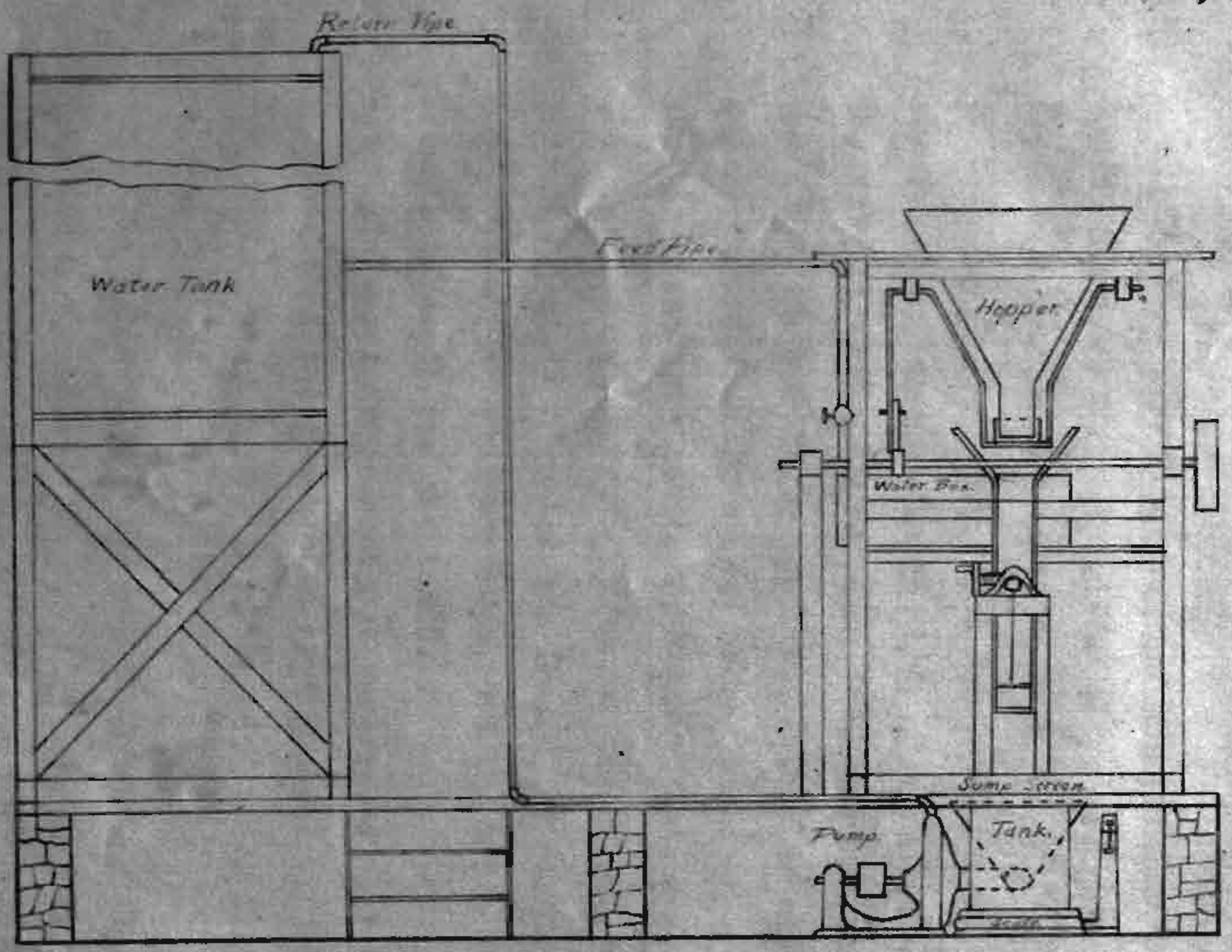
After out-lining our general course and constructing our apparatus, we were ready to take data.This data was plotted and conclusions drawn from each test.The conclusions proper were taken from a study of the resulting curves.

Fig 1.



Side View of Launder.

Fig 2.



End View of Launder.

MOST ECONOMICAL CROSS-SECTION.

The depth of water current was obtained with and without ore for a specified slope, increasing the depth with each experiment, so as to permit the finding of the best hydraulic radius. The ratio of ore to water was found to increase as the hydraulic radius. The investigations were carried on in this manner until the ratio of breadth to depth was 2.5, when the banking up of the ore caused us to abandon the experiment at that point. Subsequent tests proved that the maximum carrying power of the current was when the quanity of water was flowing at its maximum rate, i.e. on its maximum slope, and the ratio of breadth to depth was about 2.0.

Different cross-sections were tried, all tending to prove that the greatest carrying power of water for ore, occurs when the ratio of breadth to depth is between 2.5 and2.0.

The following tables are the ones from which we base our conclusions. All the tests for the following table, were made with 7-5mm. ore.

Slope.	Width.	Depth Water.	Depth Ore+Water.	
%	cm.	cm.	cm.	Test No.
1.0	11.8	2.2	2.5	1
"	"	1.6	1.9	2
"	"	1.3	1.5	3
"	9.8	2.8	3.3	4
"	7.2	3.3	3.8	5
2.0	11.8	1.7	2.1	6
"	"	1.1	1.4	7
"	"	2.1	2.5	8
"	9.8	1.1	1.5	9
"	7.2	3.1	3.5	10
3.0	11.8	1.3	1.5	11
"	"	1.6	2.6	12
"	"	1.3	1.8	13
4.0	11.8	0.9	1.3	14
"	"	1.6	2.2	15
"	"	1.1	1.5	16
"	"	0.8	1.1	17
"	9.8	2.2	2.7	18
"	"	1.4	1.9	19
"	7.2	2.5	3.0	20
"	"	1.4	1.9	21

Slope.	Width.	Depth Water.	Depth Ore+Water.	Test No.
%	cm.	cm.	cm.	
5.0	11.8	1.7	2.3	22
"	"	1.1	1.5	23
6.0	11.8	0.8	1.1	24
"	"	1.4	1.8	25
"	"	1.1	1.5	26
"	"	0.7	1.0	27
"	9.8	1.8	2.2	28
"	"	1.3	1.8	29
"	"	0.9	1.3	30
"	7.2	2.4	2.9	31
"	"	1.4	1.9	32
8.0	11.8	1.5	1.7	33
"	"	1.0	1.4	34
"	"	0.7	1.2	35
"	9.8	1.9	2.4	36
"	"	1.4	1.8	37
"	"	0.9	1.3	38
"	7.2	2.2	2.7	39
"	"	1.3	1.8	40
"	"	0.9	1.4	41

Slope. %	Width. cm.	Depth. Water. cm.	Depth Ore+Water. cm.	Test No.
12.0	11.8	1.5	1.9	42
"	9.8	0.9	1.5	43
"	"	0.6	1.4	44
"	9.8	1.5	2.2	45
"	"	1.2	1.8	46
"	"	0.8	1.3	47
"	7.2	2.0	2.5	48
"	"	1.3	1.8	49
"	"	0.9	1.4	50
15.0	11.8	1.1	1.5	51
"	"	0.8	1.6	52
"	"	0.5	1.3	53
"	9.8	1.4	2.0	54
"	"	1.1	1.6	55
"	"	0.6	1.0	56
"	7.2	1.9	2.5	57
"	"	1.3	1.9	58
"	"	0.8	1.6	59

The following results are under same conditions regarding slope, depth of water and depth of ore and water as the preceding table for its specified slope.

Slope.	Kg. Water.	Kg. Ore.	Area Water.	
%	Kg.	Kg.	sq.cm.	Test No.
1.0	113.0	----	25.96	1
"	82.0	----	18.90	2
	48.0	----	15.30	3
"	102.0	----	27.50	4
"	103.0	----	23.78	5
2.0	94.0	----	20.10	6
"	52.0	----	13.10	7
"	74.0	0.6	20.60	8
"	42.4	2.7	10.76	9
"	100.0	0.5	22.30	10
"	35.0	---	9.40	11
3.0	124.0	0.9	18.90	12
"	76.0	0.2	15.30	13
"	46.0	---	10.60	14
4.0	117.0	1.2	18.90	15
"	77.8	3.4	13.00	16
"	42.8	0.5	24.00	17

Slope.	Kg. Water.	Kg. Ore.	Area Water.	
%	Kg.	Kg.	sq.cm.	Test No.
4.0	110.00	2.7	20.96	18
"	62.00	1.2	13.7	19
"	110.00	---	18.0	20
"	49.00	0.5	10.0	21
5.0	115.20	4.8	20.1	22
"	72.00	3.0	13.0	23
"	47.00	1.5	9.4	24
6.0	130.00	9.2	16.5	25
"	80.40	3.7	13.0	26
"	43.00	3.7	8.3	27
"	112.00	8.7	17.6	28
"	76.00	4.6	12.8	29
"	65.0 0	2.0	8.8	30
"	108.0	5.1	17.3	31
"	52.0	2.4	10.0	32
8.0	89.6	12.3	17.7	33
"	74.8	8.8	11.8	34
"	44.7	5.1	8.3	35
"	98.00	8.6	18.6	36
"	72.0	4.2	13.7	37
"	42.0	3.8	8.8	38
"	112.0	7.8	15.8	39

Slope. %	Kg.Water. Kg.	Kg.Ore. Kg.	Area Water. Sq.cm.	Test No.
8.0	49.0	3.2	9.4	40
"	34.0	2.1	6.5	41
12.0	94.0	23.0	17.7	42
"	71.0	14.4	10.6	43
"	43.0	11.2	7.1	44
"	114.0	12.9	14.7	45
"	81.0	19.5	11.8	46
"	47.2	10.2	7.8	47
"	112.0	15.0	14.4	48
"	99.0	11.4	9.4	49
"	33.0	4.7	6.5	50
15.0	97.6	27.7	13.0	51
"	56.1	18.9	9.4	52
"	29.5	6.2	5.7	53
"	116.0	30.0	13.7	54
"	70.0	22.0	10.8	55
"	27.0	7.0	5.9	56
"	107.0	22.5	13.5	57
"	54.0	15.0	9.4	58
"	26.0	6.6	5.8	59

The following results are under the same conditions regarding slope, depth of water etc. as the preceding table, for its specified slope.

Slope. %	Area Ore+Water. sq.cm.	Vel. Water. Meters per Min.	Test No.
1.0	29.5	43.0	1
"	22.42	43.0	2
"	17.7	31.3	3
"	32.3	37.0	4
"	37.3	43.5	5
2.0	24.7	46.0	6
"	16.5	40.0	7
"	25.5	36.0	8
"	14.7	39.2	9
"	25.2	45.0	10
"	10.8	38.0	11
3.0	30.7	65.5	12
"	21.2	49.5	13
"	15.3	43.5	14
4.0	26.0	62.0	15
"	17.7	60.0	16
"	13.0	46.5	17

Slope. %	Area Ore+Water. sq.cm.	Vel. Water. Meters./min.	Test No.
4.0	26.5	51.0	18
"	18.6	46.0	19
"	21.6	61.2	20
"	13.7	42.0	21
5.0	27.1	55.1	22
"	17.7	55.8	23
"	13.0	51.0	24
6.0	21.2	78.0	25
"	17.7	61.8	26
"	11.8	53.0	27
"	21.6	64.0	28
"	17.6	59.2	29
"	12.7	74.0	30
"	20.8	62.5	31
"	13.7	52.0	32
8.0	20.1	50.1	33
"	16.5	63.2	34
"	14.2	54.0	35
"	23.5	53.0	36
"	17.6	52.1	37
"	12.7	48.0	38

Slope.	Area Ore+Water.	Vel. Water.	
%	sq.cm.	Meters ./min.	Test No.
8.0	19.4	71.0	39
"	13.0	53.0	40
"	10.1	52.5	41
12.0	22.4	53.0	42
"	17.2	67.0	43
"	16.5	60.5	44
"	21.6	78.0	45
"	17.6	68.5	46
"	12.7	60.5	47
"	18.0	77.5	48
"	13.0	100.4	49
"	10.1	51.0	50
15.0	17.2	75.0	51
"	18.9	60.0	52
"	15.3	52.0	53
"	19.6	85.0	54
"	15.7	64.5	55
"	9.8	45.6	56
"	18.6	78.0	57
"	13.7	57.0	58
"	11.5	45.0	59

The following results are under same conditions regarding slope, depth of water etc. as the preceding table, for its specified slope.

Slope. %	Vel. Ore+Water. Meters/min.	Ratio Breadth to Depth. cm. water.	Test No.
1.0	38.0	.18	1
"	32.4	.13	2
"	27.0	.11	3
"	29.0	.29	4
"	28.0	.46	5
2.0	38.0	.14	6
"	32.0	.09	7
"	29.0	.21	8
"	29.0	.11	9
"	34.0	.43	10
"	32.0	.18	11
3.0	38.0	.13	12
"	35.0	.11	13
"	30.0	.08	14
4.0	45.0	.13	15
"	44.0	.09	16
"	33.0	.07	17

Slope.	Vel. Ore+Water.	Ratio Breadth to Depth.	
%	Meters/min.	Water. Cm.	Test No.
4.0	43.0	.22	18
"	32.6	.14	19
"	50.0	.35	20
"	35.0	.19	21
5.0	42.0	.14	22
"	40.0	.09	23
"	37.0	.07	24
6.0	63.0	.11	25
"	46.0	.09	26
"	23.0	.06	27
"	54.0	.18	28
"	44.0	.13	29
"	55.0	.09	30
"	54.0	.33	31
"	40.0	.19	32
8.0	49.0	.12	33
"	48.0	.09	34
"	33.0	.06	35
"	61.0	.19	36
"	42.0	.14	37
"	34.0	.09	38

Slope. %	Vel. Over Water. meters/min.	Ratio Breadth to Depth. Water. cm.	Test No.
8.0	58.0	.30	39
"	40.0	.18	40
"	34.0	.12	41
12.0	48.0	.12	42
"	44.0	.08	43
"	29.0	.05	44
"	56.0	.15	45
"	51.0	.12	46
"	41.0	.08	47
"	67.0	.28	48
"	44.0	.18	49
"	36.0	.12	50
15.0	63.0	.09	51
"	31.0	.07	52
"	21.0	.04	53
"	61.0	.14	54
"	52.0	.11	55
"	32.0	.06	56
"	66.0	.26	57
"	45.0	.18	58
"	34.0	.11	59

The following results are under same conditions regarding slope, depth of water etc. as in the preceding tables, for its specified slope.

Slope. %	Ratio Breadth to Depth. Water + Ore.	Ratio Kg. Ore to Kg. Water.	Test No.
1.0	.21	---	1
"	.16	---	2
"	.12	---	3
"	.32	---	4
"	.52	---	5
2.0	.17	---	6
"	.11	---	7
"	.25	.01	8
"	.10	.06	9
"	.50	.005	10
"	.20	.---	11
3.0	.22	.008	12
"	.15	.003	13
"	.11	---	14
4.0	.18	.01	15
"	.12	.04	16
"	.09	.001	17

Slope. %	Ratio Breadth to Depth Water + Ore.	Ratio Kg. Ore. to Kg. Water.	Test No.
4.0	.28	.025	18
"	.19	.020	19
"	.41	.003	20
"	.26	.041	21
5.0	.20	.041	22
"	.12	.032	23
"	.09	.070	24
6.0	.15	.046	25
"	.12	.080	26
"	.08	.077	27
"	.22	.060	28
"	.18	.030	29
"	.13	.047	30
"	.40	.047	31
"	.26	.137	32
8.0	.14	.117	33
"	.11	.114	34
"	.10	.085	35
"	.24	.058	36
"	.18	.093	37
"	.13	.075	38

Slope. %	Ratio Breadth to Depth. Water + Ore.	Ratio Kg. Ore to Kg. Water.	Test No.
8.0	.37	.069	39
"	.25	.065	40
"	.16	.062	41
12.0	.16	.244	42
"	.12	.203	43
"	.11	.260	44
"	.22	.113	45
"	.18	.240	46
"	.13	.216	47
"	.35	.134	48
"	.25	.114	49
"	.16	.141	50
15.0	.12	.283	51
"	.13	.336	52
"	.11	.210	53
"	.20	.261	54
"	.16	.314	55
"	.10	.260	56
"	.35	.210	57
"	.26	.277	58
"	.22	.253	59

The following results are under the same conditions regarding slope, depth of water etc. as in the preceding tables, for its specified slope.

Slope. %	Liters Ore. per.min.	Test No.	Slope. %	Liters Ore. per.min.	Test No.
1.0	---	1	4.0	5.4	18
"	---	2	"	2.4	19
"	---	3	"	---	20
"	---	4	"	0.3	21
"	---	5	5.0	9.6	22
2.0	---	6	"	6.0	23
"	---	7	"	3.0	24
"	1.2	8	6.0	18.2	25
"	5.4	9	"	7.4	26
"	1.0	10	"	6.8	27
"	---	11	"	17.4	28
3.0	1.8	12	"	7.2	29
"	0.4	13	"	4.0	30
"	---	14	"	10.2	31
4.0	2.4	15	"	4.2	32
"	6.8	16	8.0	24.6	33
"	1.0	17	"	17.6	34

Slope. %	Liters Ore. per.min.	Test No.	Slope. %	Liters Ore. per.min.	Test No.
8.0	10.2	35	12.0	30.0	48
"	17.2	36	"	22.4	49
"	8.4	37	"	9.4	50
"	7.6	38	15.0	55.4	51
"	15.6	39	"	37.8	52
"	6.4	40	"	12.4	53
"	4.2	41	"	60.6	54
12.0	46.0	42	"	44.0	55
"	28.4	43	"	14.0	56
"	22.4	44	"	45.0	57
"	25.8	45	"	30.0	58
"	38.8	46	"	13.2	59
"	20.4	47			

TO FIND THE RELATION OF THE AMOUNT OF WATER AND SLOPE REQUIRED TO CARRY A GIVEN SIZED ORE, THE WATER CHANNEL HAVING A GIVEN HYDRAULIC RADIUS.

We used four sizes of chert, 10-7mm, 7-5mm, 5-2.6mm, and 2.6-0 mm. Each size was carried with a constant width of water and three different depths; namely, 1.8cm, 1.5cm, 1.2cm.

The experiments whose results are tabulated on the following pages, were performed in the same manner as those previously described.

The object in securing this last series of data, was to check the results first obtained, and to do the work in such a manner that any varying influence of hydraulic radius, would be eliminated in each set of experiments. For this purpose, a constant width of launder, 7.2cm, was used, and by varying the amount of water, a constant depth of current was secured on all slopes.

The results of each set of depths for each product, are put under separate headings.

TABLE OF THE RELATIONSHIP BETWEEN SIZED ORES, SLOPE AND WATER, HAVING A CONSTANT BREADTH AND DEPTH.

10-7mm. Chert.

Depth of water, 1.8cm. Width of Launder 7.2cm.

Slope. %	Wt.* Kg.	Liters. per.Min.	Kg.Ore. per.min.	Kg.Water. per.min.	Ore to Water.
3.0	62.8	62.3	0.7	62.0	.012
5.0	68.3	67.5	1.3	67.0	.019
7.5	89.6	86.3	5.6	84.0	.066
10.0	104.0	97.9	10.3	93.7	.110
12.5	121.2	111.5	16.2	105.0	.150
15.0	135.1	122.4	21.1	114.0	.185

Depth of Water, 1.5cm.

3.0	46.8	46.4	0.8	46.0	.016
5.0	56.2	55.5	1.2	55.0	.022
7.5	71.7	69.5	3.7	68.0	.054
10.0	84.4	80.0	7.4	77.0	.096
12.5	95.2	89.1	10.2	85.0	.122
15.0	105.0	96.0	15.7	89.7	.176

* Weight of ore plus water per.minute.

Depth of Water, 1.2cm.

Slope. %	Wt.* Kg.	Liters. per.min.	Kg.Ore. per.min.	Kg.Water. per.min.	Ore to Water.
3.0	35.0	34.7	.5	34.0	.014
5.0	45.5	45.3	.8	44.0	.020
7.5	56.0	55.4	2.0	55.0	.036
10.0	64.0	62.8	4.0	62.0	.065
12.5	73.2	69.2	6.7	66.5	.100
15.0	81.2	75.1	10.2	71.0	.144

<u>7-5mm.</u> <u>Chert.</u>

Depth of Water, 1.8. Width of Launder 7.2cm.

3.0	66.0	65.5	.84	65.0	.014
5.0	69.3	68.4	1.5	67.7	.026
7.5	90.9	87.3	7.1	83.8	.084
10.0	108.6	101.6	11.6	97.0	.120
12.5	123.0	112.8	16.9	106.1	.160
15.0	139.2	125.6	22.6	116.6	.194

*Weight of ore plus water per.minute.

Depth of Water, 1.5cm.

Slope. %	Wt.* Kg.	Liters. per.min.	Kg.Ore. per.min.	Kg.Water. per.min.	Ore to Water.
3.0	45.0	44.6	.67	44.0	.015
5.0	56.5	55.6	1.50	55.0	.028
7.5	74.3	71.3	5.00	69.3	.072
10.0	88.8	83.5	8.80	80.0	.110
12.5	97.1	89.8	12.10	85.0	.142
15.0	107.7	97.8	16.40	91.3	.180

Depth of Water, 1.2cm.

Slope. %	Wt.* Kg.	Liters. per.min.	Kg.Ore. per.min.	Kg.Water. per.min.	Ore to Water.
3.0	33.6	33.2	.60	33.0	.018
5.0	44.9	44.3	.92	44.0	.021
7.5	55.5	54.3	2.00	53.5	.037
10.0	67.7	64.3	5.70	62.0	.092
12.5	74.3	69.1	8.70	65.6	.132
15.0	82.6	75.6	11.60	71.0	.164

* Weight of ore plus water per.minute.

5-2.6mm. Chert.

Depth of Water, 1.8cm. Width of Launder 7.2cm.

Slope. %	Wt. * Kg.	Liters. per.min.	Kg.Ore. per.min.	Kg.Water. per.min.	Ore to Water.
3.0	66.7	66.0	.85	65.8	.013
5.0	71.6	70.0	2.60	69.0	.038
7.5	91.4	85.7	7.90	83.5	.094
10.0	108.0	101.4	12.60	95.4	.130
12.5	124.6	114.1	17.50	107.1	.162
15.0	135.0	120.6	23.40	111.1	.215

Depth of Water, 1.5cm.

3.0	50.0	49.6	.67	49.0	.014
5.0	56.9	56.1	1.30	55.6	.024
7.5	72.9	69.9	4.90	68.0	.072
10.0	98.0	91.8	10.30	88.0	.118
12.5	100.8	93.0	12.80	88.0	.146
15.0	105.2	94.0	18.60	86.6	.205

* Weight of ore plus water per.minute.

Depth of Water, 1.2cm.

Slope. %	Wt.* Kg.	Liters. per.min.	Kg.Ore. per.min.	Kg.Water. per.min.	Ore to Water.
3.0	32.0	31.7	.5	31.0	.016
5.0	43.4	42.9	.8	42.5	.020
7.5	56.6	54.7	3.1	53.5	.058
10.0	67.2	63.6	6.0	61.2	.098
12.5	76.1	70.6	9.1	67.0	.136
15.0	83.7	75.5	13.7	70.0	.195

2.6-0 mm. Chert.

Depth of Water, 1.8cm.

3.0	65.9	65.1	1.3	64.5	.020
5.0	73.2	71.3	3.2	70.0	.046
7.5	90.7	85.6	8.5	82.2	.104
10.0	112.6	100.8	19.6	93.0	.210
12.5	142.0	120.0	36.7	105.0	.350
15.0	156.8	130.0	44.8	112.0	.402

* Weight of ore plus water per. minute.

Depth of Water, 1.5cm.

Slope. %	Wt.* Kg.	Liters. per.min.	Kg.Ore. per.min.	Kg.Water. per.min.	Ore to Water.
3.0	45.7	45.3	.72	45.0	.016
5.0	55.9	54.8	1.90	54.0	.036
7.5	73.4	69.6	6.40	67.0	.096
10.0	91.6	83.9	12.90	78.7	.164
12.5	108.8	96.0	21.30	87.5	.244
15.0	120.3	102.7	29.30	91.0	.322

Depth of Water, 1.2cm.

3.0	35.6	35.2	.56	35.0	.016
5.0	42.0	41.4	1.02	41.0	.025
7.5	60.5	57.8	4.50	56.0	.080
10.0	70.9	65.6	8.90	62.0	.144
12.5	78.2	70.4	13.50	65.0	.208
15.0	92.2	80.1	20.20	72.0	.280

* Weight of ore plus water per. minute.

GRAPHICAL REPRESENTATION OF CURVES.

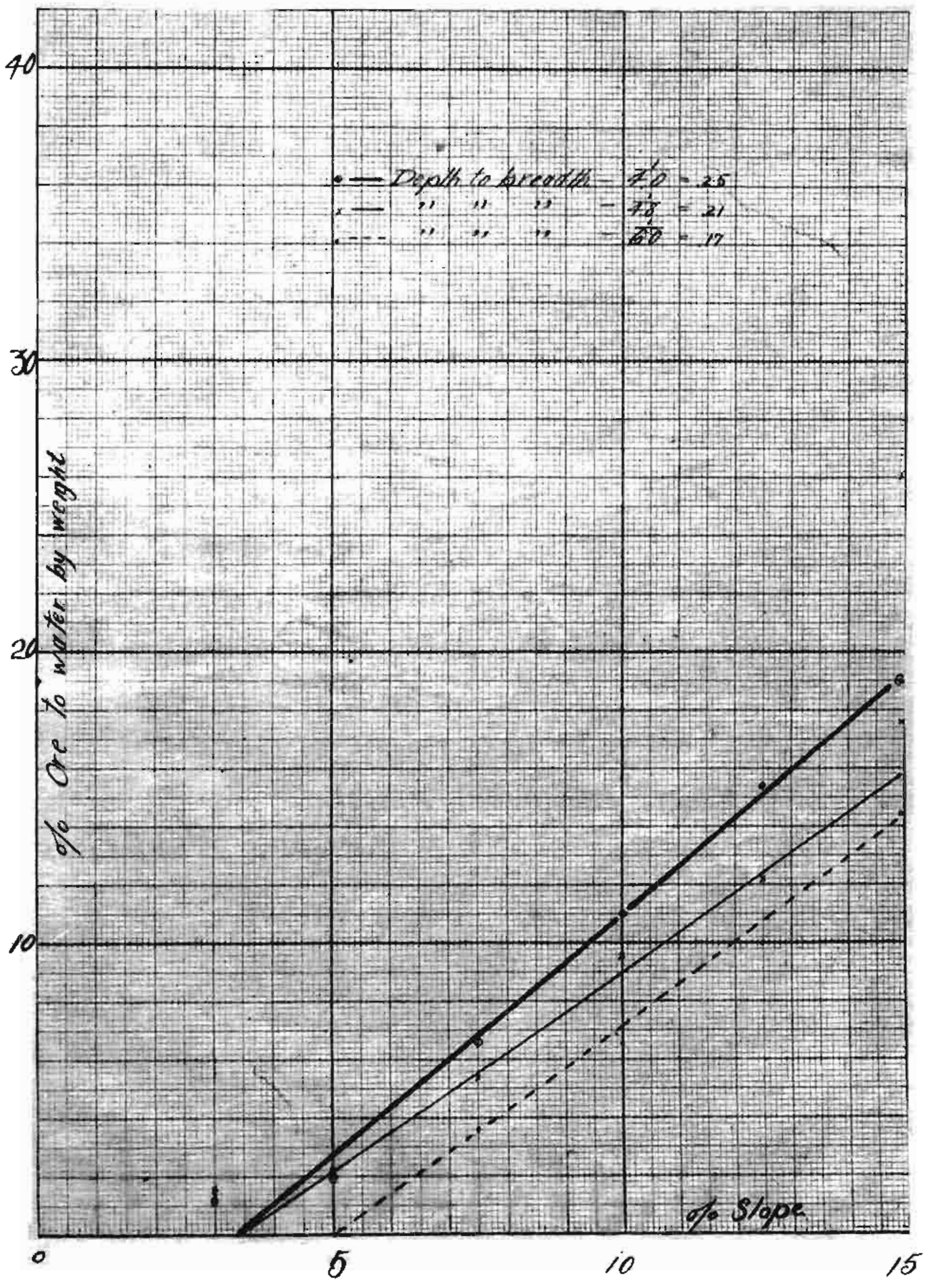
Plate No.1 shows the relation of slope of launder to the ratio R, of ore to water, for a water current 7.2cm. wide, 1.8cm., 1.5cm. and 1.2cm deep. The ore used is 10-7mm.

Plate No.2 shows the same relations under the same conditions, excepting the size of ore, which in this case is 7-5mm.

Plate No.3 shows the same relation under the same conditions as the above, excepting that the size of ore used is 5-2.6mm.

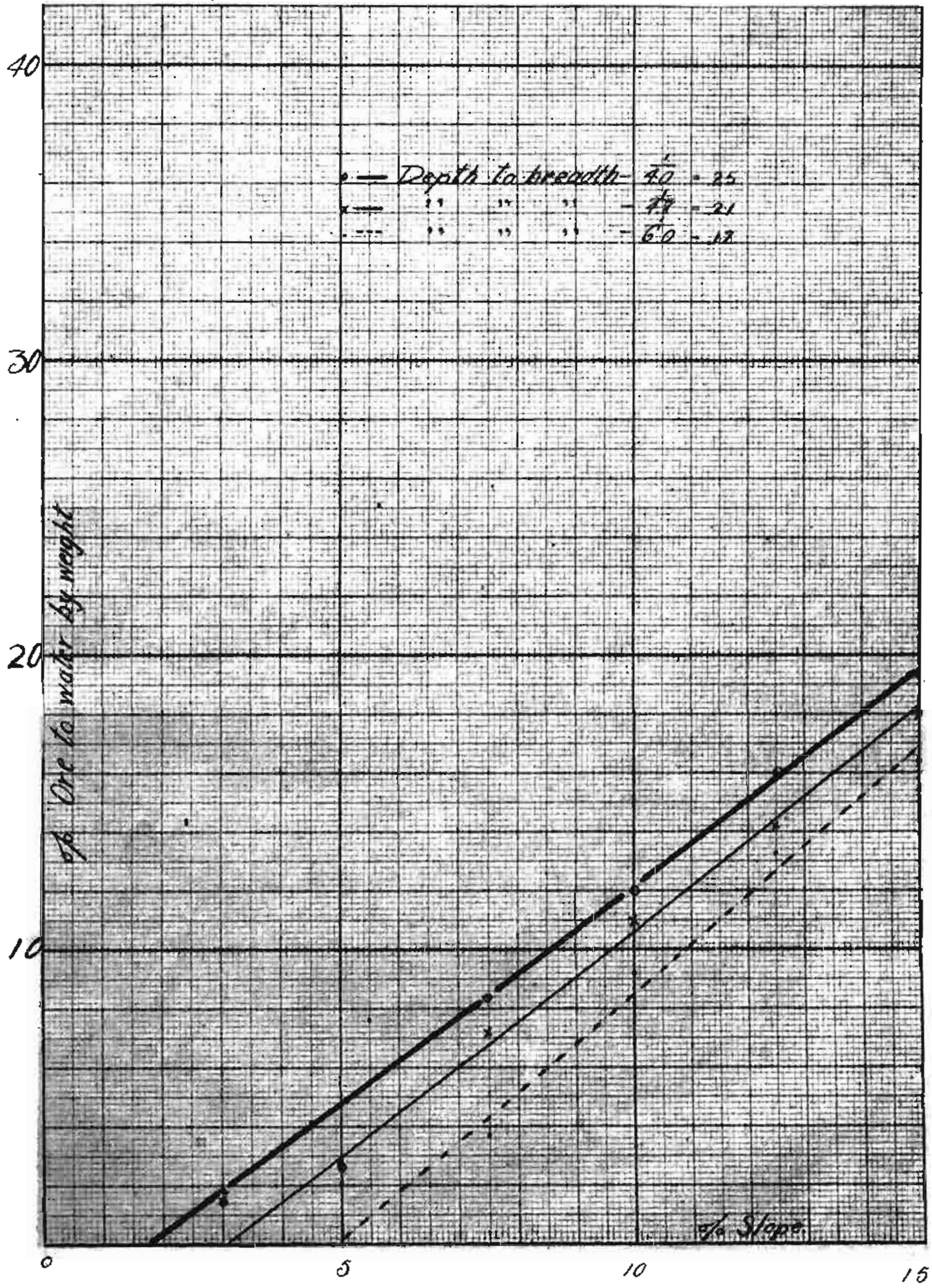
Plate No.4 represents the same as the above, under the same conditions, except that the ore in this case is 2.6-0 mm.

Quartz 10 to 7 mm



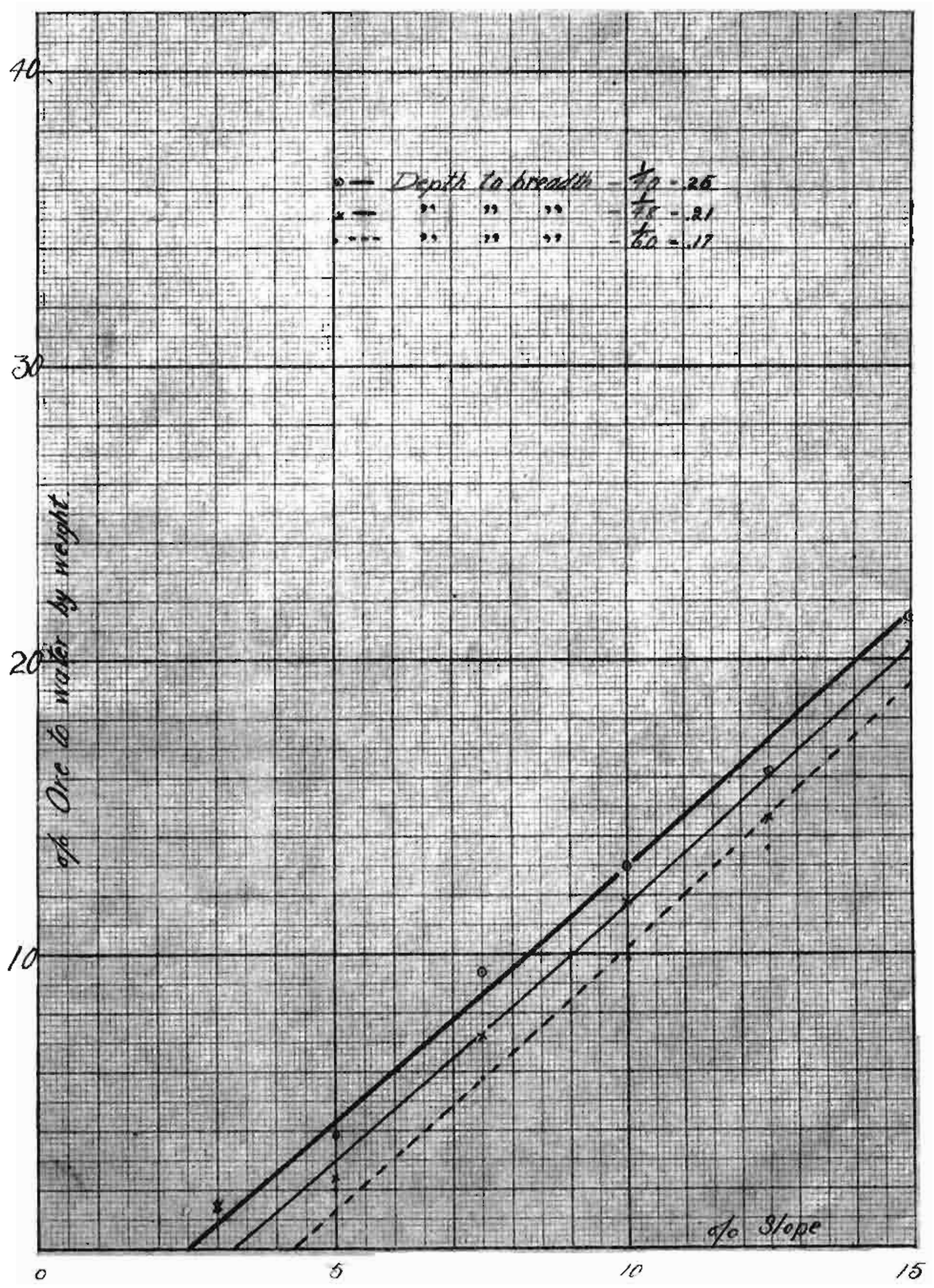
LAUNDER DIAGRAM.

Quartz 7 to 5 mm



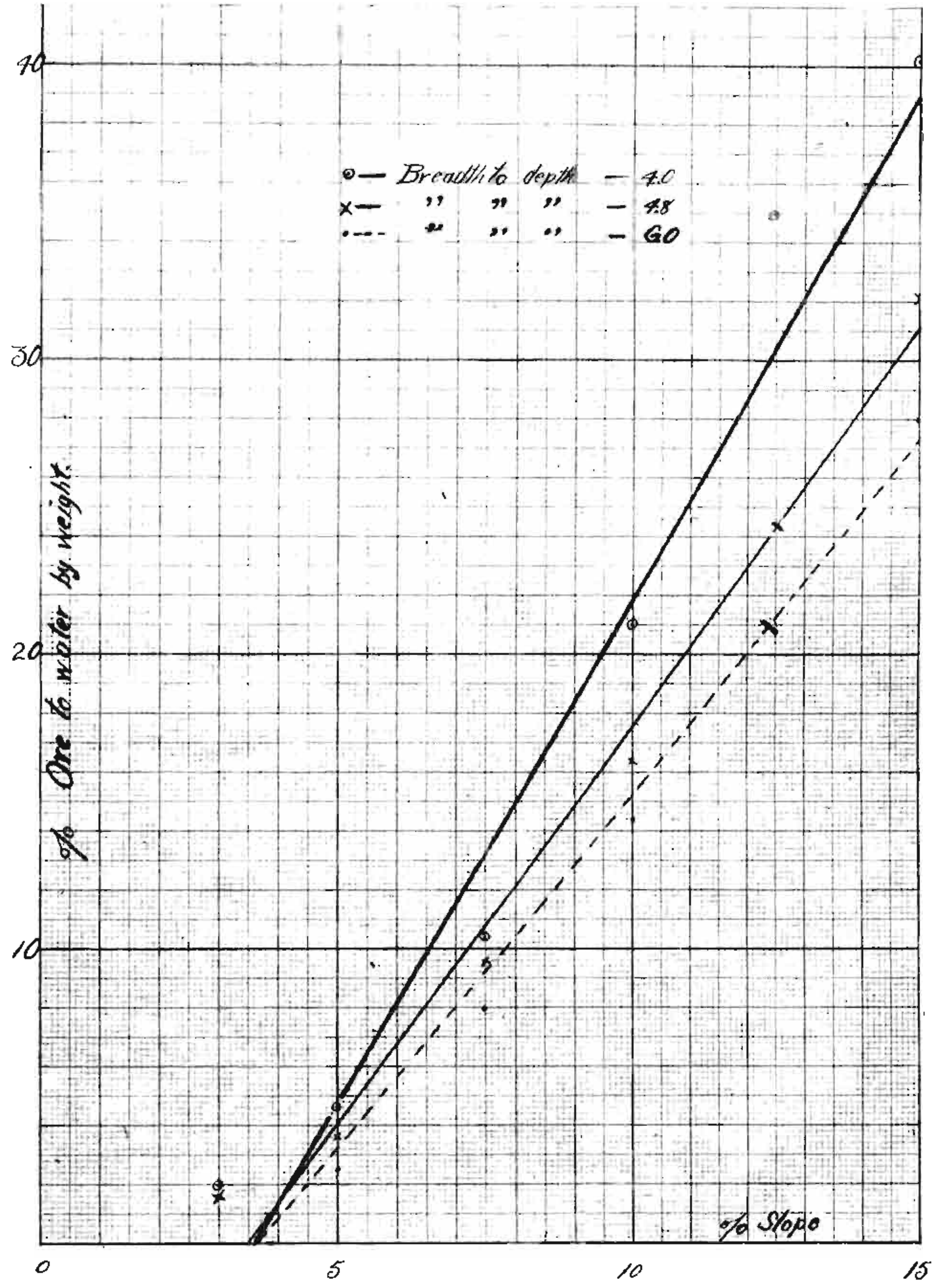
LAUNDER DIAGRAM.

Quartz 5 to 2.6 mm



LAUNDER DIAGRAM.

Quartz 2.6 to 0 mm.



LAUNDER DIAGRAM.

DERIVATION OF THE FORMULA S=K+CR.

From the preceding curves, obtained from the data obtained during the investigation, it is apparent that an equation is applicable to them, since they all tend to form a straight line.The equation of a straight line from analytics, is y=ax+b, where a and b are constants depending on the conditions of the problem. In the present case S is the slope or the grade, and therefor the same as y in the above rule.Letting b=K and the distance measured vertically from the origon as in the analytical equation. Letting x=R or the ratio of ore to water, and a=C or the distance measured horizontally from the origon to the vertical line passing through the point chosen, it is evident that our results can be formulated the same as the analytical. Therefor we have the equation S=K+CR as the one applying to our curves.

TABLE OF CONSTANTS FOR FORMULA S=K+CR.

Value of K.

Ratio Breadth to Depth.	Size of Ore.	K.
4	10-7mm.	3.4
4	7-5mm.	1.8
4	5-2.6mm.	2.6
4	2.6-0mm.	3.5
5	10-7mm.	3.4
5	7-5mm.	3.0
5	5-2.6mm.	3.4
5	2.6-0mm.	3.5
6	10-7mm.	5.0
6	7-5mm.	4.9
6	5-2.6mm.	4.4
6	2.6-0mm.	3.6

Value of C.

Ratio Breadth to Depth.	Size of Ore.	C.
4	10-7mm.	62.1
4	7-5mm.	68.0
4	5-2.6mm.	58.0
4	2.6-0mm.	32.0
5	10-7mm.	72.8
5	7-5mm.	47.2
5	5-2.6mm.	60.0
5	2.6-0mm.	38.0
6	10-7mm.	72.8
6	7-5mm.	62.0
6	5-2.6mm.	56.0
6	2.6-0mm.	48.0

EQUATIONS OBTAINED BY SUBSTITUTING CONSTANTS IN THE FORMULA S=K+CR.

10-7mm.	S=3.4+62.1(R).	For S sub-script	0.25.
	S=3.4+72.8(R).	" S subscript	0.20
	S=5.0+72.8(R).	" S "	0.16
7-5mm.	S=1.8+68(R).	" S "	0.25
	S=3.04+47.2(R).	" S "	0.20
	S=4.9+62(R).	" S "	0.16
5-2.6mm.	S=2.6+58(R).	" S "	0.25
	S=3.4+60(R).	" S "	0.20
	S=4.4+56(R).	" S "	0.16
2.6-0mm.	S=3.5+32(R).	" S "	0.25
	S=3.6+38(R).	" S "	0.20
	S=3.6+48(R).	" S "	0.16

The above results tend to show that the slope increases as the relation of breadth to depth decreases, and as the size of the ore increases.

APPLICATION OF TABLES AND FORMULA TO A PROBLEM.

To show the application of our formula and the data given, a numerical problem will be given and worked by the use of the curves, formula and data.

How much water will it take to transport twenty five tons of 5-2.6mm quartz per twenty four hours, over a slope of seven percent ? The cross-section ratio (breadth to depth) being 4.

$$S = K + CR$$

Using table for constants, K=2.6 and C=58.

S is given as 7%

Therefor $7 = 2.6 + 58R$

or $R = \frac{7-2.6}{58} = .07$

and $\frac{1}{R} = \frac{58}{7-2.6} = 13.1$ Tons of Water/24 hours.

Using the curve table headed 5-2.6mm, and a seven percent slope, we find that the ratio of ore to water(R) to be .07 checking our numerical work.

SUMMARY OF CONCLUSIONS.

The conclusions arrived at for the investigation are summarized as follows;

1. The maximum carrying power of a current of water in a launder, was when the quanity of water flowing, was at its maximum rate, i.e. when flowing on the maximum grade, and the ratio of breadth to depth was 2.
2. The ratio of ore to water increases with the hydraulic radius.
3. The slope of the launder necessary to carry ore and water, in given proportions, is a linear function of the ratio of ore to water.