Hydro Energy

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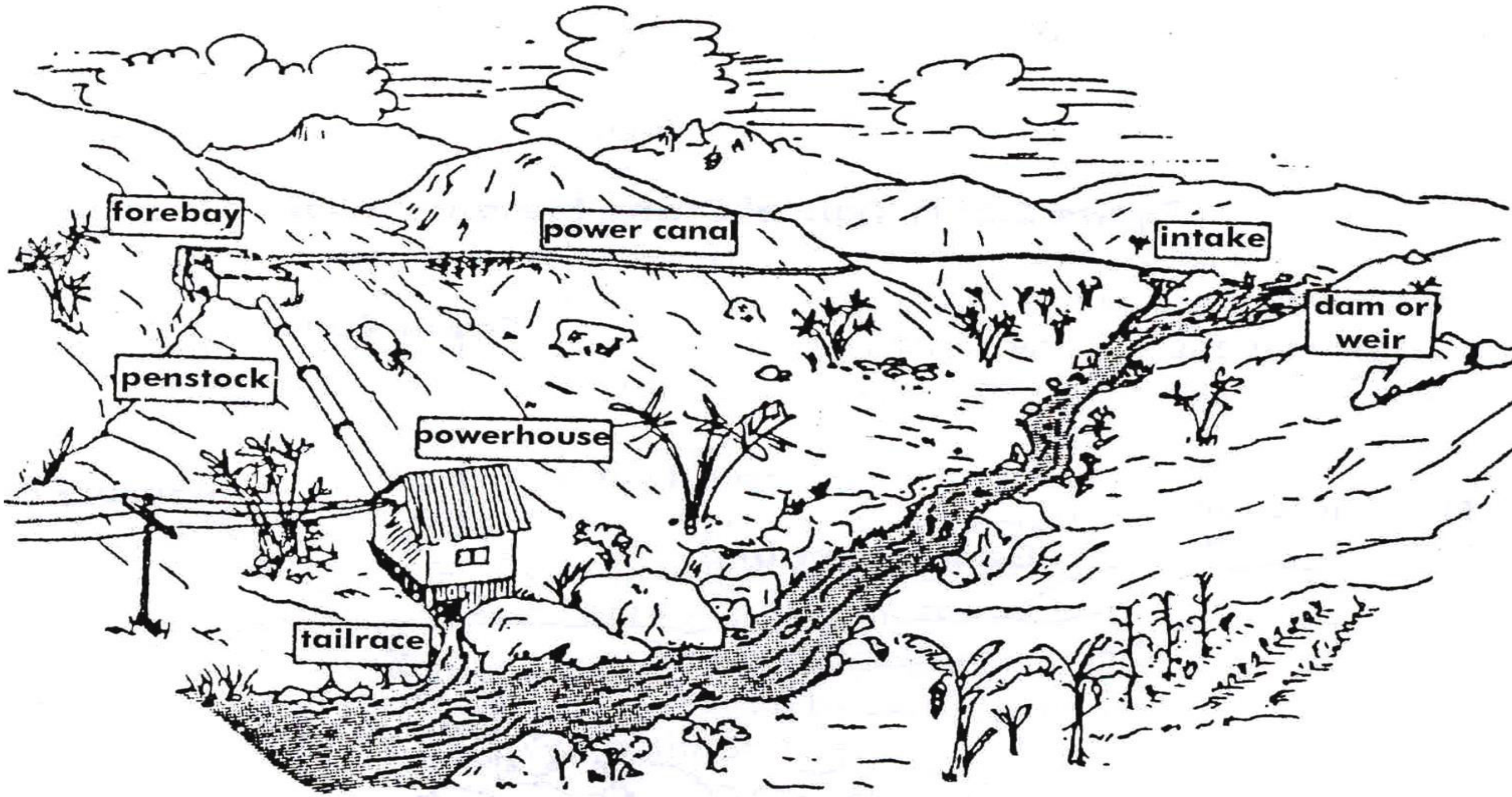
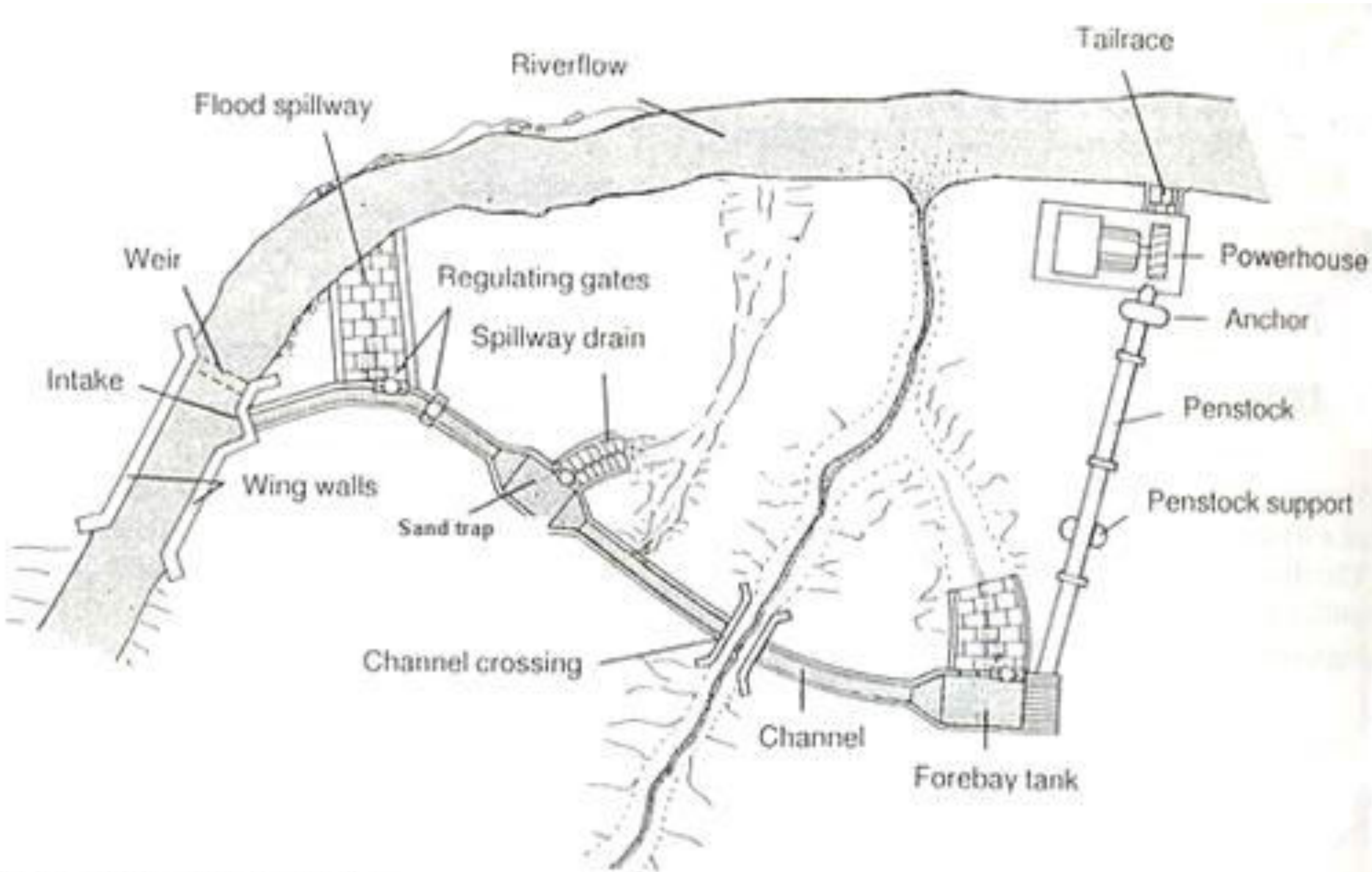
Overview


forebay
power canal
intake
dam or weir
penstock
powerhouse
tailrace

Lay-out

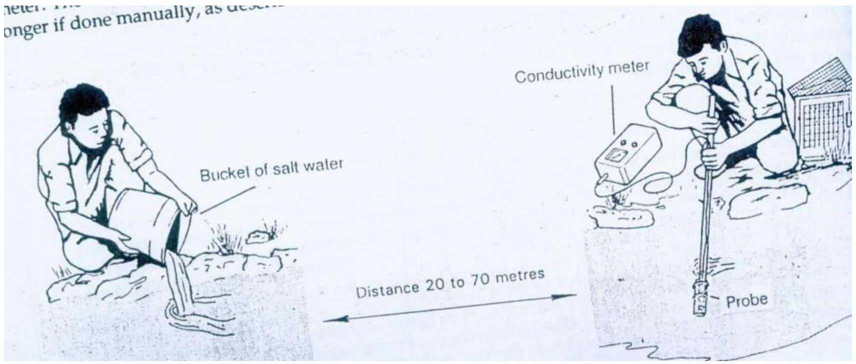


Courtesy of Micro-Hydro Design Manual, A. Harvey, 1993

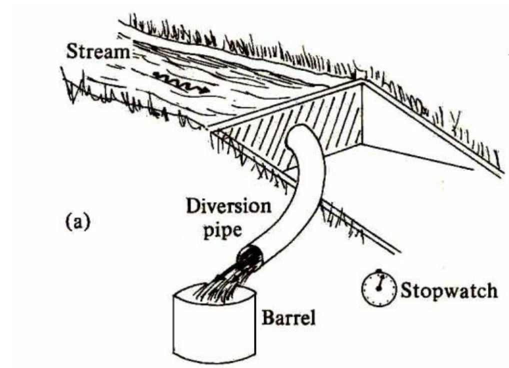
Classification of Hydro-Power

- Micro-hydropower Up to 100 kW
- Mini-hydropower above 100 kW but not exceeding 1,000 kW (1MW)
- Small-hydropower above 1 MW but not exceeding 10 MW
- Medium-hydropower above 10 MW but not exceeding 300 MW
- Large-hydropower above 300 MW

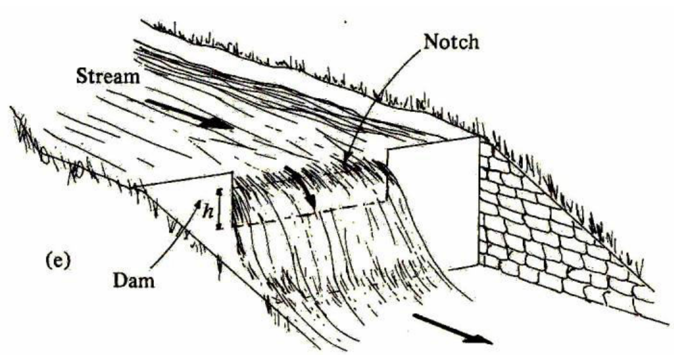
Discharge Measurement



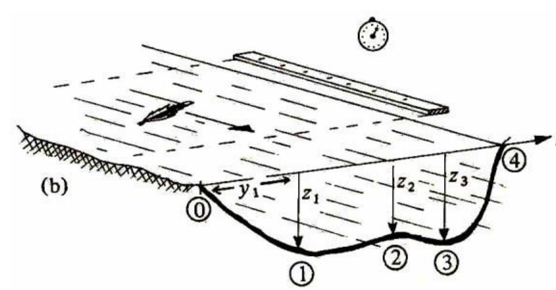
Salt dilution Method



Bucket Method

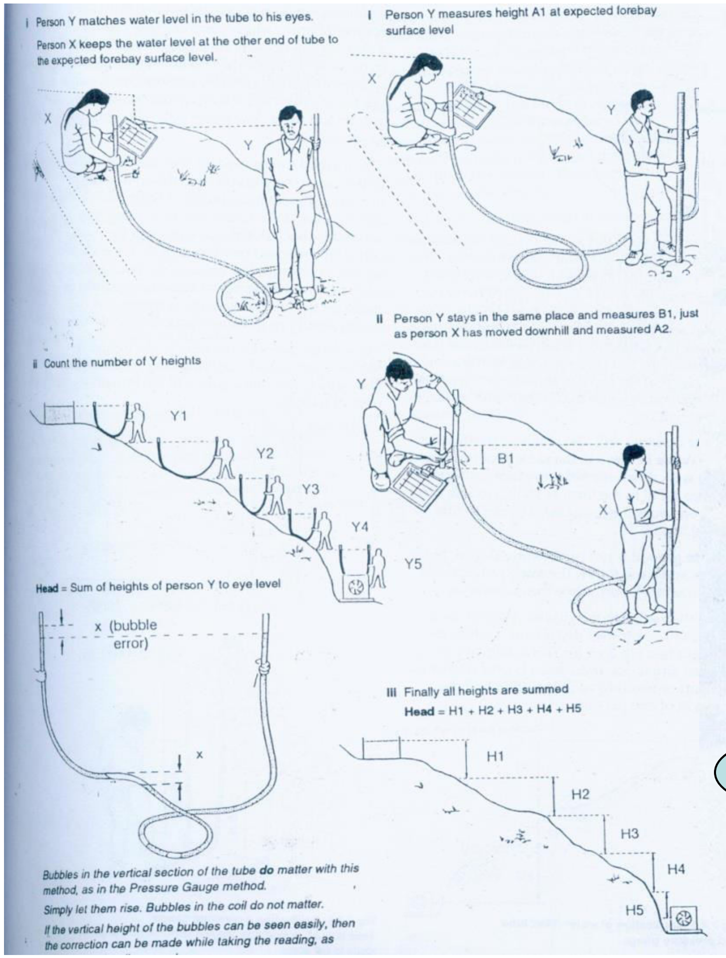


Weir method

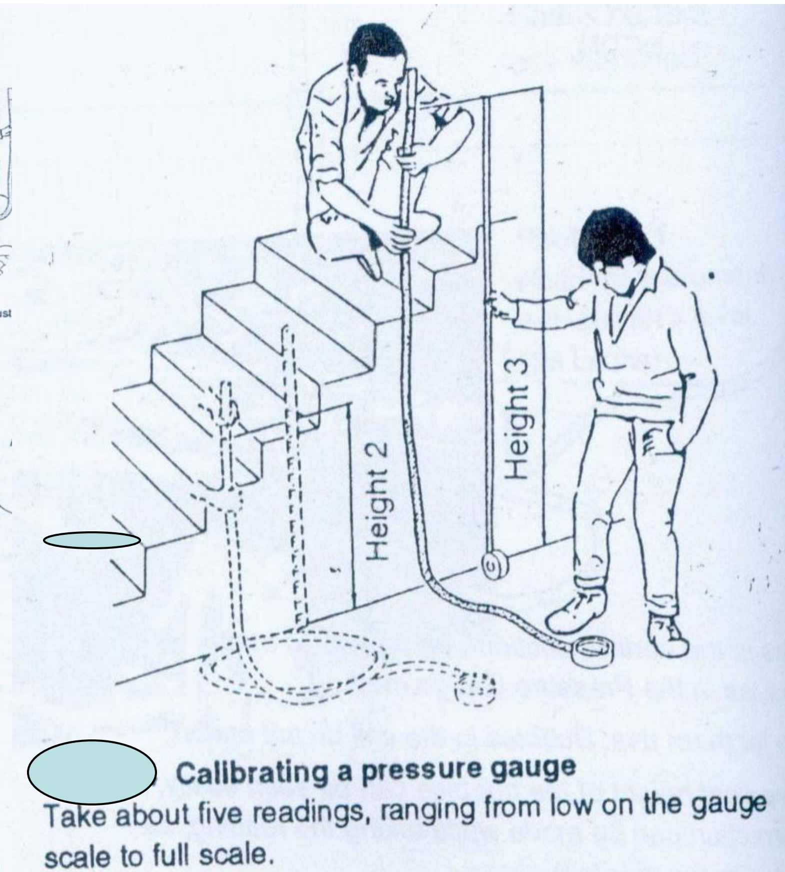


Area velocity method

Head Measurement

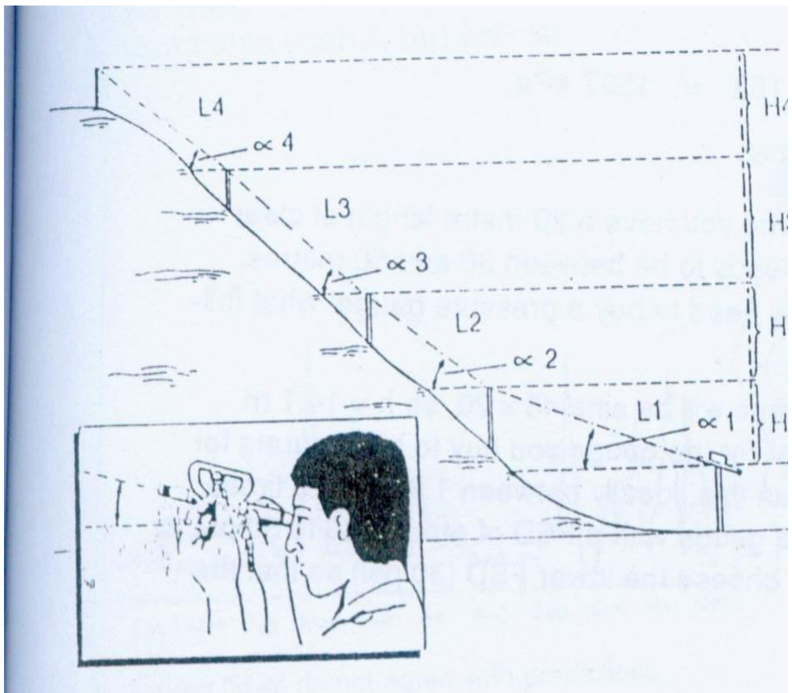


Water filled tube method

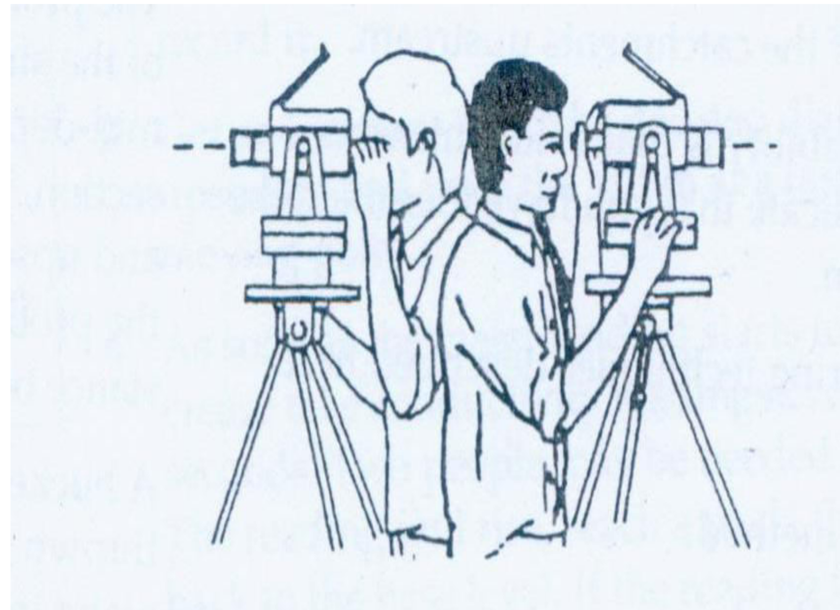


Pressure gauge method

Head Measurement



Use of sighting meters



Use of levels

Energy Calculation

$$E = mgh \qquad [1]$$

Where,

- E - energy of water in Joules
- m - mass of water in kg
- g - acceleration due to gravity in m/s2
- h – elevation of water with respect to the sea level in m

Calculation of Energy

Equation [1] may be rewritten as

$E \quad = \rho \times V \times g \times h$ [(kg/m3) x (m3) x (m/s2) x m]

$= 1000 \times V \times g \times h$ [kg x (m/s2) x m]

$= 1000 \times V \times g \times h$ [N x m]

$= 1000 \times V \times g \times h$ [J]

The corresponding power may be calculated as

$P \quad = E/t$ [J/s] $= E/t$ [W]

$= 1000 \times V \times g \times h/t$ [W]

$= 1000 \times (V/t) \times g \times h$ [W]

$= Q \times g \times h$ [kW]

$P = 9.81\ Qh$ [kW]

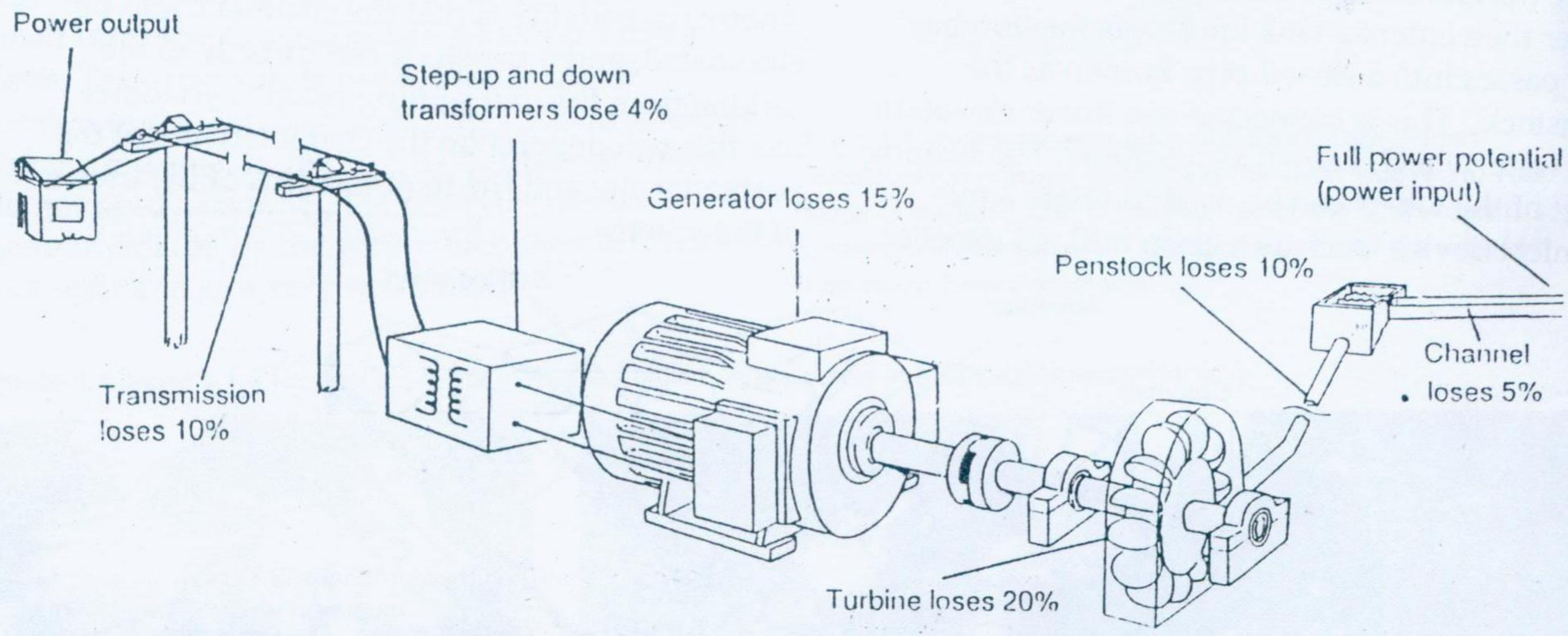
Calculation of Power

- Equation [2] represents the theoretical power that may be generated from elevated water. In reality some losses are involved in power generation.
- Let η be the efficiency of the process of power generation. Then equation [2] may be rewritten as

$$\mathbf{P = 9.8 \times \rho \times \eta \times Q \times h} \qquad [3]$$

- This equation is known as hydropower equation. η represents in equation [3] accounts for losses in water conveyance, such as canal, penstock, losses etc., turbine and generator.

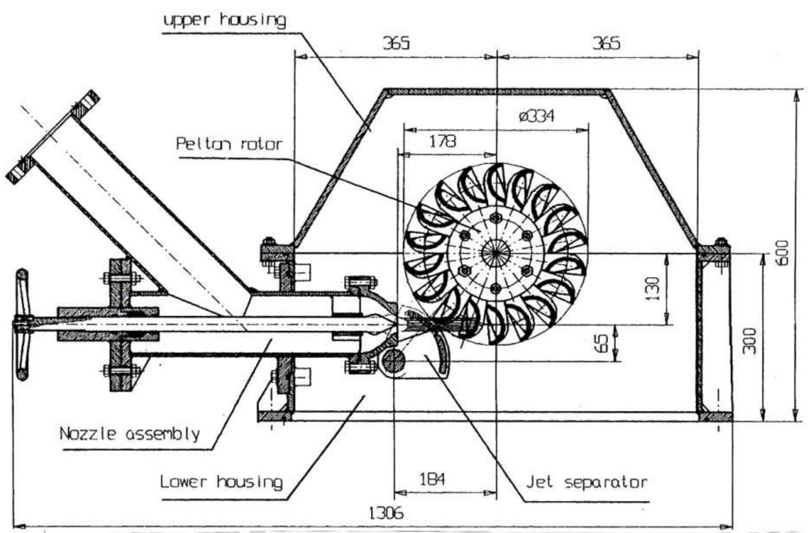
Typical system efficiency

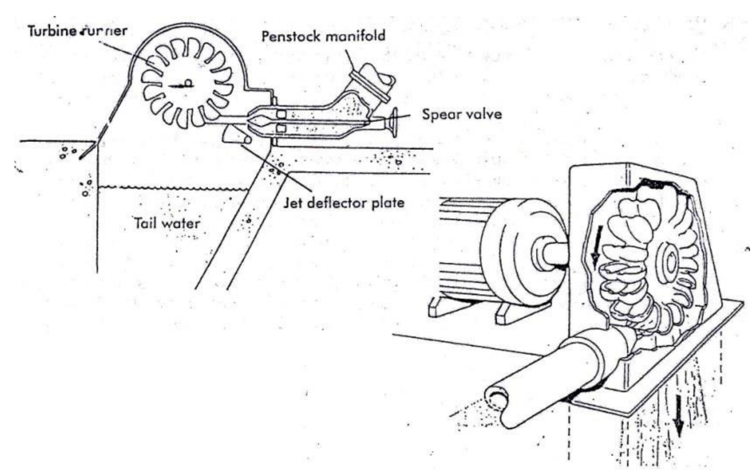


$$
\begin{aligned}
\text{Power output} &= e_{\text{civil works}} \times e_{\text{penstock}} \times e_{\text{turbine}} \times e_{\text{generator}} \times e_{\text{line}} \times \text{power input} \\
&= e_o \times \text{power input} \\
&= 0.95 \times 0.9 \times 0.8 \times 0.85 \times 0.96 \times 0.9 \times \text{power input} \\
&= 0.5 \times \text{power input}
\end{aligned}
$$

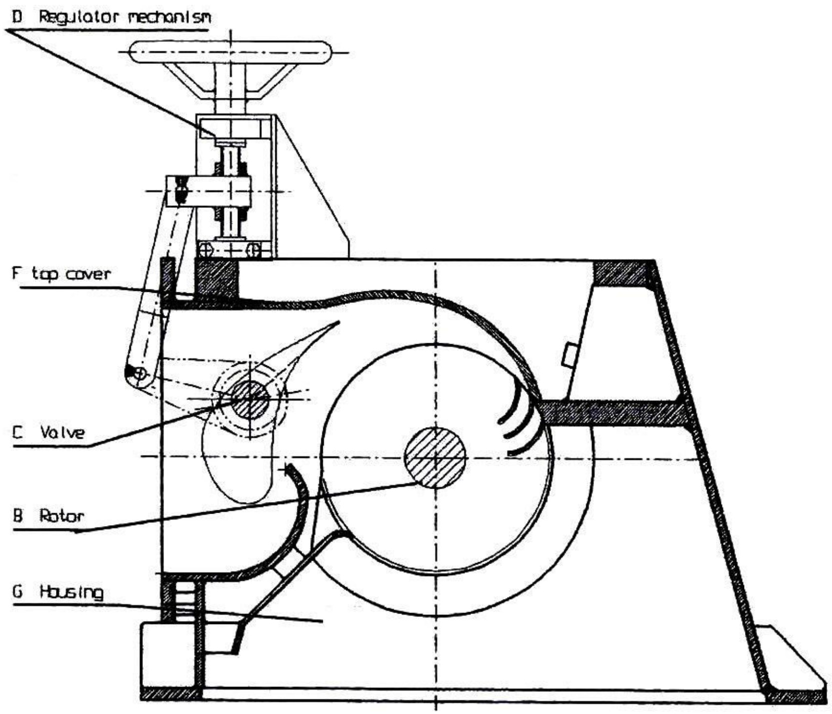
Typical system efficiencies for a scheme running at full design flow.

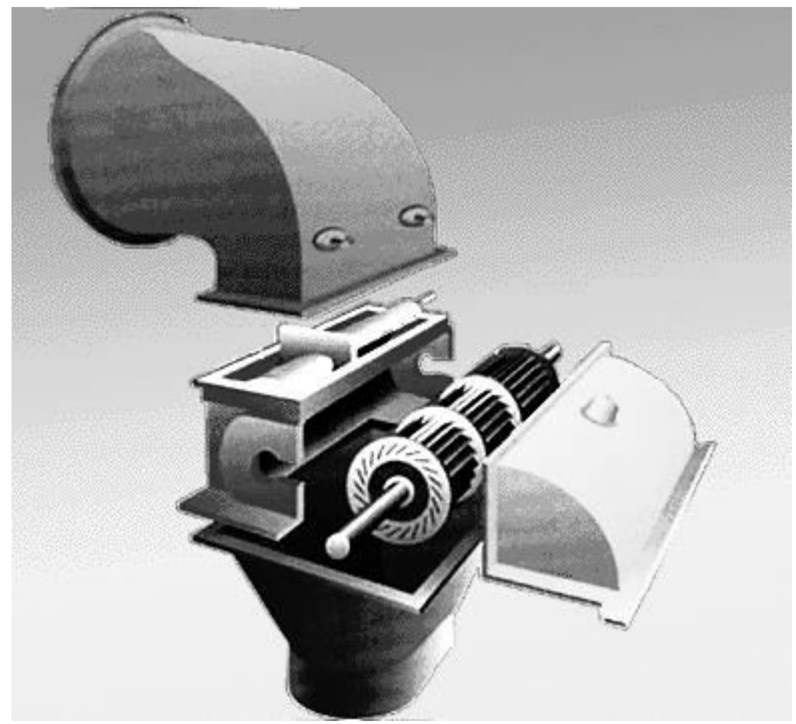
Pelton Turbine (Single jet with horizontal shaft)



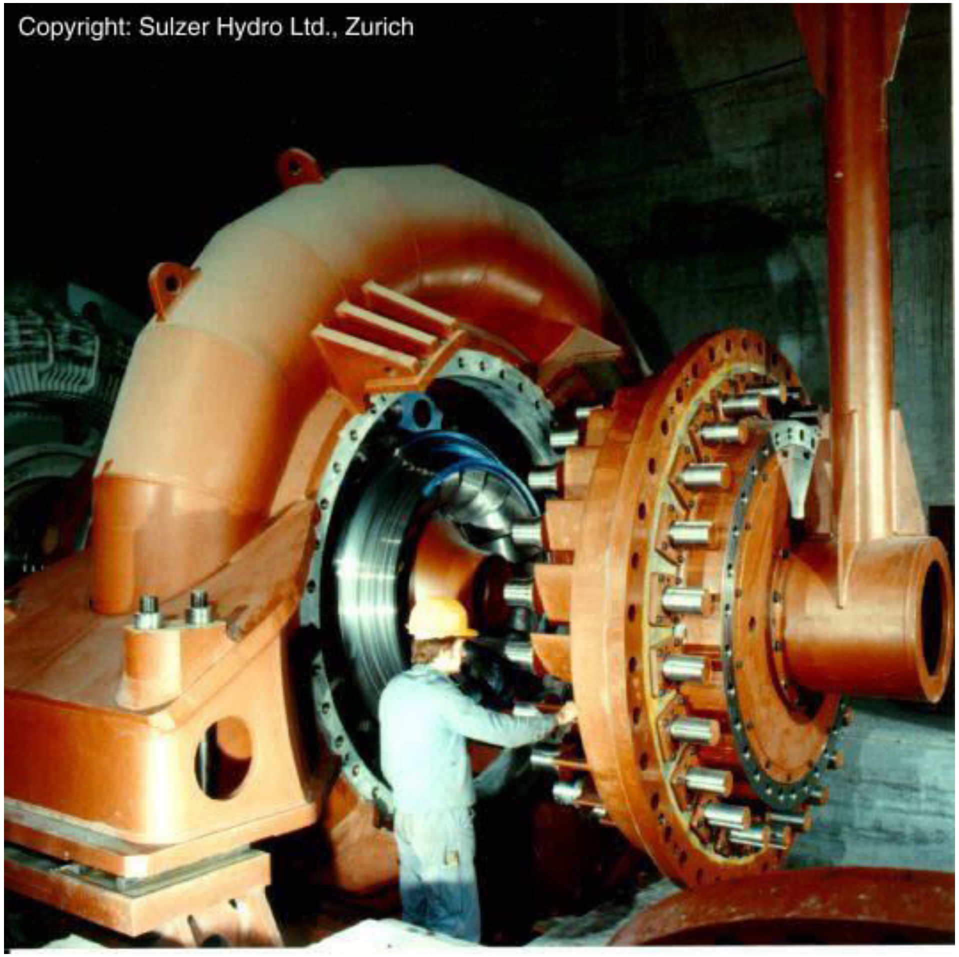


Crossflow Turbine

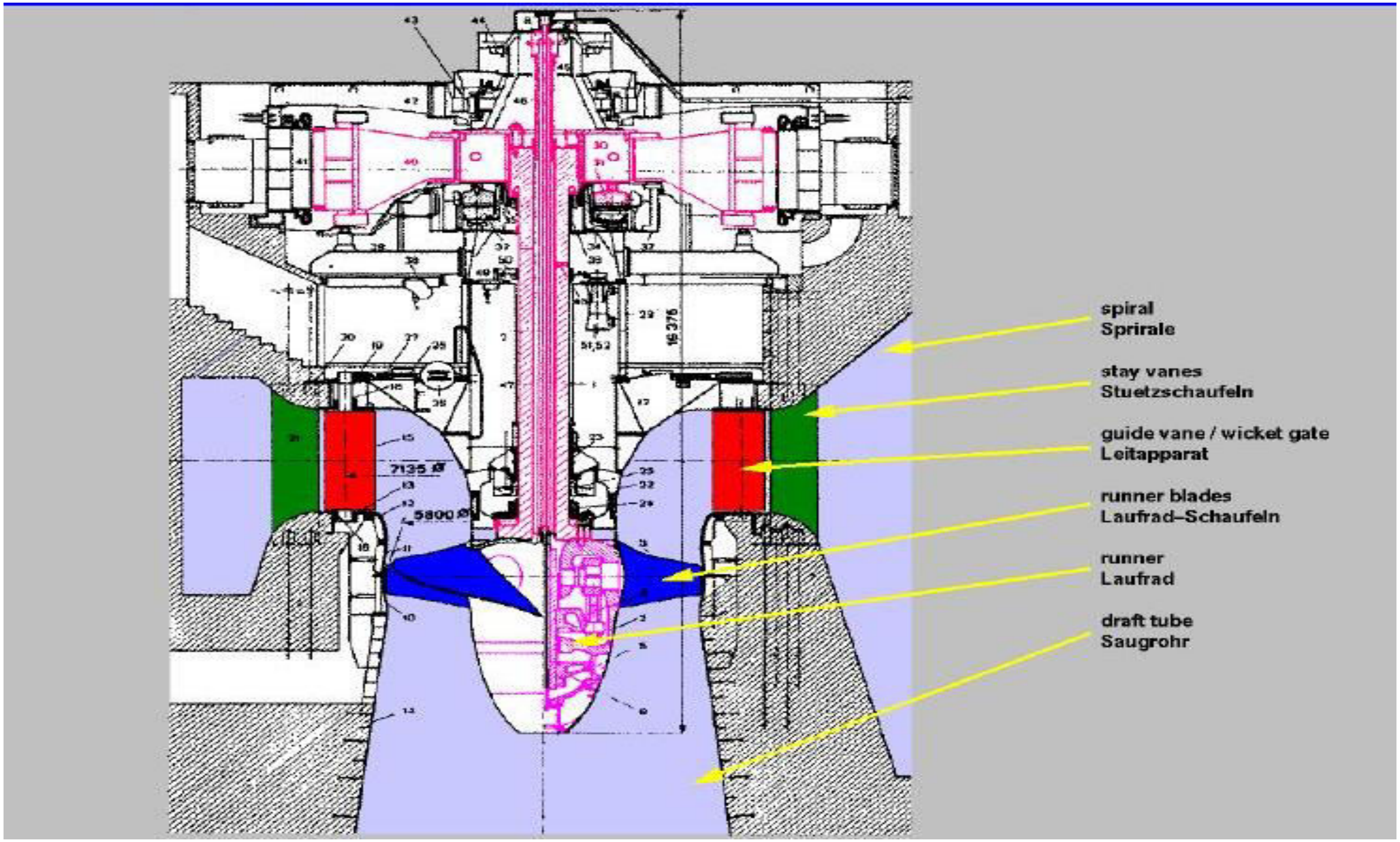




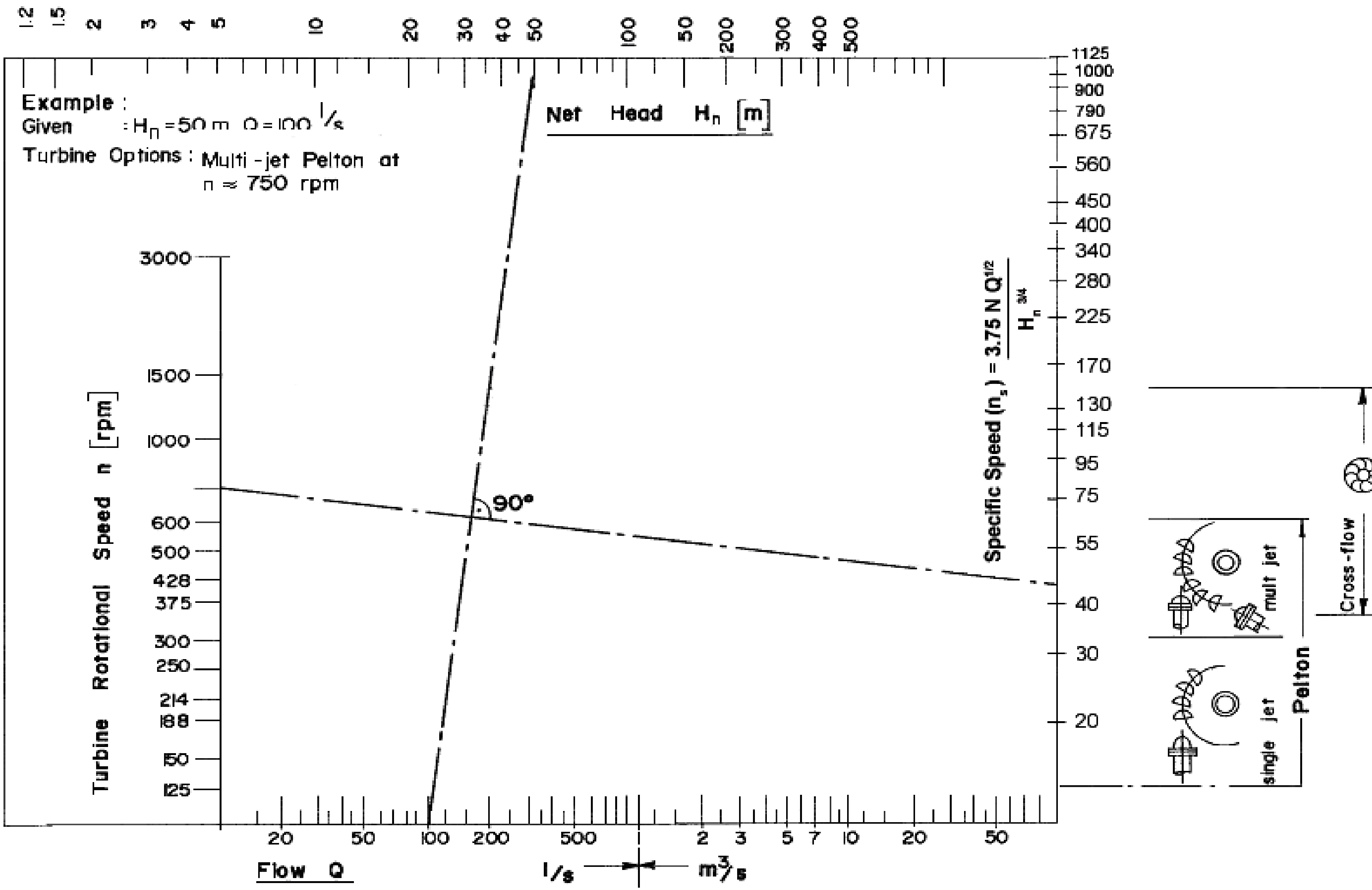
Francis Turbine



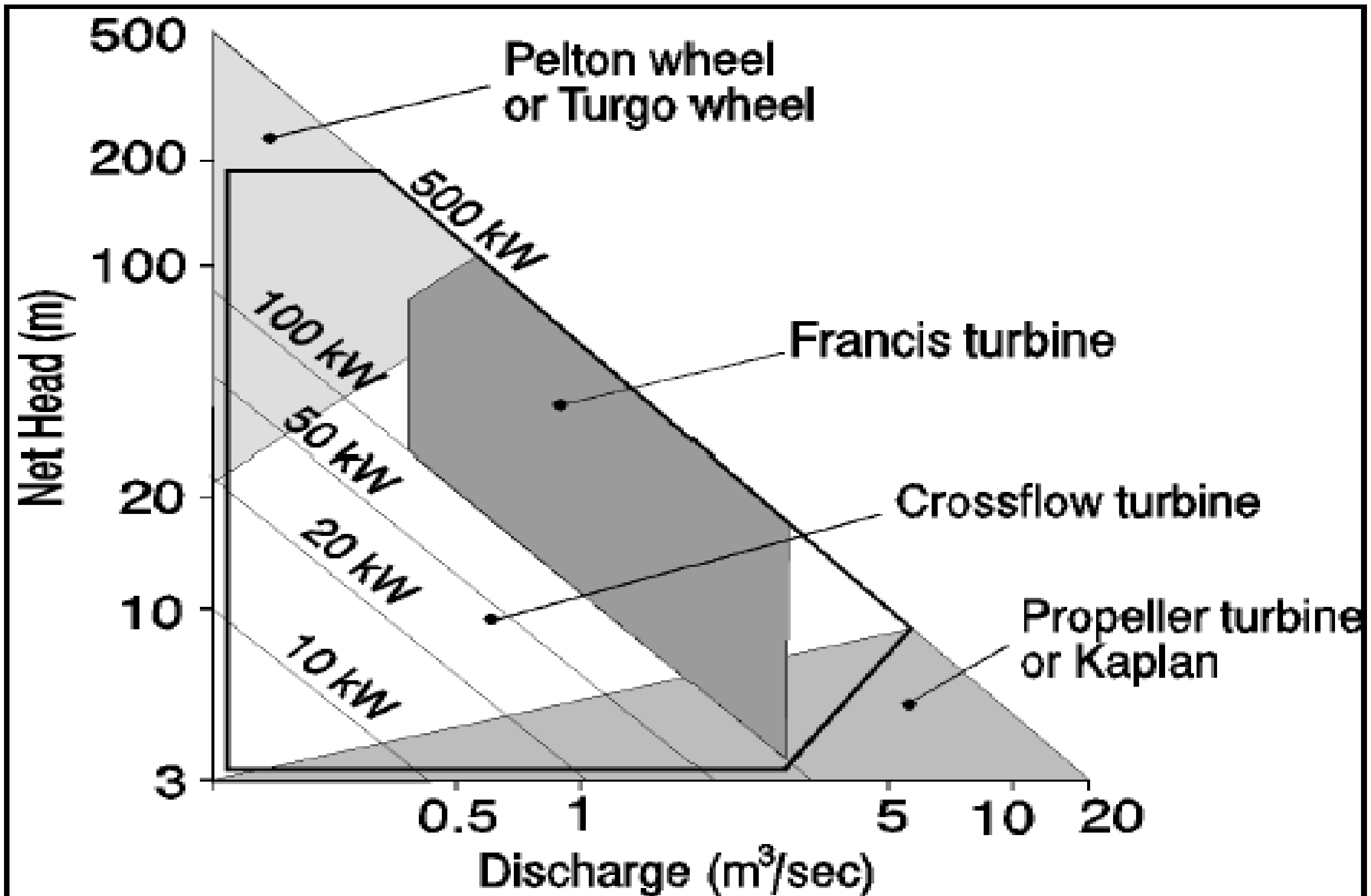
Kaplan / Propeller Turbine



Turbine Selection Nomogram:



HEAD-FLOW RANGES OF SMALL HYDRO TURBINES



CES-MICROHYDRO

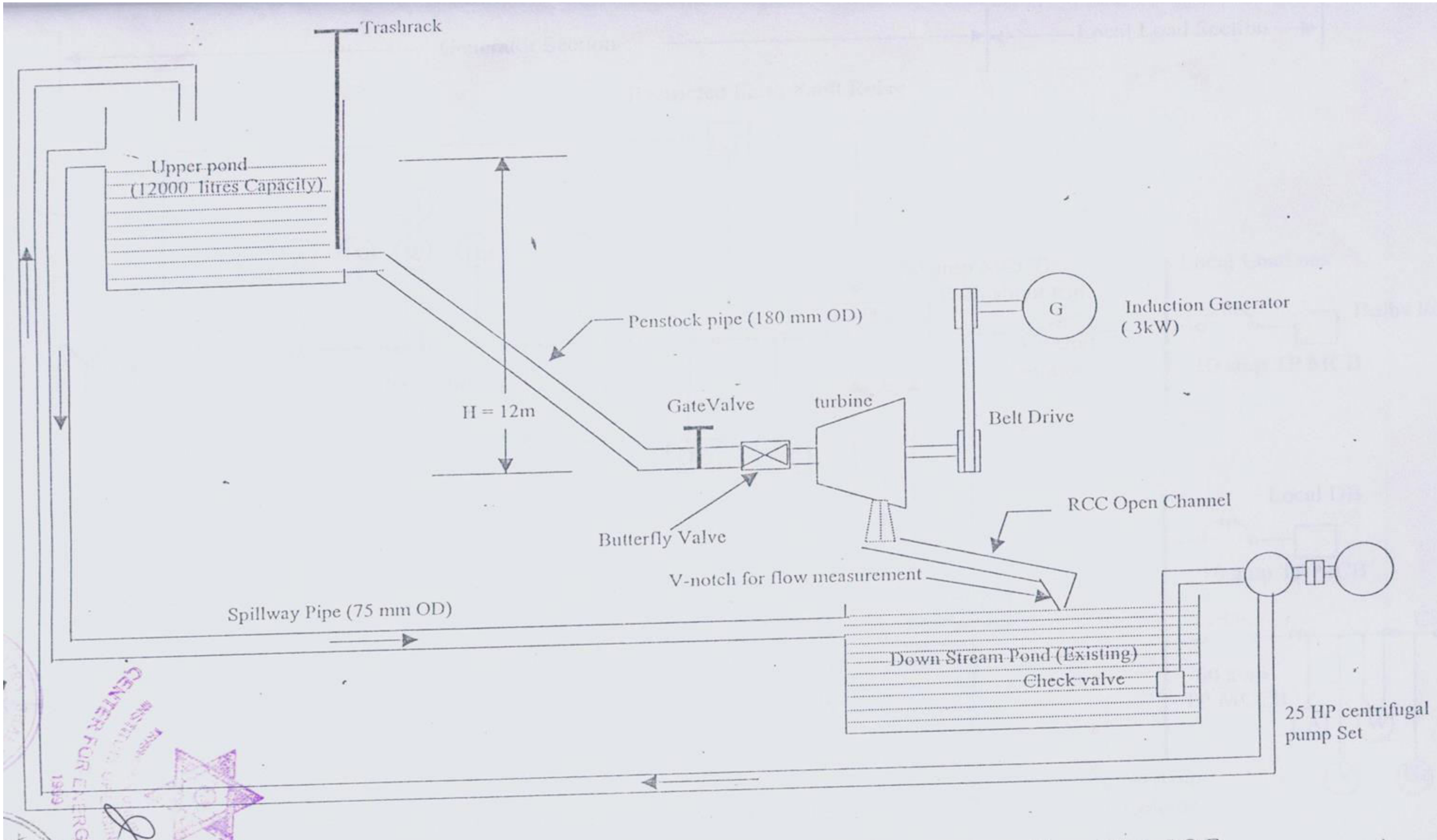


Fig.1 General Arrangement of Hydraulic System of Micro-Hydro Plant at Energy Park, I.O.E.

Parameters

Turbine Type

- Cross-flow turbine
- Output- 3 kW
- Net design head 11 m
- Design discharge : 65 lit/sec
- Rated Speed 1500 rpm

Transmission System

- V belt, pulley (633 to 1500 rpm) to transmit torque from turbine shaft to generator shaft.

Induction Generator

- Capacity – 3 kW
- Voltage Rating- 380 Volts, Line to line
- Frequency – 50 Hz
- Connection – Star

Ballast load

- Capacity: 1.35 kW per phase
- Voltage rating: 230 Volts per phase
- Type: Air heater

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