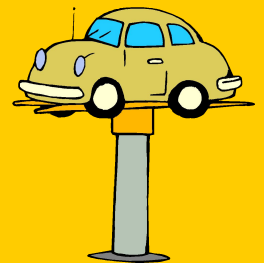




Hydraulics

hy·drau·lics [h dróllicks] *noun*
study of fluids: the study of
water or other fluids at rest or in
motion, especially with respect
to engineering applications



Objectives

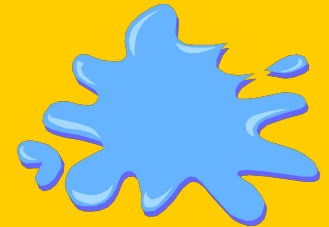
- Behavior of liquids & theory of operation
- Basic hydraulic system components
- Advantages & disadvantages of hydraulics
- Electrohydraulic systems including speed gears & steering gears

Introduction/Uses

- Hydraulics used in many applications:
 - Steering/control systems (rudder, planes)
 - Deck machinery (anchor windlass, capstans, winches)
 - Masts & antennae on submarines
 - Weapons systems (loading & launching)
 - Other: elevators, presses

Hydraulic Theory

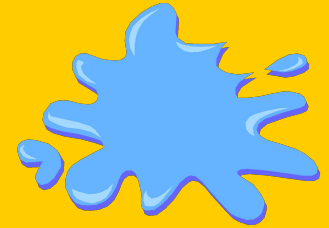
- Hydraulics
 - Covers the physical behavior of liquids in motion
 - Pressurized oil used to gain mechanical advantage and perform work
- Important Properties
 - Shapelessness
 - Incompressibility
 - Transmission of Force



Important Properties

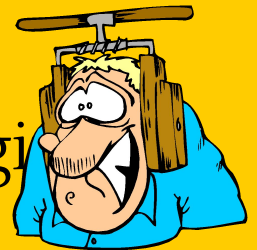
- “Shapelessness”

- Liquids have no neutral form
- Conform to shape of container
- Easily transferred through piping from one location to another



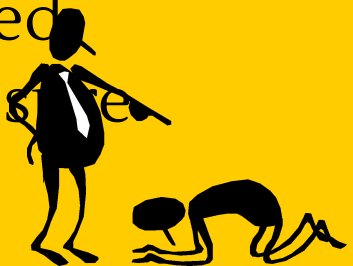
- Incompressibility

- Liquids are essentially incompressible
- Once force is removed, liquid returns to original volume (no permanent distortion)



- Transmission of Force

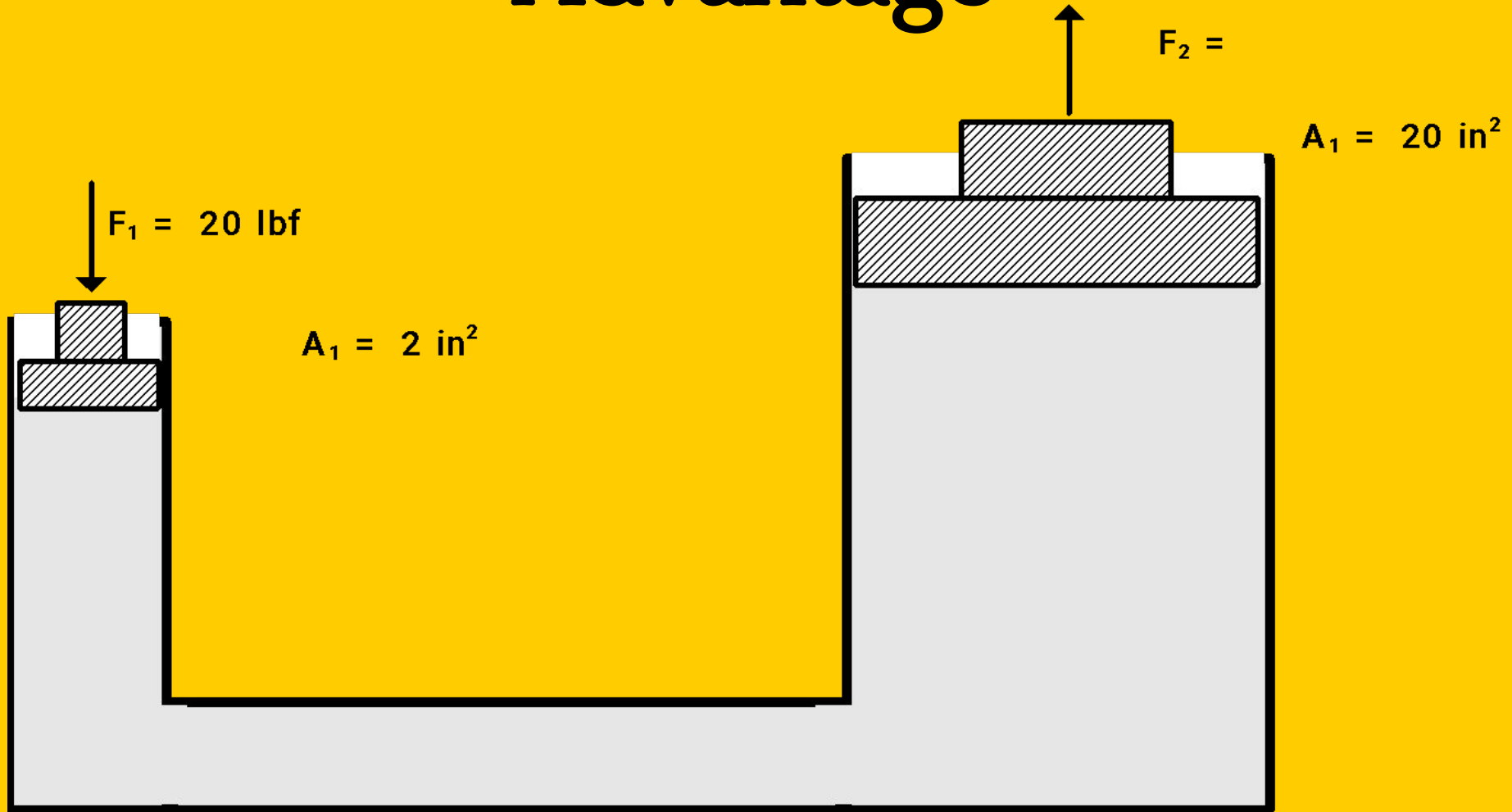
- Force is transmitted equally & undiminished in every direction -> vessel filled with pressurized liquid



Hydraulic Theory

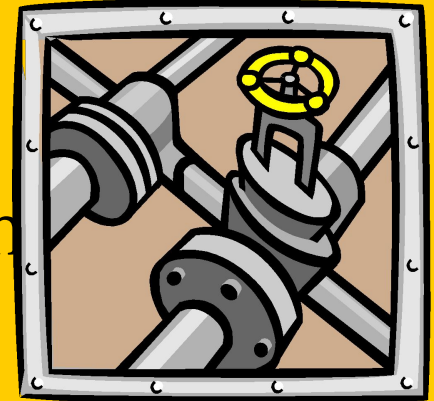
- Pascal's Law
 - Magnitude of force transferred is in direct proportion to the surface area ($F = P \cdot A$)
 - **Pressure = Force/Area**
- Liquid properties enable large objects (rudder, planes, etc) to be moved smoothly

Hydraulic Mechanical Advantage



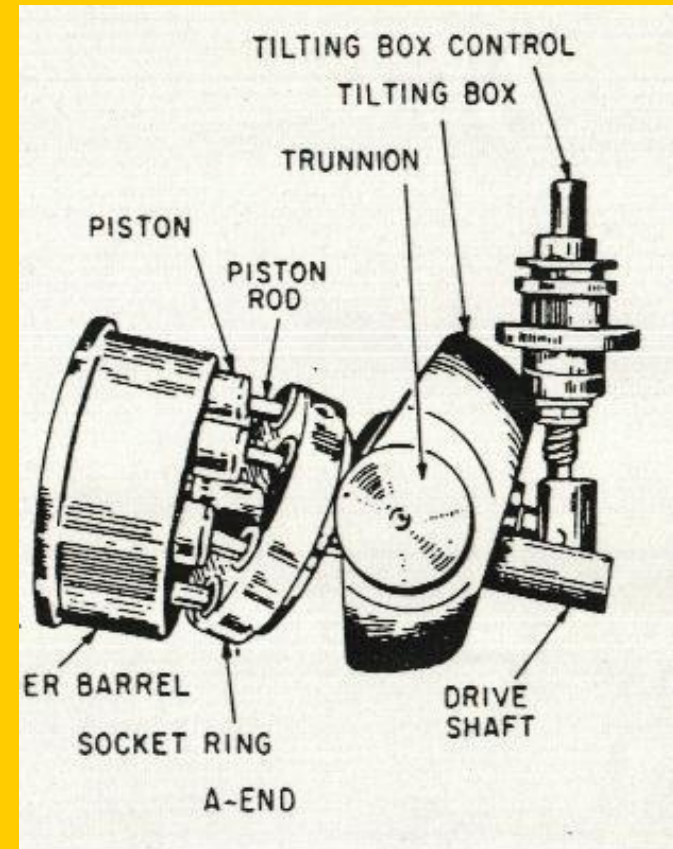
Basic Hydraulic System

- Hydraulic Fluid
 - Usually oil (2190 TEP)
- Pressure Source
 - Hydraulic pump (A-end of system)
- Pressure user
 - Hydraulic motor (B-end of system)
- Piping system (w/ valves, tanks, etc)
 - Get fluid from A-end to B-end



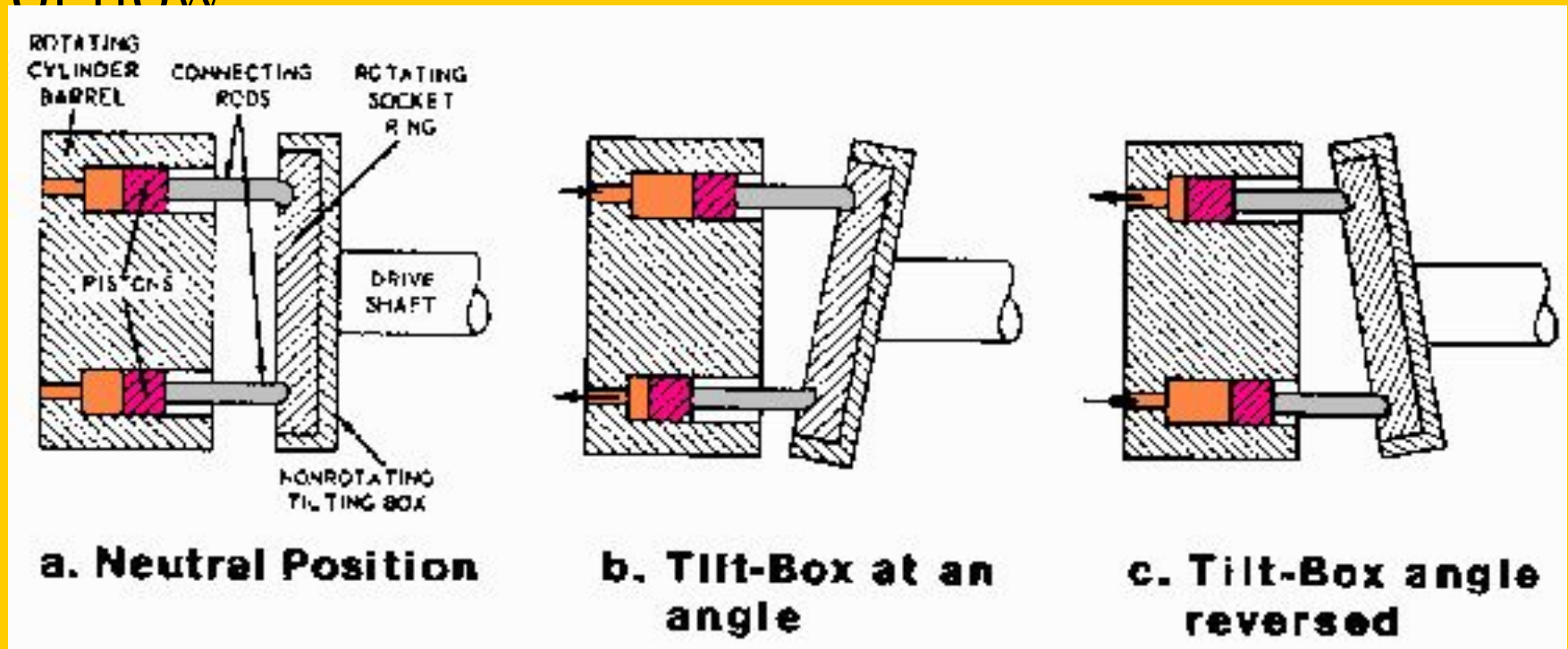
Hydraulic Pump (A-End)

- Pumps can be positive displacement or centrifugal
- Waterbury pump
 - Variable-stroke piston pump
 - Tilting box can tilt fwd/aft while pump rotates
 - Angle of tilting box determines capacity and direction of oil flow



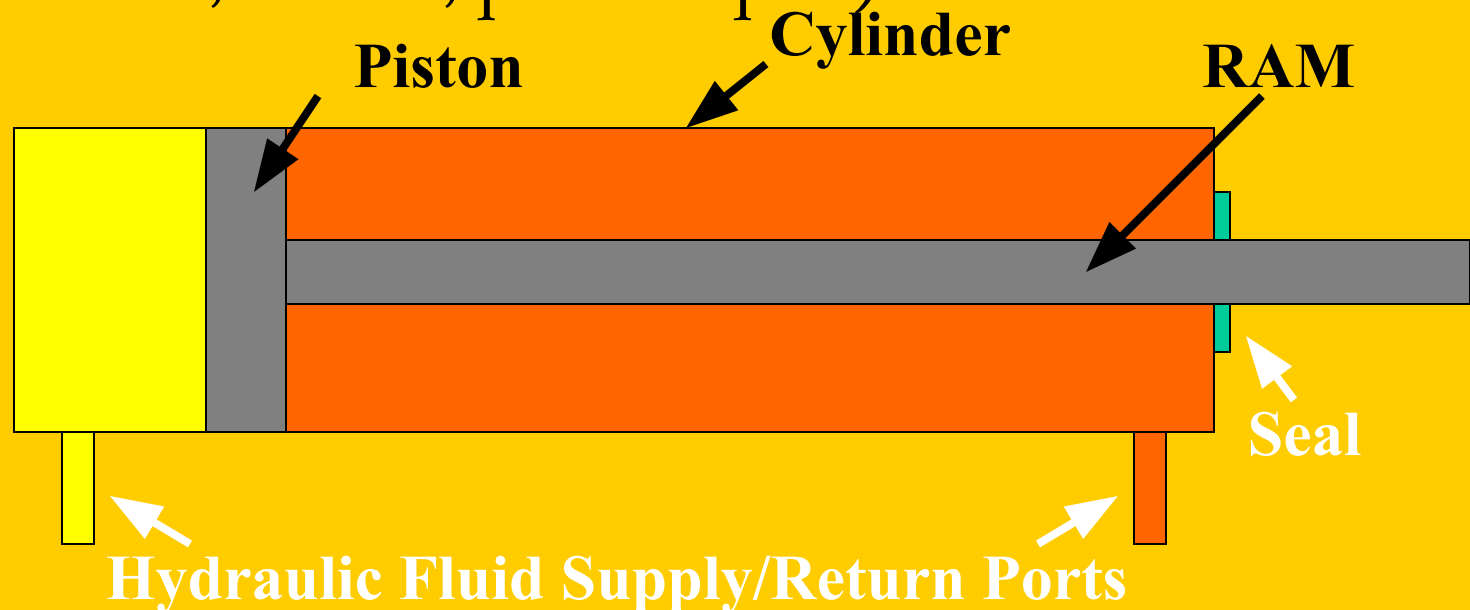
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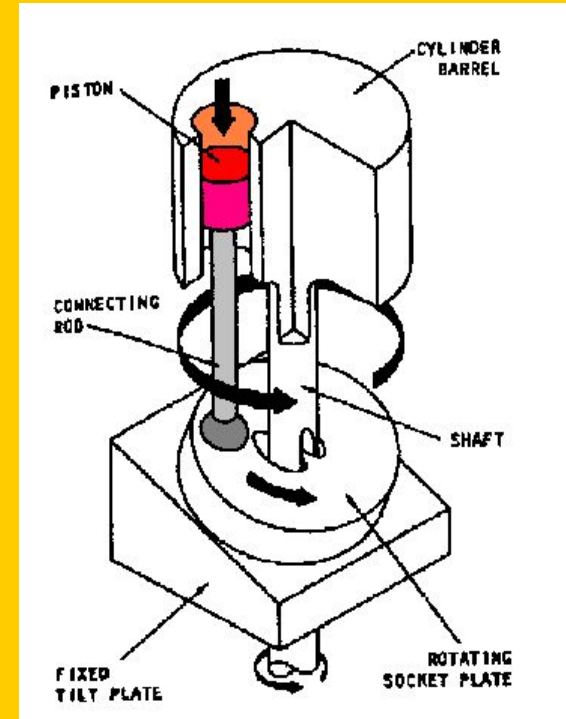
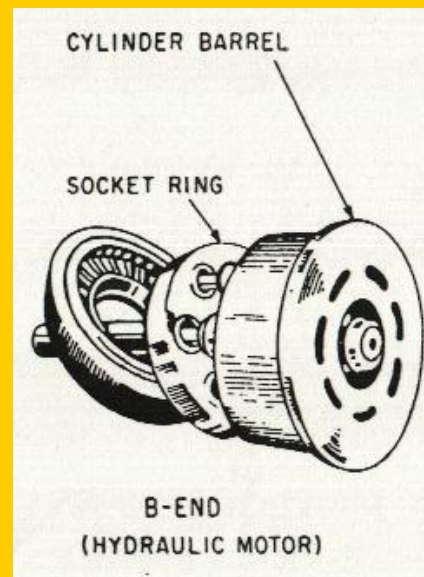
Cylinder/Motor (B-end)

- Piston/cylinder used if desired motion is linear
 - Hydraulic pressure moves piston & ram
 - Load is connected to ram (rudder, planes, masts, periscopes)



Cylinder/Motor (B-end)

- Motor used if desired motion is rotary
 - Essentially a variable-stroke pump in reverse
 - Used for capstan, anchor windlass, etc

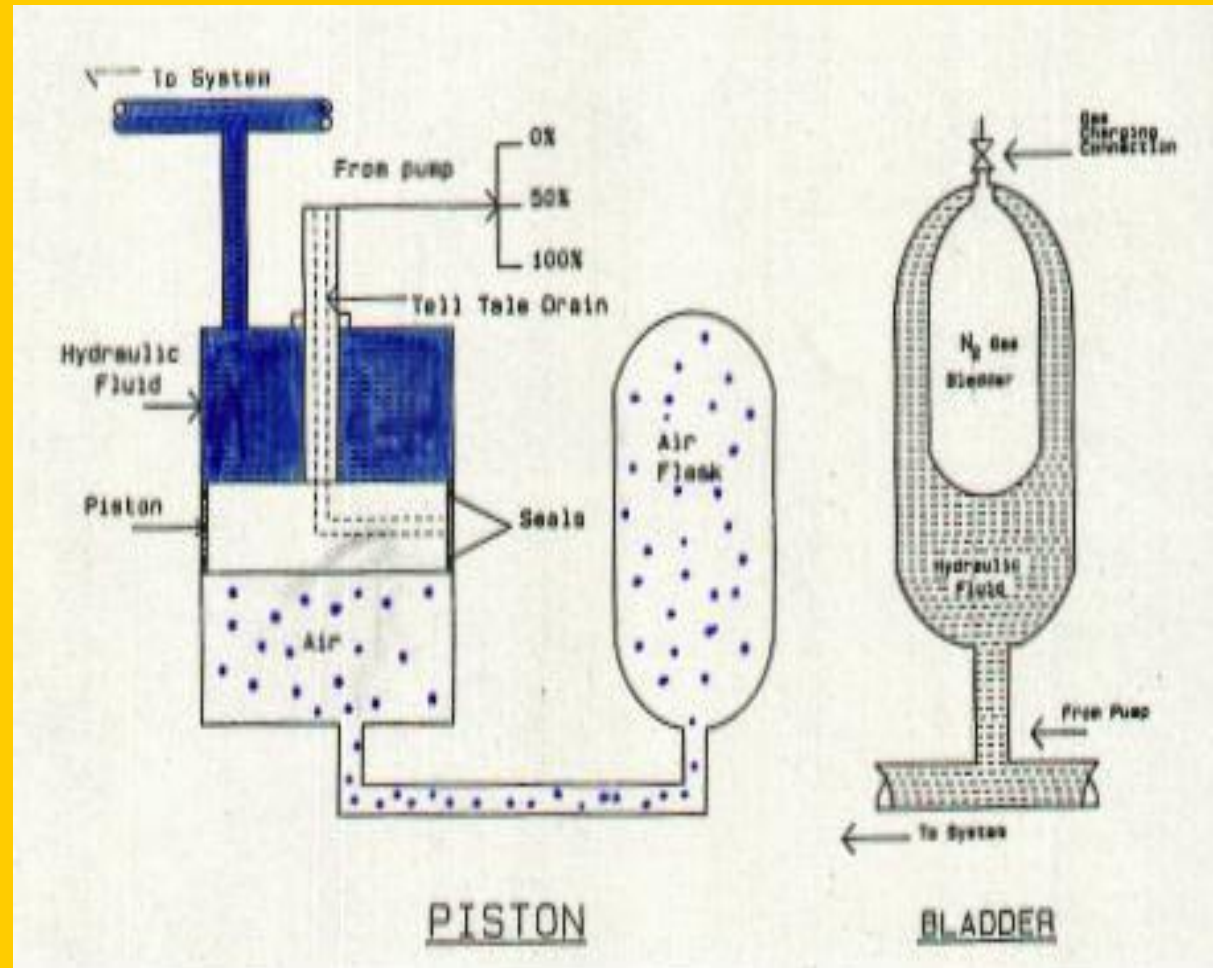


Piping System

- Has to withstand excessive pressure
- Valves, filters, & HX's all necessary
- Accumulators
 - Holds system under pressure (w/out contin. pump)
 - Provides hydraulics when pump off/lost
 - Compensates for leakage/makeup volume
 - Types: piston, bladder, & direct contact

Accumulator Types


- Piston
 - Most common
- Bladder
 - Gun mounts
 - Steering systems
- Direct contact
 - Least common



Advantages

- Convenient power transfer
 - Few moving parts
 - Low losses over long distances
 - Little wear
- Flexibility
 - Distribute force in multiple directions
 - Safe and reliable for many uses
 - Can be stored under pressure for long periods
- Variable speed control
 - Quick response (linear and rotary)

Disadvantages

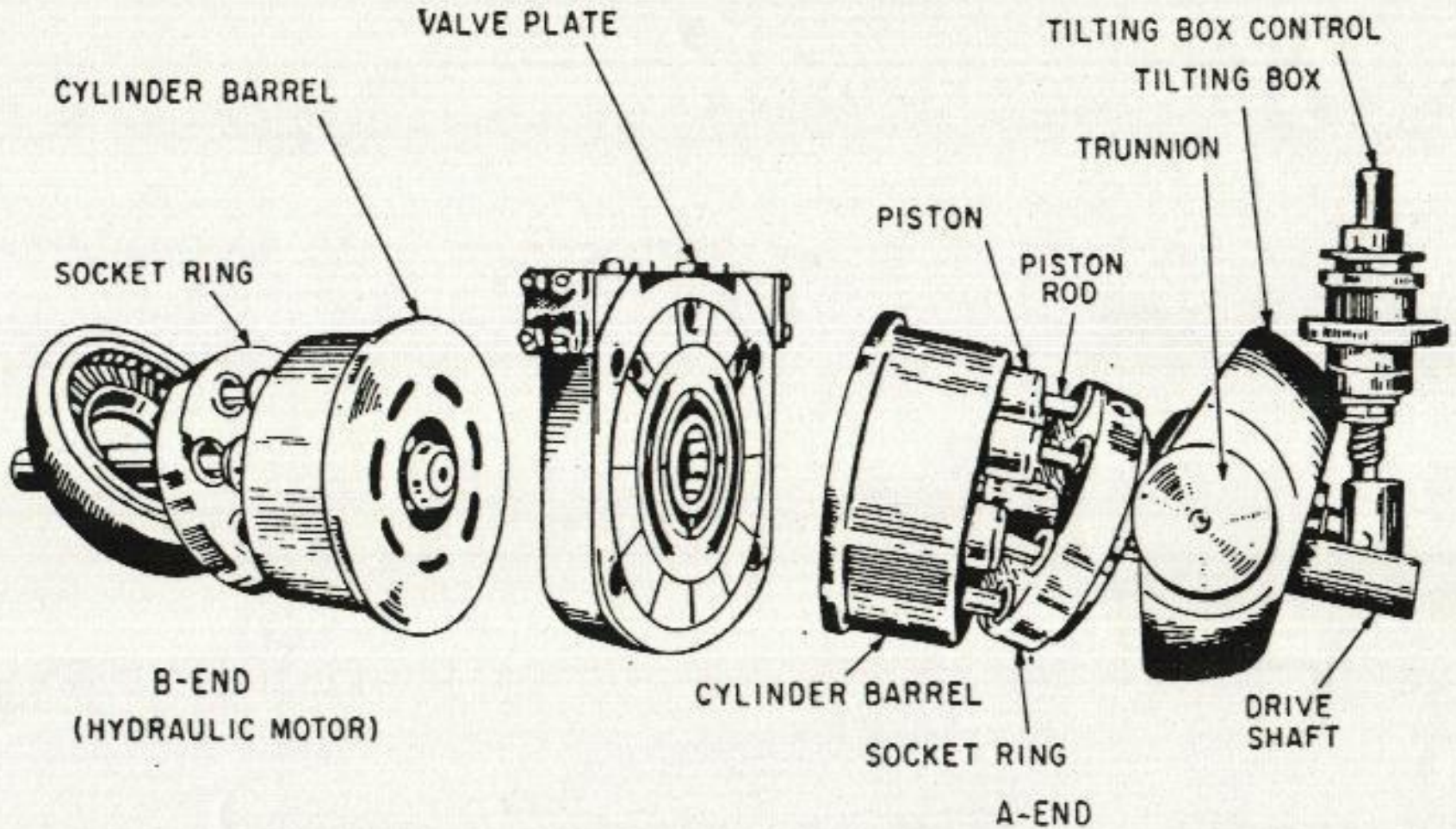
- Requires positive confinement (to give shape)
-  Fire/explosive hazard if leaks or ruptures
- Filtration critical - must be free of debris
- Manpower intensive to clean up



Electrohydraulic Drive System

- Uses hydraulics to transfer power from electric motor to load
- Rotary: Waterbury pump connected to rotary piston hydraulic motor (speed gear)
 - Tilting box of A-end controls direction/speed of B-end
 - Adv: high starting torque, reversibility, high power-to-weight ratio
- ex: Electrohydraulic Speed Gear or Steering Gear
 - capstan, anchor windlass, cranes, elevator,

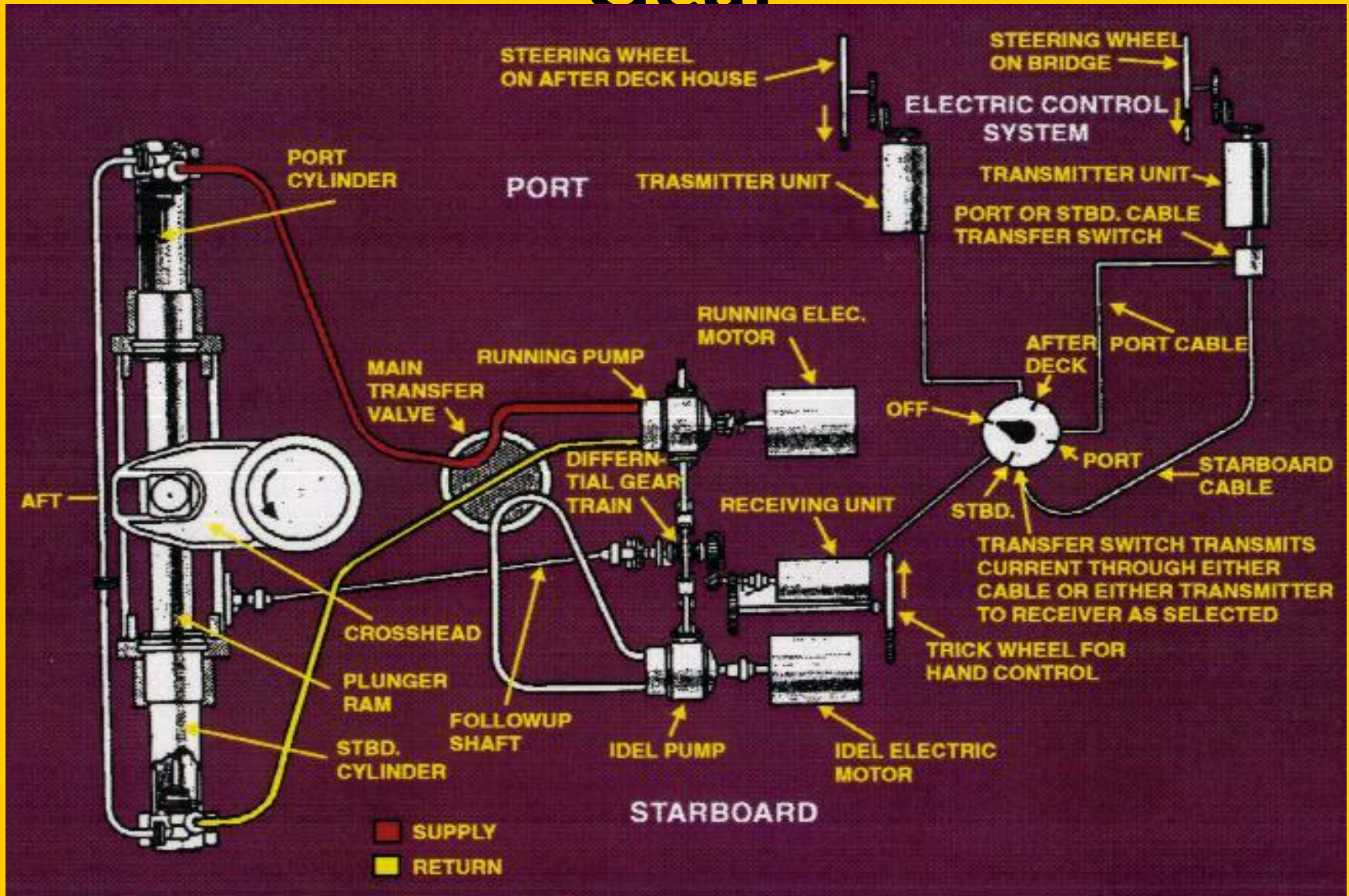
Electrohydraulic Speed Gear



Electrohydraulic Steering Gear

- Same as speed gear except B-end is a hydraulic cylinder to produce linear motion
- Waterbury pumps connected by piping to hydraulic ram cylinder
 - Various methods for connecting rams to tillers
 - Two pumps for redundancy & reliability
 - Movement of steering wheel through hydraulic system moves rudder

Electrohydraulic Steering Gear



Control of System

- Remote control
 - Normal method
 - Control from bridge
- Emergency
 - Take local control
 - Manually position control surface/rudder





Questions?