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OUTPUT POWER MEASUREMENT AND DETAIL ANALYSIS OF MICRO-HYDRO TURBINE CONSTRUCTION AND PRACTICAL DEMONSTRATION OF HYDRAULIC RAM

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by

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INTRODUCTION

The purpose of this simple presentation is to get consideration upon development of small-scale hydro power plants in developing countries. Most of the developing countries meet difficulties in bringing electricity to the country side for the improvement of rural life. In some parts of the world, the villagers still have to use their hands for lifting water, sawing wocd, grinding grain. One of the resources to overcome backbreaking drudgery is water power.

GENERAL INFORMATION

Water Wheel

The power source extensively coming from flowing water is that impinging directly upon paddles attached to a wheel or filling buckets attached to a wheel. Water wheels took over many laborious and monotonous tasks such as grinding grain, raising water to some reasonable head for irrigation and domestic water supply. The various types of water wheels such as overshot wheel, undershot wheel and breast shot wheel have been used since a long time ago.

Water Turbine

Water turbines are vastly superior to the water wheel from almost any practical point of view. It could generate much more power than the largest water wheel in a much smaller volume of equipment.

It could operate at a greater number of revolutions per minute than the water wheels. Basically there are two types of turbines such as impulse turbine and reaction turbine. For impulse turbines there are tangential type, diagonal type and cross flow type turbines. The impulse turbines are being offered only for high head. Reaction turbines such as Francis turbine, propeller type turbine and Kaplan turbine are generally low head turbines.

Hydraulic Ram

The basic principle of the hydraulic ram is that of a water hammer, using the kinetic energy of water flowing in a pipe to elevate part of this water to a height greater than that causing the flow, with an

efficiency of 60 percent. Though the hydraulic ram is a device for pumping water, it has also been used to compress air.

Hydraulic Air Compressor

The Hydraulic air compressor is the inversion of the air lift pump. Water is allowed to flow for some elevations into a vertical pipe through a circumferential venturi entrance. At the minimum area of the venturi section, openings are provided into the pipe and into a chamber where the air is trapped and compressed by the conversion of its kinetic energy to potential energy.

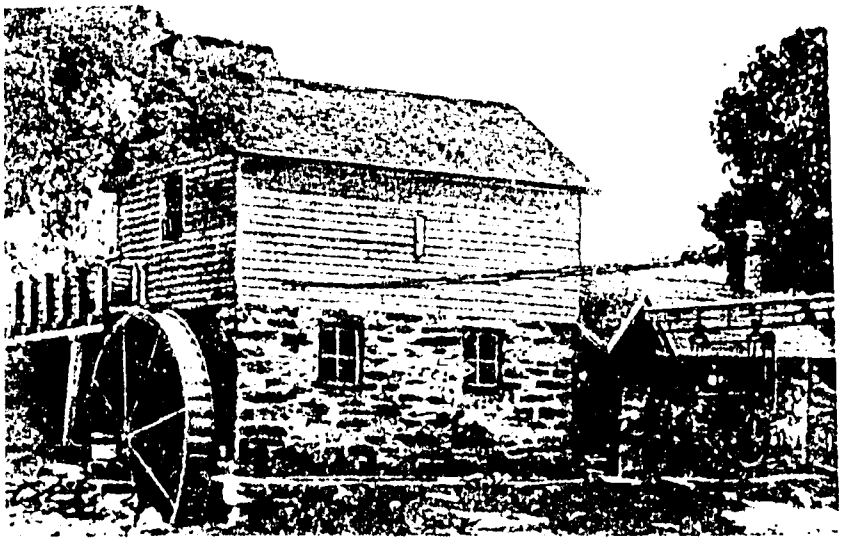


Fig. 1 Overshot Wheel

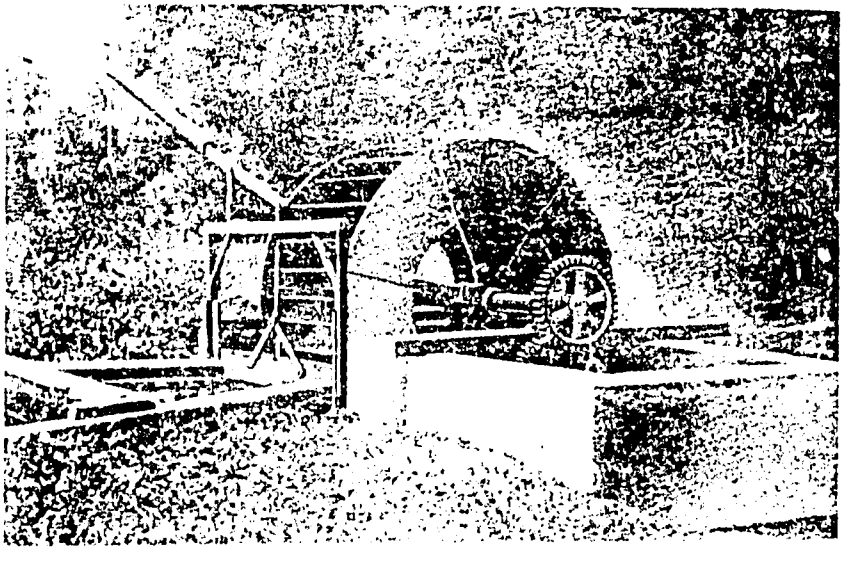
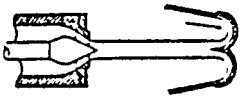


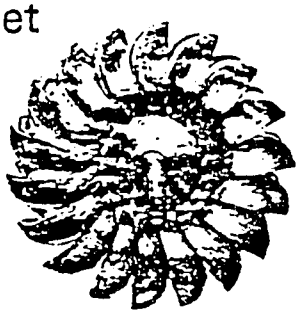
Fig. 2 Undershot Wheel

IMPULSE RUNNERS

Pelton, Doble
(Tangential)

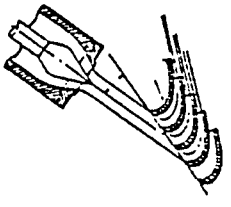
Low Speed

Nozzle  Bucket

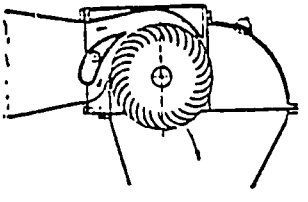


High Speed

Turgo
(Diagonal)

Nozzle  Buckets

Michell, Banki
(Crossflow)



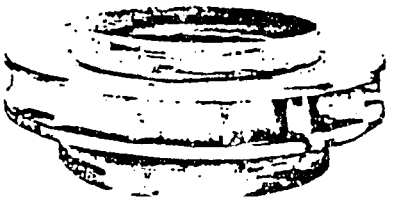
High Head - Low Volume
Low RPM For Given Head
Head Measured To Nozzle or Centerline
Do Not Recover "Suction" Head

Fig. 3

REACTION RUNNERS

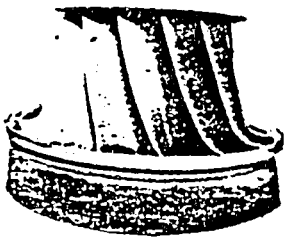
Francis

High Head



Medium Head

Low Head



Propeller

Dariez

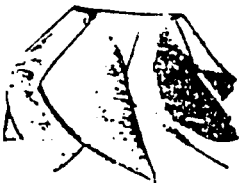
Mixed Flow

Adjustable Blades

Fixed Blades

Axial Flow

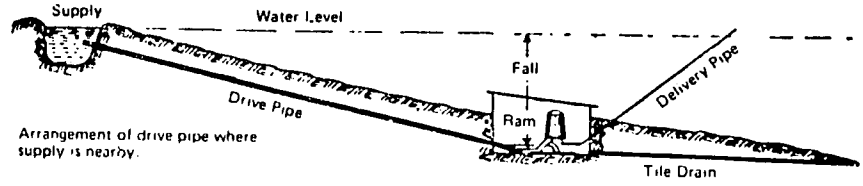
Medium Head



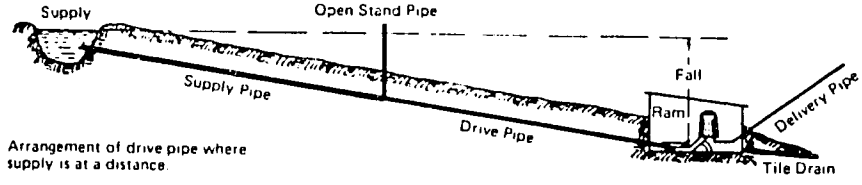
Kaplan = Coordinated Blades & Gates

Low Head - High Volume
Higher RPM For Given Head
Output Limited By Cavitation

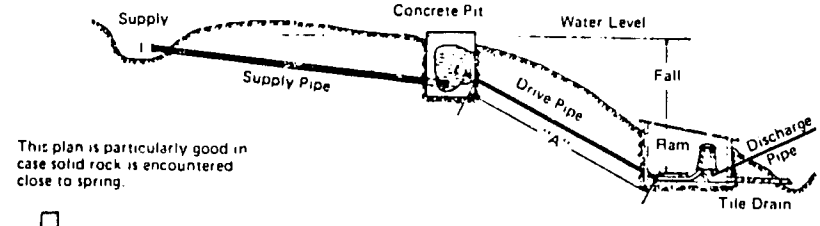
Fig. 4



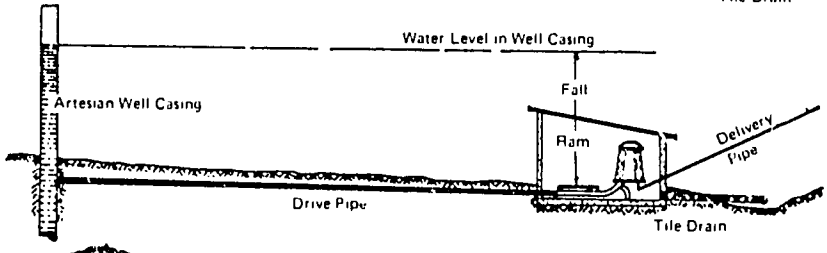
Arrangement of drive pipe where supply is nearby.



Arrangement of drive pipe where supply is at a distance.



This plan is particularly good in case solid rock is encountered close to spring.



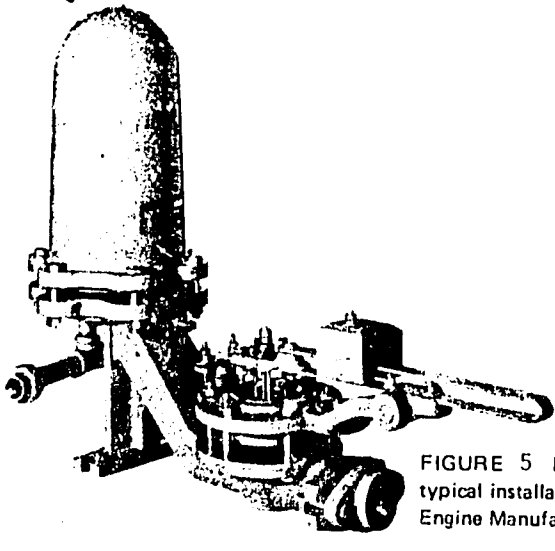


FIGURE 5 Hydraulic ram and examples of typical installations. [Courtesy Rife Hydraulic Engine Manufacturing Co.]

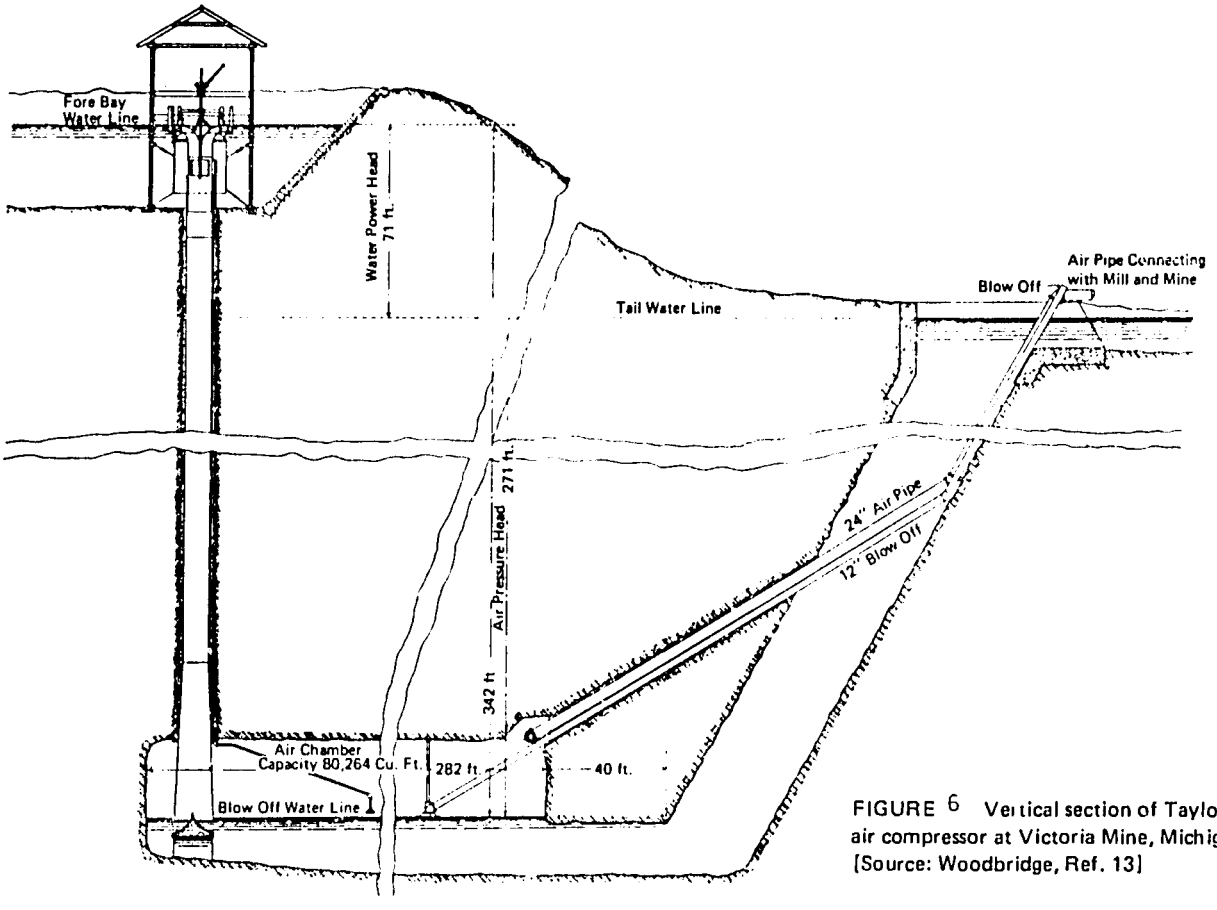


FIGURE 6 Vertical section of Taylor hydraulic air compressor at Victoria Mine, Michigan. [Source: Woodbridge, Ref. 13]

OUTPUT POWER MEASUREMENT

AND

DETAIL ANALYSIS OF MICRO HYDRO TURBINE

Description	Data 1	Data 2	Data 3	Data 4	Data 5
(i) Wt. of water in lb. . . .	10.66	5.58	4.52	6.25	6.36
(ii) Time in sec..	50	15	10	13	10
(iii) Nozzle pressure in p.s.i.	30	35	50	55	95
(iv) R.P.M.	80	96	160	178	296
(v) Torque in ft. lb. . . . . (Measured by means of P)	.19	.25	.31	.38	.5
Calculated					
(i) Volume of water	.266	.089	.072	.1	.1
(ii) Flow Q in ft.^{3}/sec.	.0053	.0059	.0072	.0077	.0102
(iii) Velocity in ft./sec. $(\frac{Q}{A})$ (Nozzle area = .0002 ft.^{2})	26.5	29.5	36	38.5	51
(iv) Head calculated from pressure gauge reading $H = \frac{P}{2.31}$	12.98	15.15	21.65	23.8	41.12
(v) Head calcuated from velocity $\frac{V^2}{2g}$	11.08	13.52	20.14	23.04	40.35
(vi) Measured H.P. (output) $= \frac{2\pi NT}{33000}$	.003	.005	.009	.013	.028
(vii) Theoretical H.P. (input) $= \frac{CFS \times Head}{11.8}$	.005	.007	.012	.015	.035
(viii) Efficiency $\eta = \frac{output}{input}$	60	71	75	87	80

CONSTRUCTION OF HYDRAULIC RAM

According to the sketch below, the hydraulic ram was constructed with P.V.C. pipes, P.V.C. sheets, unused hacksaw blade, rubber flat and some wooden pieces for support

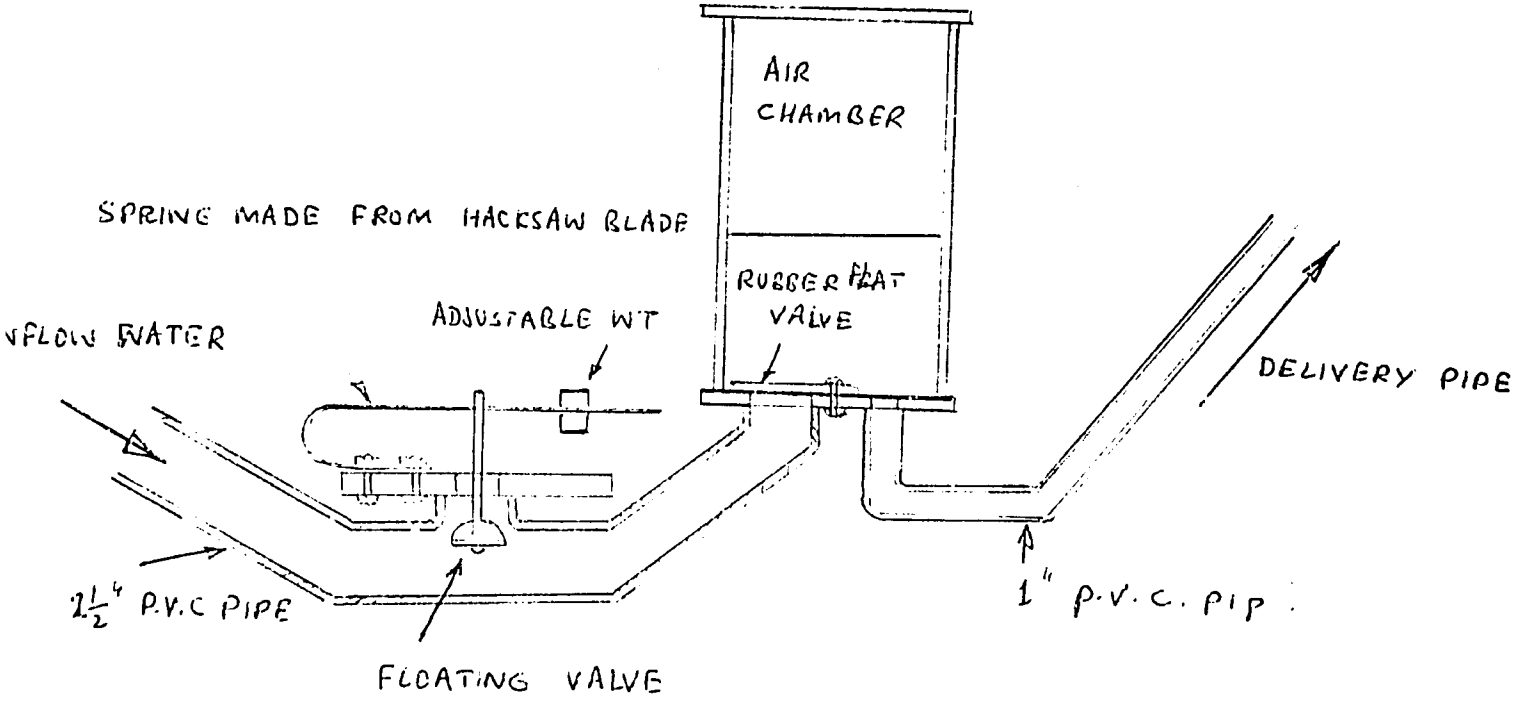


Fig. 7

PRACTICAL DEMONSTRATION AND DATA TAKEN

The constructed small hydraulic ram started to work when inflow water with a head of approximately 5 ft. was flowing and delivered up to a 12 ft. head. Four readings taken for inflow Q and delivery water Q_2 as follows:

Q_1 ft.^{3}/sec.	.12	.11	.1	.09
Q_2 ft.^{3}/sec.	.004	.003	.004	.004
η	3%	2.7%	4%	4.4%

Maximum efficiency for net head 7 ft. is 4.4% and the volume of water delivered is .004 ft.^{3}/sec. So pump capacity is approximately 2 gallons/min.

CONCLUSION

The results of measurements and calculations show that the small micro-hydro turbine of the TREEO Center has the maximum output capacity of .028 h.p.; that is, approximately 20 watts and the small hydraulic ram can raise water up to 12 ft. with a capacity of 2 g.p.m.