POWER MACHINERY, LLC

By:

Steven G. Reyenga

POWER MACHINERY, LLC
Pipeline And Refinery Equipment

"CENTRIFUGAL PUMP RERATES" OPTIONS AND ECONOMICS

BY: STEVEN G. REYENGA

I. PROCESS PUMPS
   A. Efficiency
   B. NPSHR = NSS Considerations
   C. Flow Range vs. Head
   D. Cost vs. Performance

II. HIGH ENERGY MULTISTAGE AND BARREL DESIGNS
   A. Efficiency
   B. NPSHR = NSS Considerations
   C. Flow Range vs. Head
   D. Cost vs. Performance

III. GENERAL HYDRAULIC DESIGNS FOR VARIOUS SPECIFIC SPEED DESIGN CRITERIA
   A. Efficiency
   B. NPSHR = NSS Considerations
   C. Flow Range vs. Head
   D. Cost vs. Performance

IV.

13424 HEMPSTEAD ROAD
HOUSTON, TX 77040
E-mail: info@pmi-pump.com
TEL: 713-462-3176
FAX: 713-462-4097
Web-site: http://www.pmi-pump.com/

DESIGN CONSIDERATIONS

A. Volute Lip and Nozzle Sizes (areas)
   a. Insert (Low flow)
   b. Cut Back (High flow)

B. Base Circle versus Impeller Hydraulics
   a. Clearance
   b. Hydraulic Centerline and Mechanical Centerline

C. Speed versus Design Conditions
   a. Velocity
   b. Kinetic Energy to Pressure Energy

D. Cost to Modify
   a. Volute Lip Cut Back
   b. Volute Lip Insert
   c. Impeller Change
      - Low Flow
      - High Flow
      - Number Vanes
      - Curve Shape
   d. Hydraulic Balance

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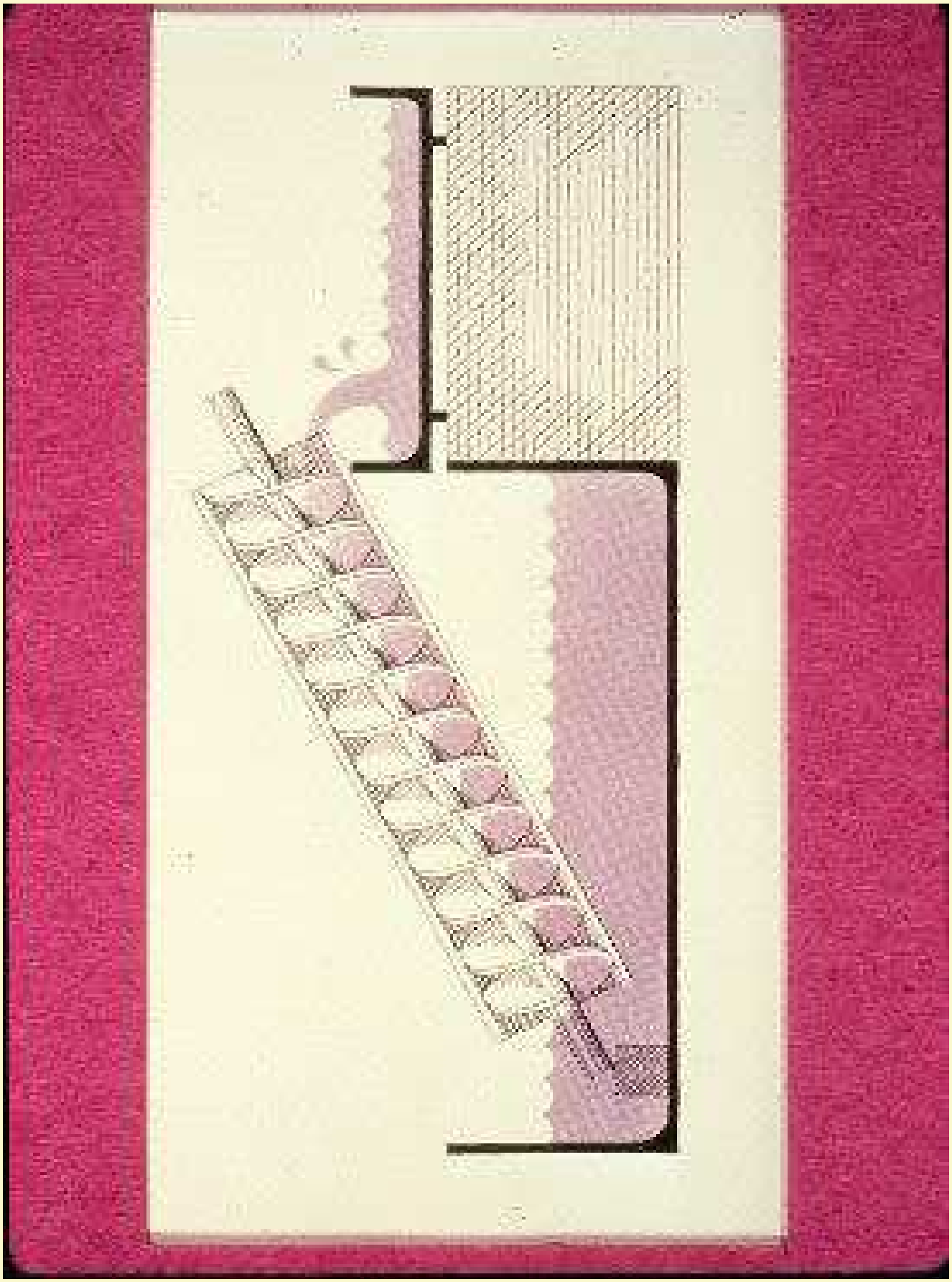
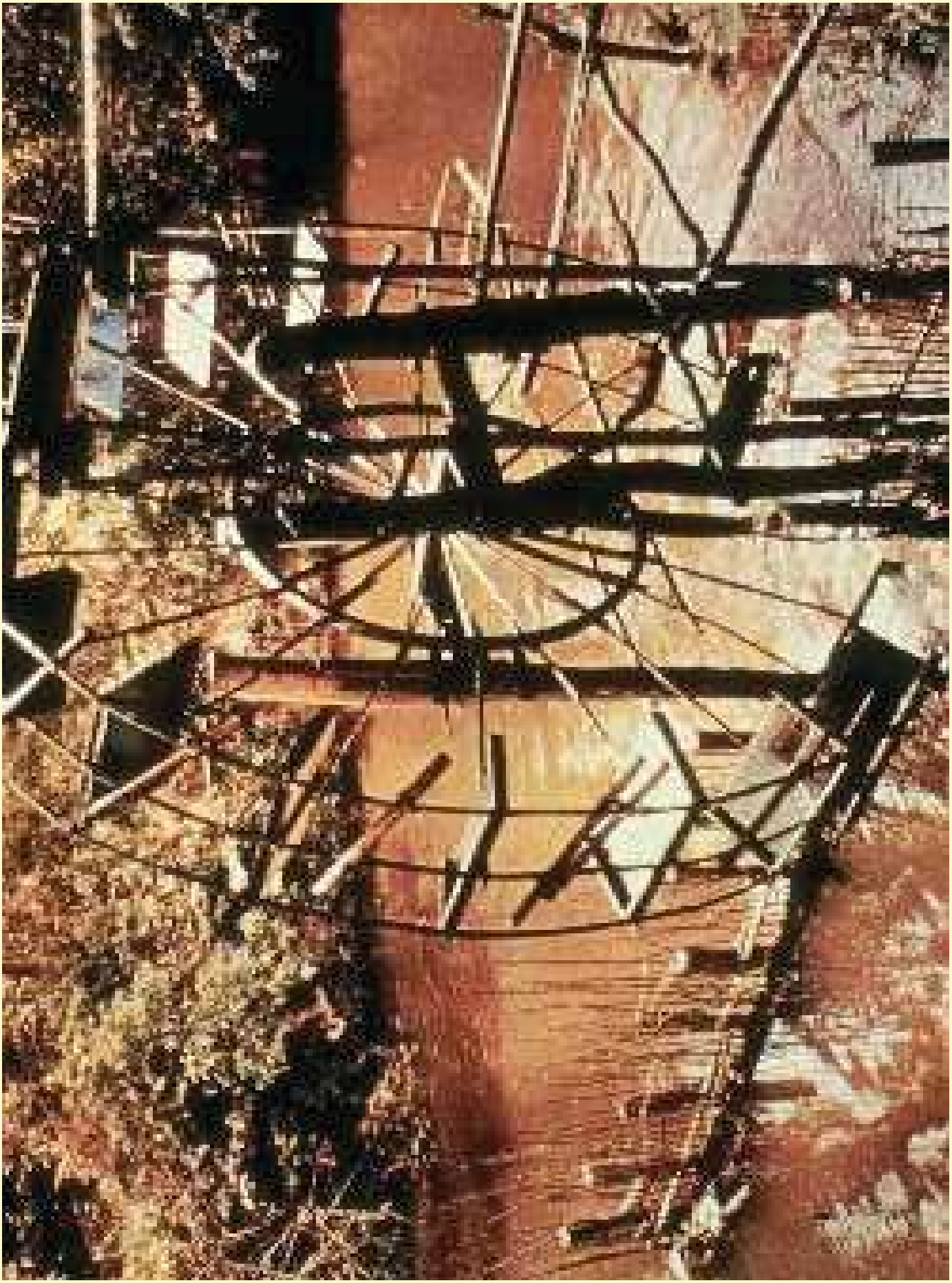
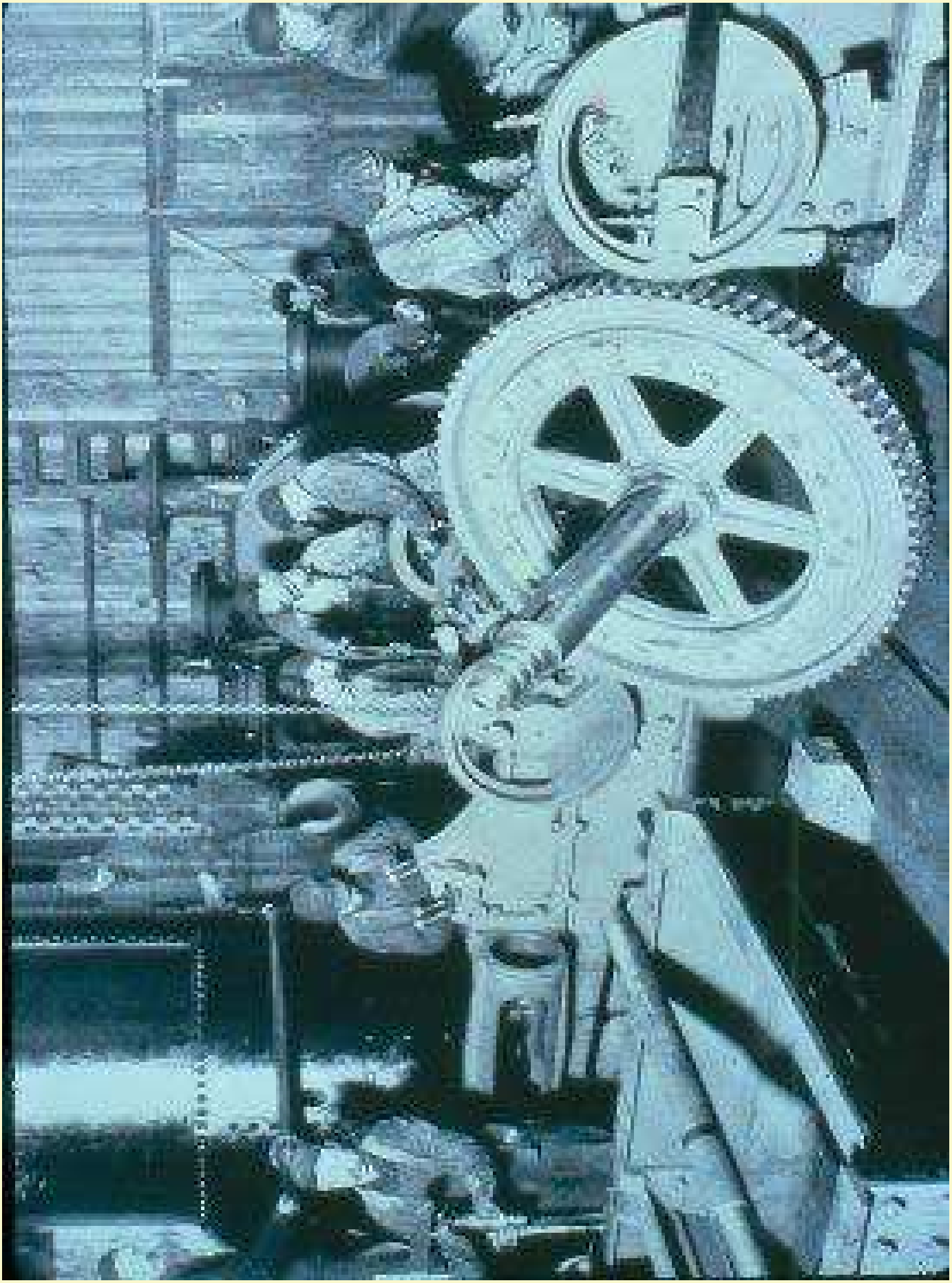






Engineering Data Book

directed to a center 3 : of or relating to a nerve center — **cen·tri·cal·ly** \-tri-k(ə-)lē\ *adv* — **cen·tric·i·ty** \sen-'tris-ət-ē\ *n*

-cen·tric \'sen-trik\ *adj comb form* [ML *-centricus*, fr. L *centrum* center] : having (such) a center or (such or so many) centers ⟨*polycentric*⟩ ; having (something specified) as its center ⟨*heliocentric*⟩

¹cen·trif·u·gal \sen-'trif-yə-gəl, -'trif-i-gal\ *adj* [NL *centrifugus*, fr. *centr-* + L *fugere* to flee] 1 : proceeding or acting in a direction away from a center or axis 2 : using or acting by centrifugal force 3 : EFFERENT — **cen·trif·u·gal·ly** \-gə-lē\ *adv*

²centrifugal *n* : a centrifuged machine or a drum in such a machine

centrifugal force *n* : the force that tends to impel a thing or parts of a thing outward from a center of rotation

cen·trif·u·ga·tion \(,)sen,trif-(y)ə-'gā-shən, (,)sin-\ *n* : the process of centrifuging

¹cen·tri·fuge \'sen-trə,fyüj, 'sän-\ *n* [F, fr. *centrifuge* centrifugal, fr. NL *centrifugus*] : a machine using centrifugal force for separating substances of different densities, for removing moisture, or for simulating gravitational effects

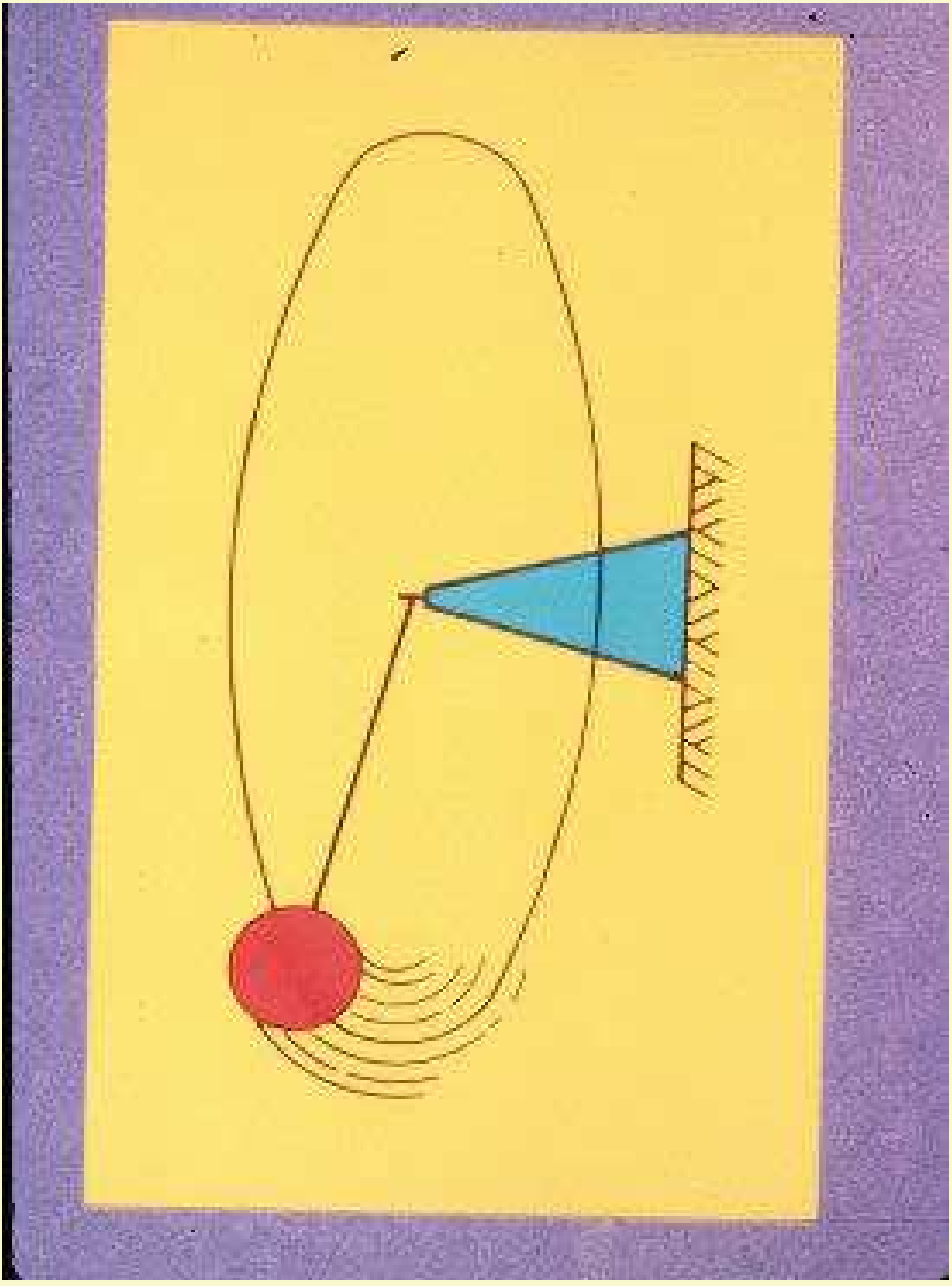
²centrifuge *vt* : to subject to centrifugal action esp. in a centrifuge

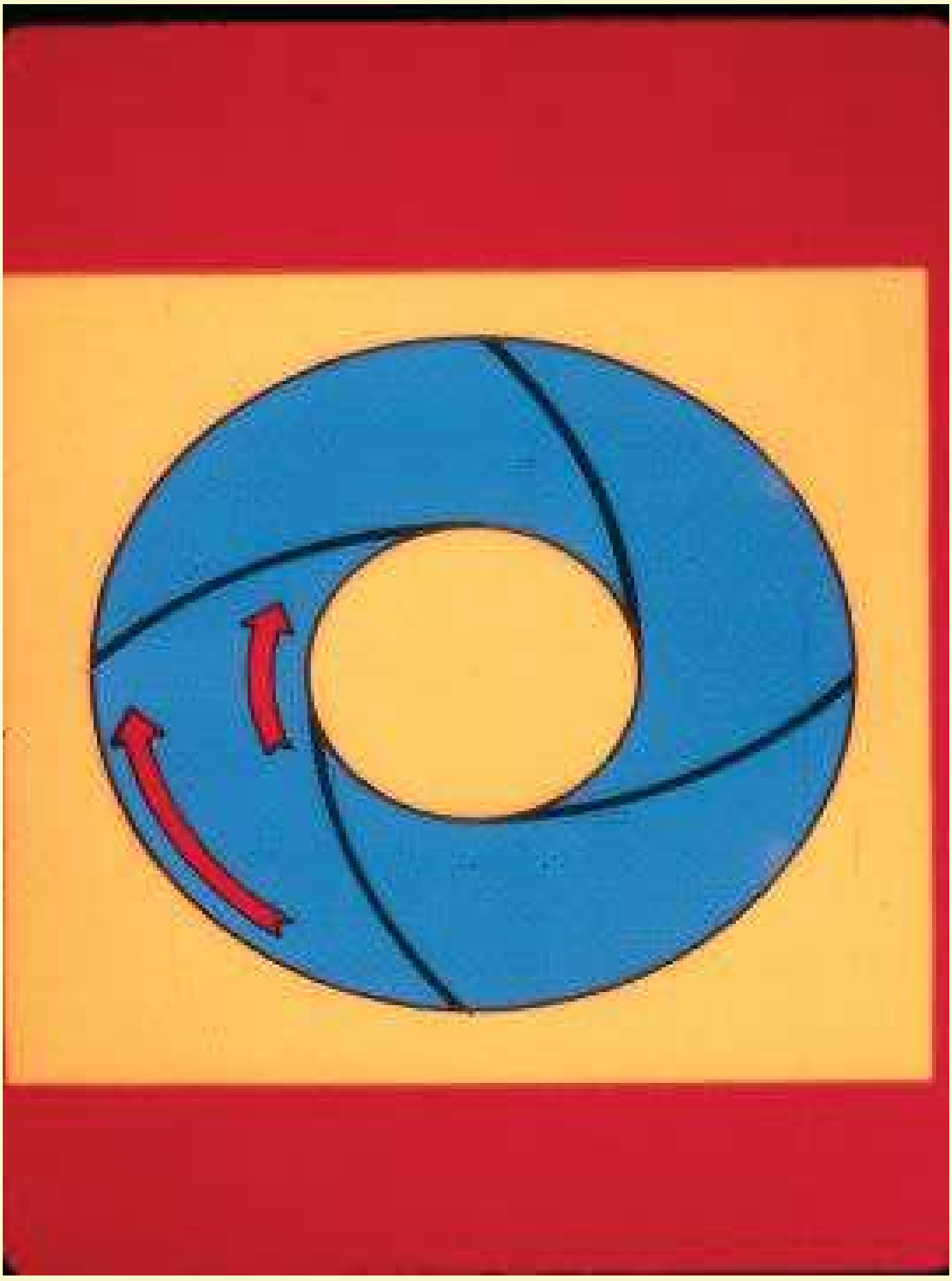
cen·tri·ole \'sen-trē-,ōl\ *n* [G *centriol*, fr. *zentrum* center] 1 : a minute body forming the center of a centrosome 2 : CENTROSOME 1

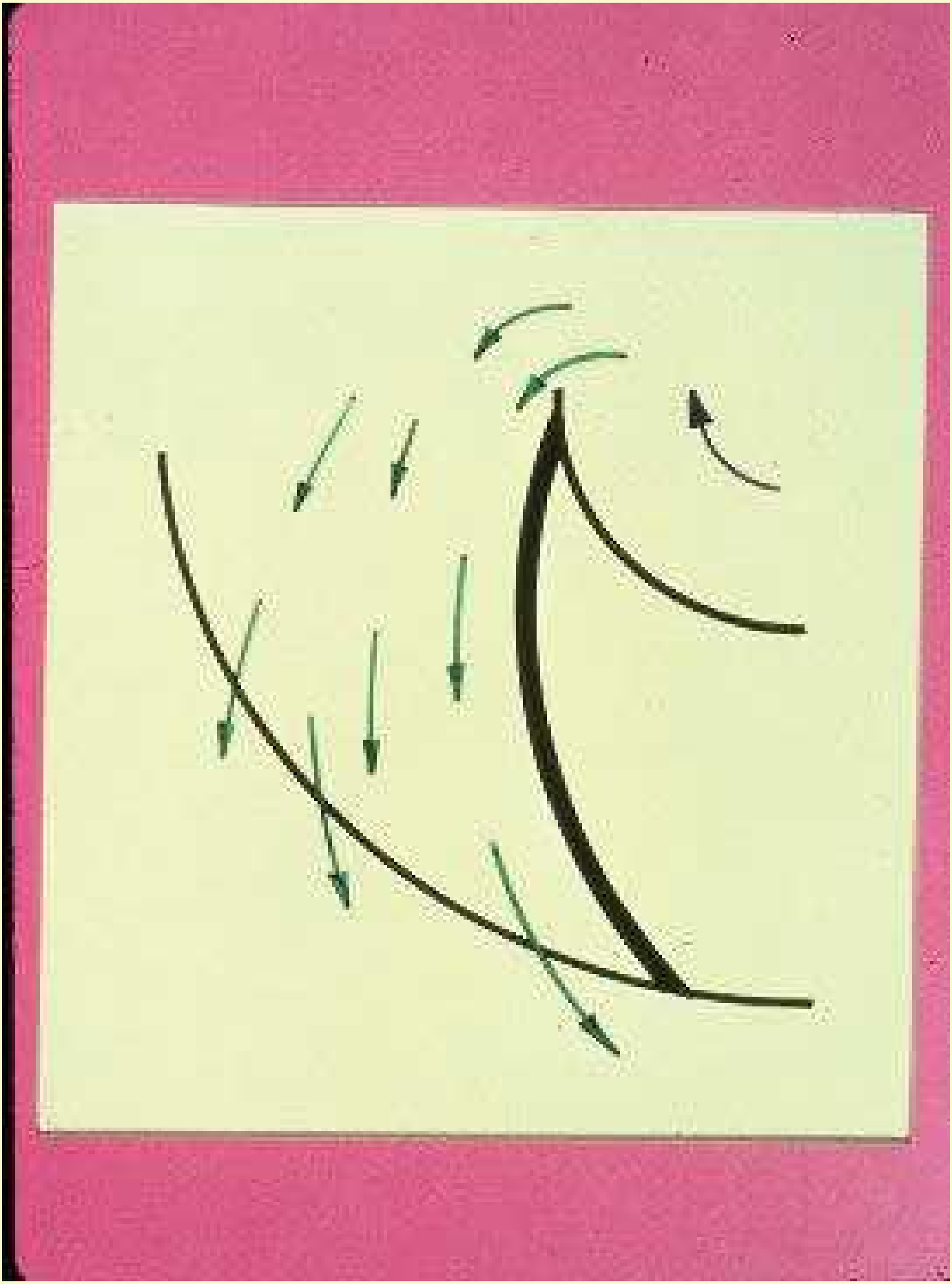
cen·trip·e·tal \sen-'trip-ət-ᵊl\ *adj* [NL *centripetus*, fr. *centr-* + L *petere* to go to, seek] 1 : proceeding or acting in a direction toward a center or axis 2 : AFFERENT — **cen·trip·e·tal·ly** \-ᵊl-ē\ *adv*

centripetal force *n* : the force that tends to impel a thing or parts of a thing inward toward a center of rotation

cen·trist \'sen-trəst\ *n* 1 *often cap* : a member of a center party







SPECIFIC SPEED

SPECIFIC SPEED IS THE SPEED IN REVOLUTIONS PER MINUTE AN IMPELLER WOULD RUN IF REDUCED IN SIZE TO DELIVER A CAPACITY OF ONE GALLON PER MINUTE WHILE PUMPING AGAINST A HEAD OF ONE FOOT.

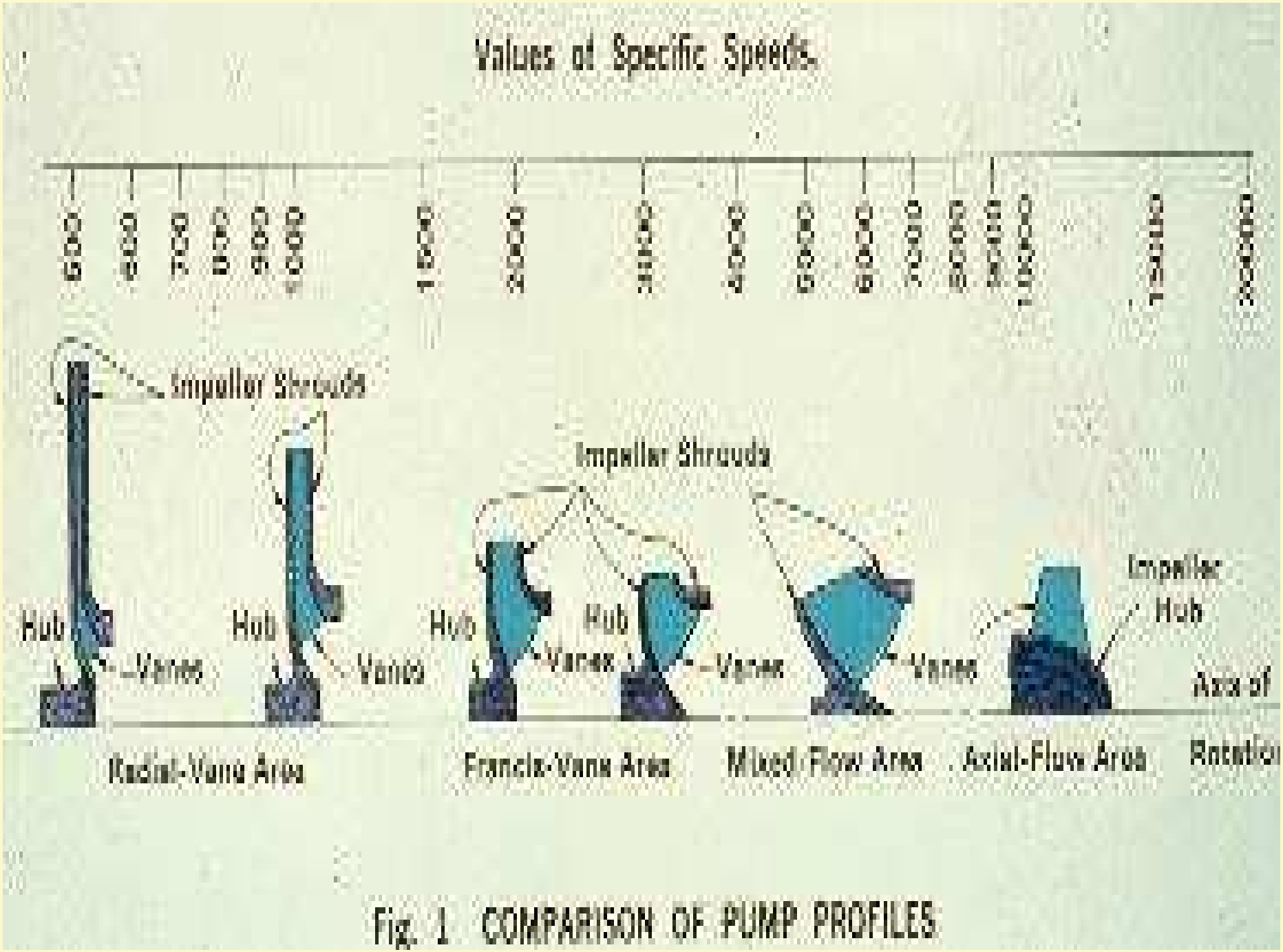


Fig. 1 COMPARISON OF PUMP PROFILES

SPECIFIC SPEED (N_S)

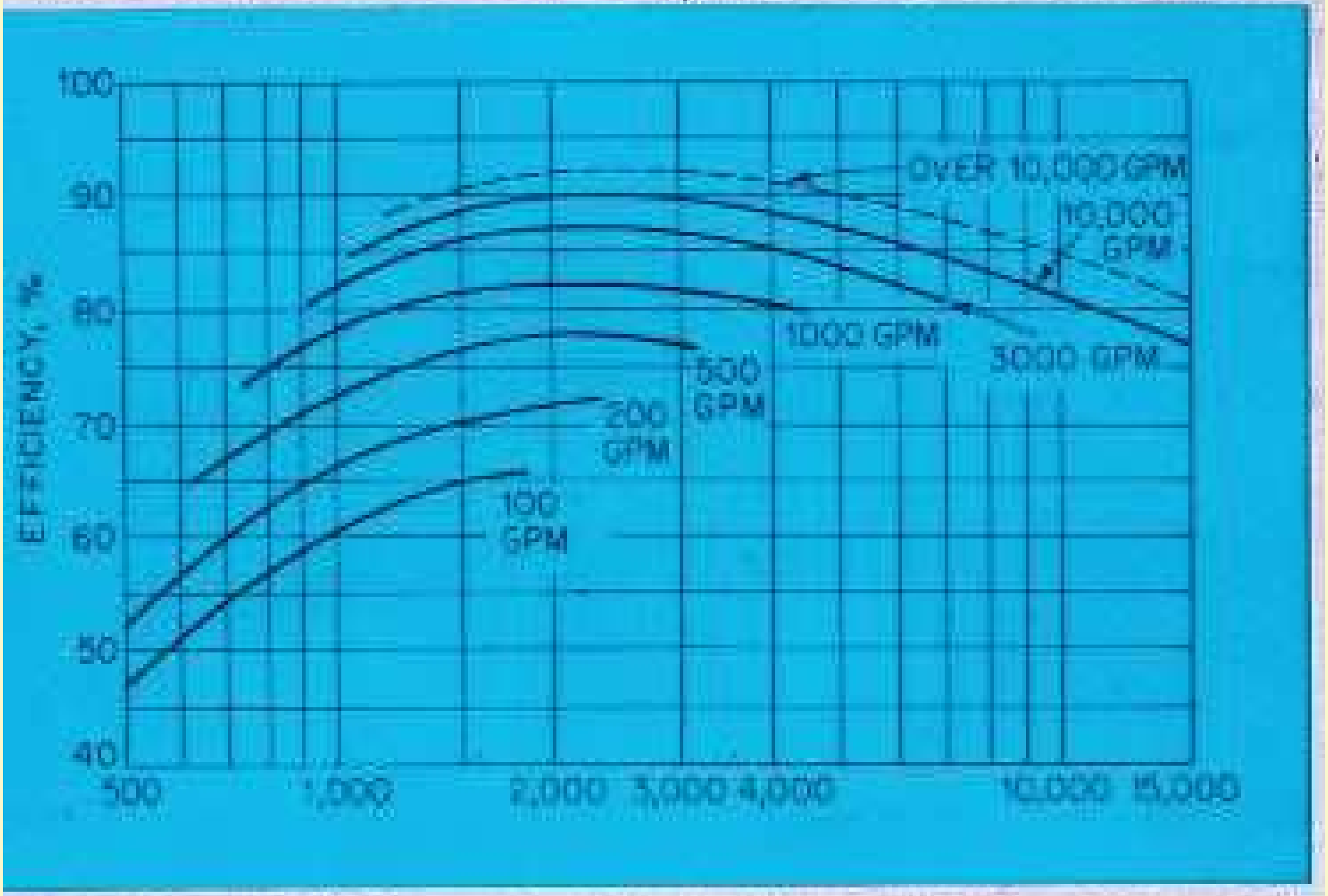
$$N_S = \frac{N Q^{1/2}}{H^{3/4}}$$

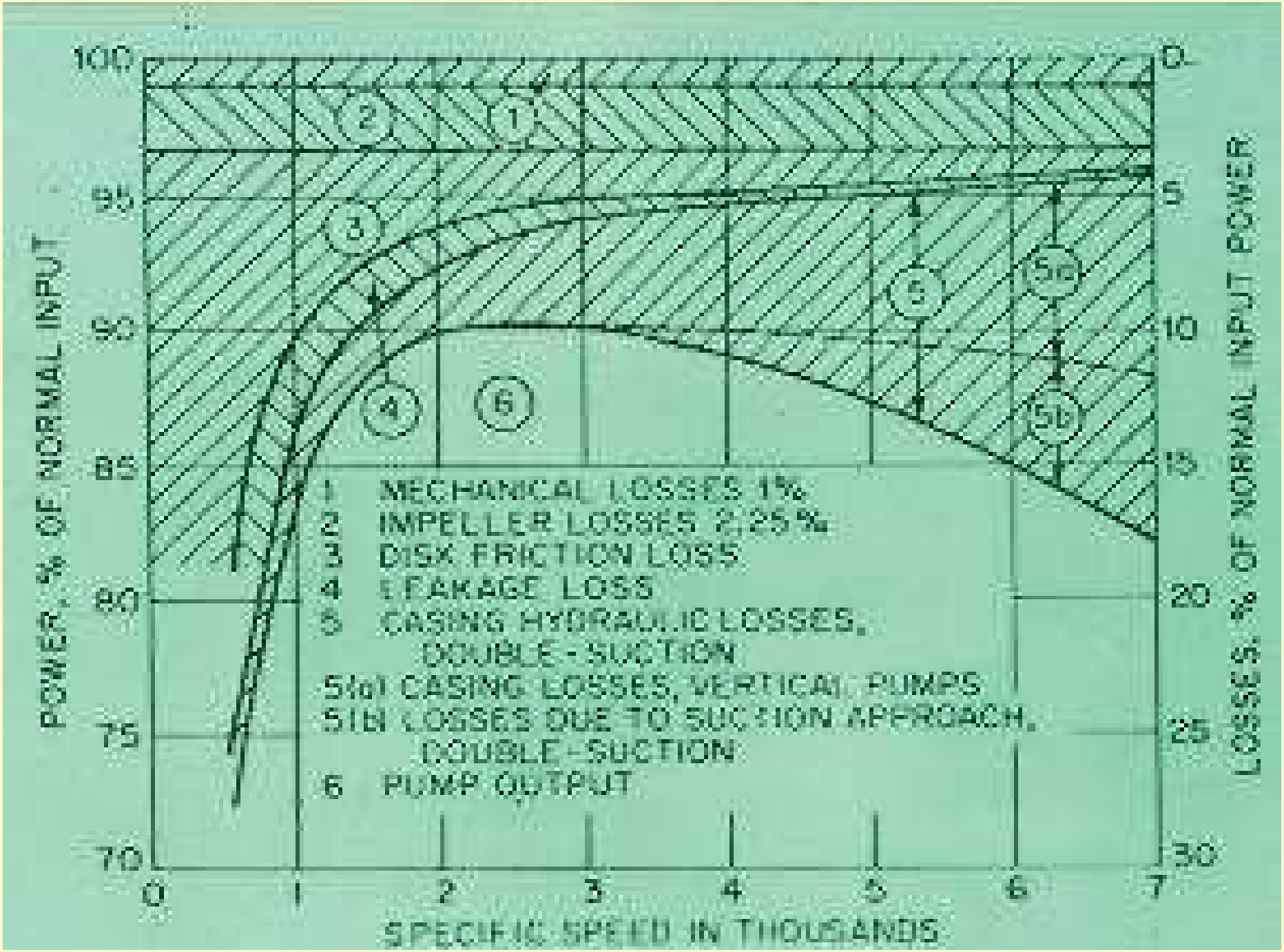
Where N is the speed (RPM)

Q is the capacity (GPM)

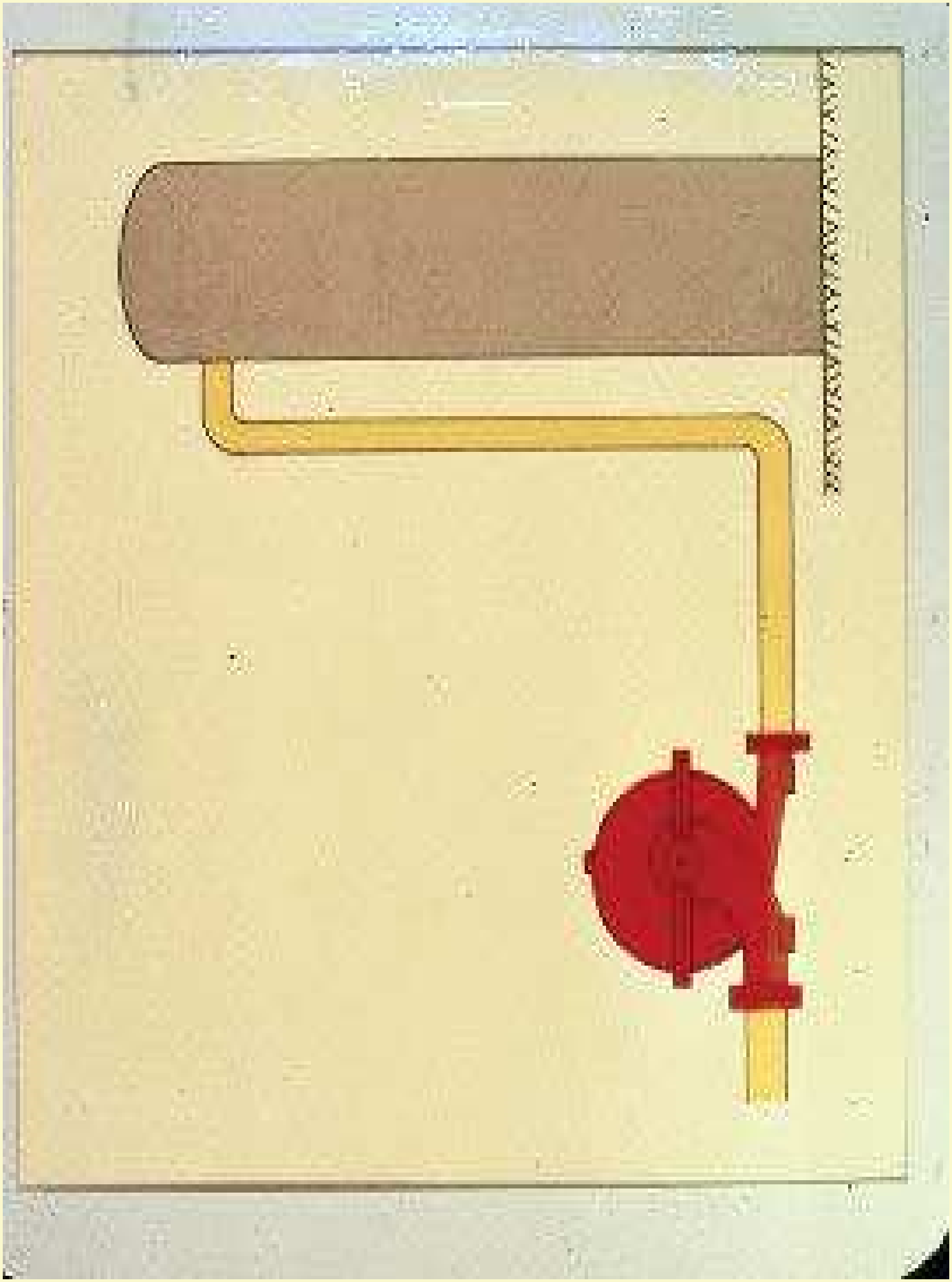
H is the head (FT)

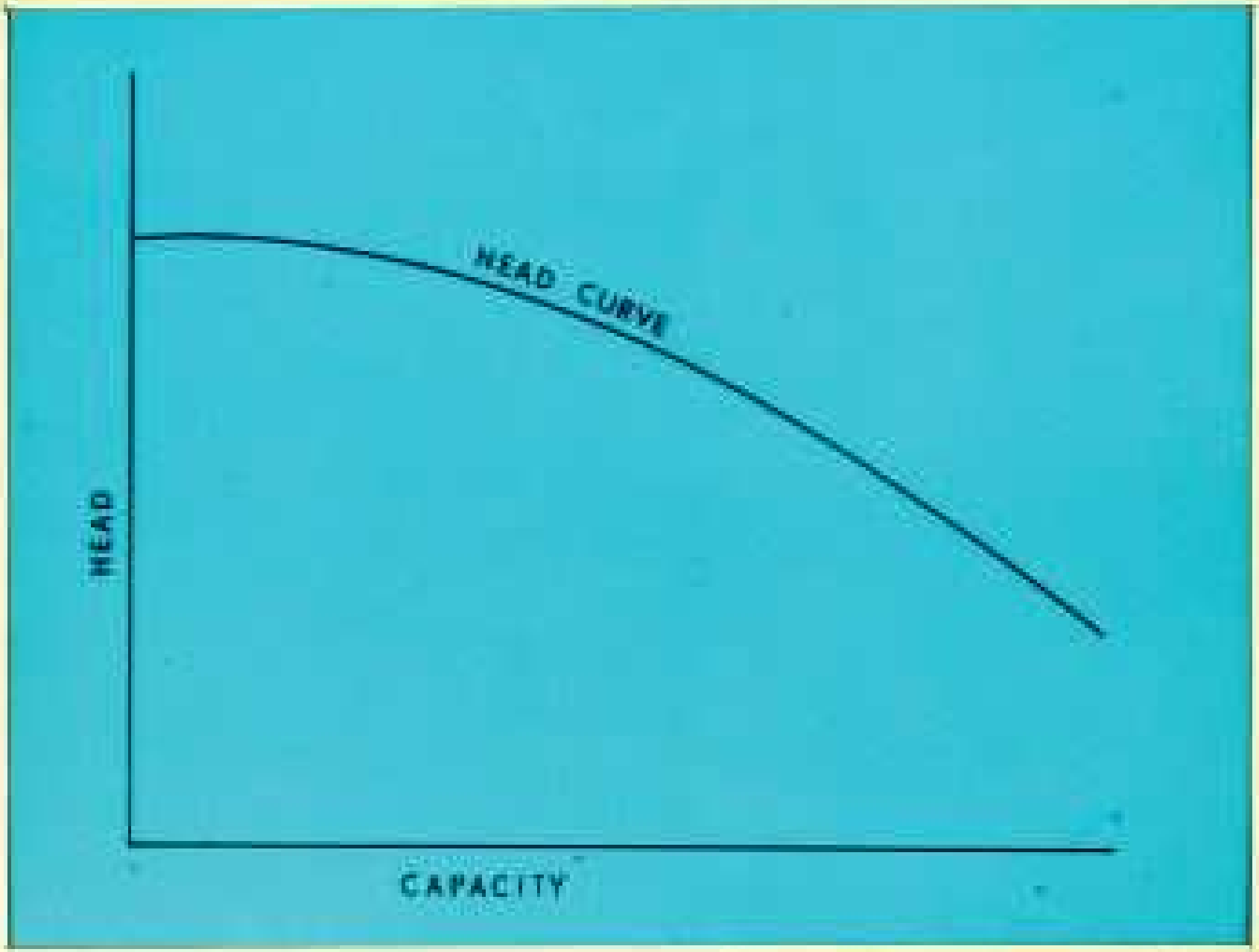
All terms taken at peak efficiency.

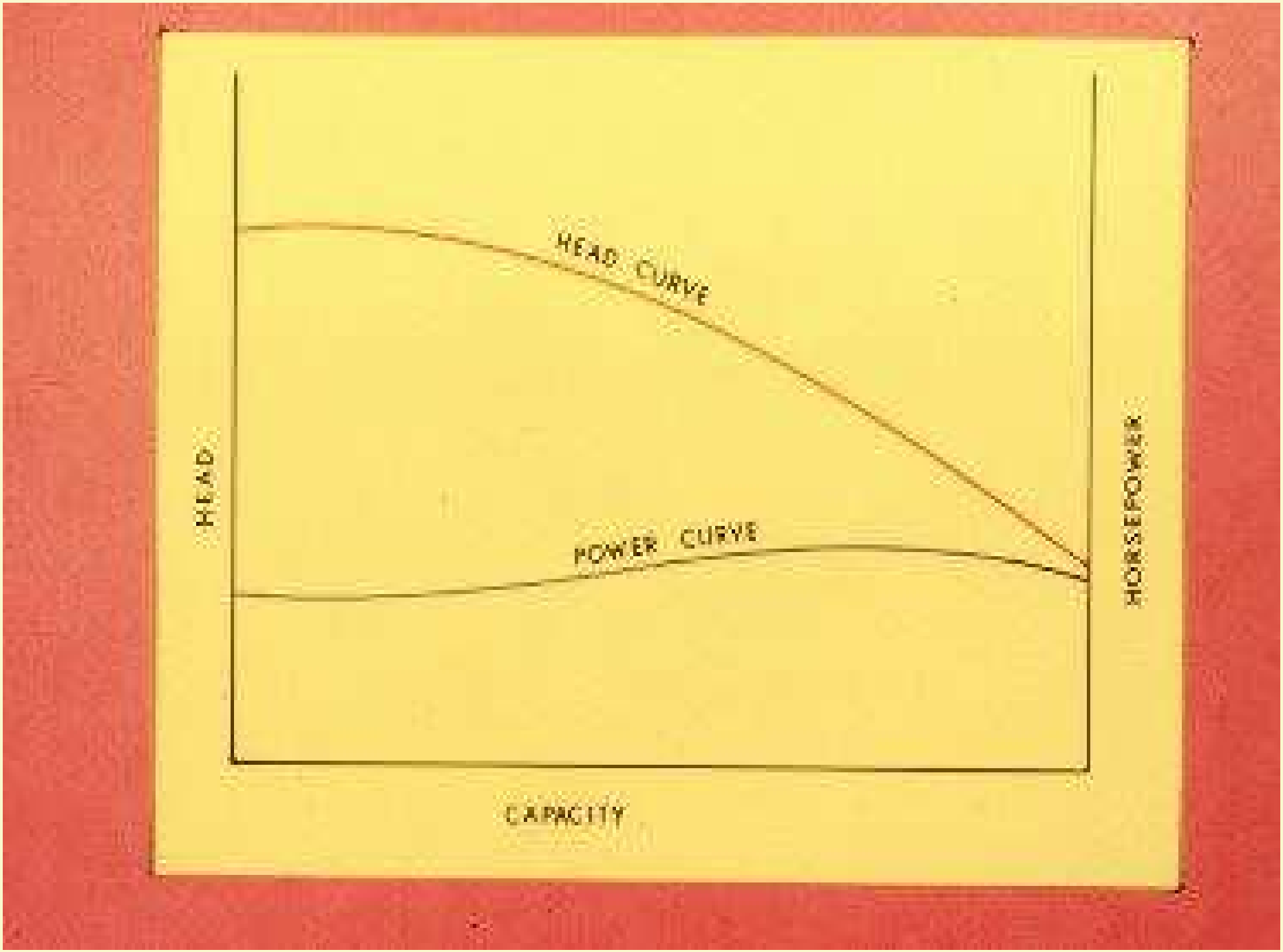

EFFICIENCY, %
100
90
80
70
60
50
40
500
1,500
2,000
3,000
4,000
10,000
15,000
OVER 10,000 GPM
10,000 GPM
3000 GPM
1000 GPM
500 GPM
200 GPM
100 GPM

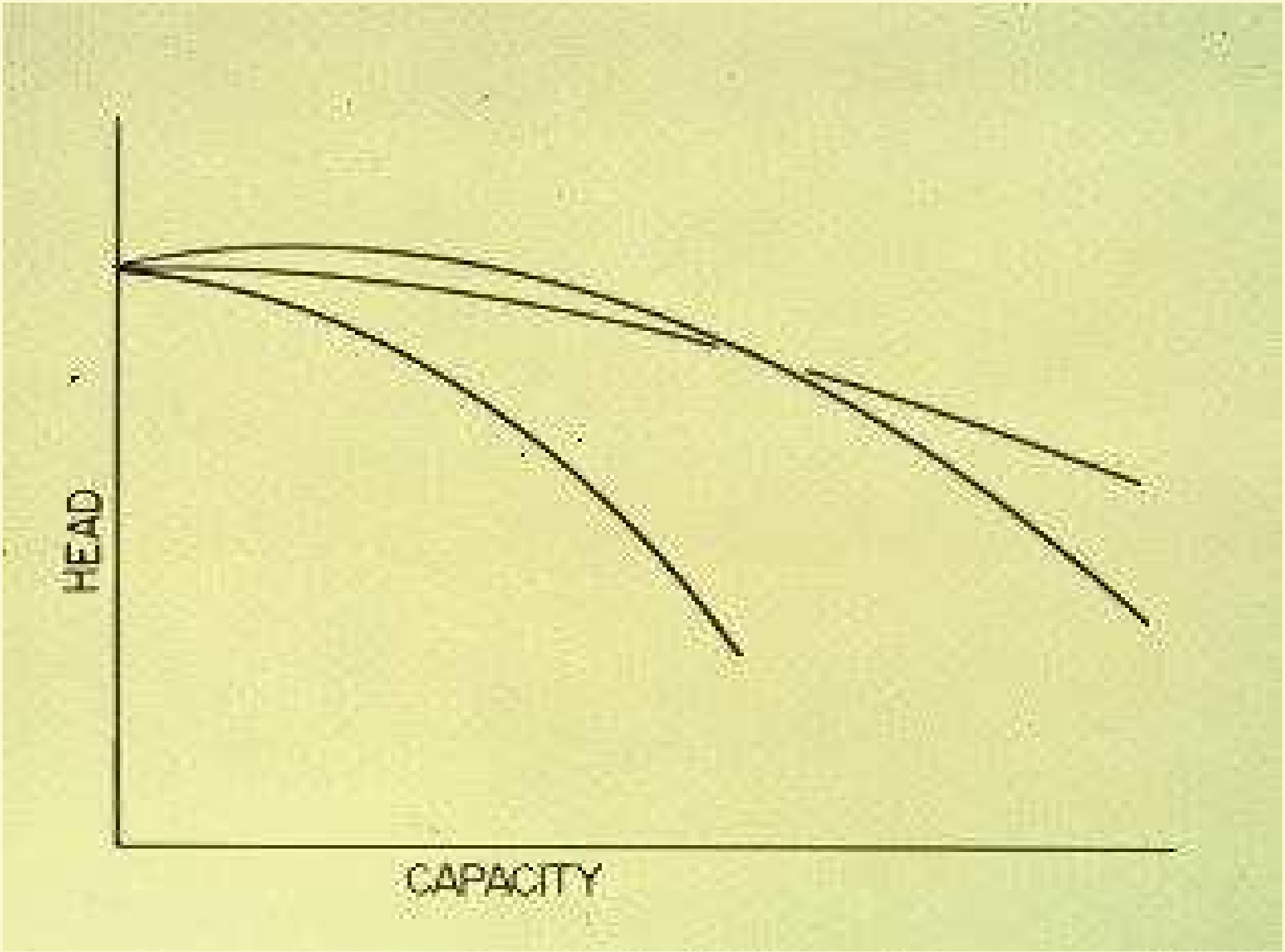

POWER, % OF NORMAL INPUT
LOSS, % OF NORMAL INPUT POWER
100
95
90
85
80
75
70
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7
SPECIFIC SPEED IN THOUSANDS
1 MECHANICAL LOSSES 1%
2 IMPELLER LOSSES 2.25%
3 DISK FRICTION LOSS
4 LEAKAGE LOSS
5 CASING HYDRAULIC LOSSES, DOUBLE-SUCTION
5(a) CASING LOSSES, VERTICAL PUMPS
5(b) LOSSES DUE TO SUCTION APPROACH, DOUBLE-SUCTION
6 PUMP OUTPUT

2E 941/942
G-6629

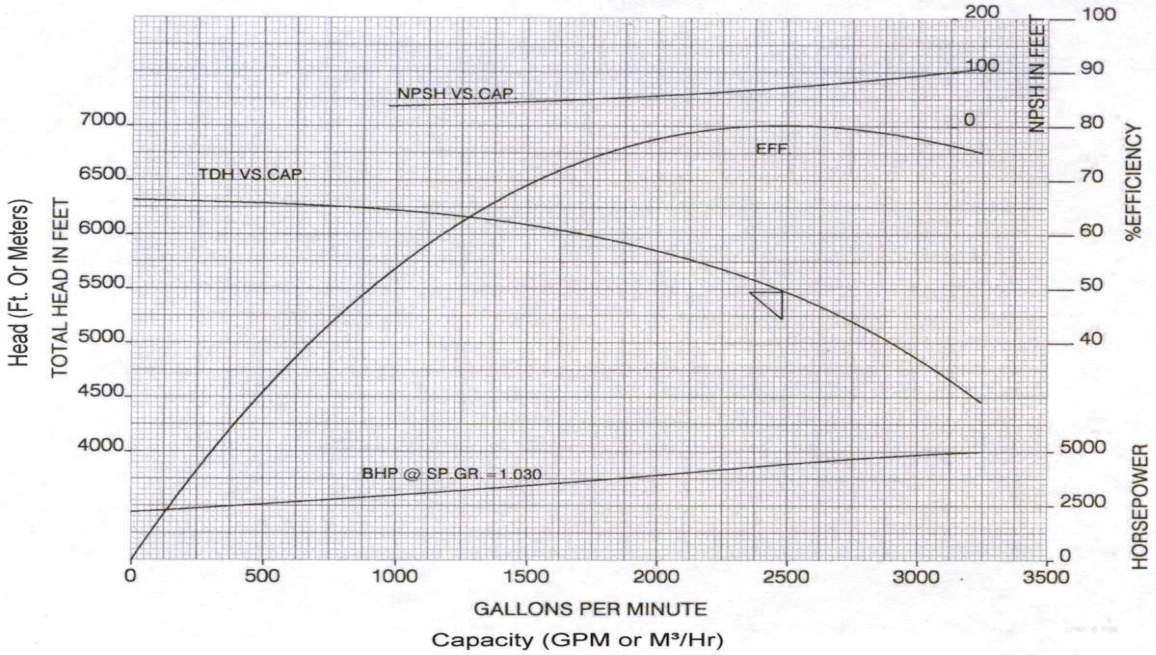



HEAD CURVE
HEAD
CAPACITY


HEAD CURVE
POWER CURVE
HEAD
HORSEPOWER
CAPACITY


HEAD
CAPACITY

CENTRIFUGAL PUMP PEROFRMANCE CURVE

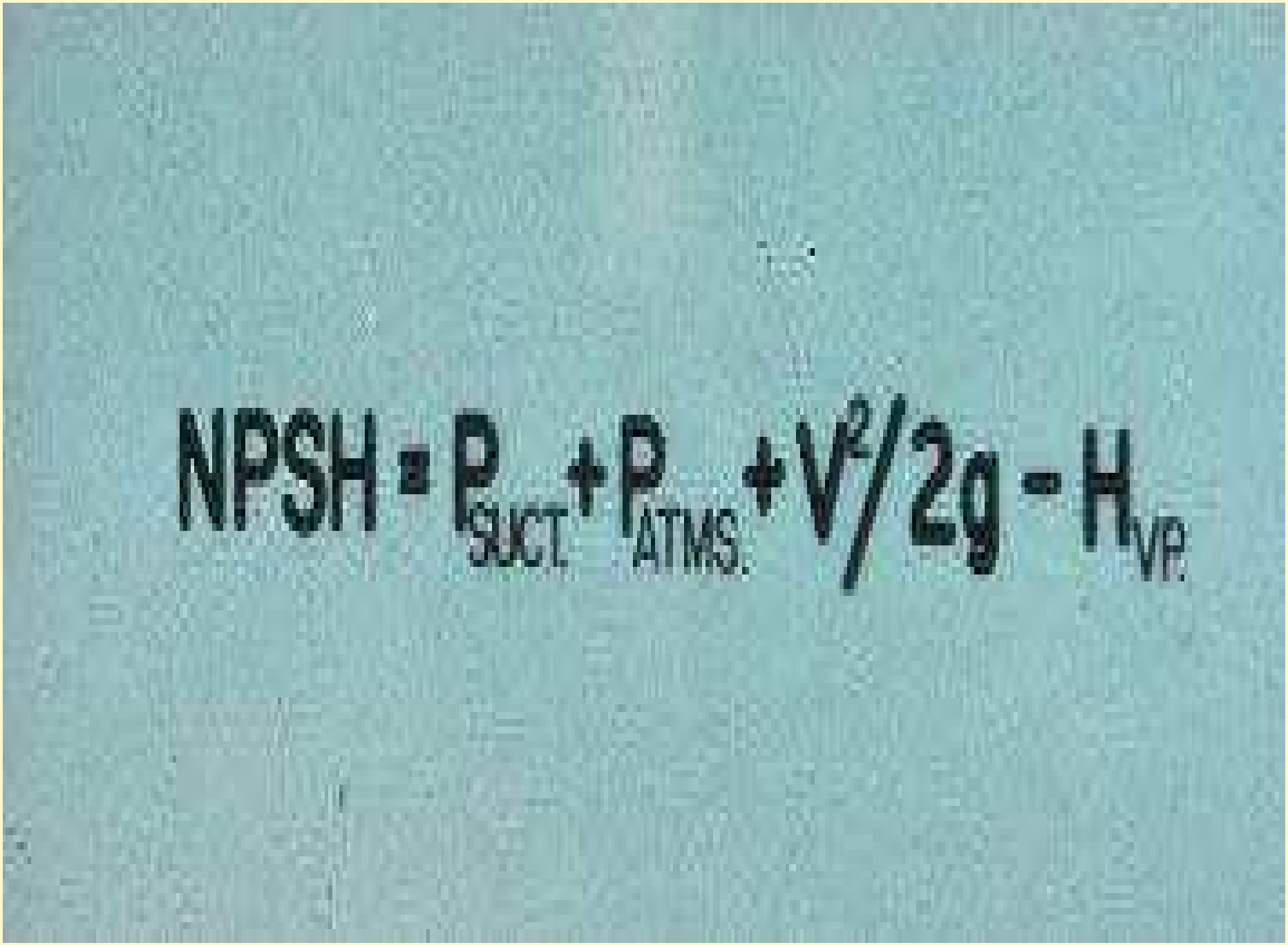


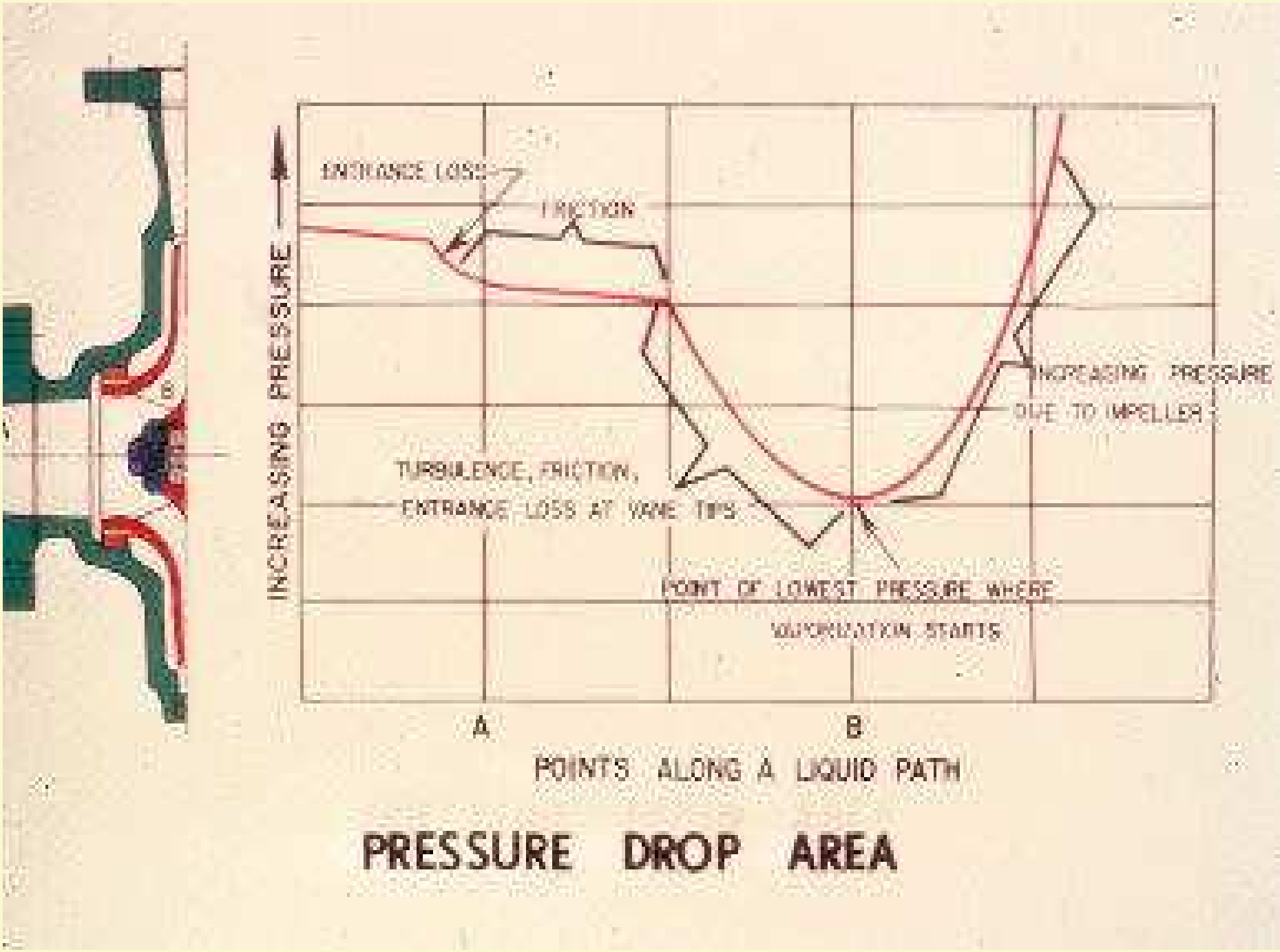
Curve shown at a given constant speed @ a set trim diameter.

* Case and impeller combinations to accommodate hydraulic sizes can vary to meet a specific performance. Changes need to be within design parameters achievable both physically and structurally as not to jeopardize the machine's integrity.

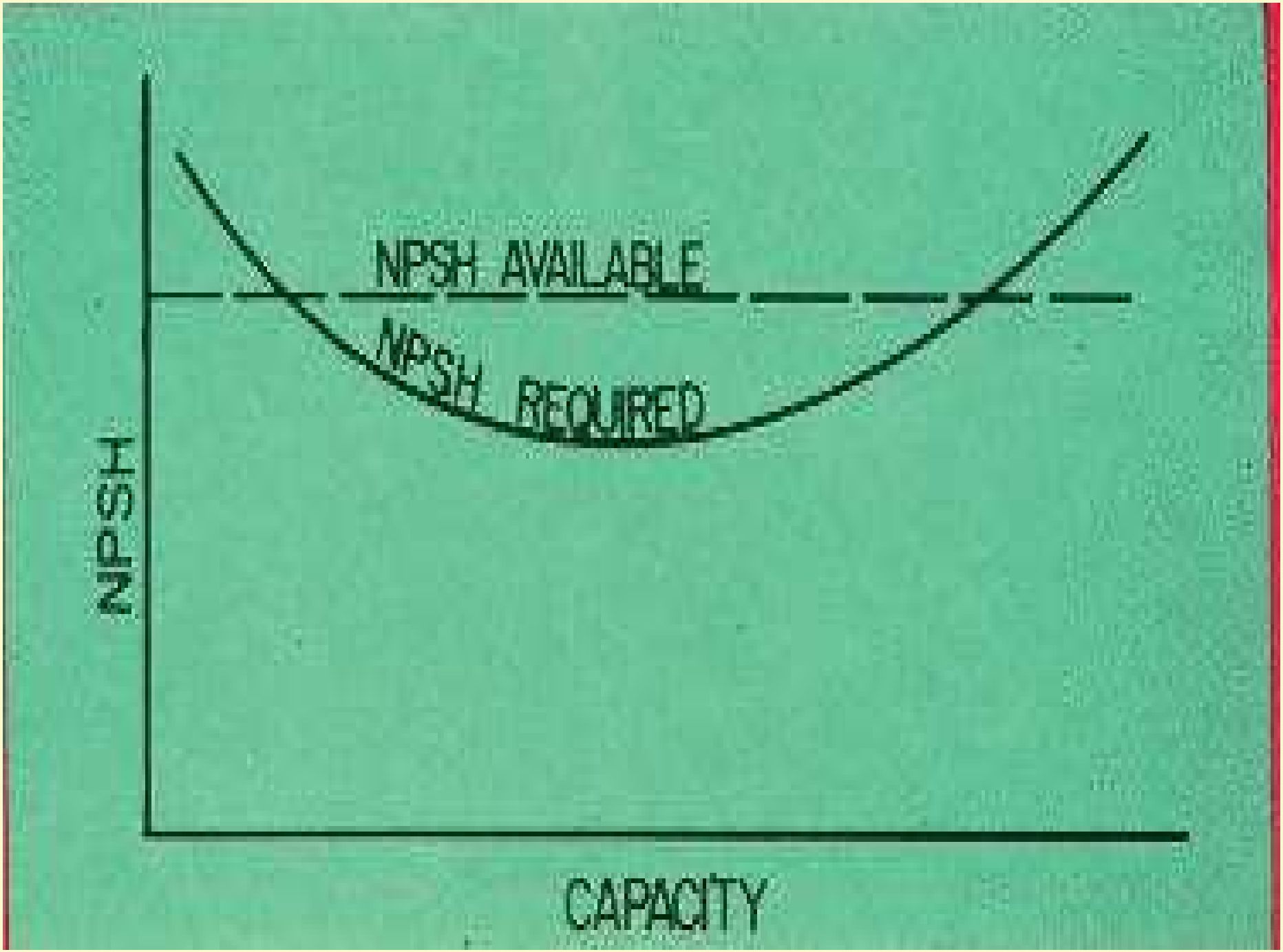
NPSH

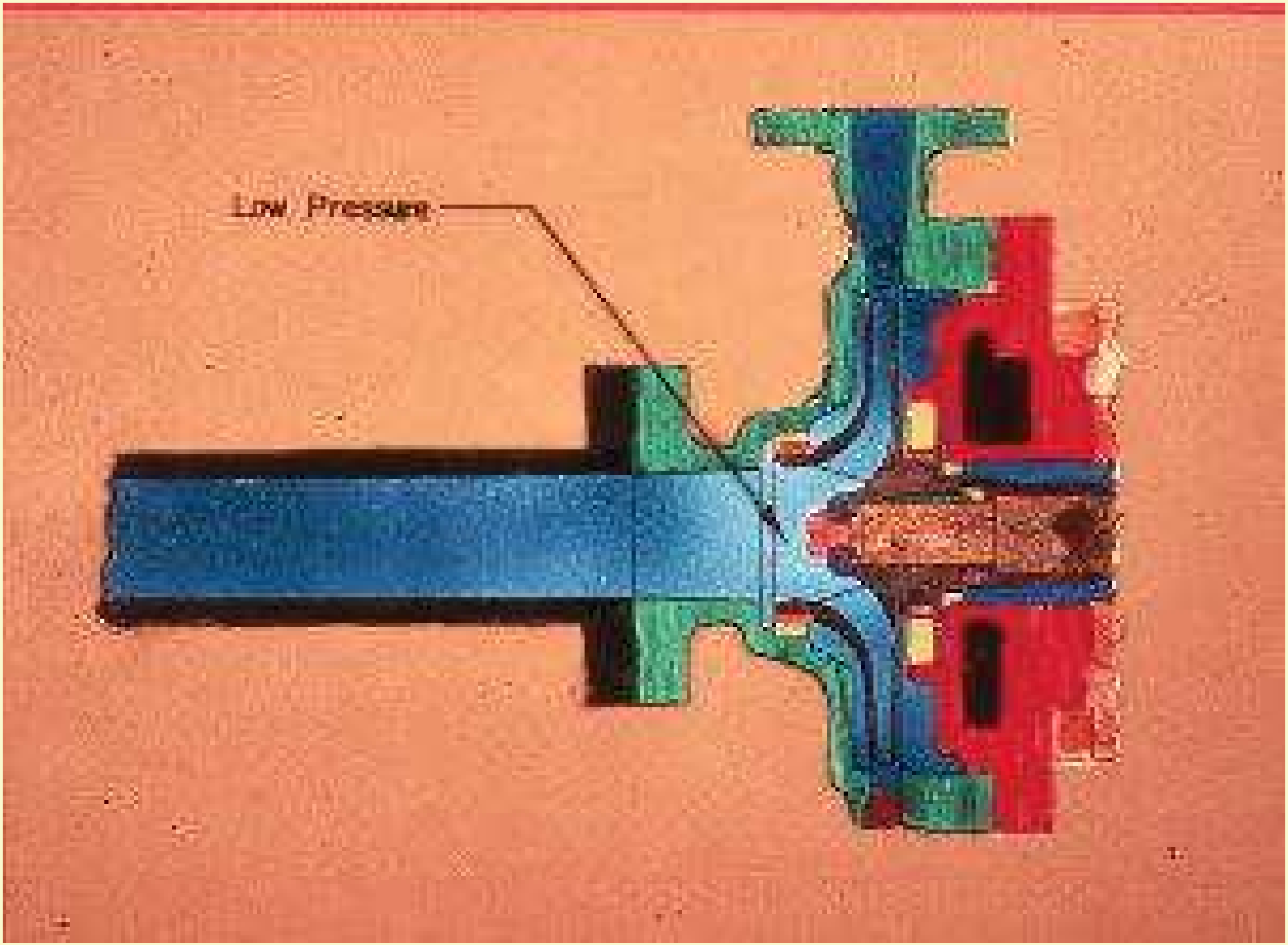
THE TOTAL HEAD IN FEET OF LIQUID ABSOLUTE DETERMINED AT THE PUMP NOZZLE (OR REFERED TO A DATUM) LESS THE VAPOR PRESSURE OF THE LIQUID IN FEET ABSOLUTE.

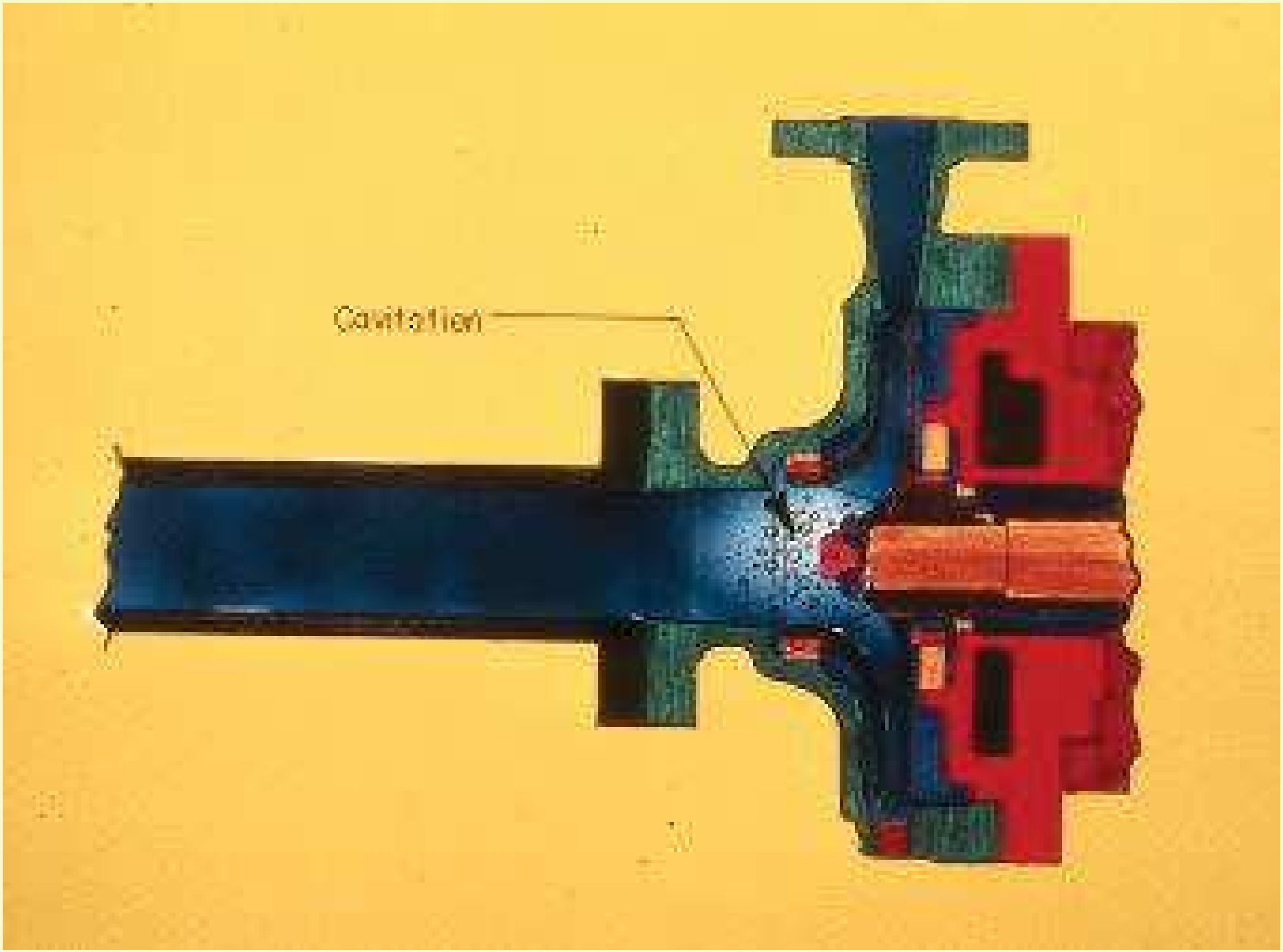

NPSH = P SUCT. + P ATMS. + V²/2g - H VP.

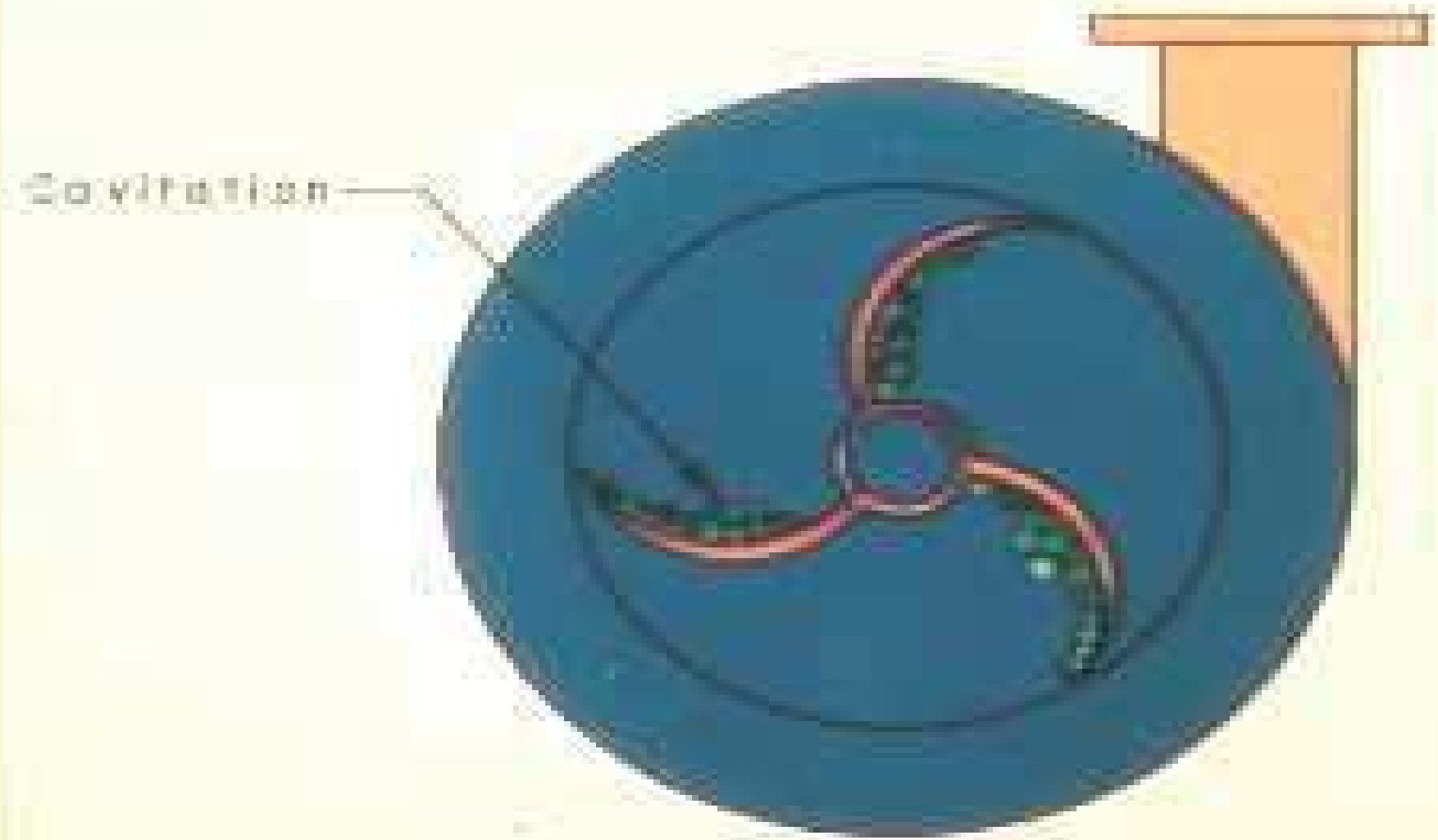


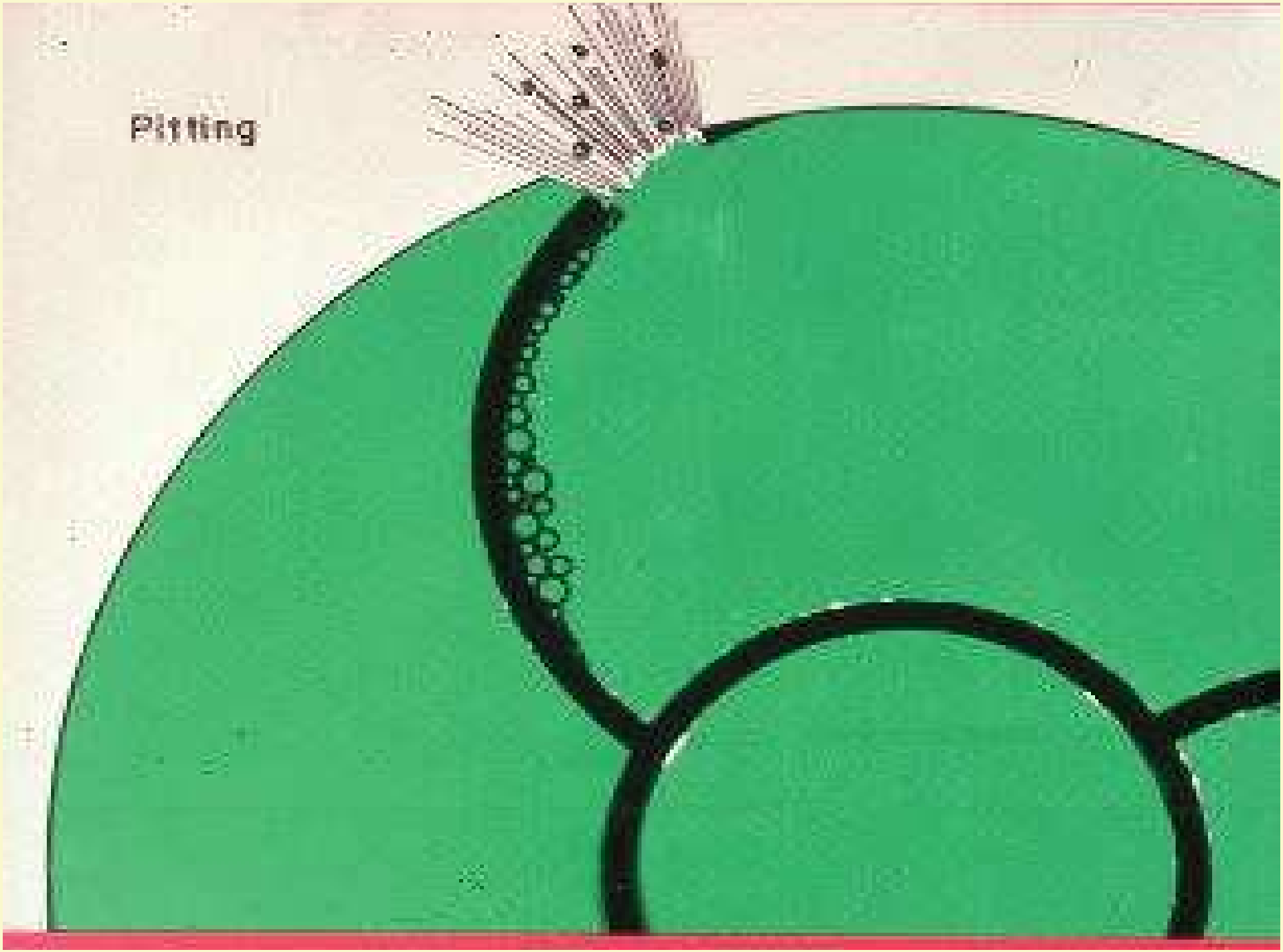
PRESSURE DROP AREA

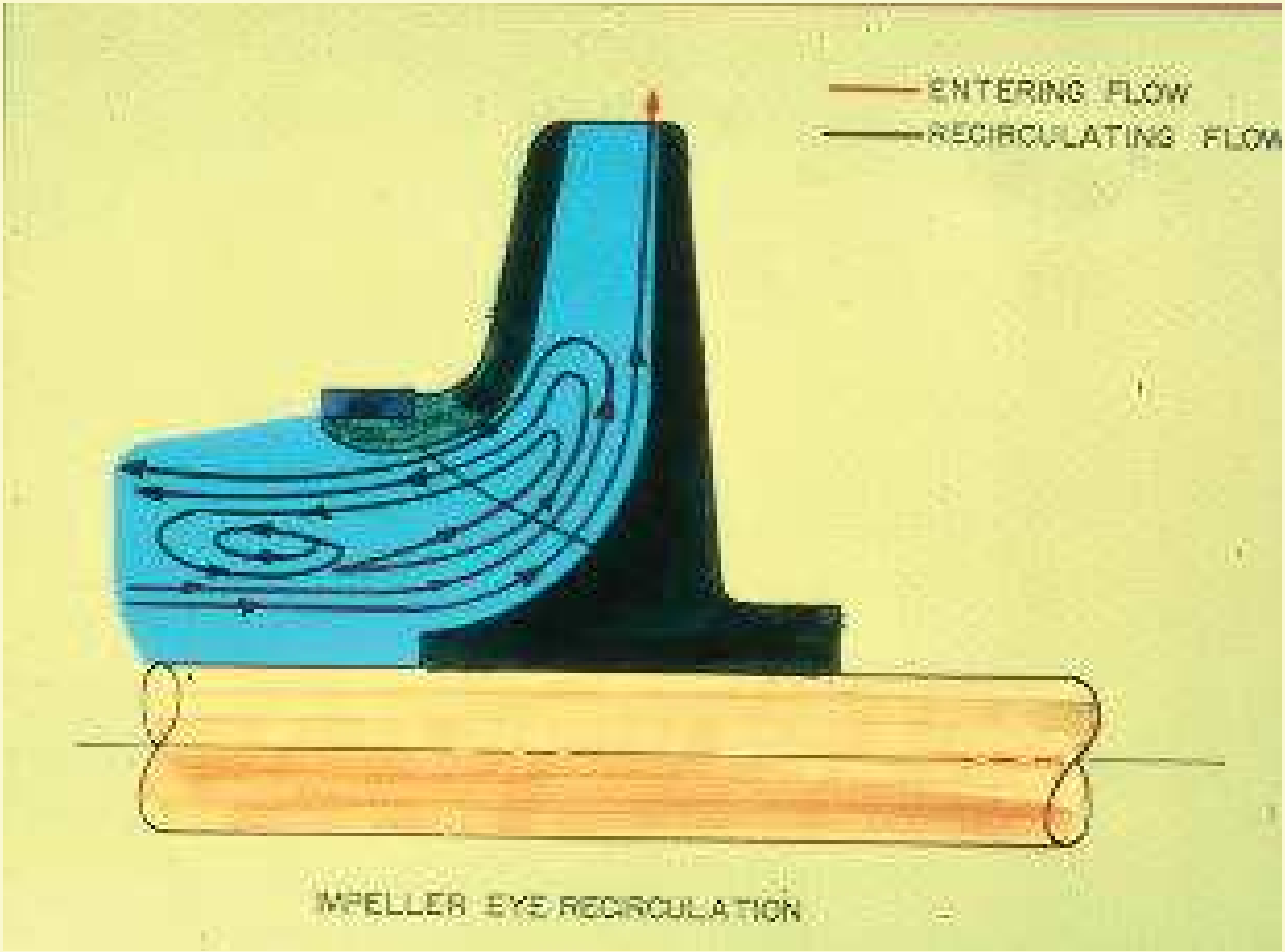

NPSH AVAILABLE
NPSH REQUIRED
NPSH
CAPACITY

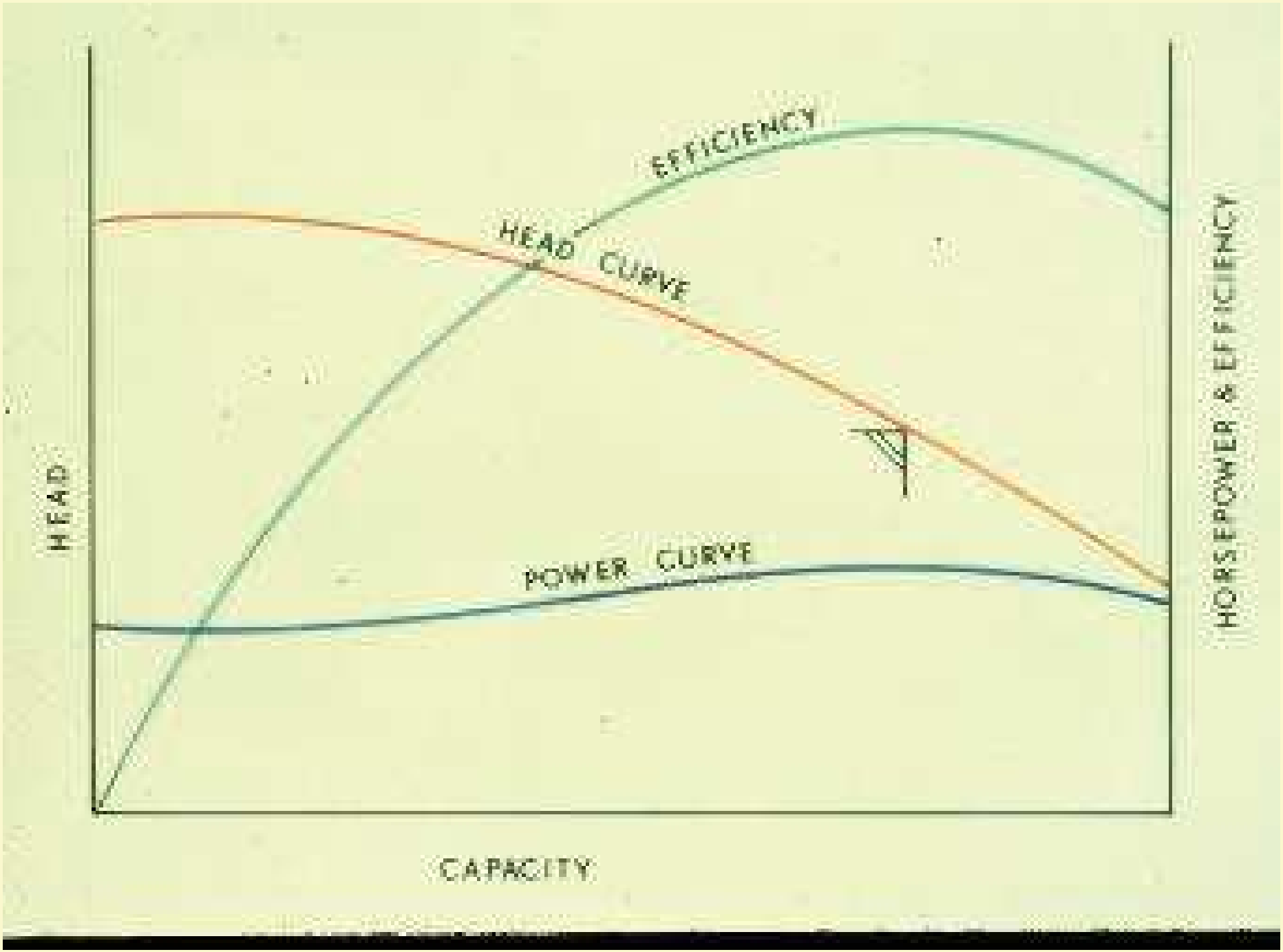

Low Pressure

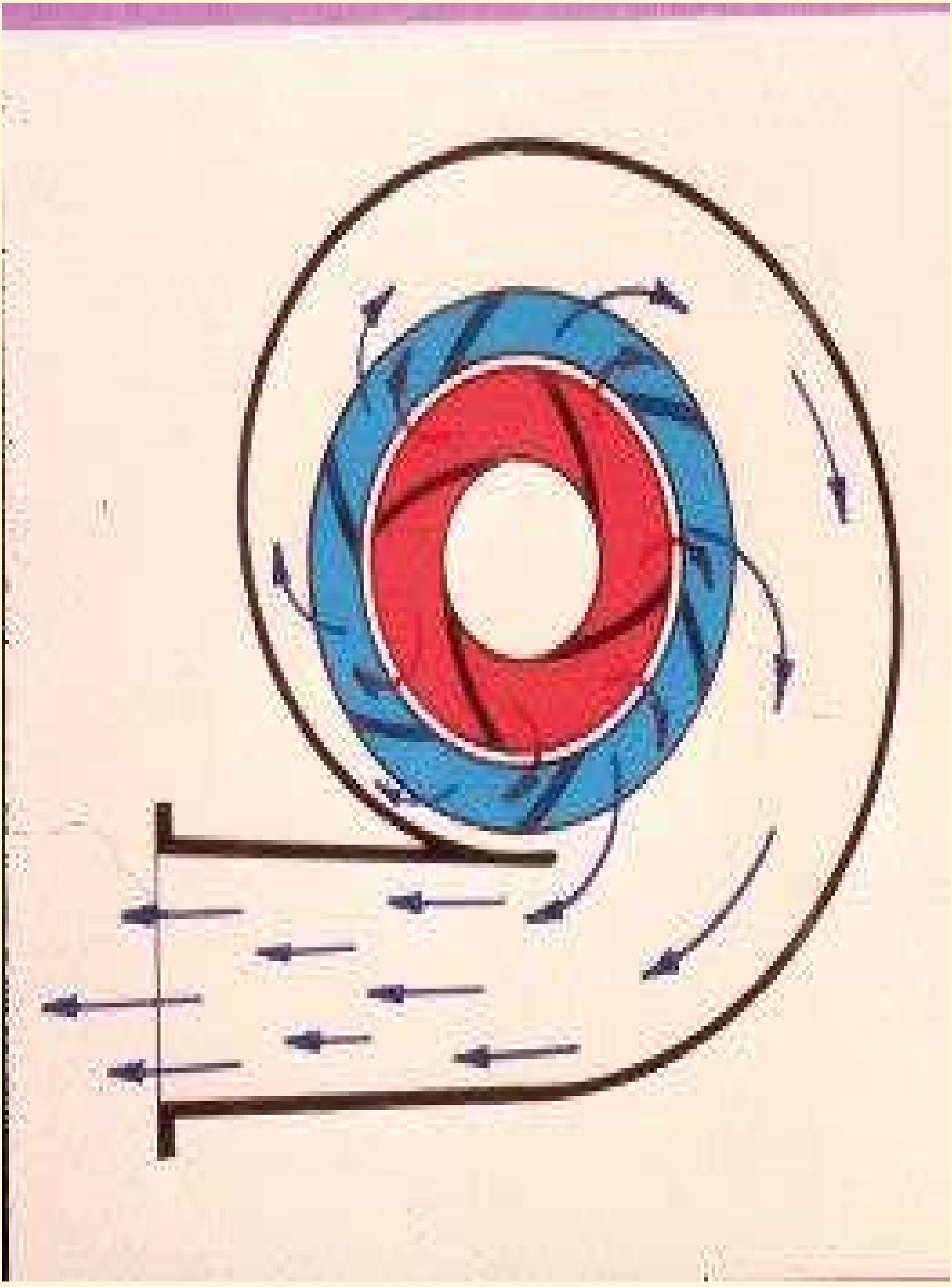

Cavitation


Cavitation

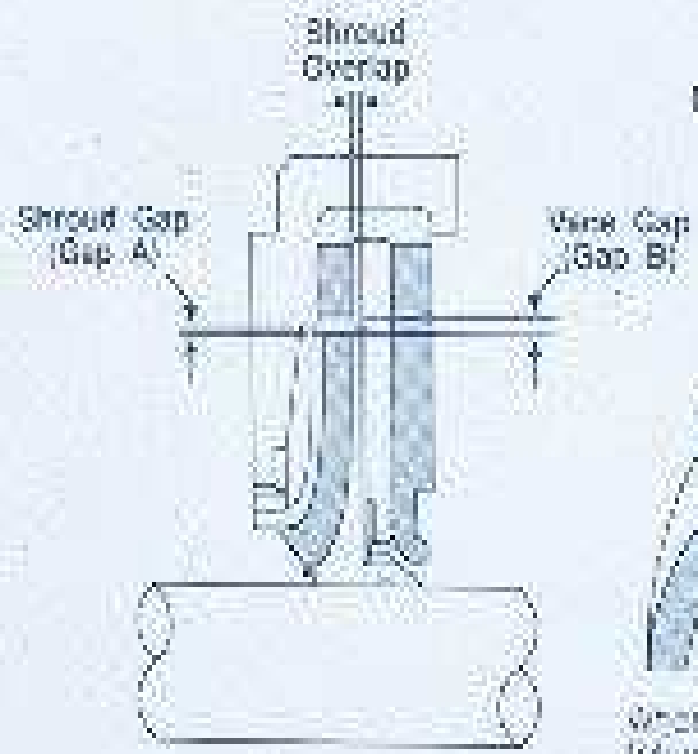

Pitting

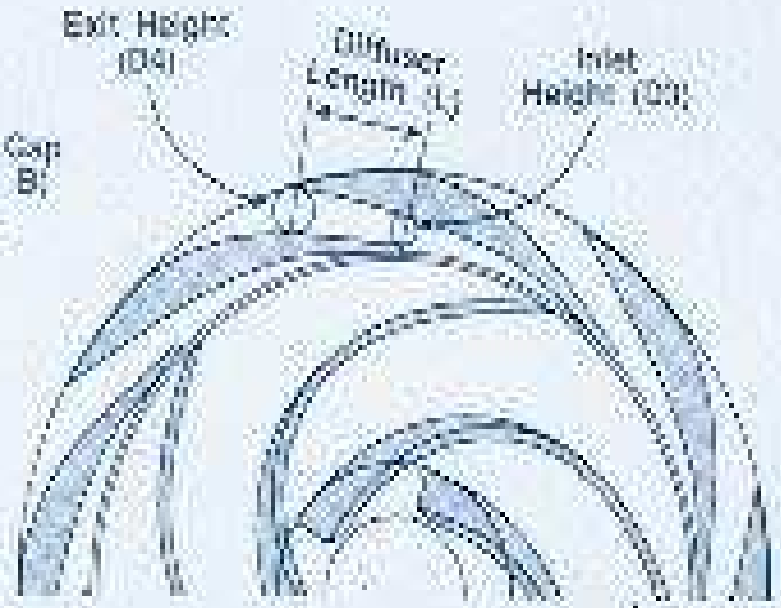

ENTERING FLOW
RECIRCULATING FLOW
IMPELLER EYE RECIRCULATION


EFFICIENCY
HEAD CURVE
POWER CURVE
HEAD
HORSEPOWER & EFFICIENCY
CAPACITY



A-B Gap Considerations, Diffuser Pumps





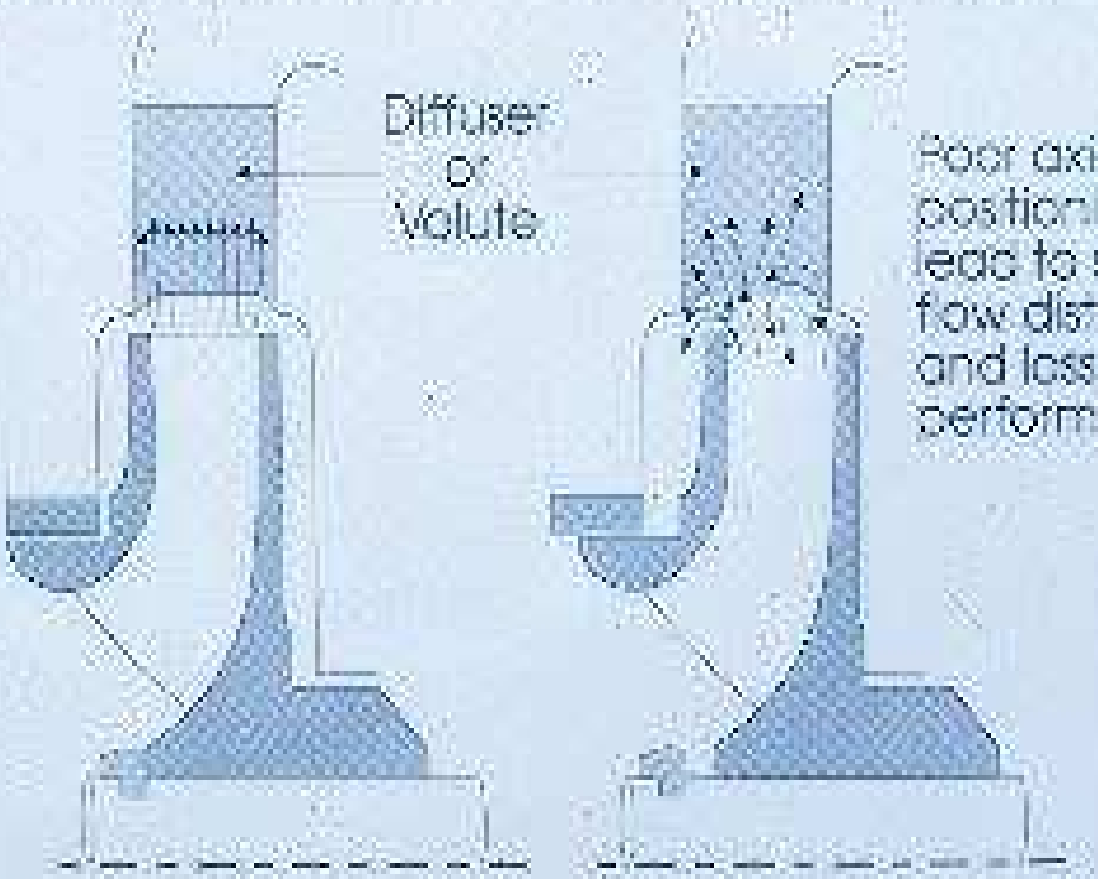
When considering Gap/Modifications, care must be taken to maintain proper diffuser geometry including an adequate diffusion ratio (D3). This will vary depending on diffuser design and manufacturer.

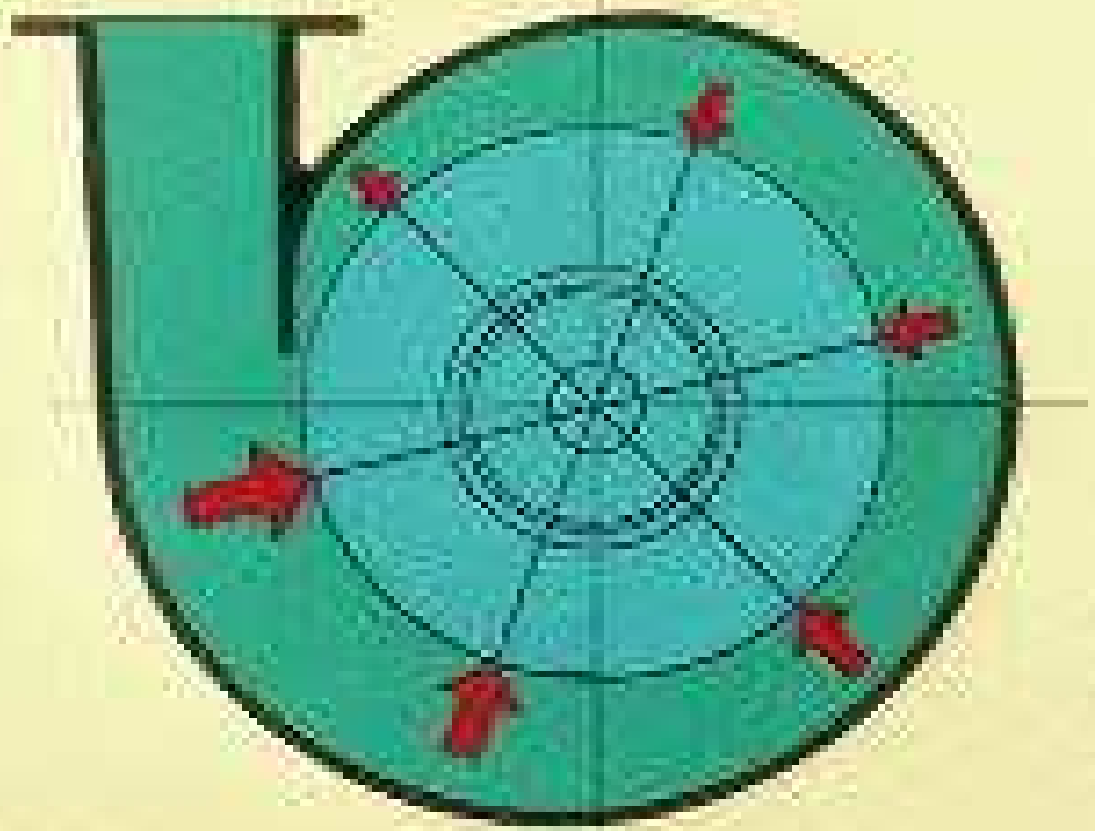
Improper diffuser geometry can impact:

- Curve Stability
- Pump Head
- Hydraulic Efficiency

Courtesy Ingersoll Dresser Pump Company

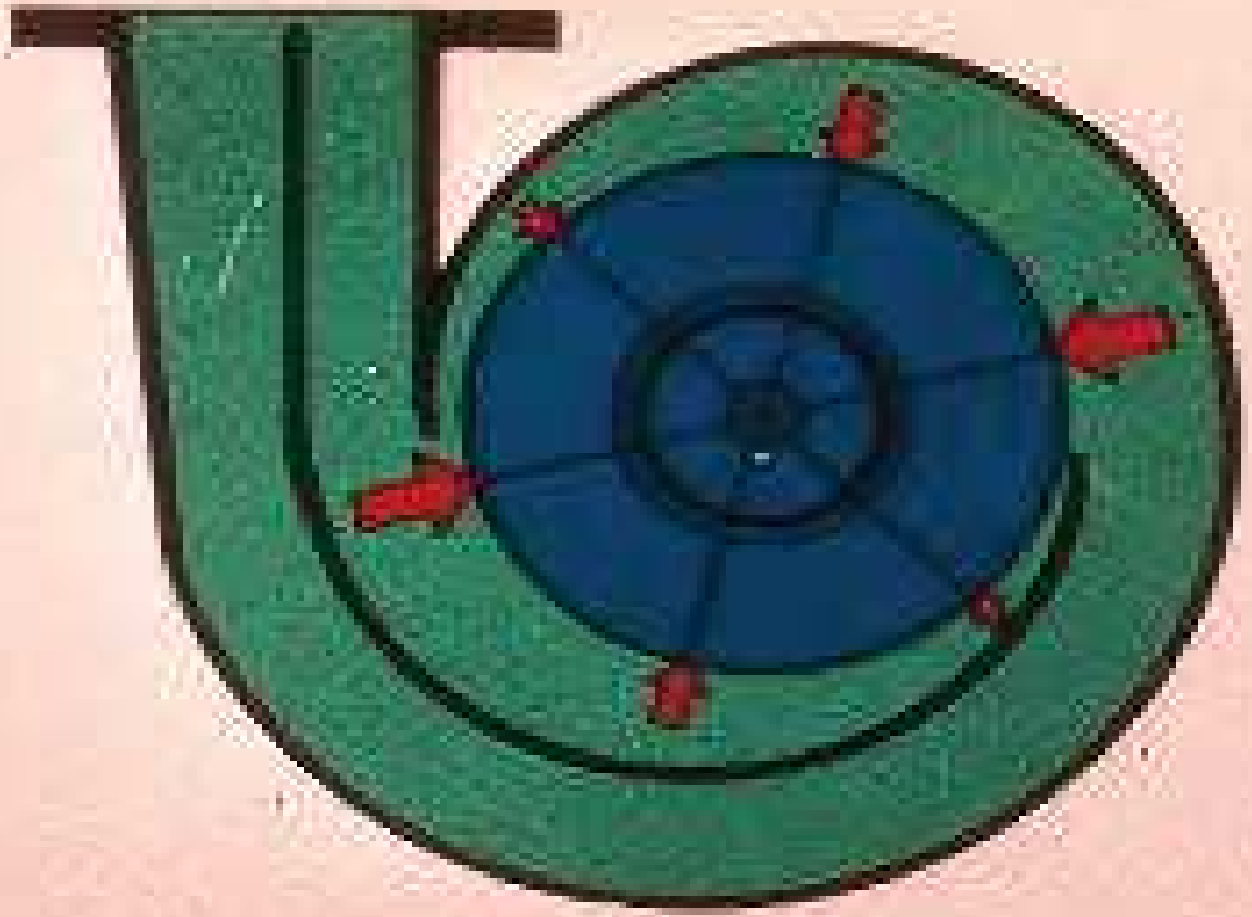
Importance of Axial Stage Positioning





SINGLE VOLUTE CONSTRUCTION

Diagram of single volute pump case indicating unequal pressure at opposite points around the periphery of the impeller.



DOUBLE VOLUTE CONSTRUCTION

Diagram of a "Double Volute", single discharge case of a single stage pump showing equal pressures on opposite sides of impeller.

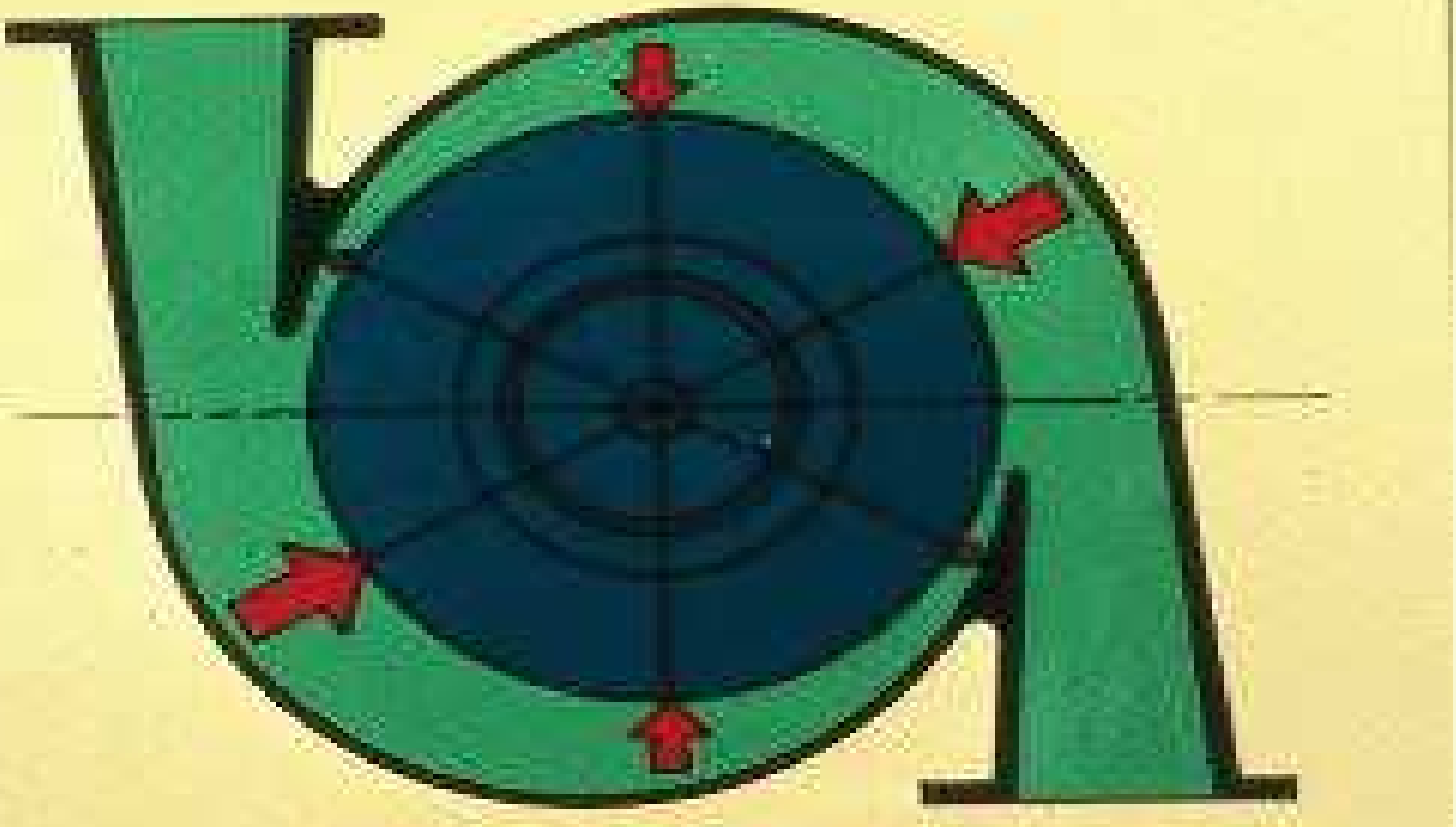
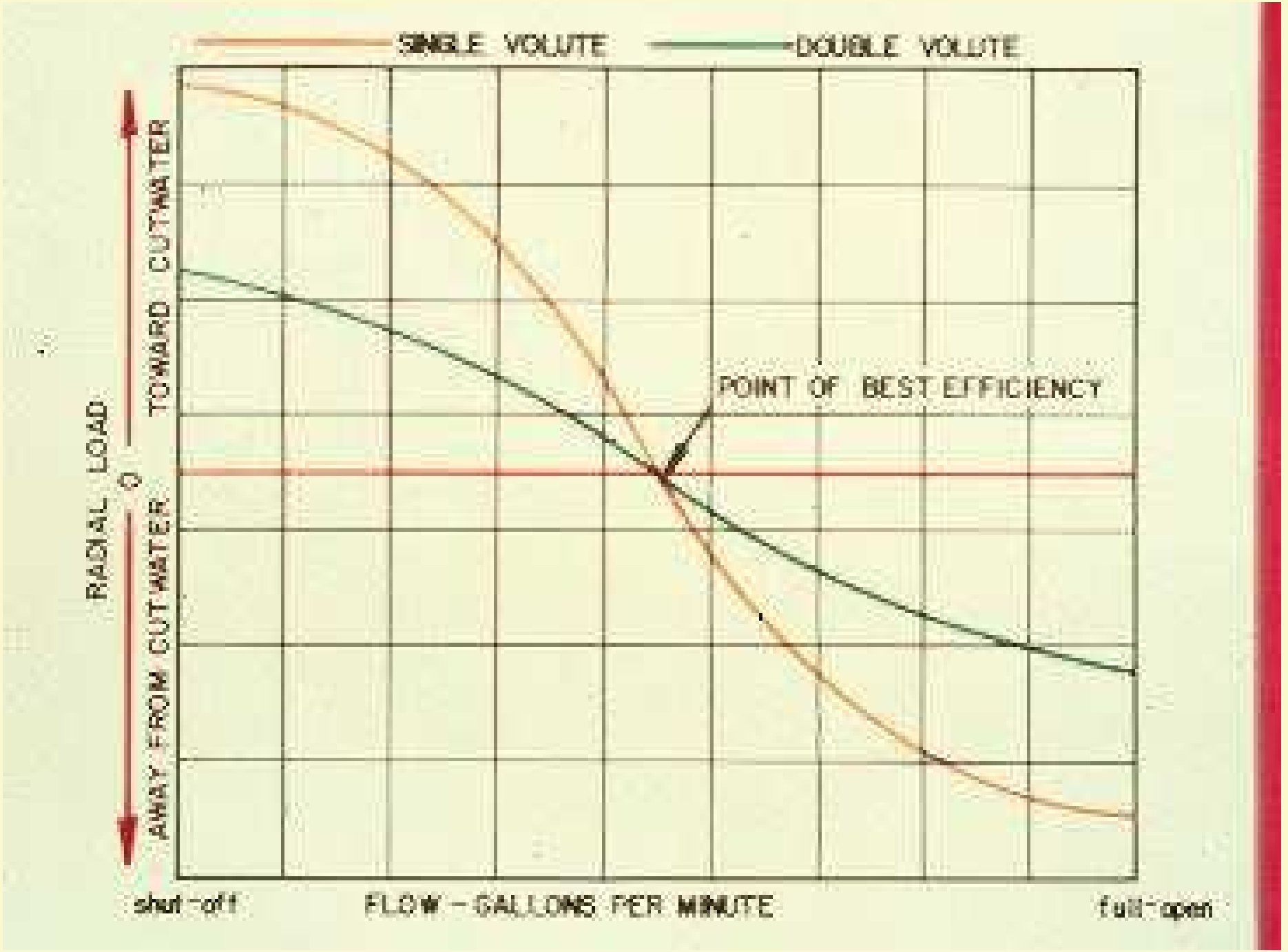
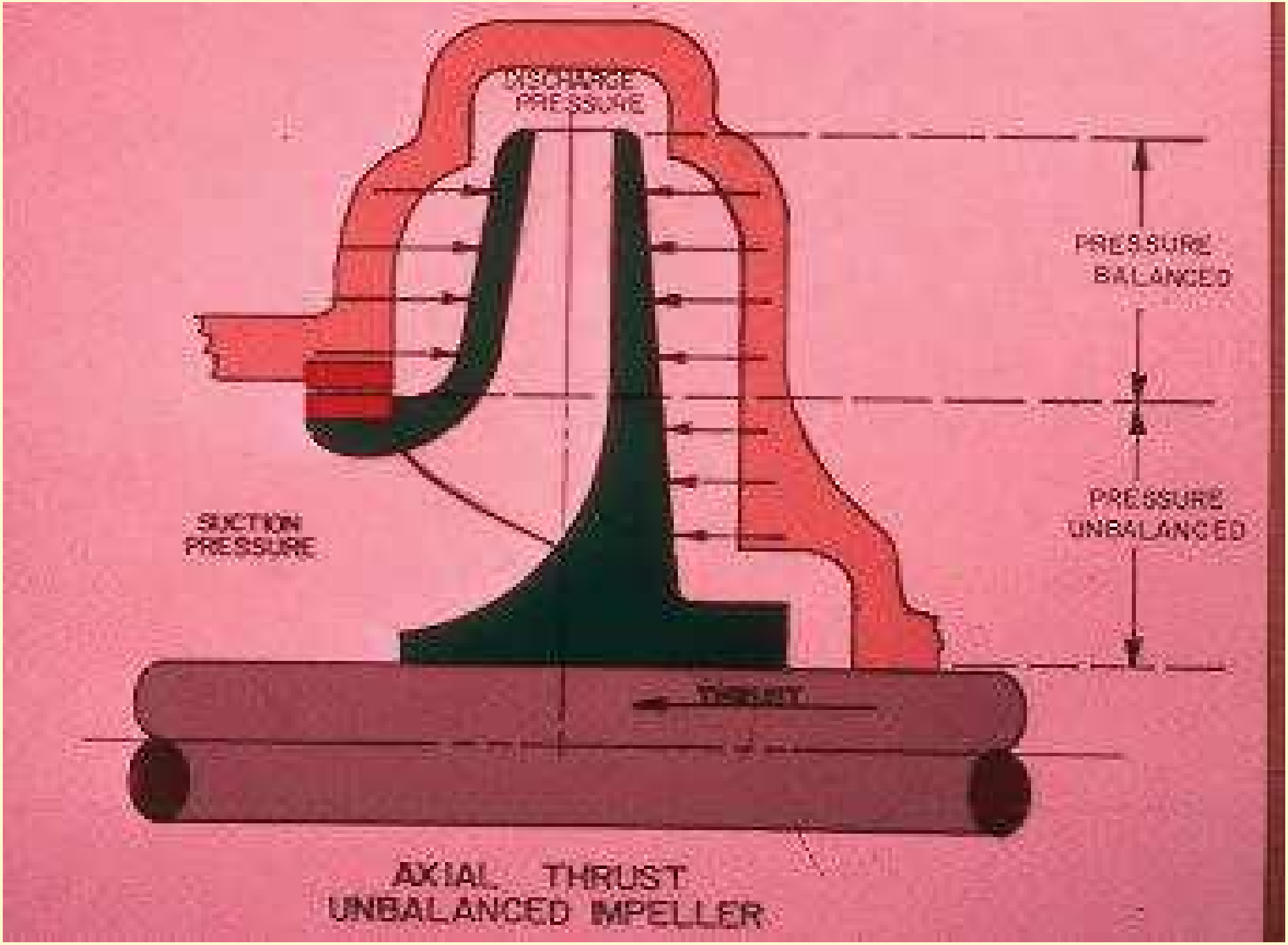


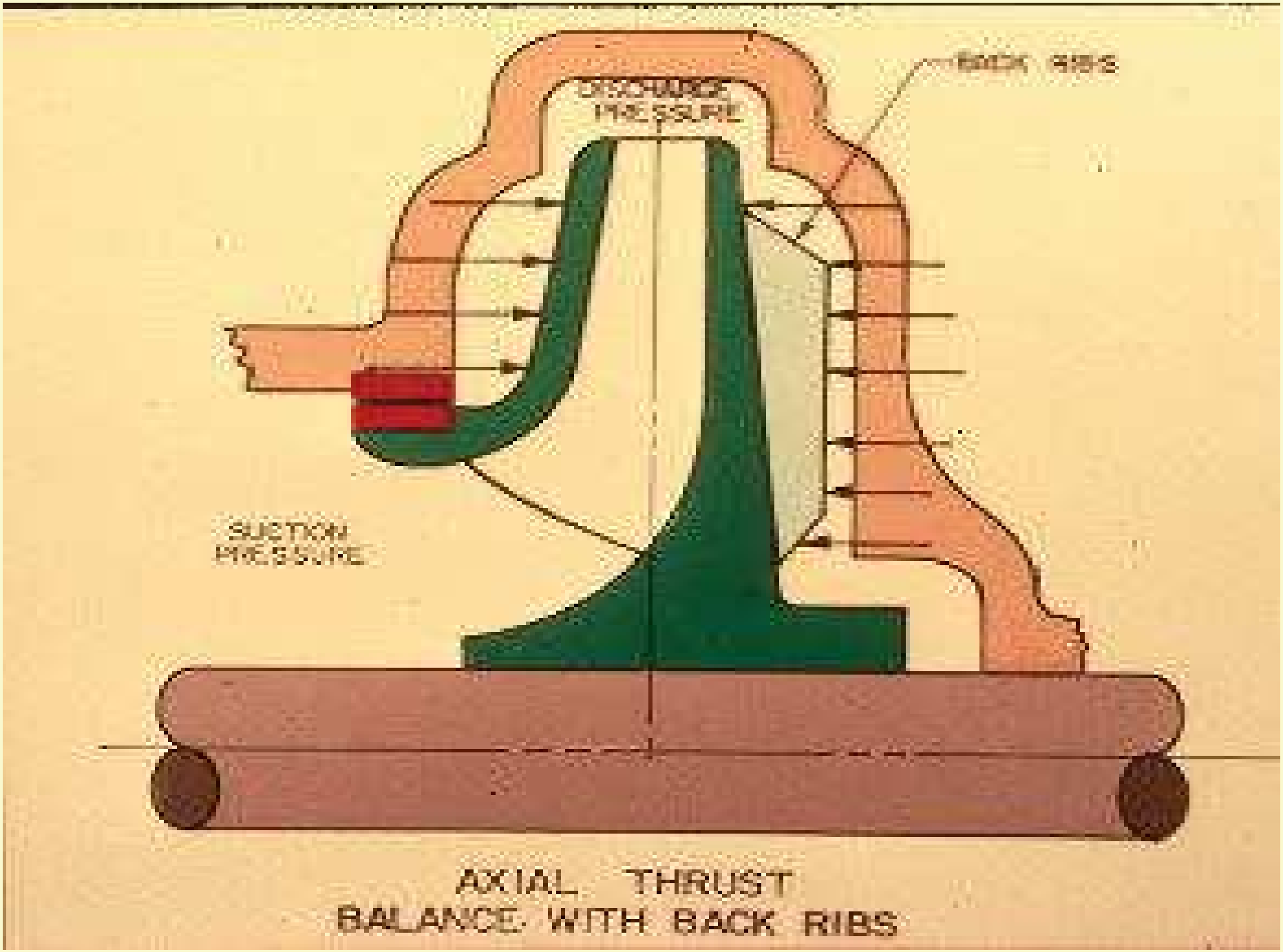
Diagram of a "Double Volute" double discharge case of a multistage pump showing equal pressures on opposite sides of impeller.

DOUBLE VOLUTE
Bingham
RADIAL BALANCE

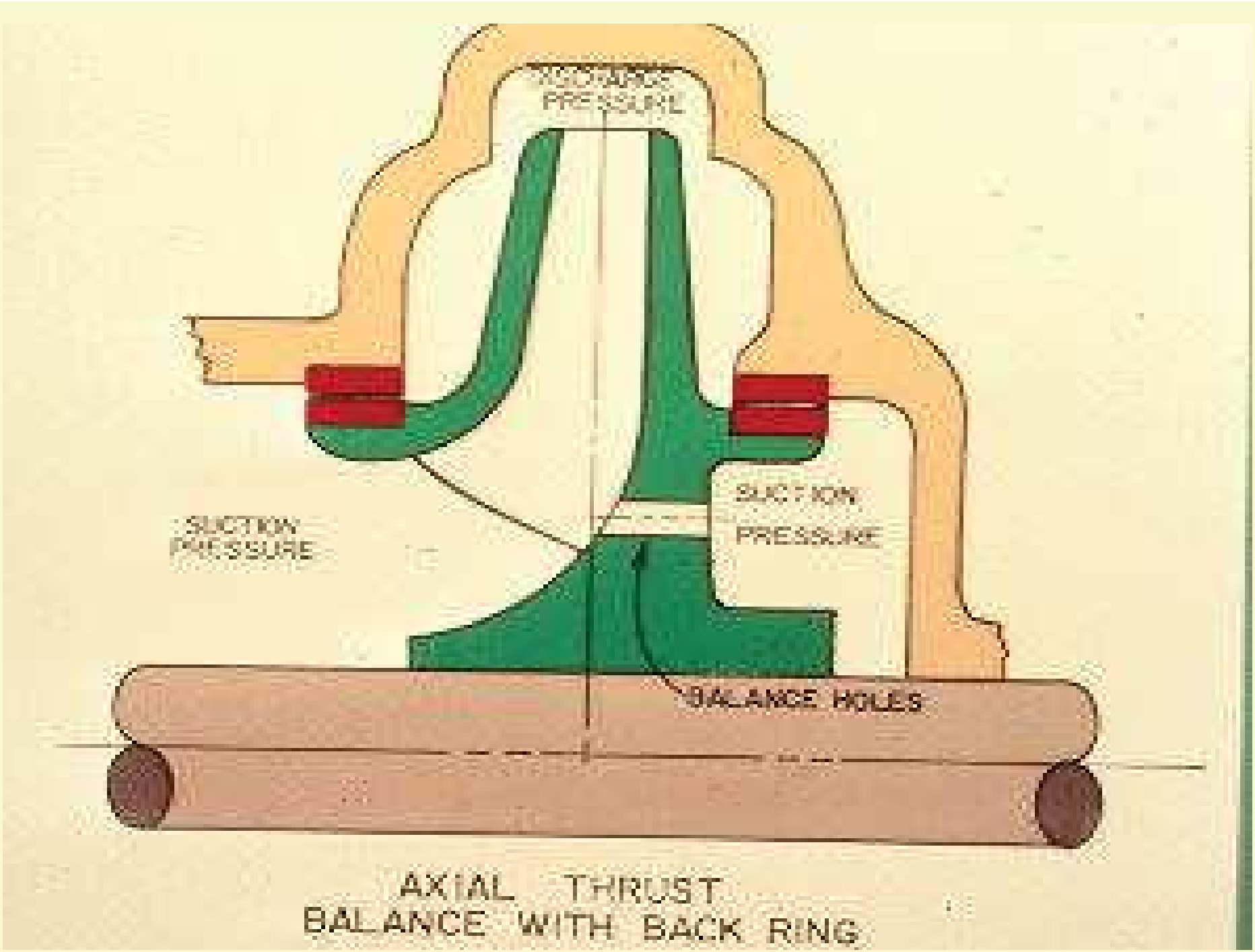

SINGLE VOLUTE
DOUBLE VOLUTE
RADIAL LOAD
TOWARD CUTWATER
0
AWAY FROM CUTWATER
POINT OF BEST EFFICIENCY
shut-off
FLOW - GALLONS PER MINUTE
full open



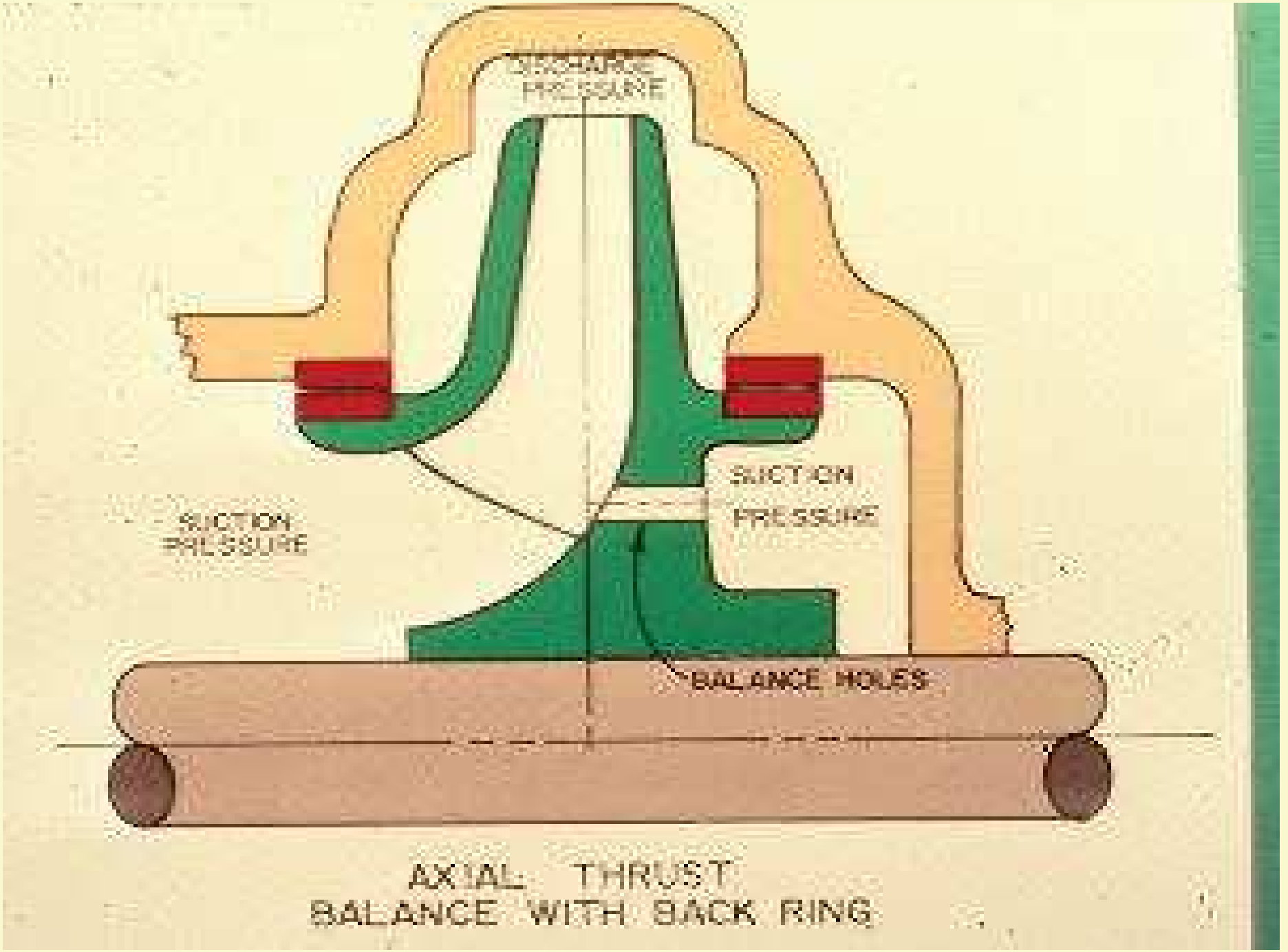
AXIAL THRUST
UNBALANCED IMPELLER



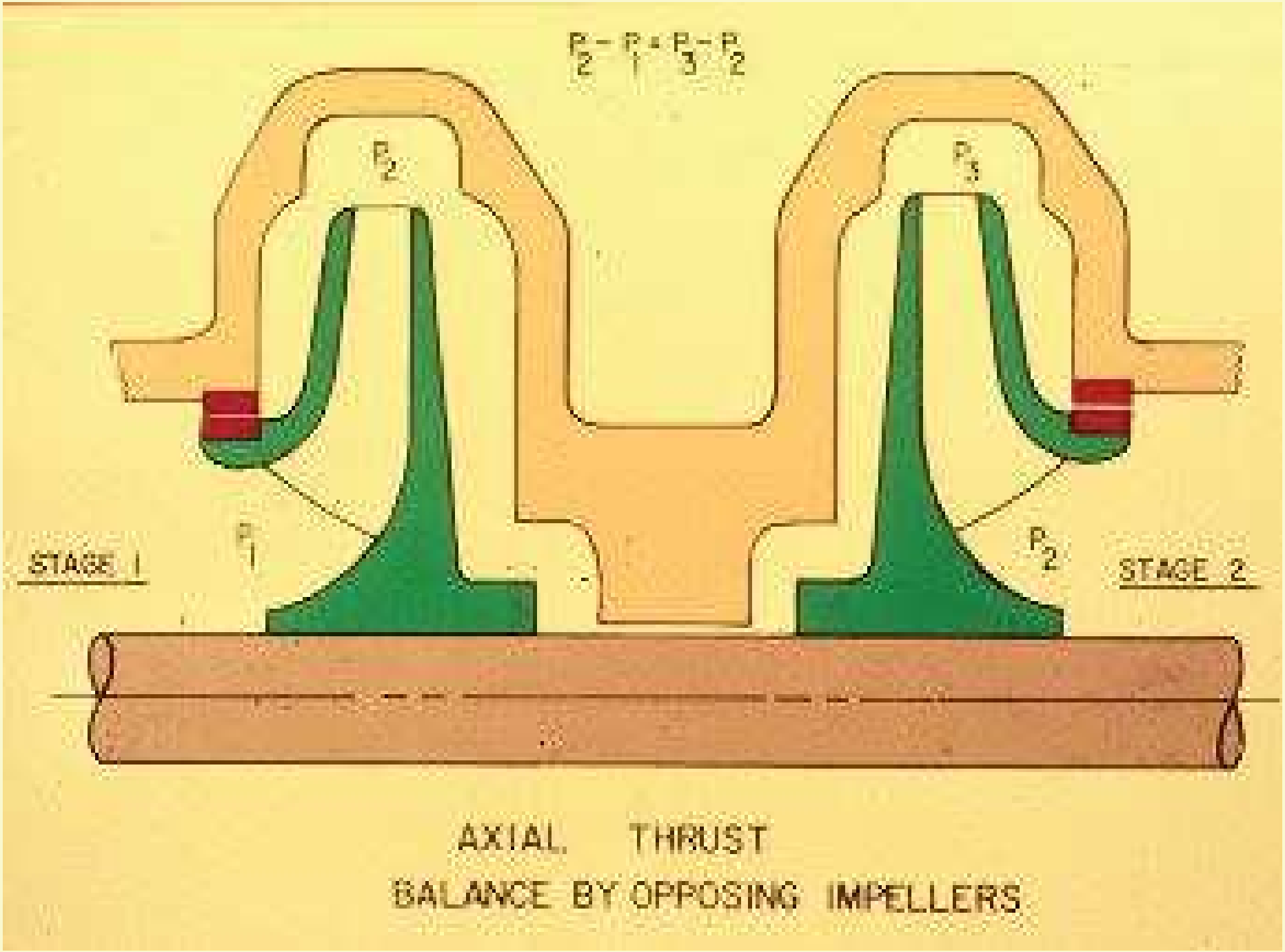
AXIAL THRUST
BALANCE WITH BACK RIBS



AXIAL THRUST
BALANCE WITH BACK RING

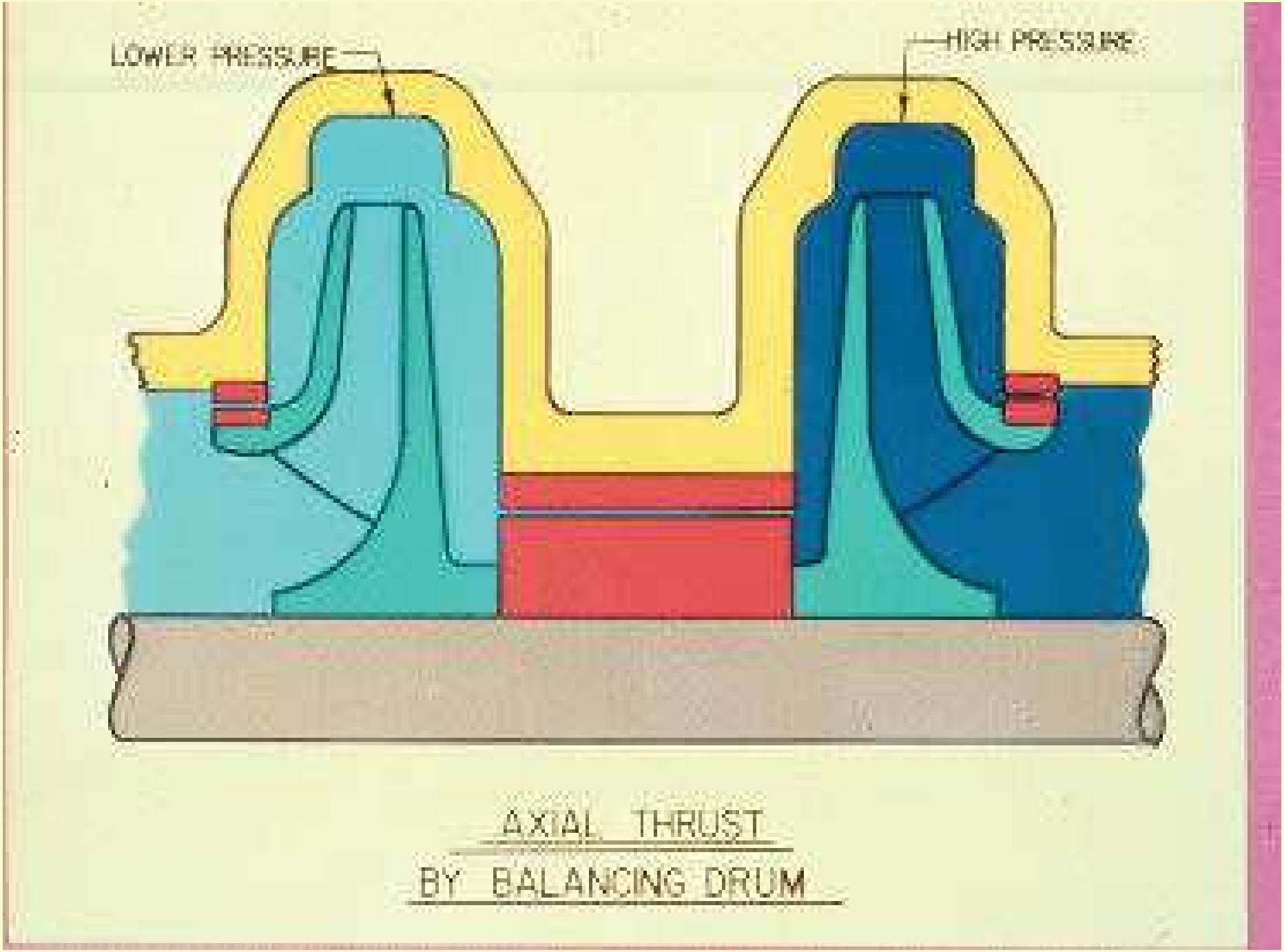


AXIAL THRUST
BALANCE WITH BACK RING

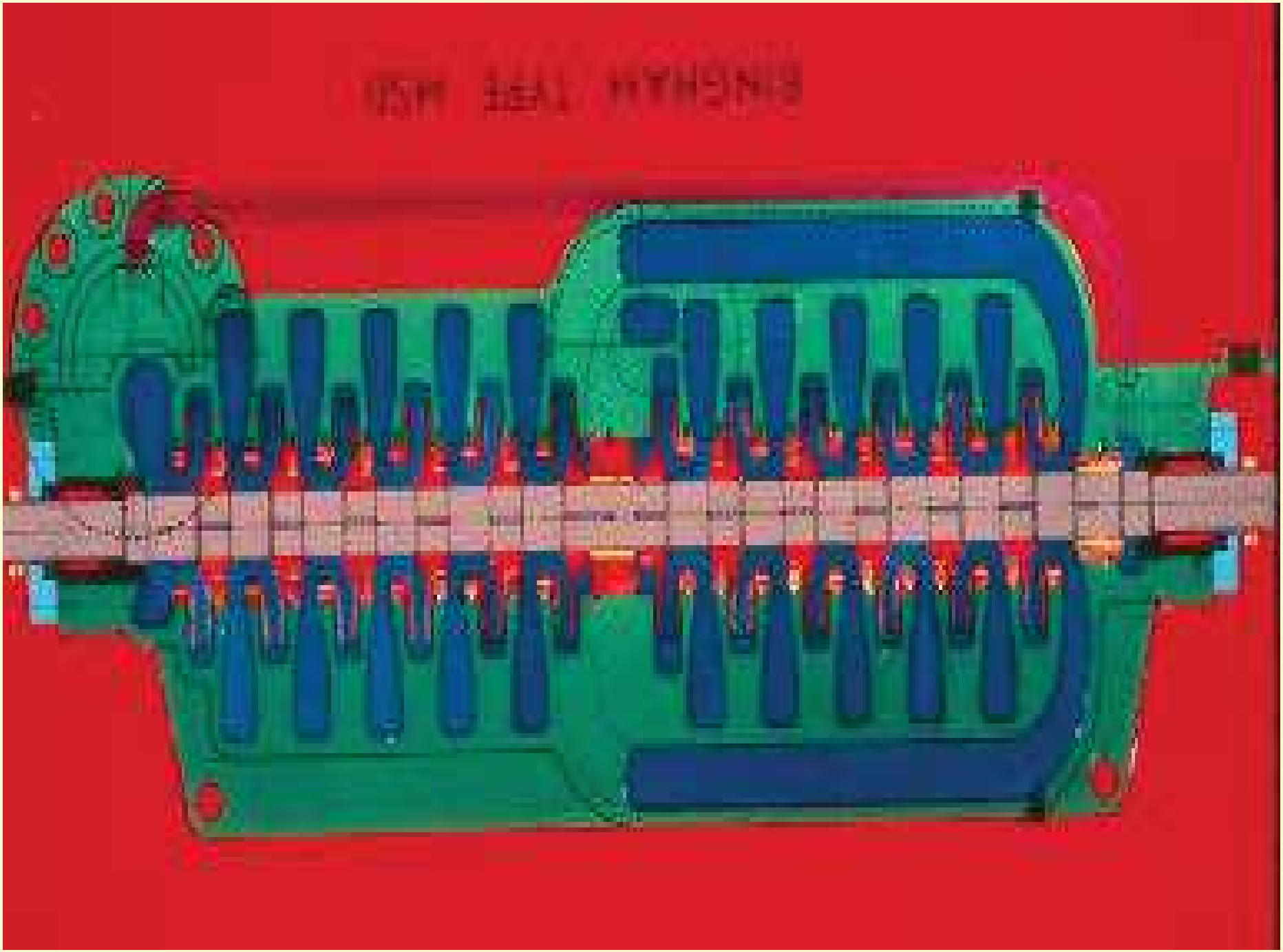


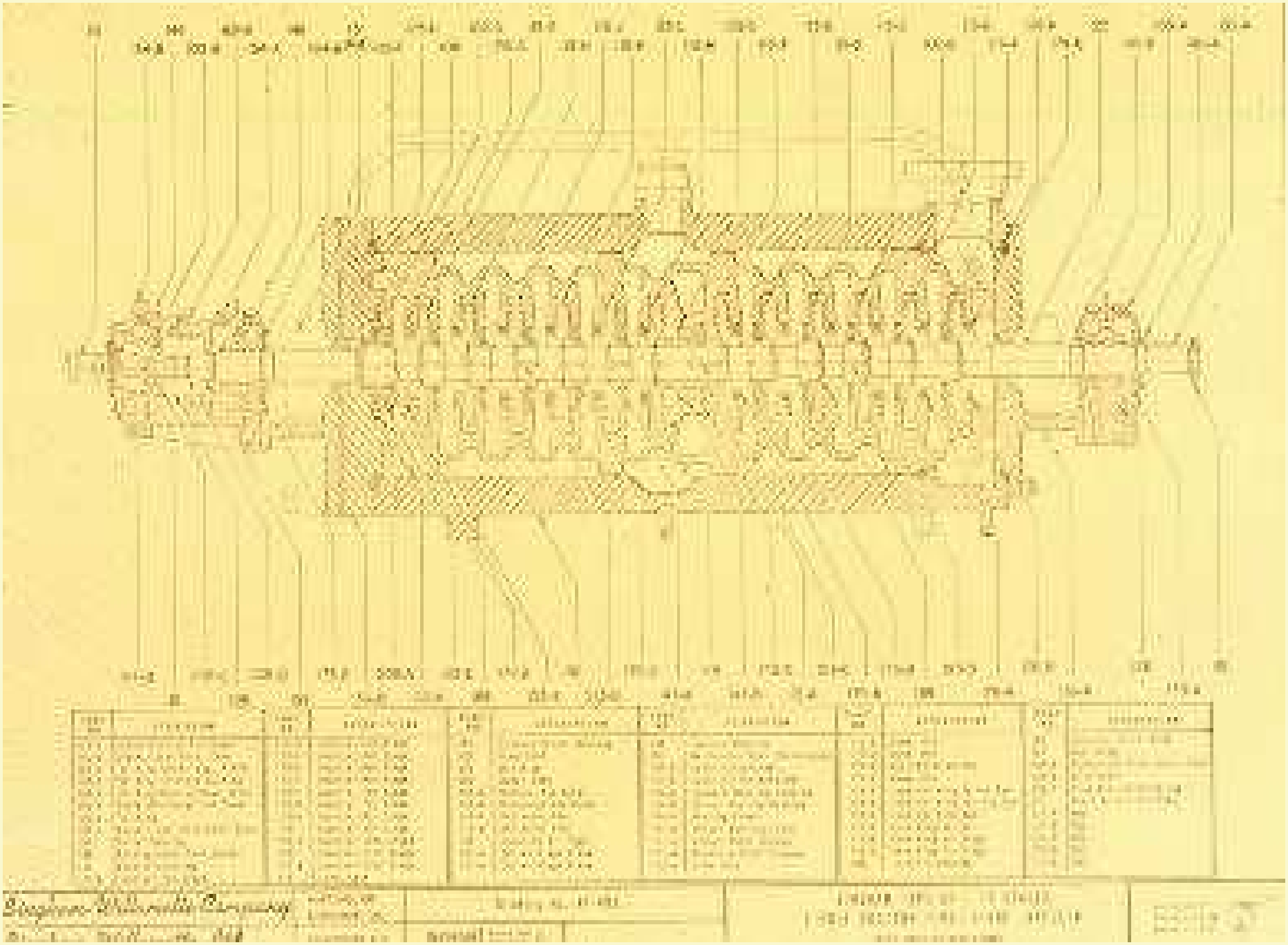
AXIAL THRUST

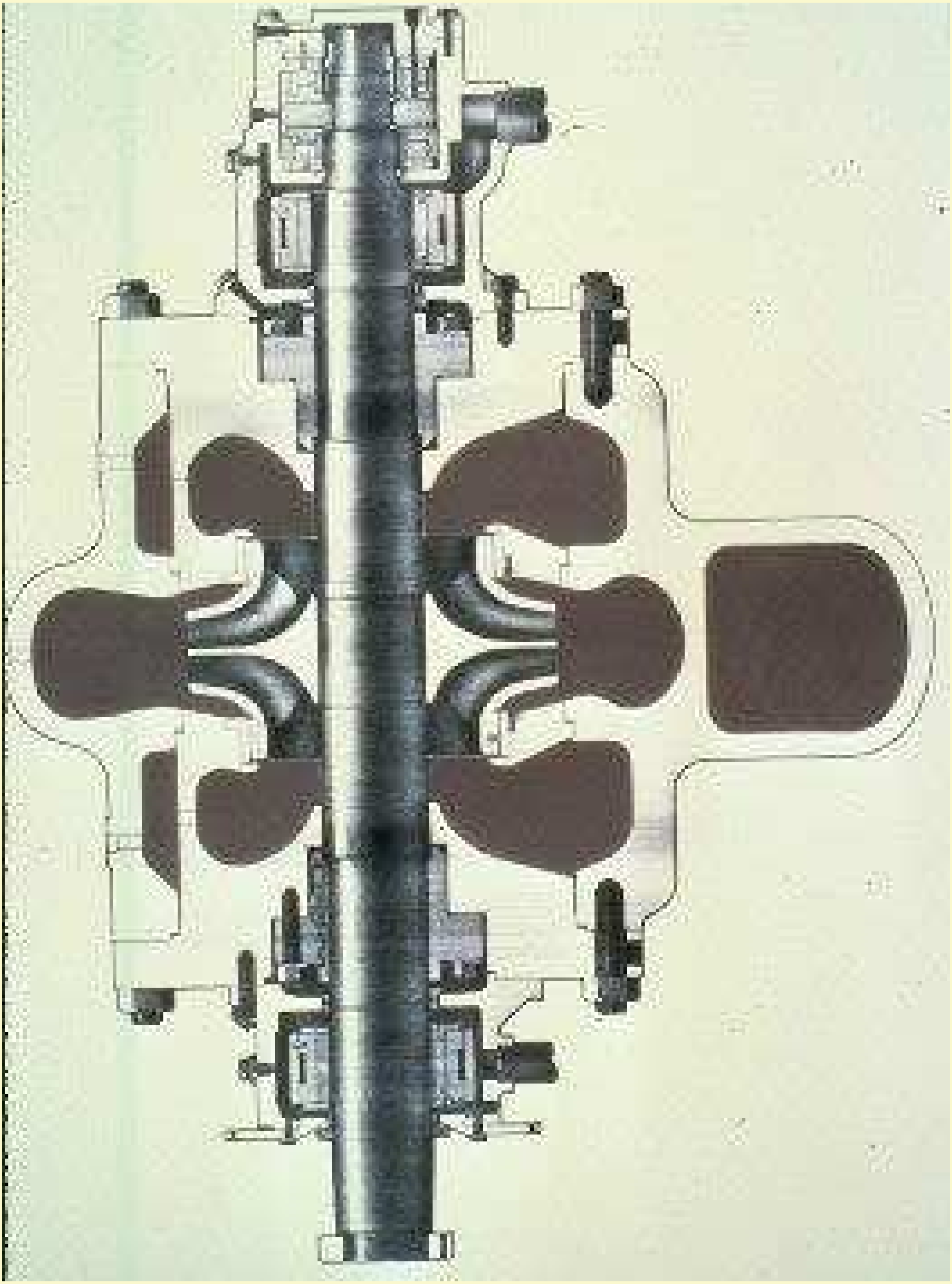
BALANCE BY OPPOSING IMPELLERS

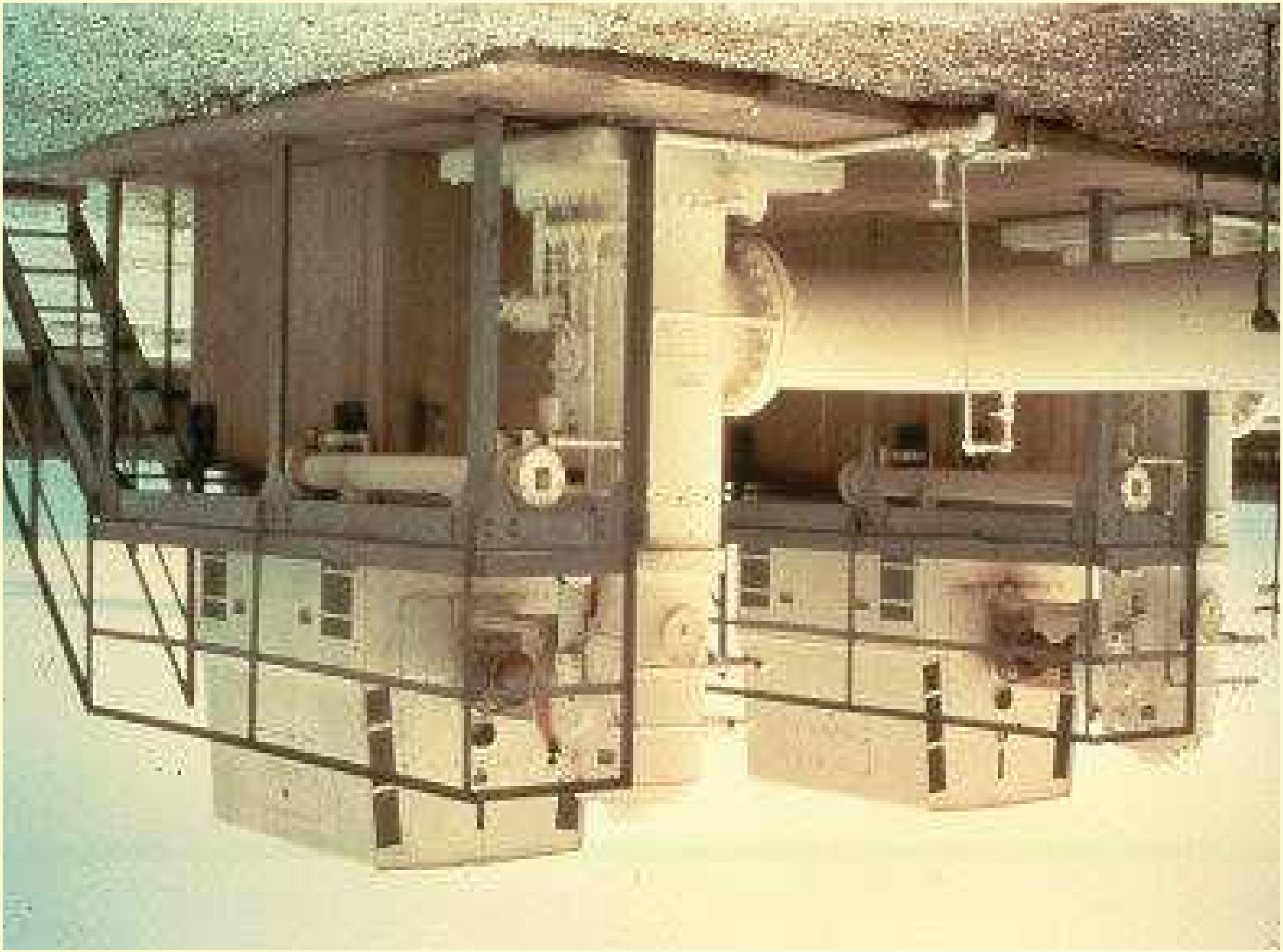


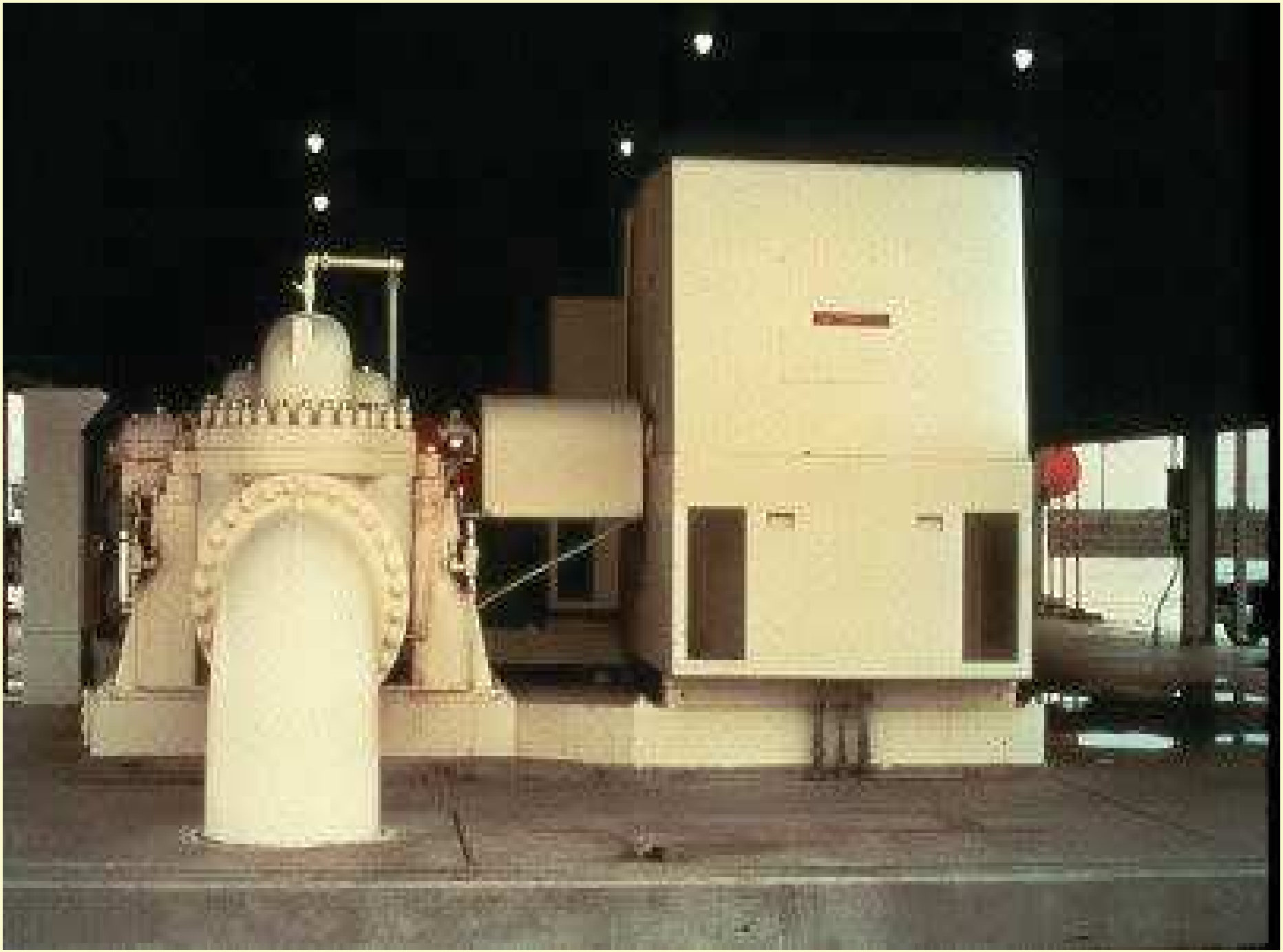
AXIAL THRUST
BY BALANCING DRUM

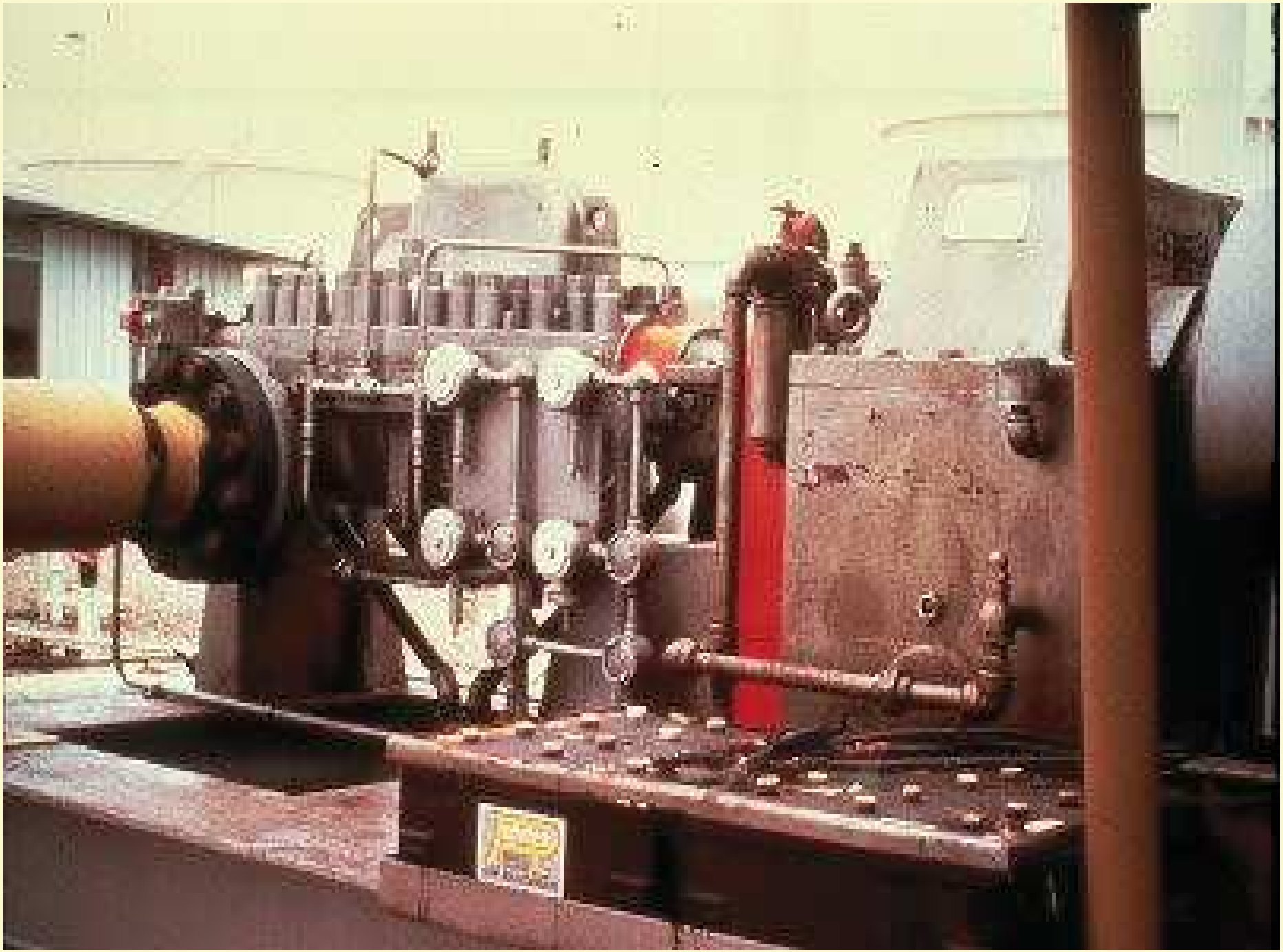


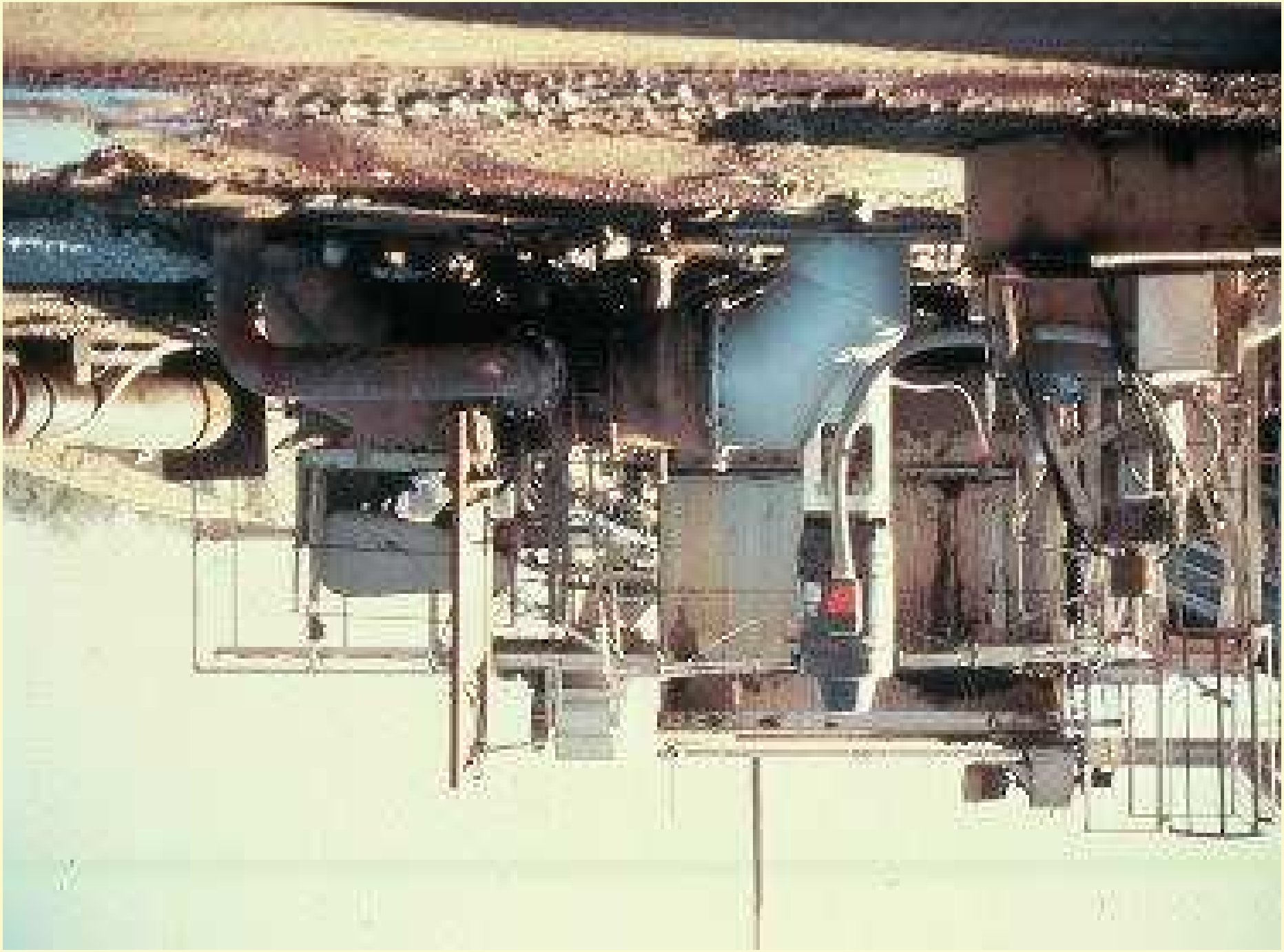


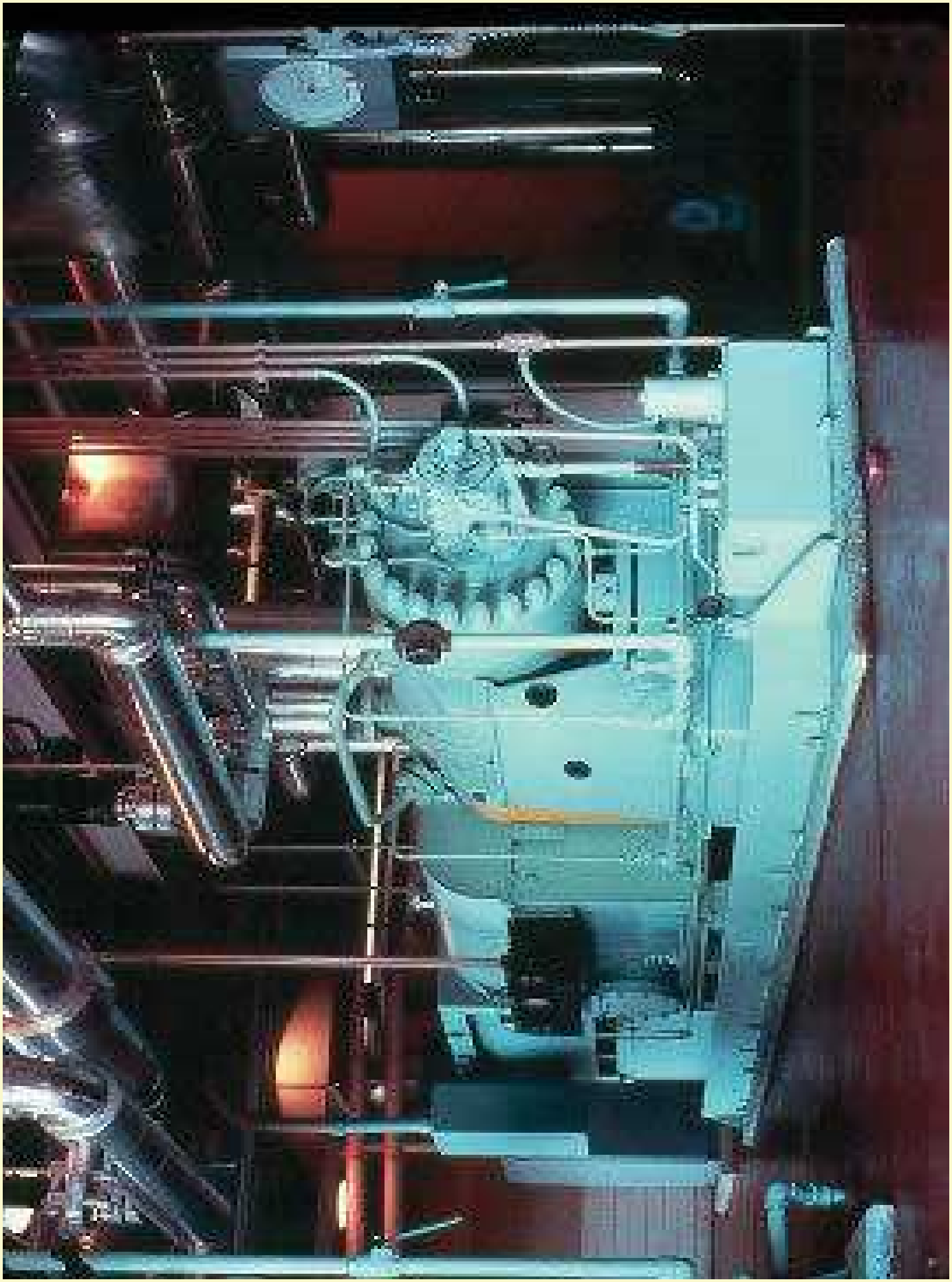


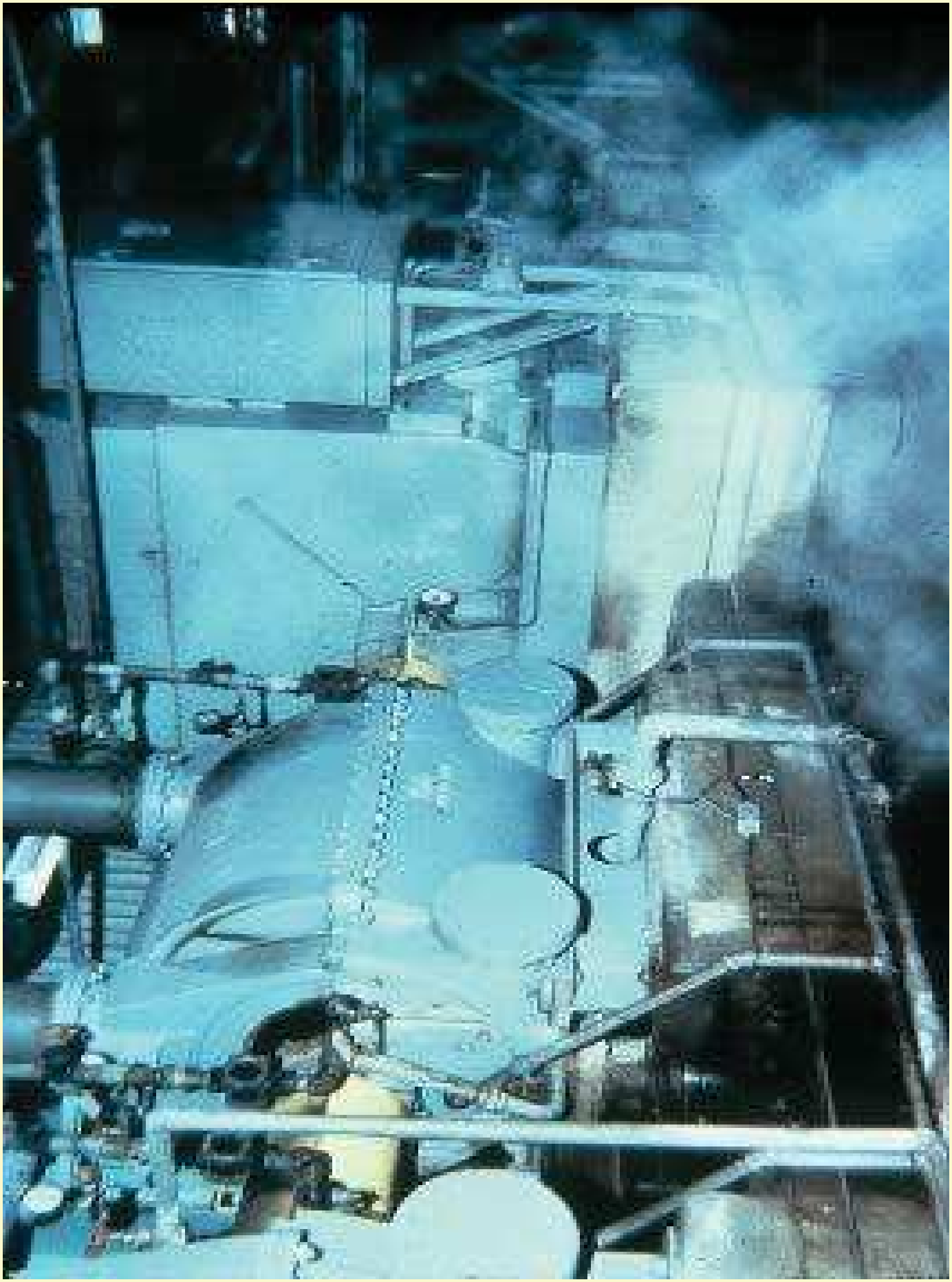


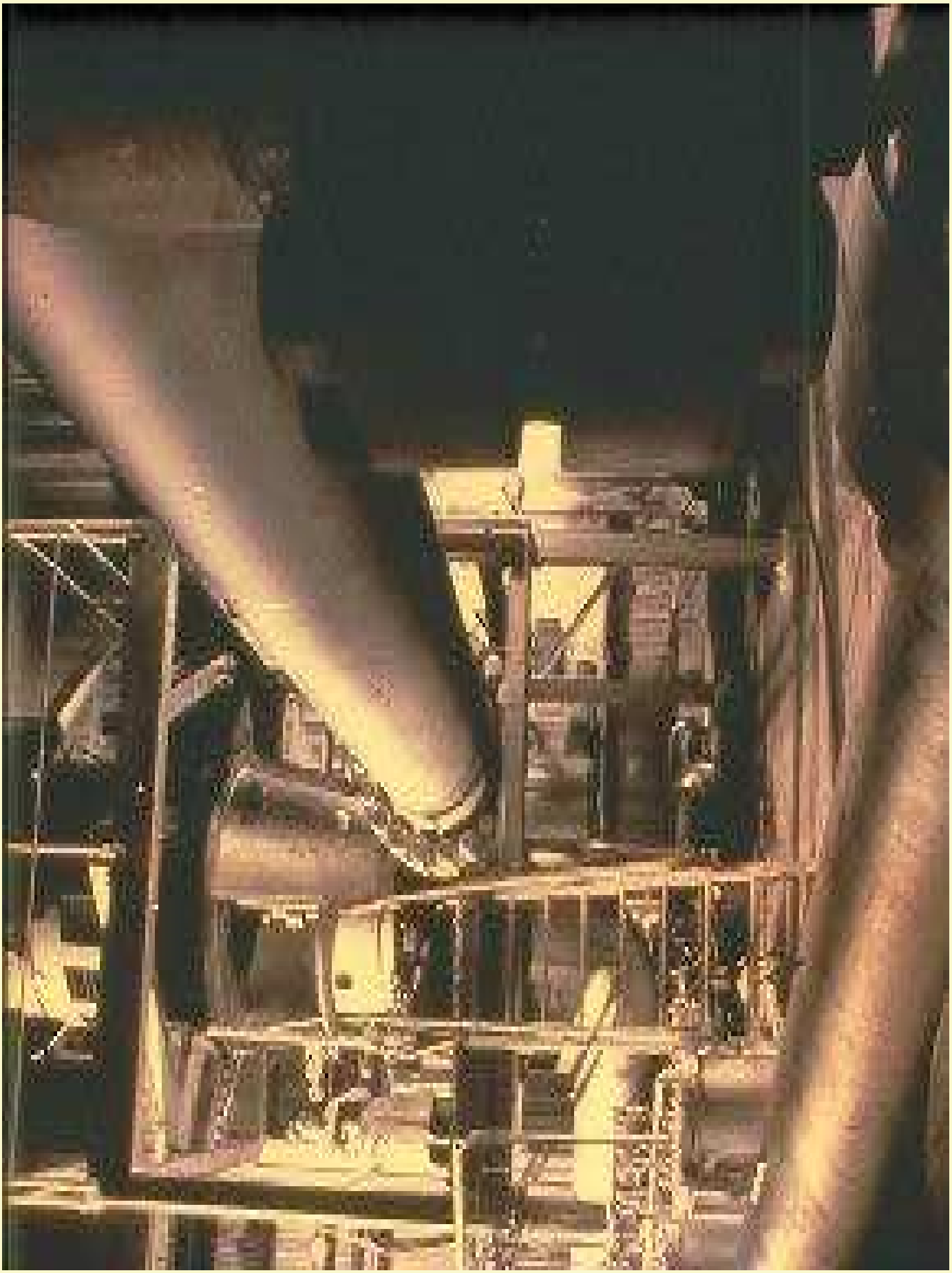


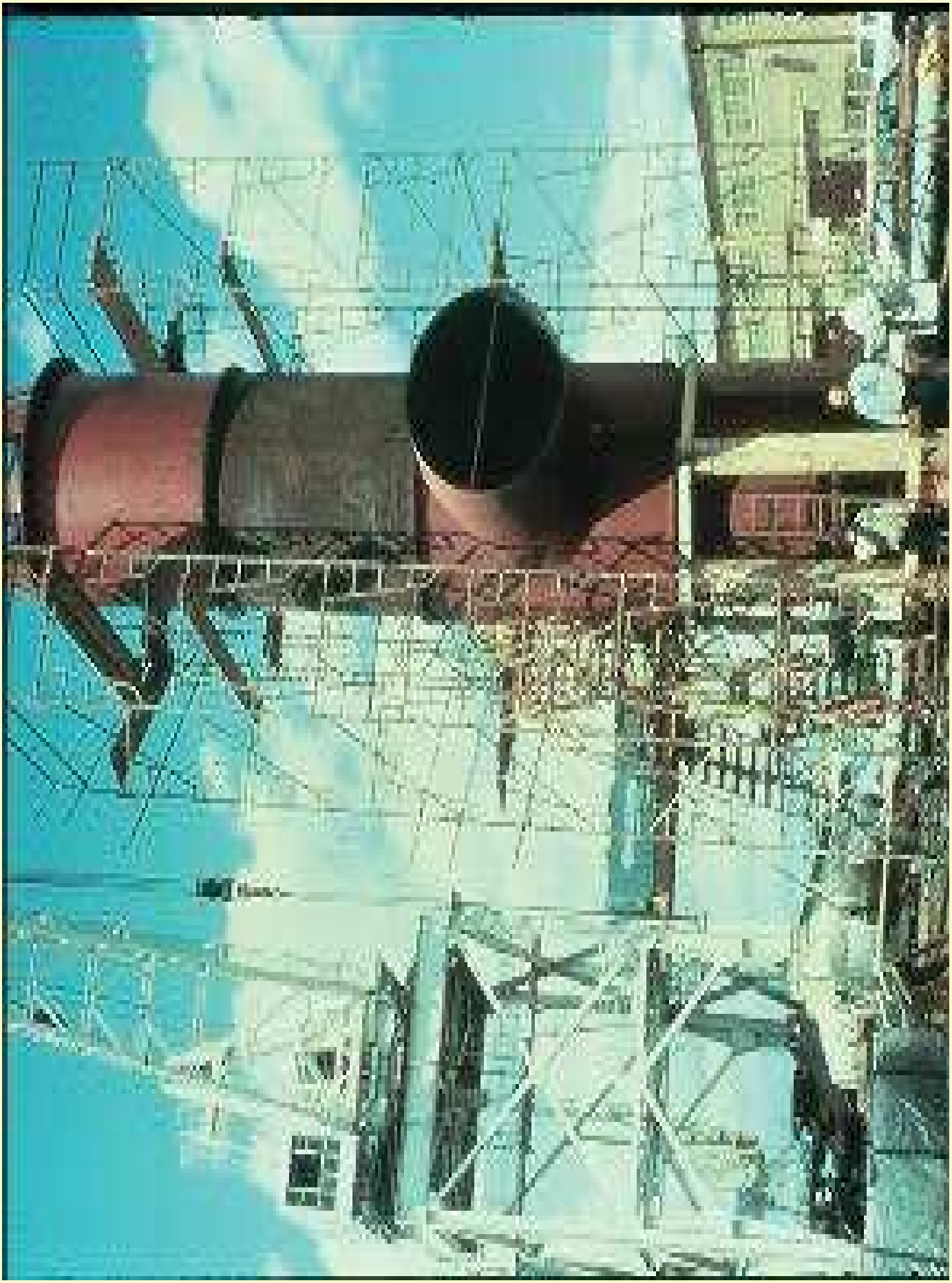


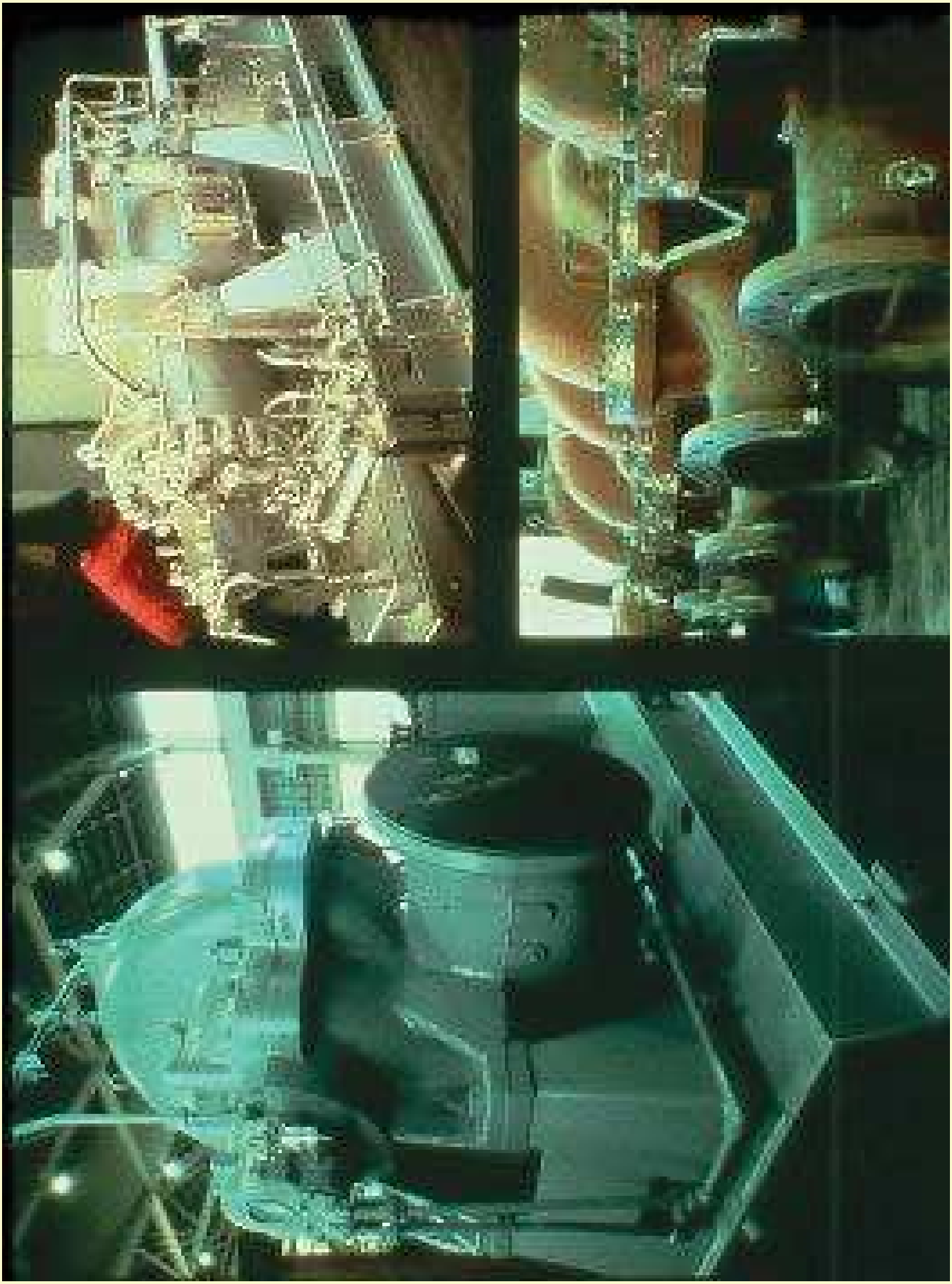


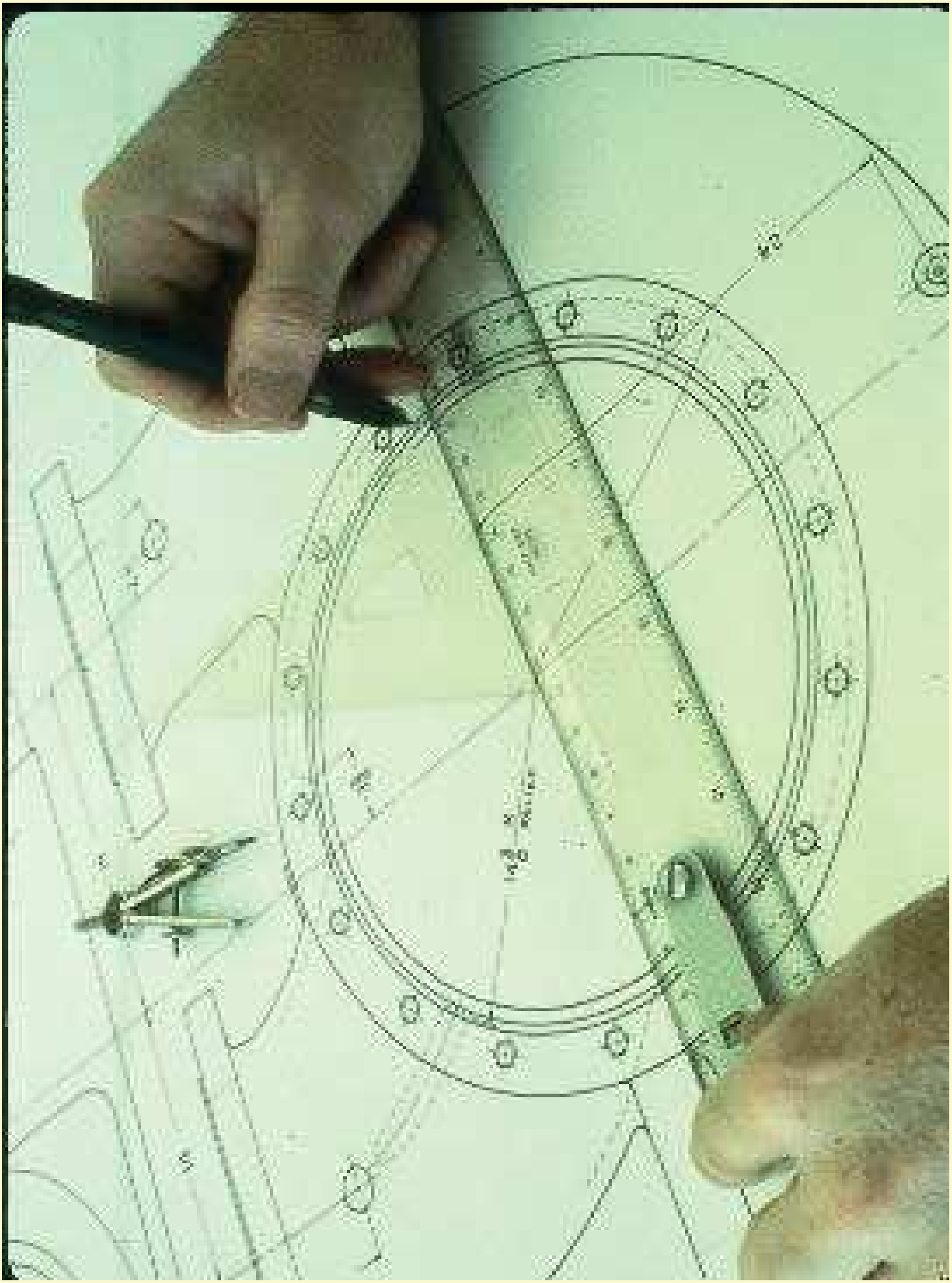


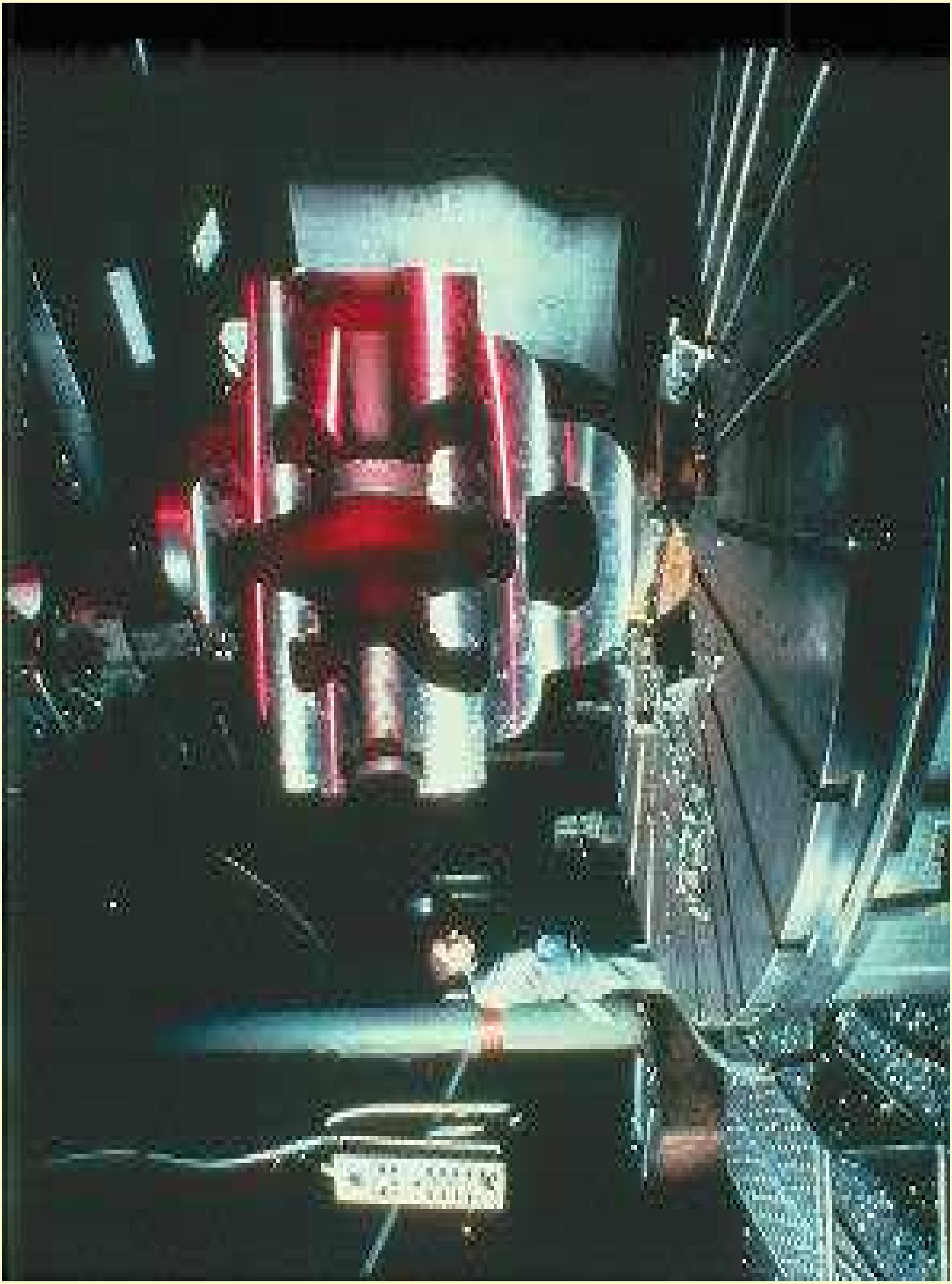






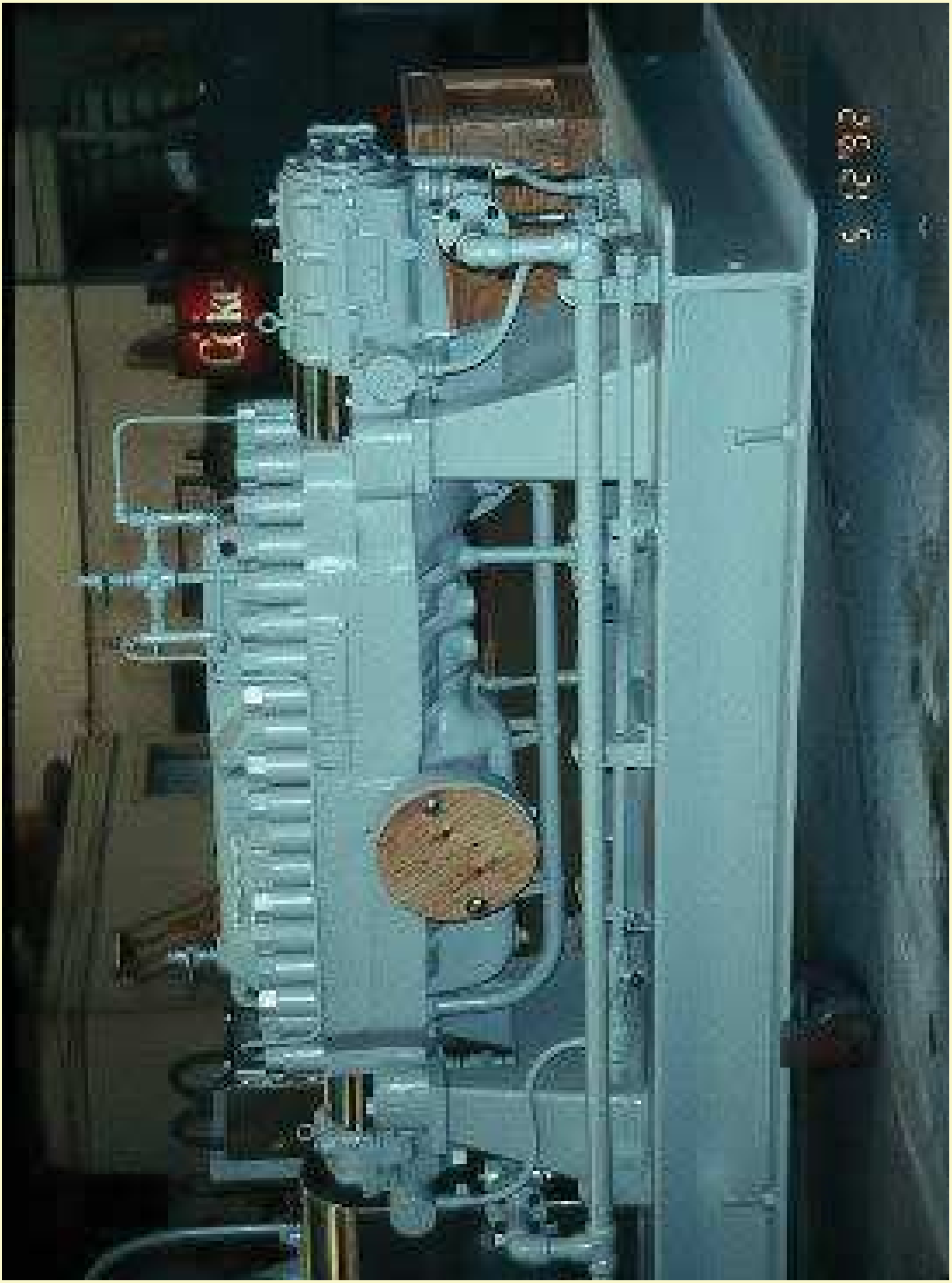


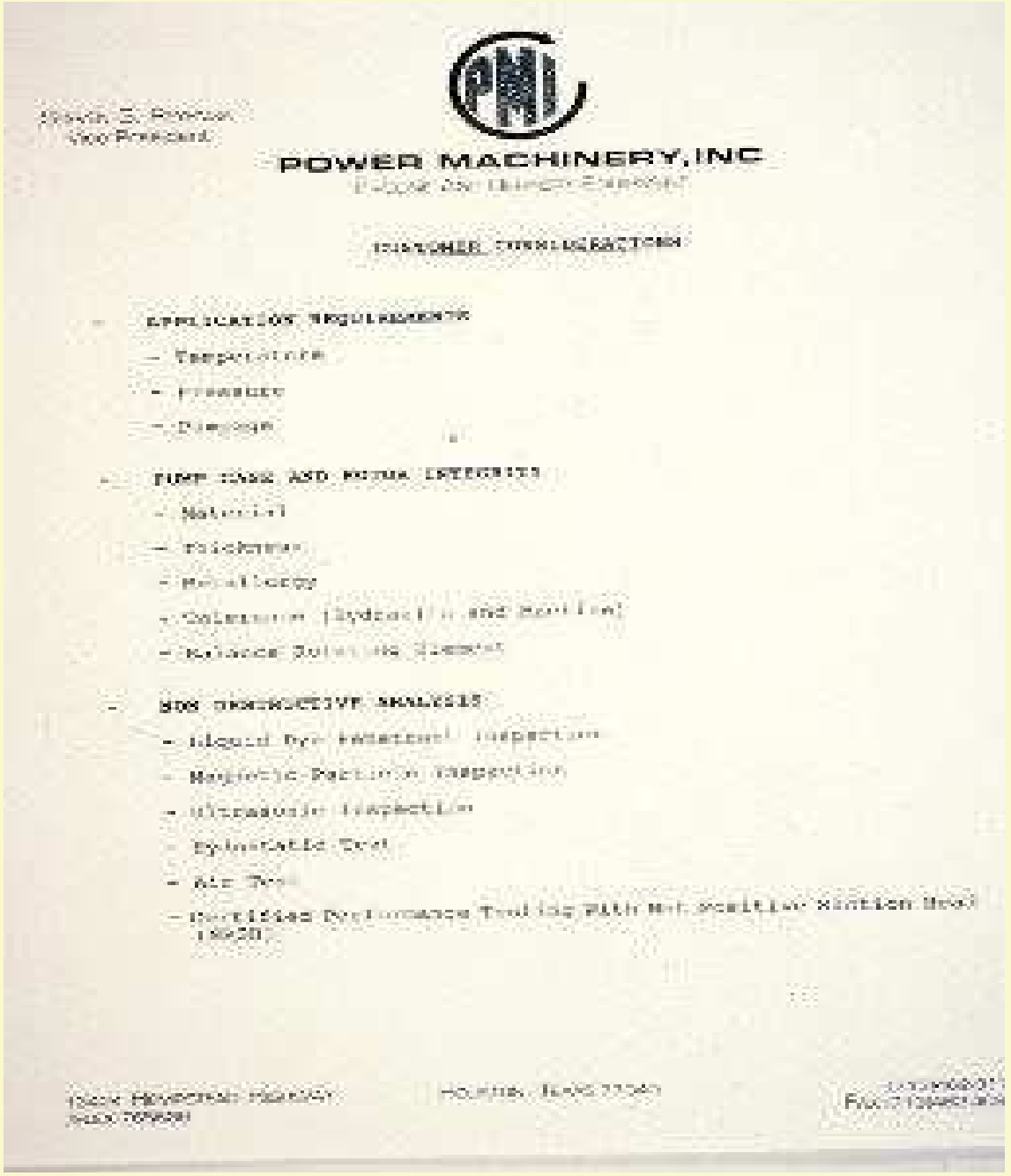




FINAL
DIM. INSPECTION
ACCEPTED
Bingham
ORIGINAL REPLACEMENT PARTS
BINGHAM-WILLAMETTE COMPANY

WINK
PUMP NO.1





[illegible]
Vice President

POWER MACHINERY, INC

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CUSTOMER CONSIDERATIONS

- **APPLICATION REQUIREMENTS**
  - Temperature
  - Pressure
  - Damage
- **PUMP CASE AND ROTOR INTEGRITY**
  - Material
  - Thickness
  - Metallurgy
  - Tolerance (Hydraulic and Mechanical)
  - Balance Rotating Element
- **NON DESTRUCTIVE ANALYSIS**
  - Liquid Dye Penetrant Inspection
  - Magnetic-Particle Inspection
  - Ultrasonic Inspection
  - Hydrostatic Test
  - Air Test
  - Certified Performance Testing With Net Positive Suction Head (NPSH)

[illegible] HEMPSTEAD HIGHWAY
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HOUSTON, TEXAS [illegible]
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FAX [illegible]