The Rankine Cycle

Presented by
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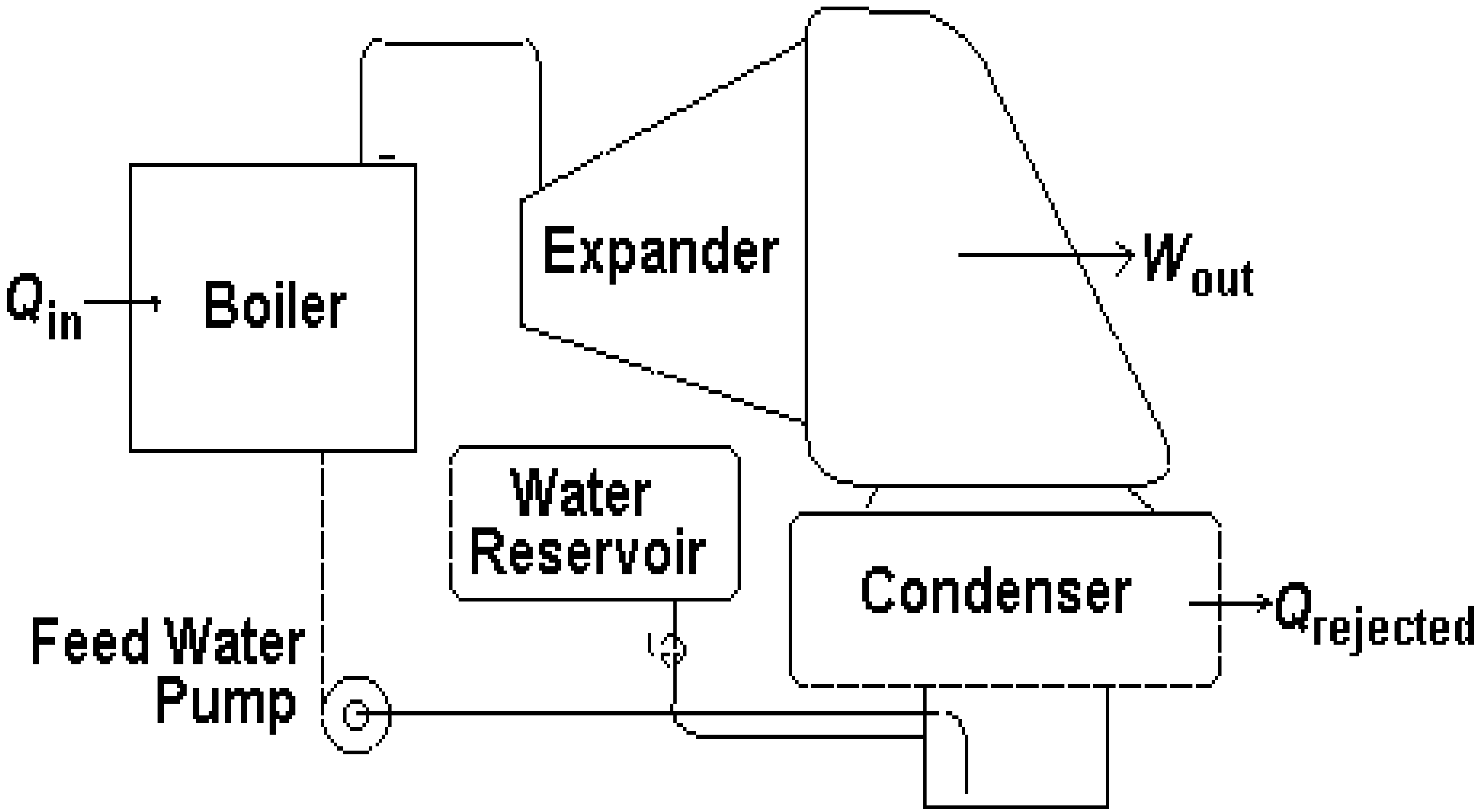
Trained as a civil engineer, **William Rankine** was appointed to the chair of civil engineering and mechanics at Glasgow in 1855. He developed methods to solve the force distribution in frame structures. He worked on heat, and attempted to derive Sadi Carnot**'s** law from his own hypothesis. His work was extended by Maxwell**.** Rankine also wrote on fatigue in the metal of railway axles, on Earth pressures in soil mechanics and the stability of walls. He was elected a Fellow of the Royal Society in 1853.
Among his most important works are *Manual of Applied Mechanics* (1858), *Manual of the Steam Engine and Other Prime Movers* (1859) and *On the Thermodynamic Theory of Waves of Finite Longitudinal Disturbance*.

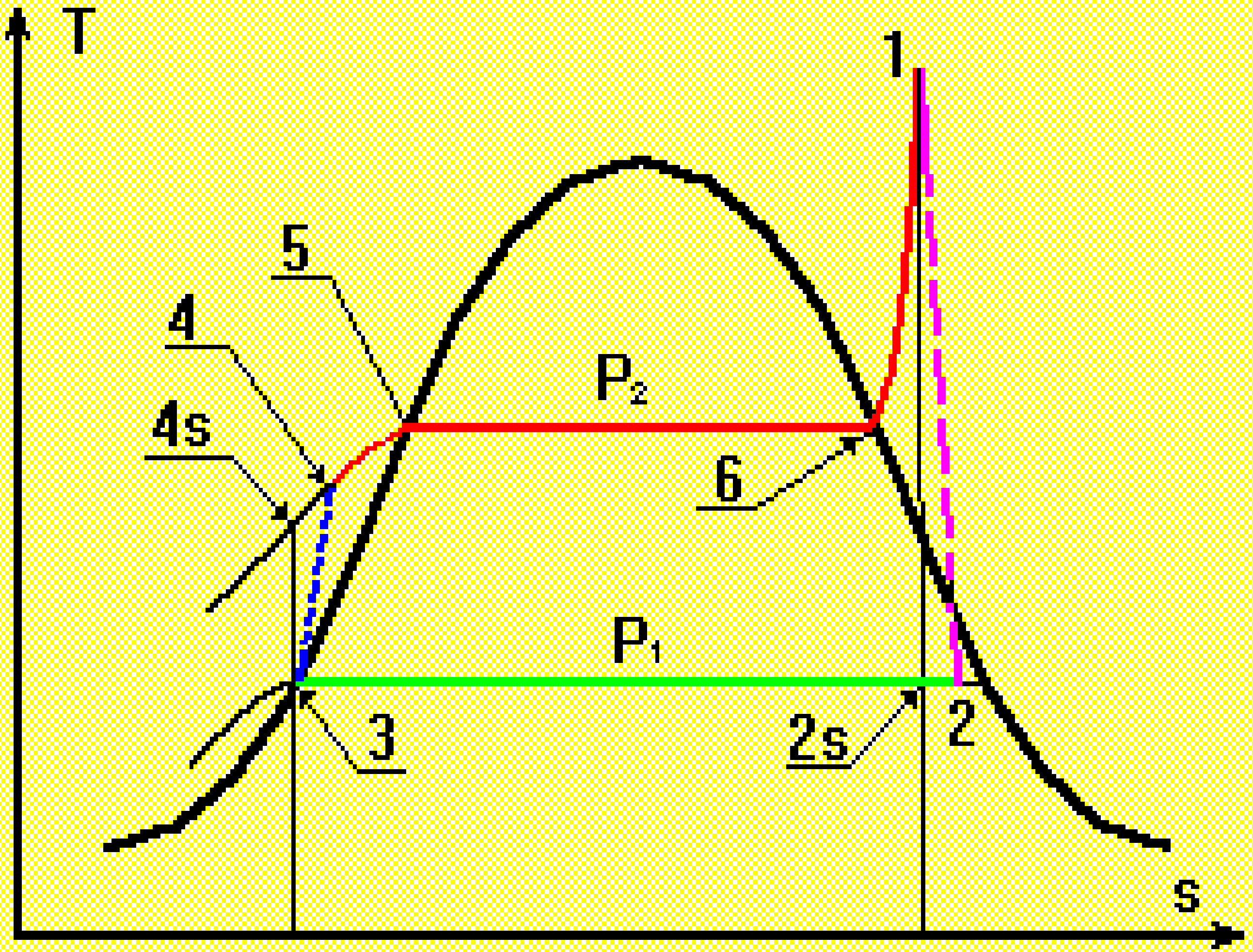
Objectives

- Brief overview of Rankine Cycle
- Basic plant layout including:
  - Steam Generator
  - Turbine Generator
  - Condensor
  - Pump
- Calculations and Examples
- Review
- Q & A

The Basic Rankine Cycle

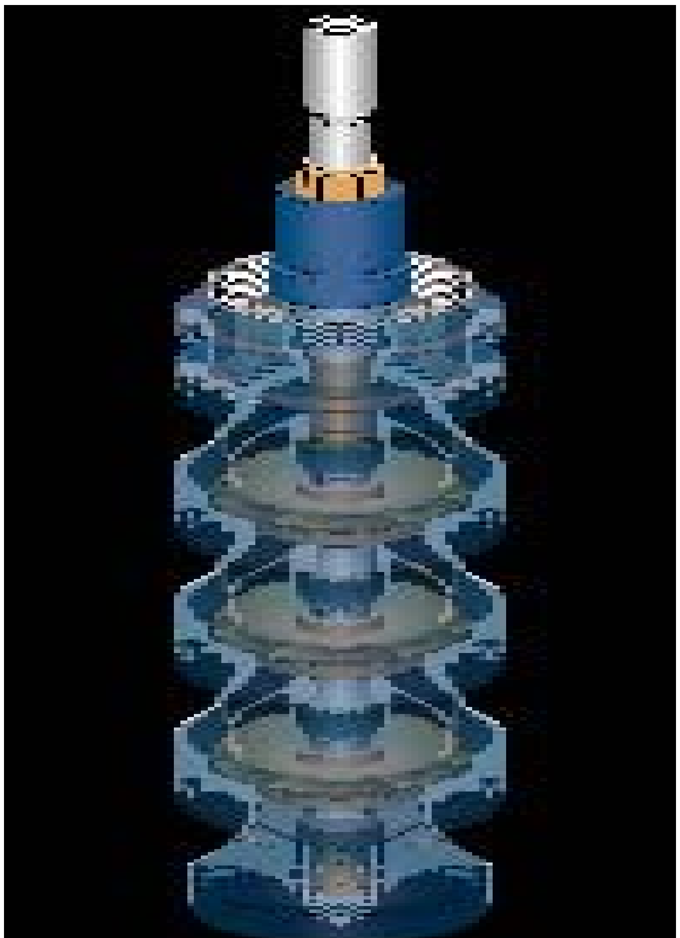


Temperature Entropy Diagram



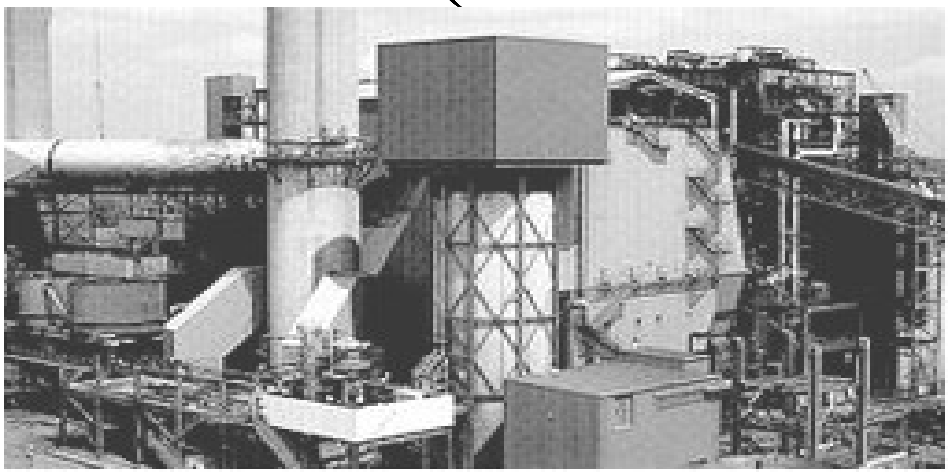
T-s diagram for a Rankine cycle.

Isentropic Compression (via Centrifugal Pump)

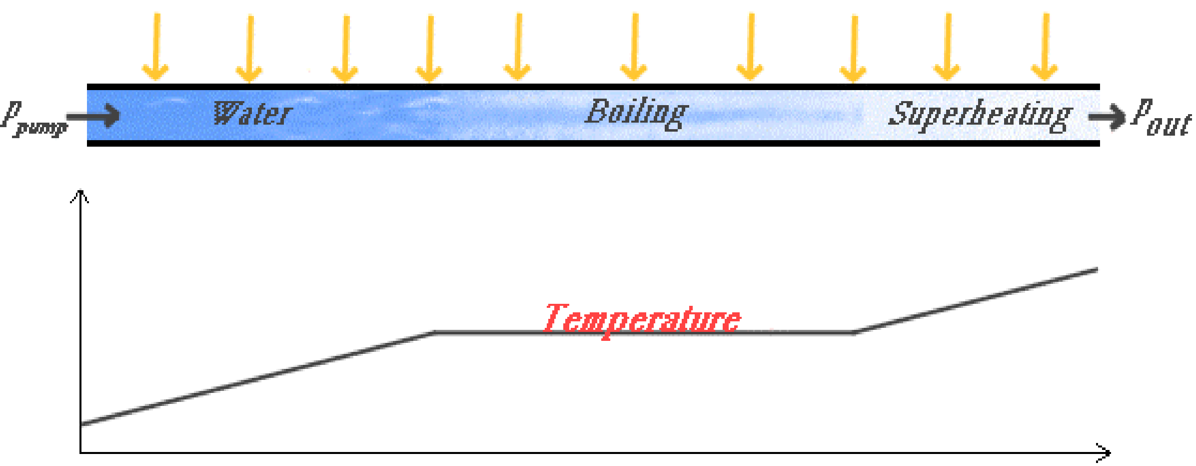


- **3 to 4: Isentropic compression (Pump)**
- **Work of the Pump**
  - $W_P = m(h_3 - h_4)$

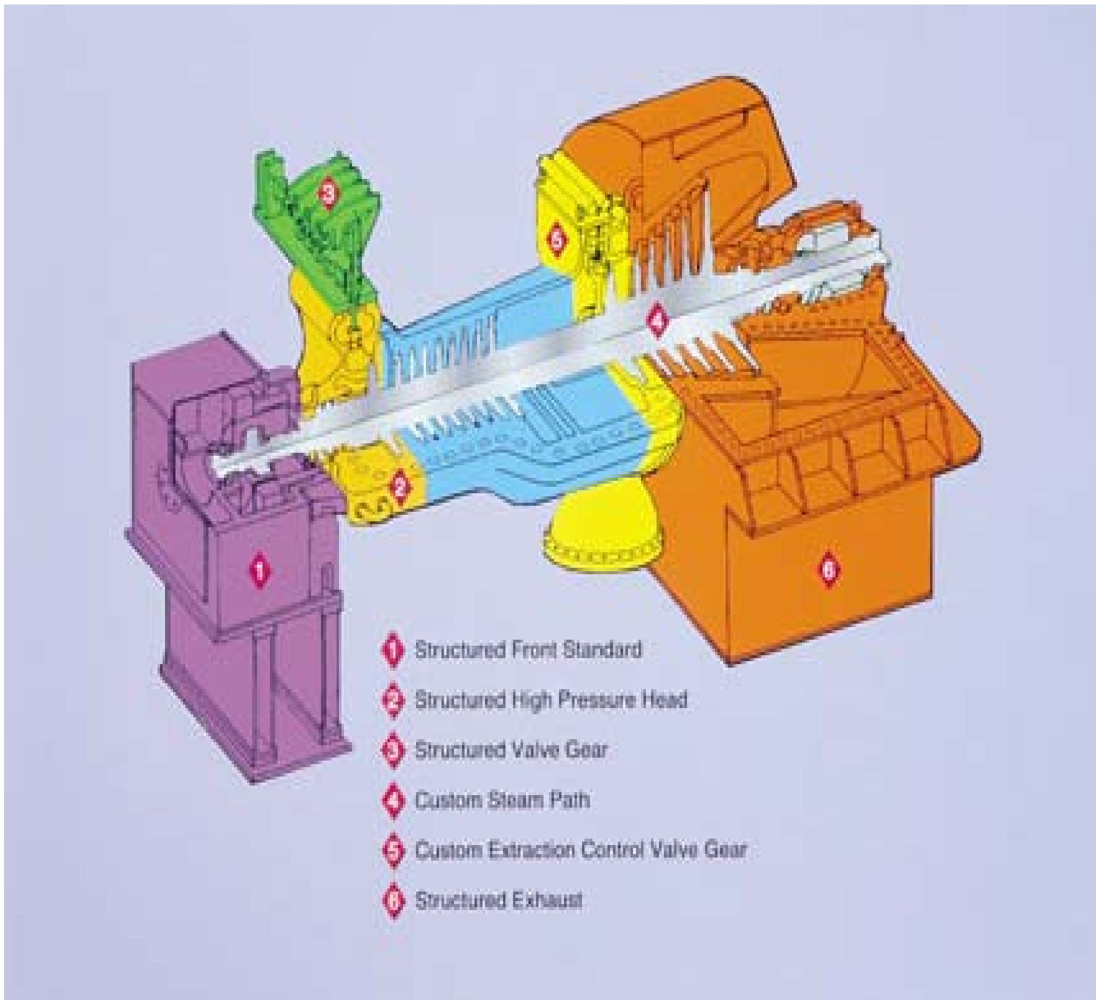
Isobaric Heat Transfer (via Steam Generator)



- 4 to 1: Isobaric heat supply (Steam Generator)
- Energy added in Steam Generator:
  - $Q_{IN}=m(h_1-h_4)$



Isentropic Expansion of Steam
(Energy Extracted via Turbine Generator)



- **1 to 2: Isentropic expansion (Steam turbine)**
- **Work done on Turbine:**
  - **$W_T = m(h_1 - h_2)$**

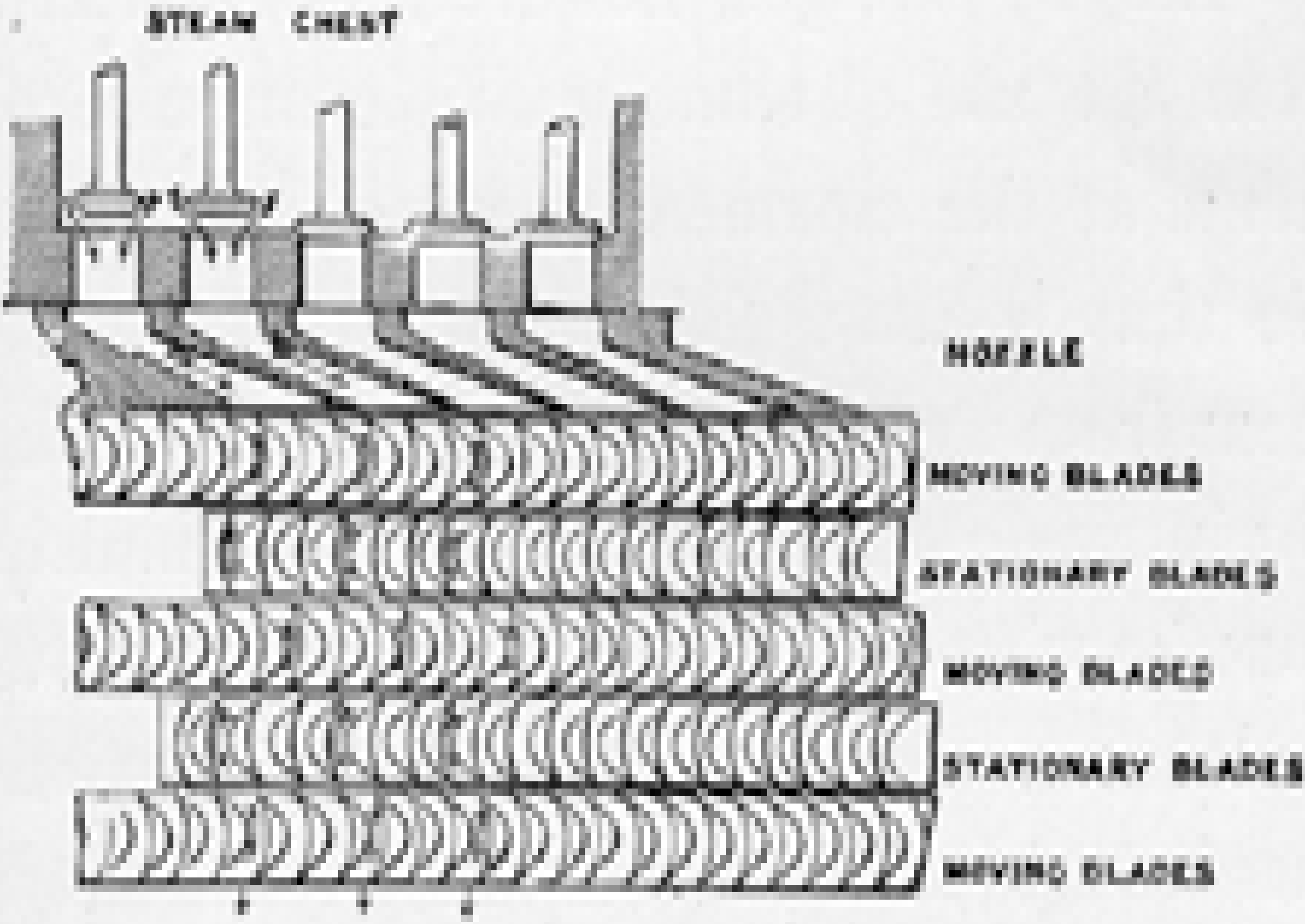
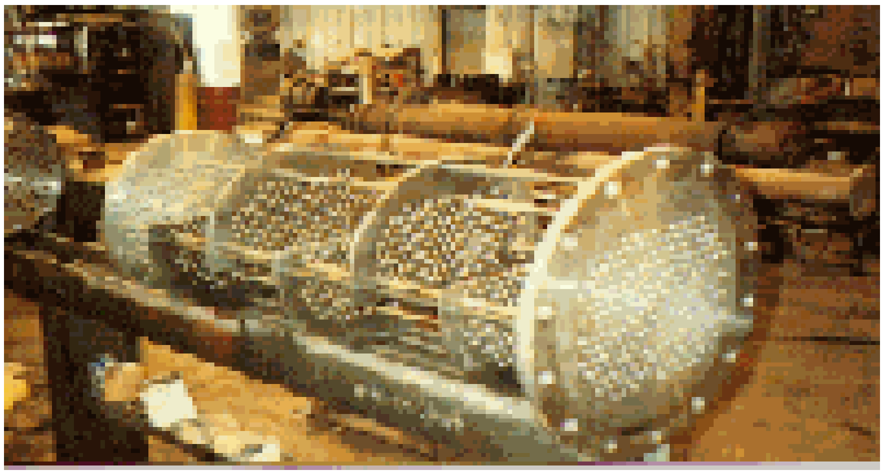



Fig. 27. Diagram of Curtis Blades and Nozzles.

Isobaric Heat Rejection (via Condenser)



- 2 to 3: Isobaric heat rejection (Condenser)
- Heat Rejected in Condenser
  - $Q_{OUT}=m(h_2-h_3)$

Calculations

- Work output of the cycle (Steam turbine), **W1** and work input to the cycle (Pump), **W2** are:

  $W_T = m\ (h1-h2)$ $\qquad$ $W_P = m\ (h4-h3)$

  - where **m** is the mass flow of the cycle.
- Heat supplied to the cycle (boiler), **Q1** and heat rejected from the cycle (condenser), **Q2** are:

  $Q_{IN} = m\ (h_1-h_4)$ $\qquad$ $Q2 = m\ (h2-h3)$
- The net work output of the cycle is:
  - $W_{NET} = W_T - W_P$
- The thermal efficiency of a Rankine cycle is:
  - $\eta = W_{NET} / Q_{IN}$