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PERFORMANCE EVALUATION OF A HYDRAULIC RAM

TRAINING IN ALTERNATIVE ENERGY TECHNOLOGIES

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INTRODUCTION:

A hydraulic ram is a self-contained pumping device used to pump water from a spring or stream to a tank or reservoir at a higher level. It uses no electricty or other power except the force of gravity, and under certain favorable conditions, it is a most economical method of pumping water.

The extreme simplicity of the hydraulic ram, together with the ease with which it can be adjusted to work with varying quantities of water, render it particularly suitable for pumping in remote places, and for supplying water, for fountains and domestic purposes, to country houses situated near a stream, spring or reservoir.

The hydraulic ram is an age-old device used for pumping water and is readily available in the market. Yet it could not become popular because of 1) the natural source of water should be at least more than a meter above the ground level, and, 2) the waste of water as spillage compared to the discharge is very high. Information is available about the construction and installation of a hydraulic ram. [1]. The author could get very little information about its performance with the variation of different parameters. Mostly the efficiency at different head ratios is produced as the performance curve. And it is reported that it can achieve an efficiency of 80 to 90 percent at a head ratio of eight. The objective of this work is to evaluate the performance of a commercially made ram and to compare its performance with that of a laboratory made one.

Operation and Description: A hydraulic ram is of simple construction, with only two principal moving parts: impetus valve and check valve. Water flows downward from the source of supply through the drive pipe.(1)

It enters the ram and flows out through the impetus valve into the surrounding area. Power is developed by the weight and velocity of the water flowing to the ram. When the water attains sufficient velocity, the impetus valve closes suddenly, diverting the water into the air chamber. When the pressure in the air chamber equalizes and overcomes the driving force, a rebound takes place which closes the check valve in the air chamber and opens the impetus valve. When this rebound takes place, a small amount of air is drawn in through the air intake valve and is forced into the air chamber in the next cycle of operation. During this time, part of the water in the chamber has been forced out through the delivery pipe. The efficiency of a hydraulic ram can be explained with a simple relation. Let us assume the delivery is H, the discharge head is h and W and W are the flow rate of the impetus valve, spillage, and discharge, respectively. Therefore the input power to the pump is the product of the delivery head and flow rate in the delivery pipe. The flow rate in delivery is equal to the summation of W and W. The power coming out of the ram is the product of the discharge head and discharge rate. Therefore, efficiency, , is equal to the ratio of the out-put power to input-power of the ram. Which can be expressed as $= \frac{hxw}{HxW}$:

The ram intake post is connected to the water supply with a delivery pipe to reduce unwanted losses. And the length of the delivery pipe should be equal to the height of the discharge head so that the water in the delivery pipe has sufficient time to accelerate. The supply stream should not be less than 0.6 meter or more than 5 meters for the smooth operation of the ram. It is not necessary that the path of flow between the reservoir and the discharge tank be straight.

SCOPE OF THE WORK: It was initially decided to compare the performance of a purchased ram with a laboratory made one. It was also decided to study the variation in efficiency with the change in head ratio. But the efficiency or the discharge of a hydraulic ram not only depends on the head ratio, it also depends on the weight or spring tension (in the case of spring loaded) of the impetus valve. The laboratory made ram does not have the provision to attach additional weight or a spring with the impetus valve. But the purchased ram can be modified to study the influence of a loaded impetus valve. Therefore, in the first phase of the work both the ram could be tested at various head ratios to study the performance, and, in the second phase the load on the impetus valve could be varied to study the influence on discharge number of stokes and efficiency. A study could be made to estimate influence of bends on the delivery line.

With the above scope of the work, an experimental set-up was built (plate-1). Two oil drums were welded together to have a long cylindrical reservoir so that the delivery head could be changed widely. To maintain the reservoir level a 1 1/2" P.V.C. pipe with several outlets was attached at the side of the drum and each outlet height from the ram level was marked. To maintain a desired delivery head the corresponding outlet could be opened. The reservoir could be fed continuously from the tap and the flow can be controlled in such a way that there would be continuous overflow from the side outlet. The ram was connected from the bottom of the reservoir tank. A brass adaptor with the provision to attach different weights was made to load the impetus valve. The discharge was taken with a flexible pipe and tied on the roof of the building. It was not convenient to change the discharge head and it was held constant.

The following parameters need to be measured: 1) the height of the reservoir head with respect to the ram; 2) the height of the discharge point with respect to the ram; 3) the number of strokes per minute of the impetus valve; 4) the spillage rate at the impetus valve i.e. weight of the spillage for a given time; 5) the discharge rate, i.e., weight of the discharge water for a given time.

The height of different side taps of the reservoir with respect to the ram was measured with the help of a spirit level and measuring scale. Similarly, the discharge head from ram was measured with the help of a steel tape. A theodolite could have been used in both the cases for better accuracy. The discharge spillage impetus valve and discharge at the roof end were collected separately in a bucket and the corresponding time taken was measured with the help of a stop watch. The bucket with the water was weighed accurately. The weight of the empty bucket was deducted to get the weight of the water in each case and divided by the corresponding time interval to get the flow rate. The impetus valve, adaptor and several weights were measured to find the load on the impetus valve in each case.

The reservoir was filled from the regular tap and a side tap was opened to maintain the reservoir level. The impetus valve was loaded with the adapter and weights. Then the ram was put into operation by slowly opening the delivery line valve. Sometimes it may be required to operate the valve manually to start the ram. The discharge line could be opened as soon as the ram continued its operation on its own. Sufficient time was given to reach the steady state. The delivery head, discharge head, and number of strokes in a given time were noted. The load on the impetus valve was changed and the procedure was repeated with the same delivery and discharge head.

The same experimentation was carried out with different heads of the reservoir supply. This data is shown in Table 1. The stroke rate, spillage rate and discharge rate were calculated from the above data. The efficiency was calculated from Equation-1. The reduced data was represented in Table No-2.

RESULTS AND DISCUSSION: The variation in discharge with the head ratio at a constant impetus valve weight are presented in Fig.-4a. It can be noticed that the discharge rate-head ratio curve follows a hyperbolic path particularly at a higher impetus valve load. But at a lower impetus valve load, the variation in discharge is quite irregular. Initially, it decreases with the increase of head ratio. Then increases, and finally decreases with a further increase of head ratio. It is interesting to note that the influence of the impetus valve load on the discharge rate is not significant at low head. And the impetus valve load influences the discharge rate widely with the higher head ratio.

The efficiency against head-ratio is plotted in Fig. 4b. At a lower impetus valve load, the relation is parabolic, but with the increase of impetus valve load it becomes irregular and has the same nature as the discharge head ratio relation. A ram has higher efficencies at some particular weight (in this case 206) at all head ratio.

The influence of impetus valve load on discharge is shown in Fig. 5a. For a particular head ratio the variation in discharge rate with impetus valve load is small. But the discharge rate vs impetus valve load curve shifts upward with the decrease of head ratio.

The efficiency against impetus valve load at different head ratio is plotted in Fig. 5c. The efficiency varies quite widely with the impetus valve weight, but it is interesting to note that with impetus valve weight between 0.2 to 0.3 kg the efficiency of the ram varies from 35% to 45%, at all head ratio. But with the impetus valve weight less than 0.2 kg or more than 0.3 kg, the efficiency varies widely with the impetus valve load at different head ratios.

The variation in the spillage rate with the discharge rate is presented in Fig 6a. Generally spillage increases with impetus valve load. With the increase in spillage rate, the discharge rate increases rapidly, then reaches a peak and finally decreases slowly.

The number of strokes per minute reduces (Fig. 6b) with impulse valve load in general at all head ratios. But at a head ratio of 5.5, number of strokes increases with the impetus valve load at the very initial stage. It can be also be seen that the curves for a lower head ratio shift outwards. The variation in the discharge ratio with the head ratio for different impetus valve loads is shown in Fig. 7a. The curves are a family of parabolas.

Fig. 7e shows the performance of the laboratory made hydraulic ram. It can be seen that for a particular range of head ratios there is a point of best efficiency.

CONCLUSION: In this present work it was tried to evaluate the performance of a hydraulic ram at different conditions. From the experimental results the following can be concluded:

1) For a particular ram, a particular impetus valve load is required for the most efficient working.

2) A ram may have a most efficient range of working with slight variation in impetus valve load for all head ratios. This imformation will be useful to the hydraulic ram designer to choose the correct impetus valve loading device.

The ram could have been tested for higher head ratio for more authentic results. Because of lack of time the experimental set-up was made simple to complete the work within the scheduled time. The author wants to conclude the report with the following recomondations. A theoretical analysis could have been made to back up the experimental results. The laboratory made hydraulic ram might be modified to load on the impetus valve for performance analysis.

TABLE 1

EXPERIMENTAL DATA REGISTER FORMAT

DELI. HEAD	SPILLAGE kg-SEC.	NO OF STROKES/SEC.	ADDITIONAL VALVE-wt(gr)	DISCHARGE HEAD	DISCHARGE kg - Sec.
43"	2960-30	52-30	7	19-8"	.952-100
43"	2621-30	56-30	62	19-8"	.841-100
43"	3105-30	42-30	96	19-8"	1.047-100
43"	3688-25	34-30	193	19-8"	0.960-100
43"	4385-25	29-30	250	19-8"	0.880-100
43"	4655-25	24-30	302-5	19-8"	.743-100

TABLE 2

REDUCED DATA FORMAT

NO. OF STROKE	DELIVERY HEAD	DISHCARGE HEAD	SPILLAGE RATE	DISCHARGE RATE	FLOW RATE	EFFICIENCY	HEAD RATIO	CHECK VAL. COT. kg
104	1.09	5.99	0.092	0.0075	0.0995	41.42	5.50	0.110
112		5.99	0.081	0.0064	0.0876	40.24	5.50	0.152
84		5.99	0.096	0 0085	0.1045	44.70	5.50	0.206
68		5.99	0.139	0.0076	0.1466	35.98	5.50	0.303
58		5.99	0.167	0.0068	0.1738	21.50	5.50	0.360
68		5.99	0.178	0.0054	0.1836	16.18	5.50	0.4125

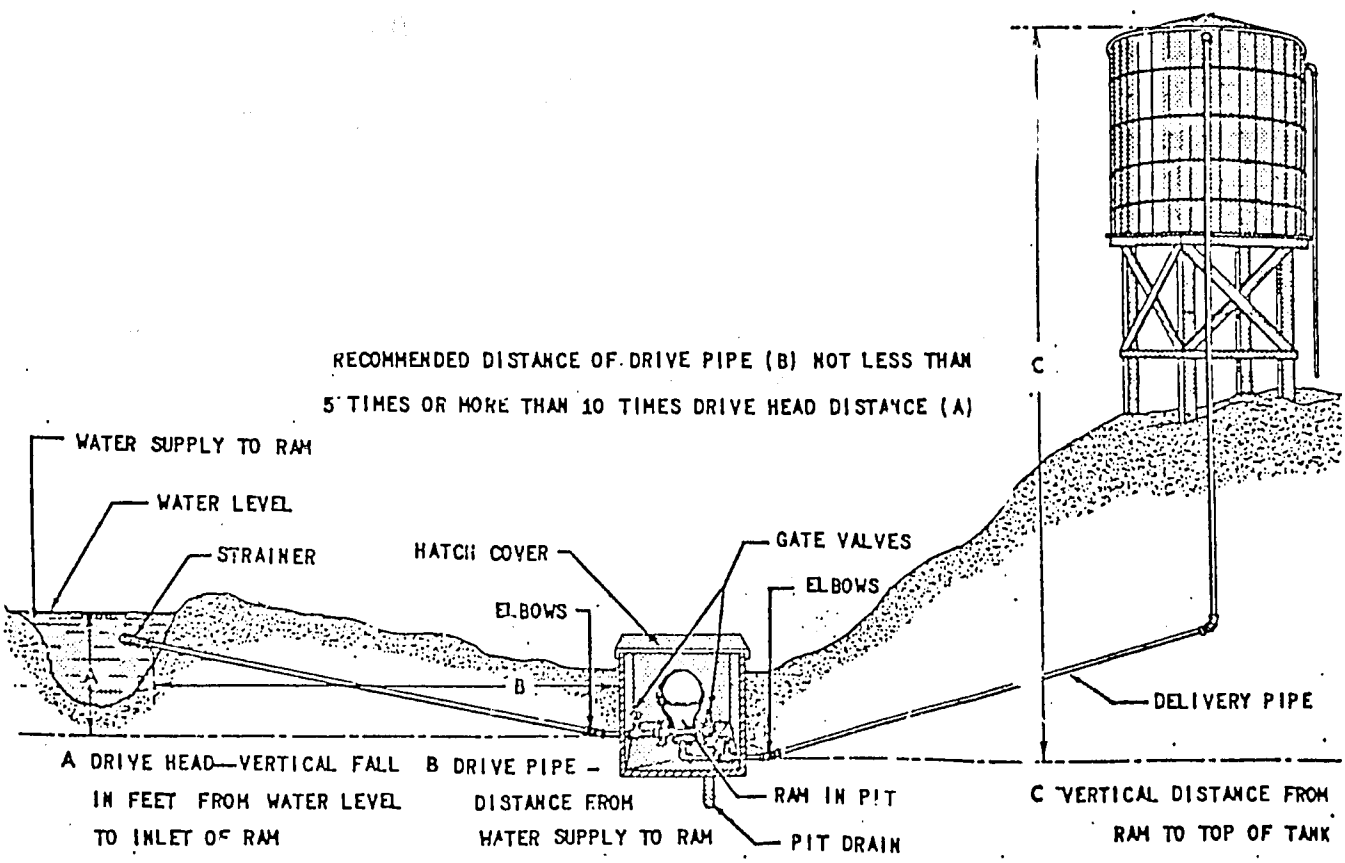

RECOMMENDED DISTANCE OF DRIVE PIPE (B) NOT LESS THAN
5 TIMES OR MORE THAN 10 TIMES DRIVE HEAD DISTANCE (A)
WATER SUPPLY TO RAM
WATER LEVEL
STRAINER
HATCH COVER
GATE VALVES
ELBOWS
ELBOWS
C
B
DELIVERY PIPE
A DRIVE HEAD—VERTICAL FALL IN FEET FROM WATER LEVEL TO INLET OF RAM
B DRIVE PIPE - DISTANCE FROM WATER SUPPLY TO RAM
RAM IN PIT
PIT DRAIN
C VERTICAL DISTANCE FROM RAM TO TOP OF TANK

Figure 1

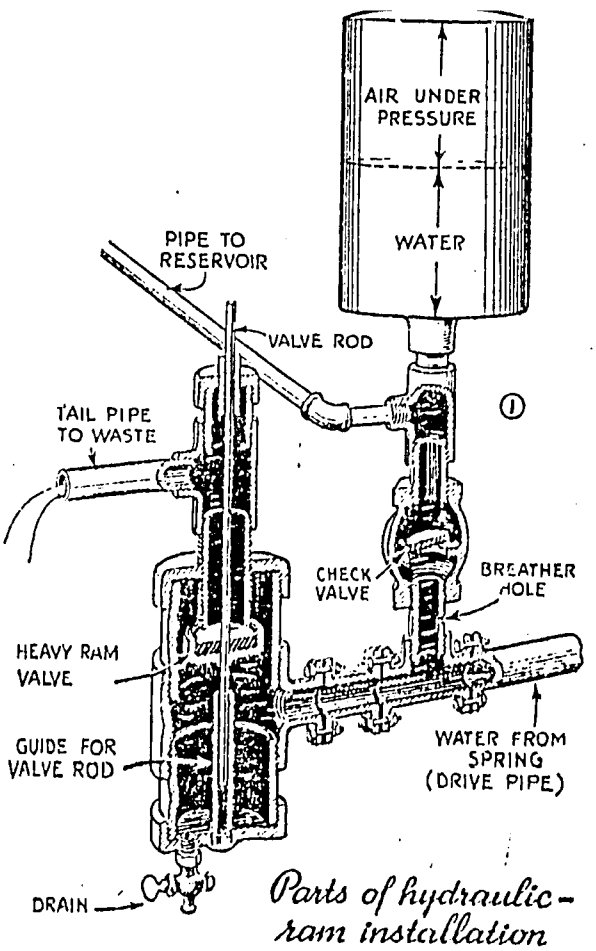

AIR UNDER PRESSURE
WATER
PIPE TO RESERVOIR
VALVE ROD
TAIL PIPE TO WASTE
CHECK VALVE
BREATHER HOLE
HEAVY RAM VALVE
GUIDE FOR VALVE ROD
WATER FROM SPRING (DRIVE PIPE)
DRAIN
Parts of hydraulic-ram installation

Figure 2

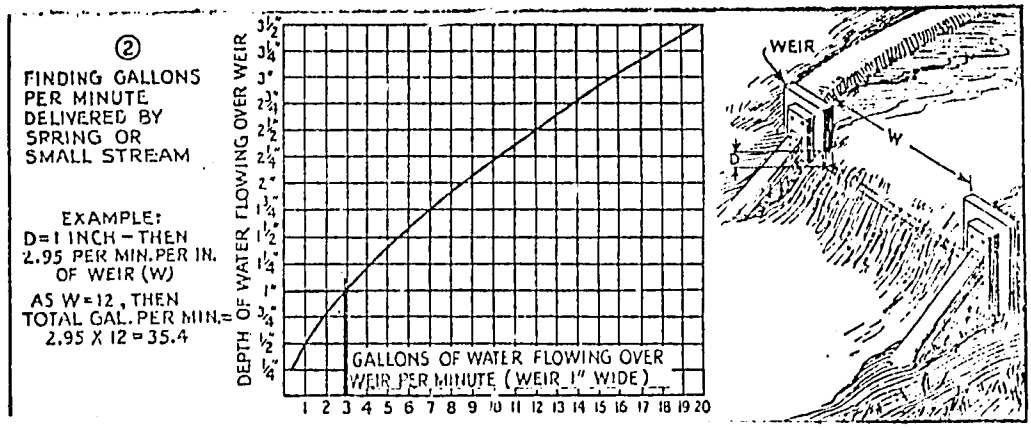

②
FINDING GALLONS PER MINUTE DELIVERED BY SPRING OR SMALL STREAM
EXAMPLE:
D=1 INCH – THEN 2.95 PER MIN. PER IN. OF WEIR (W)
AS W=12, THEN TOTAL GAL. PER MIN.= 2.95 X 12 = 35.4
DEPTH OF WATER FLOWING OVER WEIR
3½" 3¼" 3" 2¾" 2½" 2¼" 2" 1¾" 1½" 1¼" 1" ¾" ½" ¼"
GALLONS OF WATER FLOWING OVER WEIR PER MINUTE (WEIR 1" WIDE)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
WEIR
W
D

Figure 3

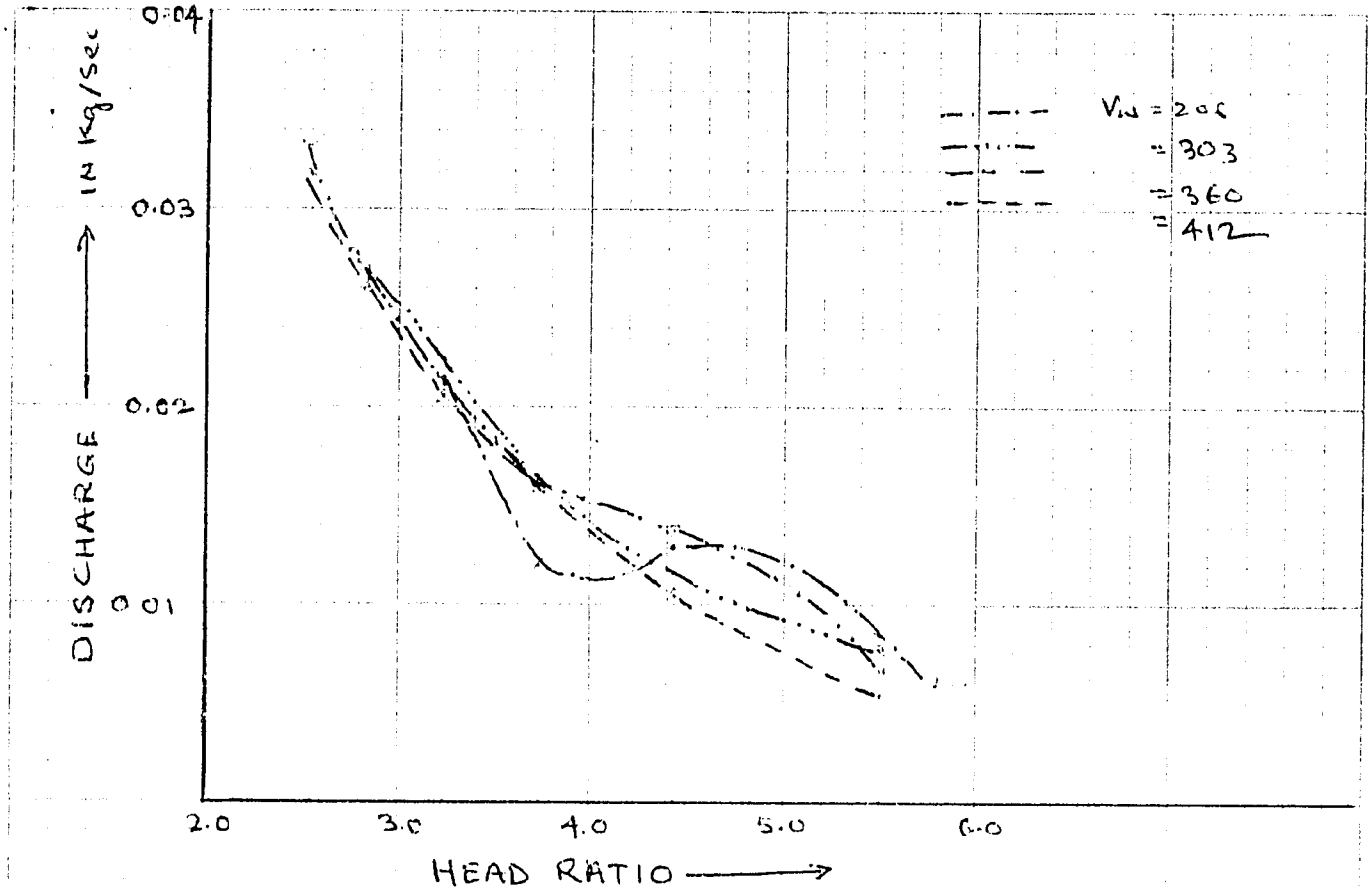


Figure 4a

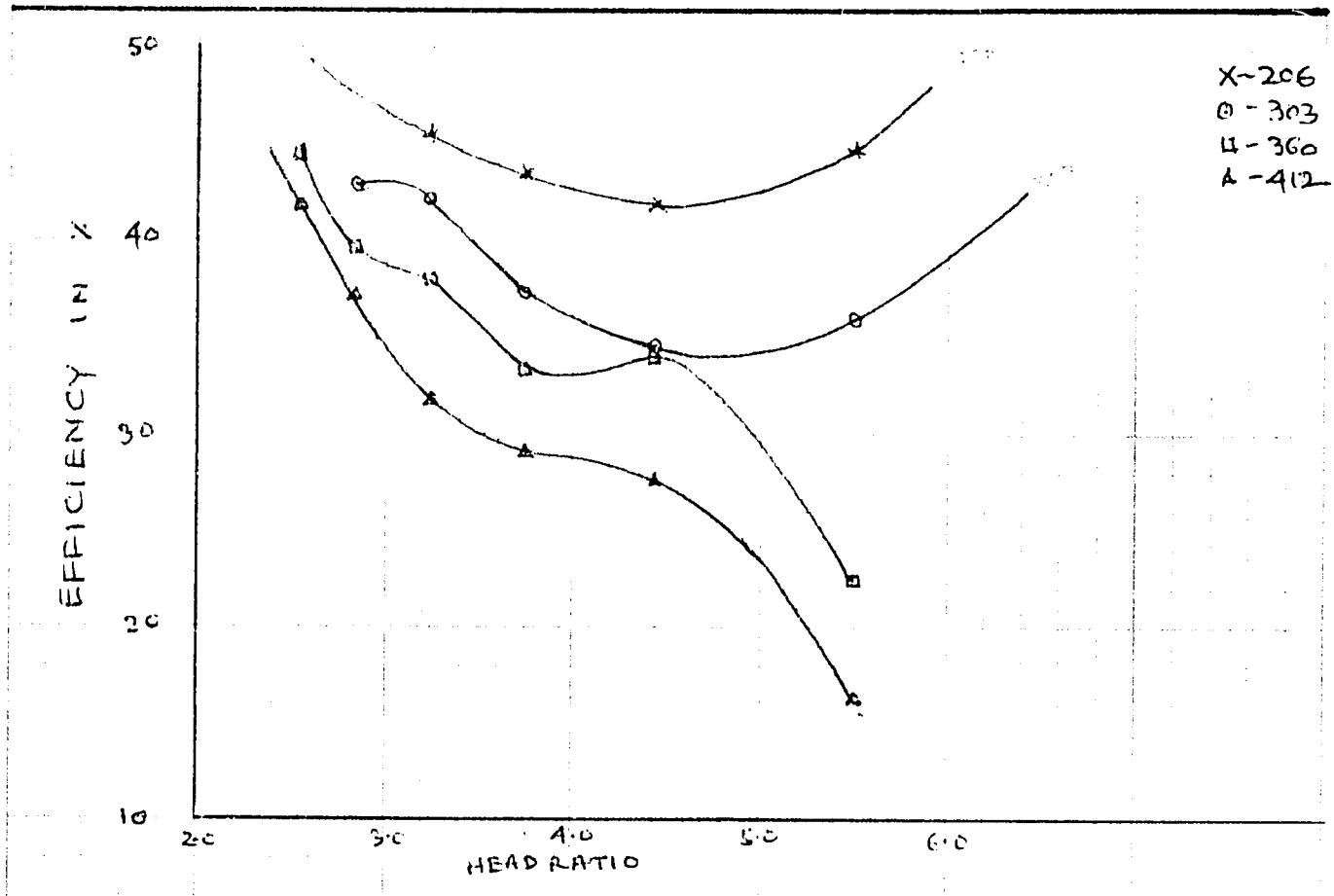


Figure 4b

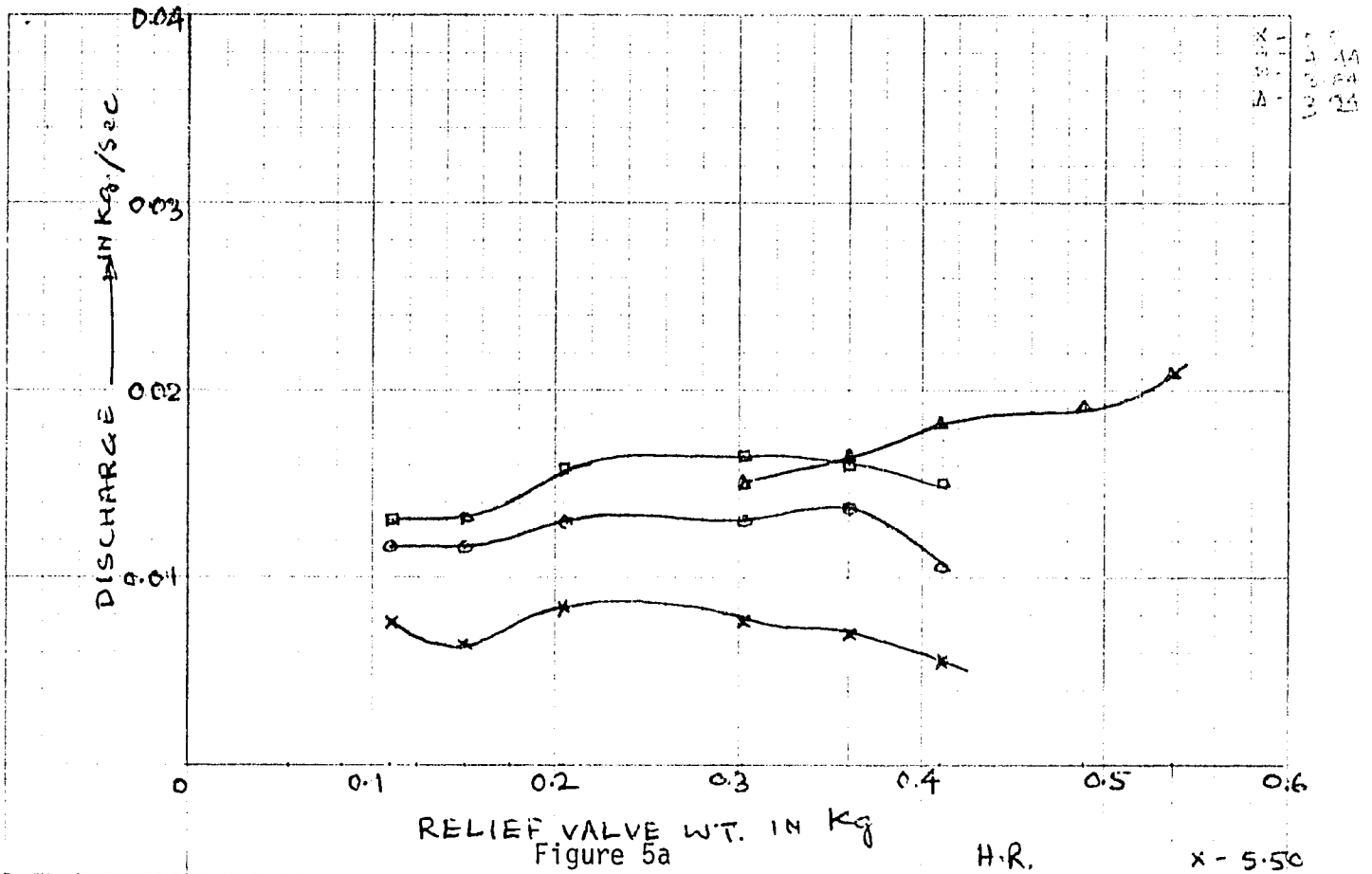


Figure 5a

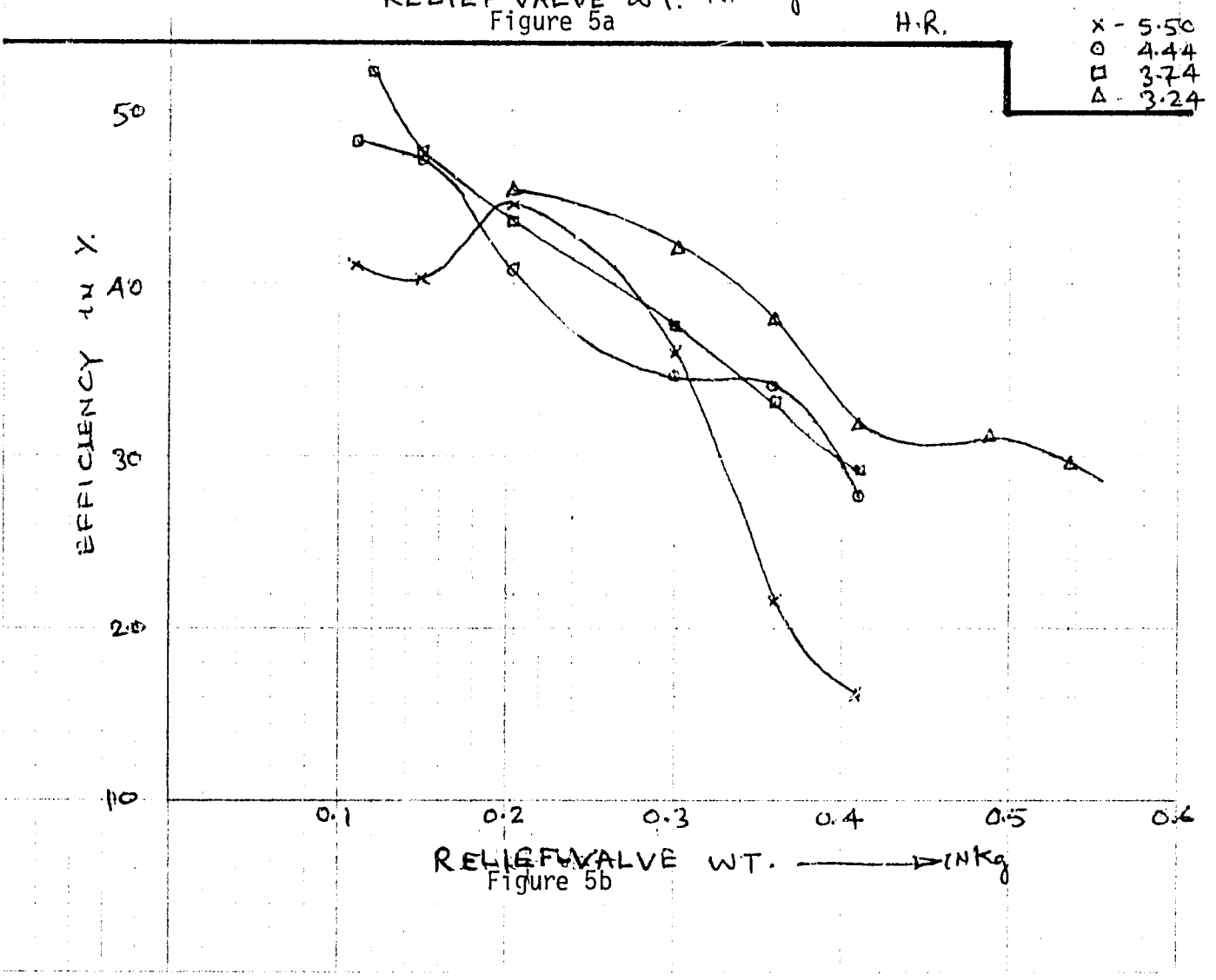


Figure 5b

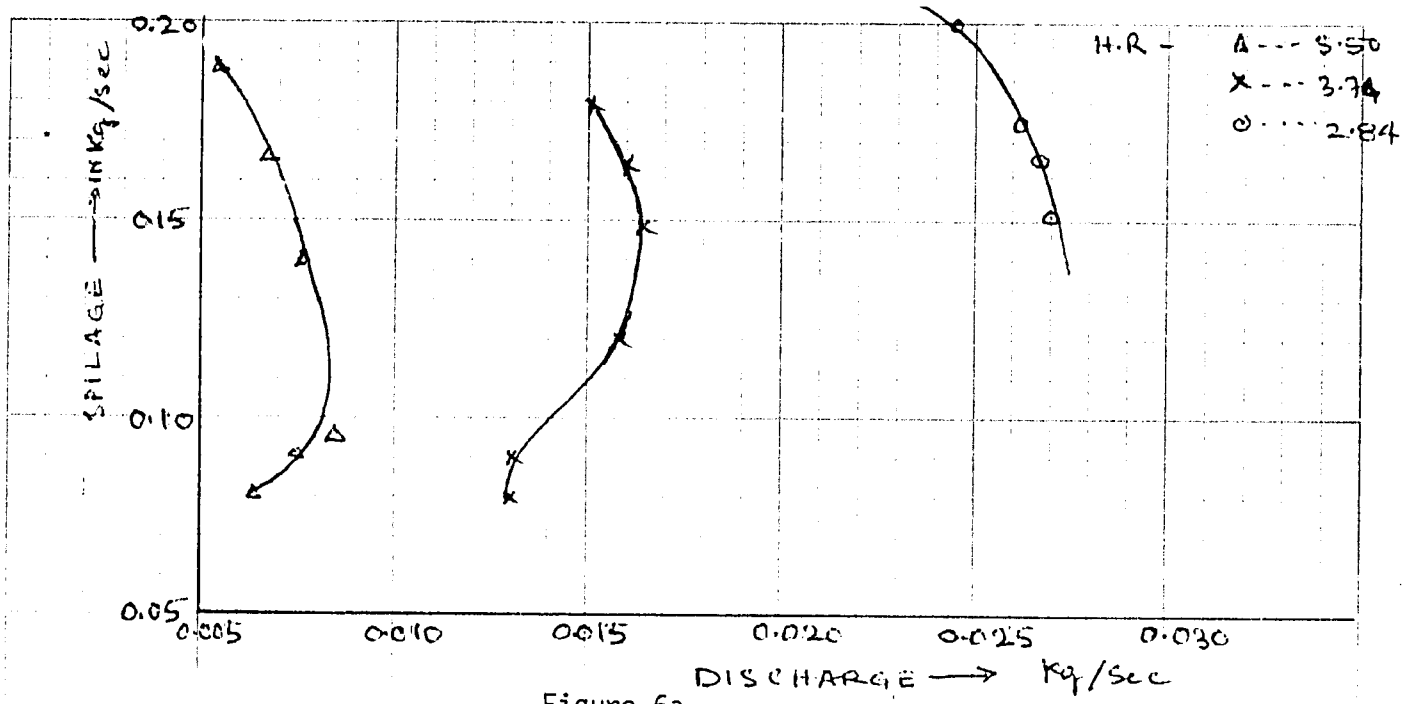


Figure 6a

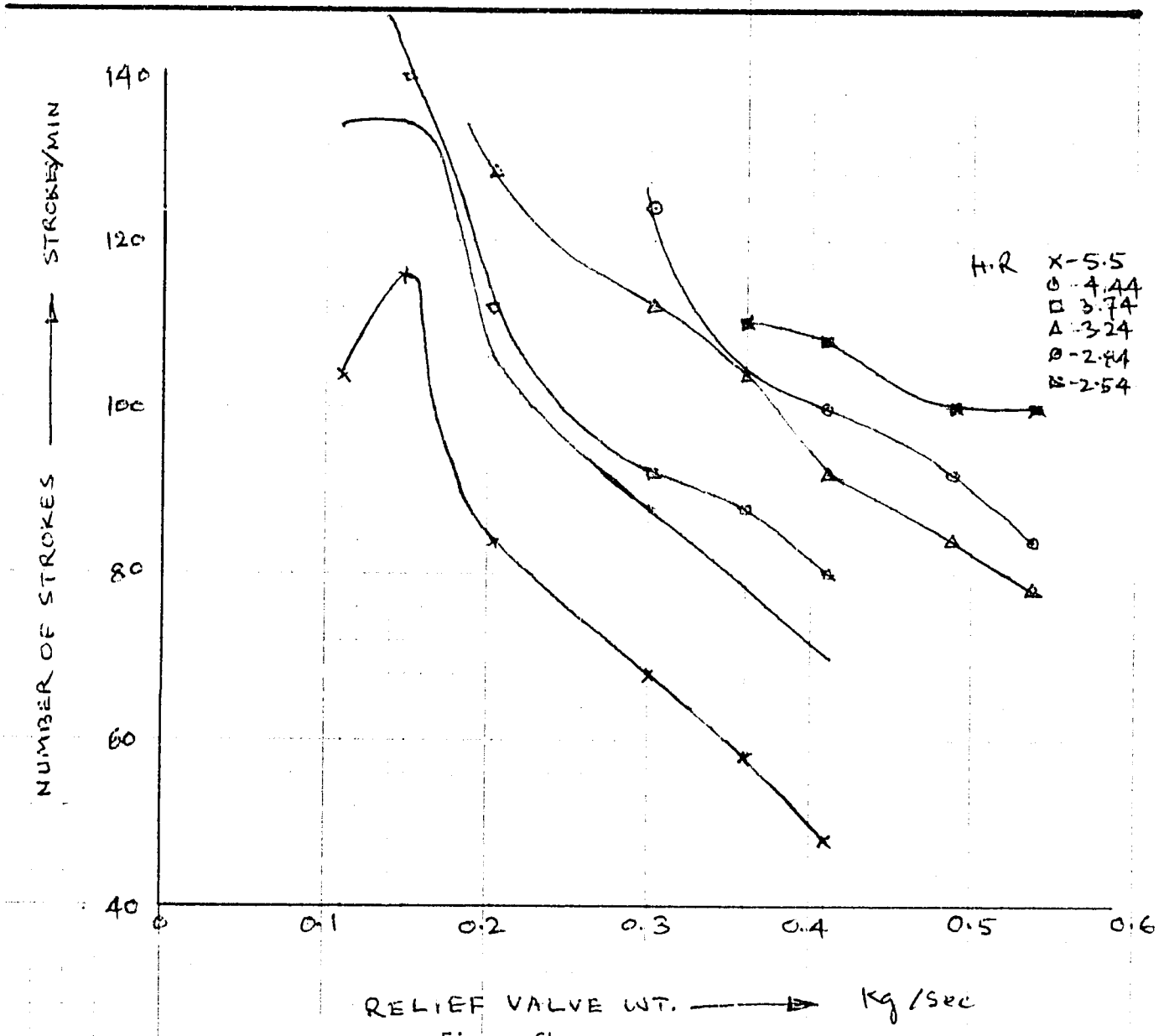


Figure 6b

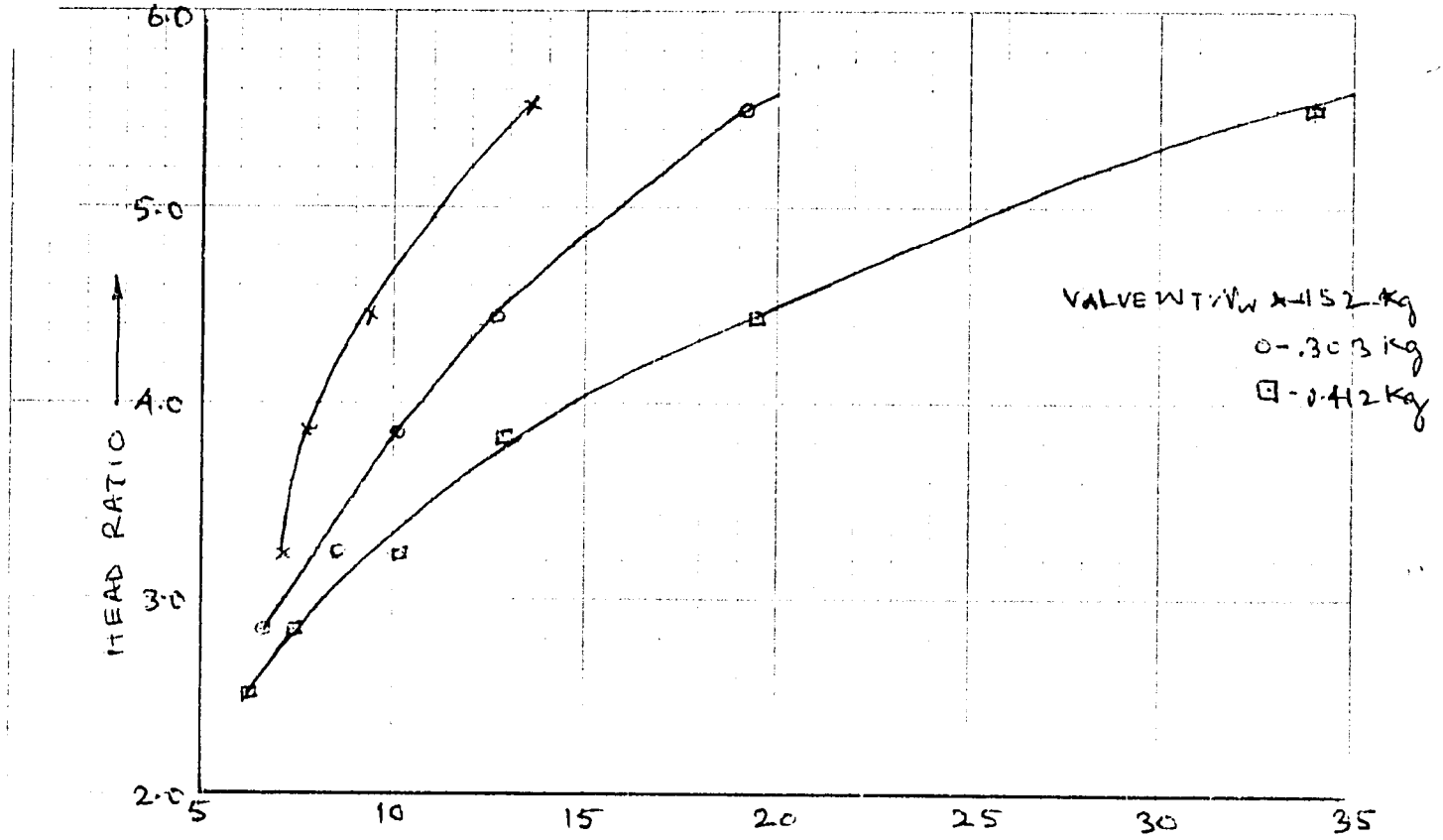
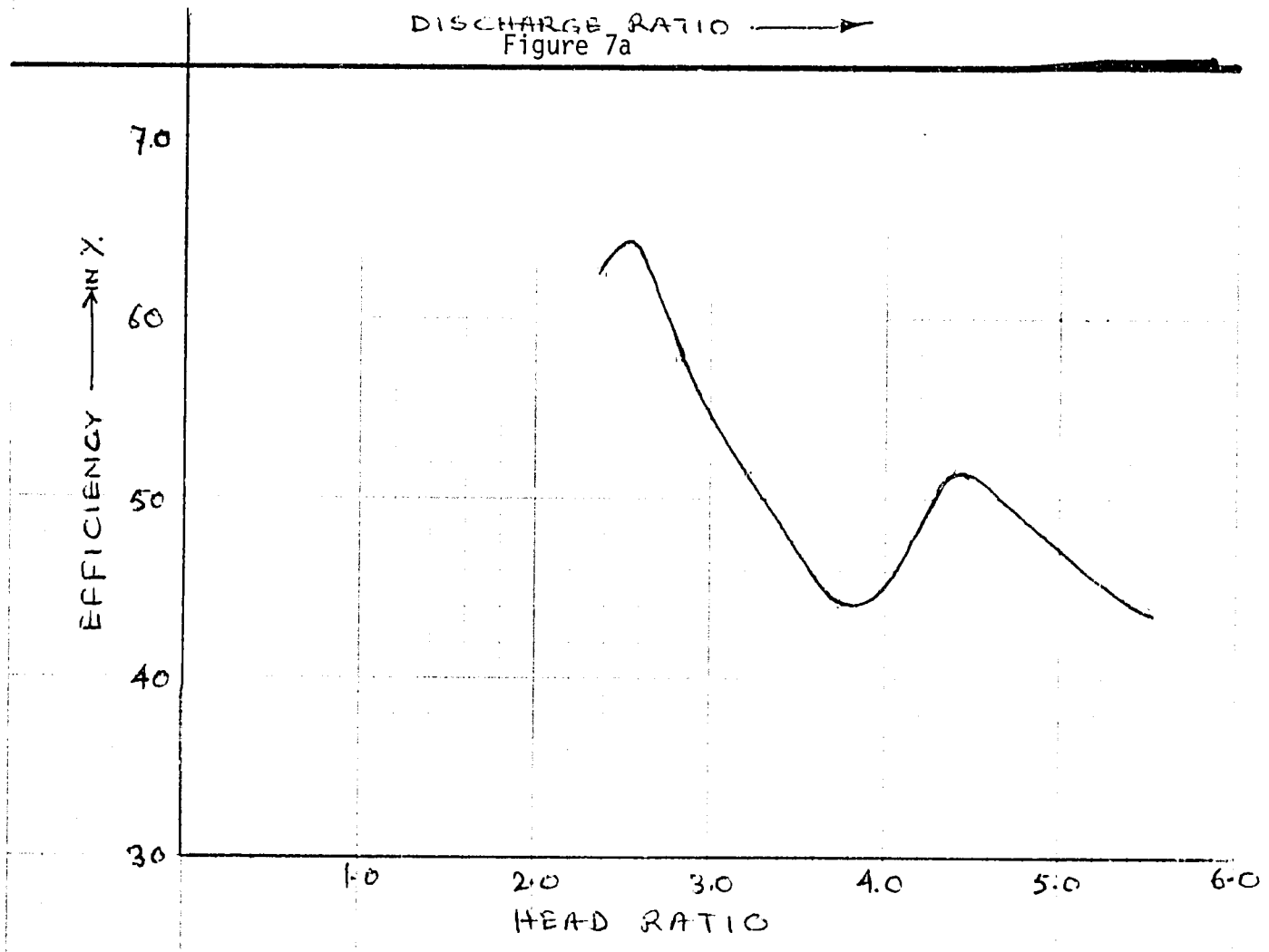


Figure 7a



HAND-MADE PUMP
Figure 7b