SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF MECHANICAL ENGINEERING

CLUTCHES
III YEAR VISEM

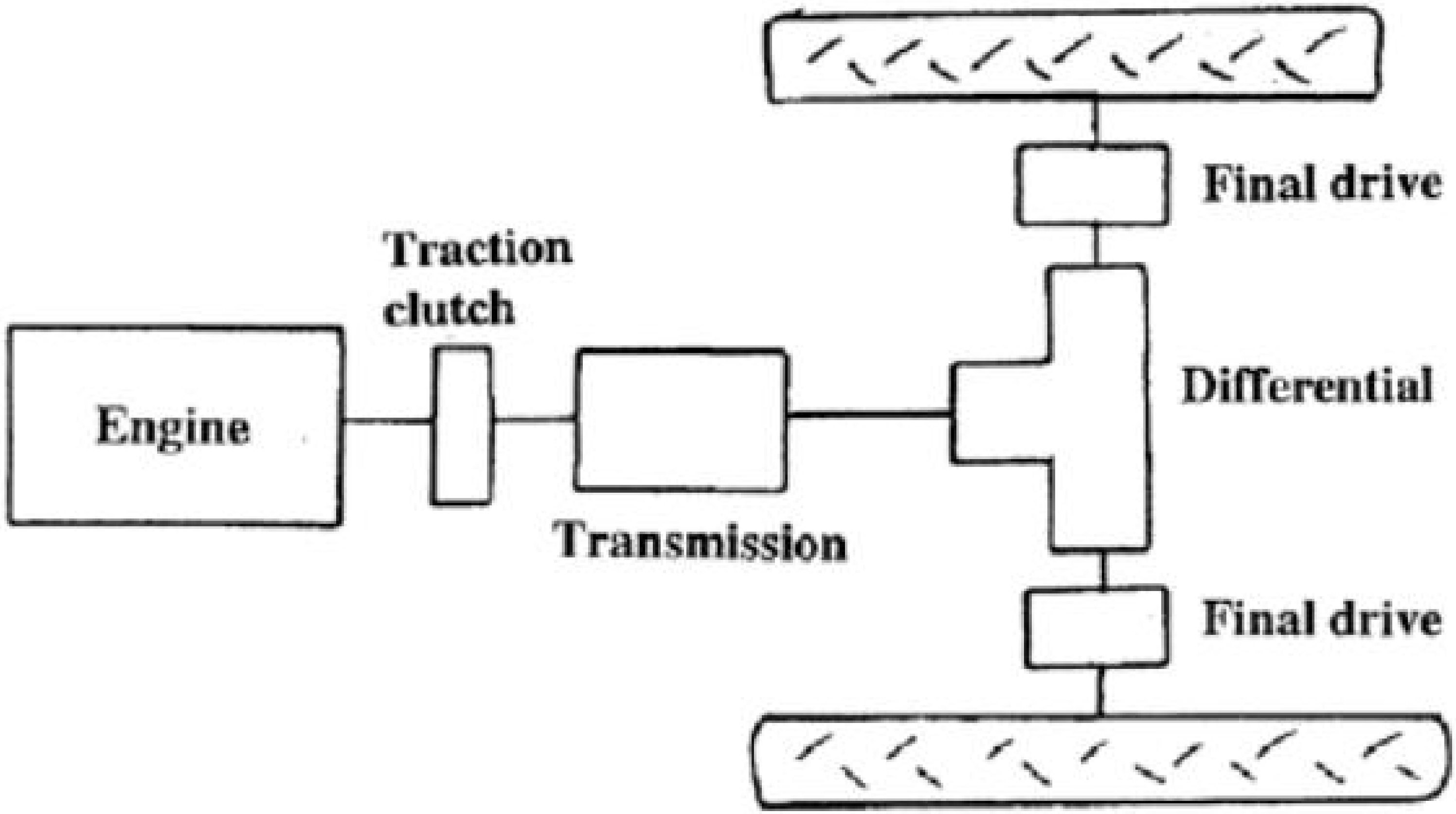
UNIT 5– Clutches and Brakes

Introduction :

Drive trains serve the following functions:

- Transmit power from engine to drive wheels and PTO.
- A means of smoothly engaging engine power at start-up.
- Transform engine torque and speed to meet load requirements.
- Provides means for reversing the direction of travel.
- Provides a means of smoothly stopping the vehicle.

Vehicle drive-train.



Purpose

- A clutch is designed with the following requirements
  - Allow the vehicle to come to a stop while the transmission remains in gear
  - Allow the driver to smoothly take off from a dead stop
  - Allow the driver to smoothly change gears
  - Must not slip under heavy loads and full engine power

Purpose of the Clutch

- Allows engine to be *disengaged* from transmission for shifting gears and coming to a stop
- Allows smooth *engagement* of engine to transmission

Types of Clutches

(i) Positive Clutches (ii) Friction clutches

Types of friction clutches

(i) Plate clutch (Single plate) (multiple plate)

(ii) Cone clutch

(iii) Centrifugal clutch

(iv) Dry

(v) Magnetic current clutches

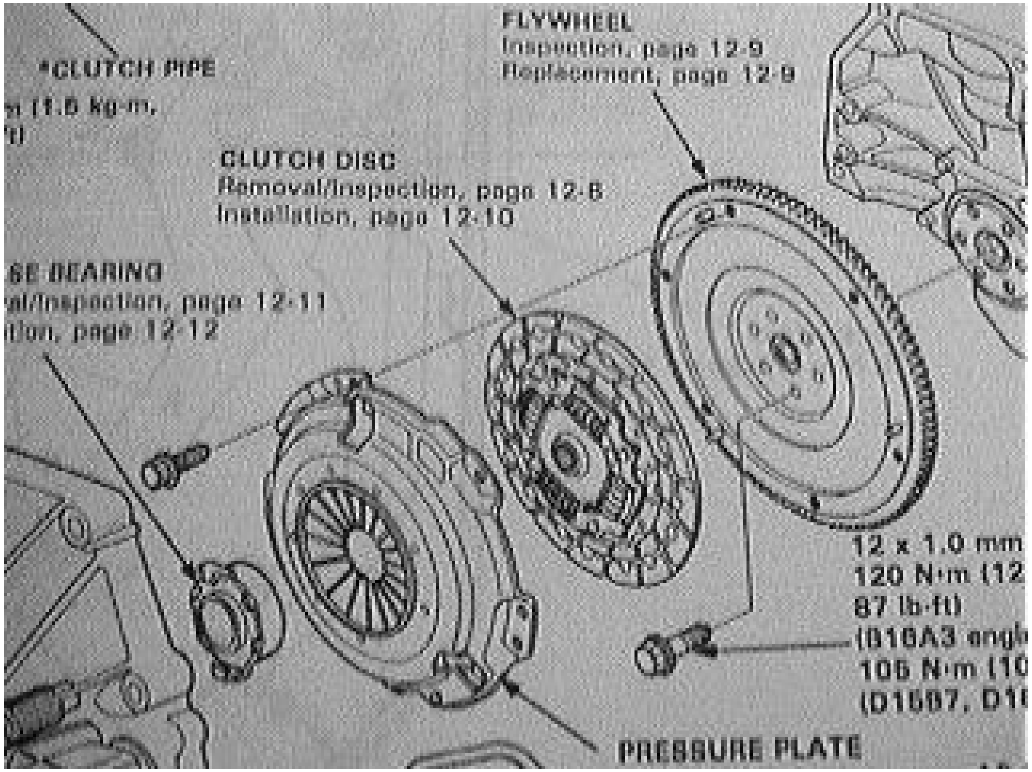
(vi) Eddy current clutches

Brakes and clutches are essentially the same devices.
Each is associated with the rotation

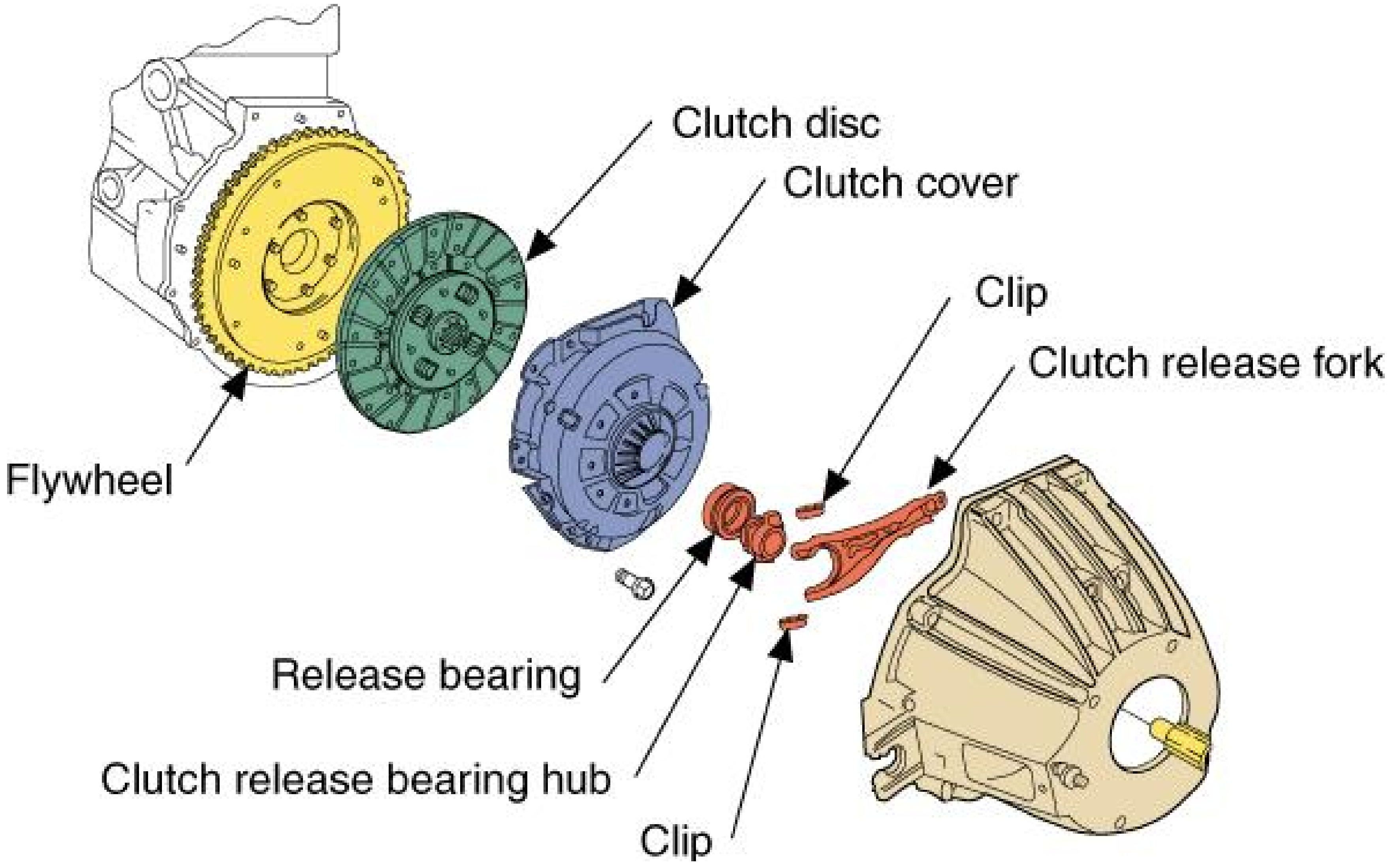
- Brakes, absorb kinetic energy of the moving bodies and covert it to heat
- Clutches Transmit power between two shafts

Components

- Primary components
  - Flywheel
  - Clutch disc
  - Pressure plate
  - Throwout bearing
- Secondary components
  - Pilot bearing
  - Release fork
  - Slave cylinder

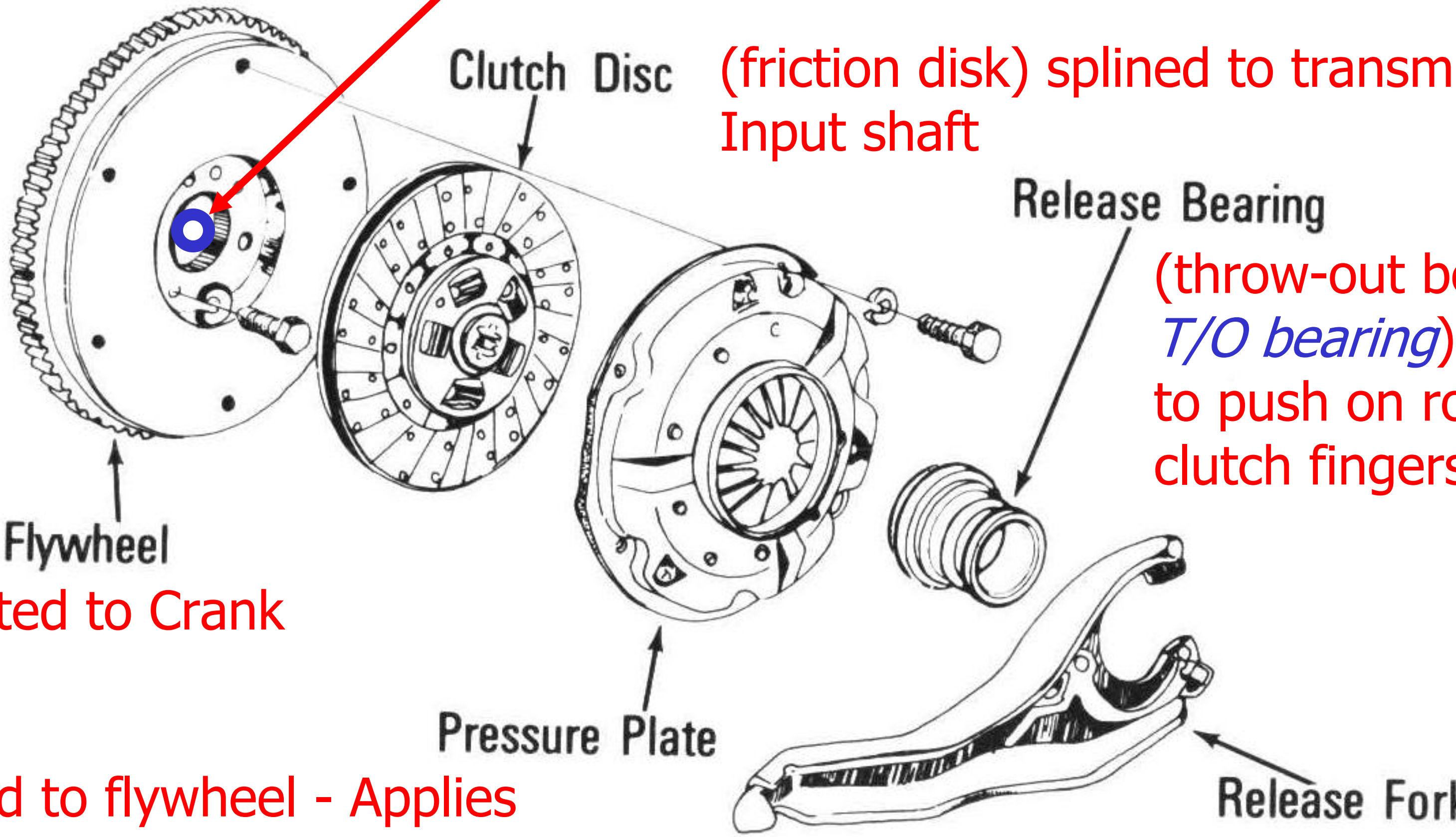


[How a Clutch Works](#)


Clutch disc
Clutch cover
Clip
Clutch release fork
Flywheel
Release bearing
Clutch release bearing hub
Clip

Clutches

Pilot bushing or bearing in center of flywheel or crankshaft, supports the end of input shaft



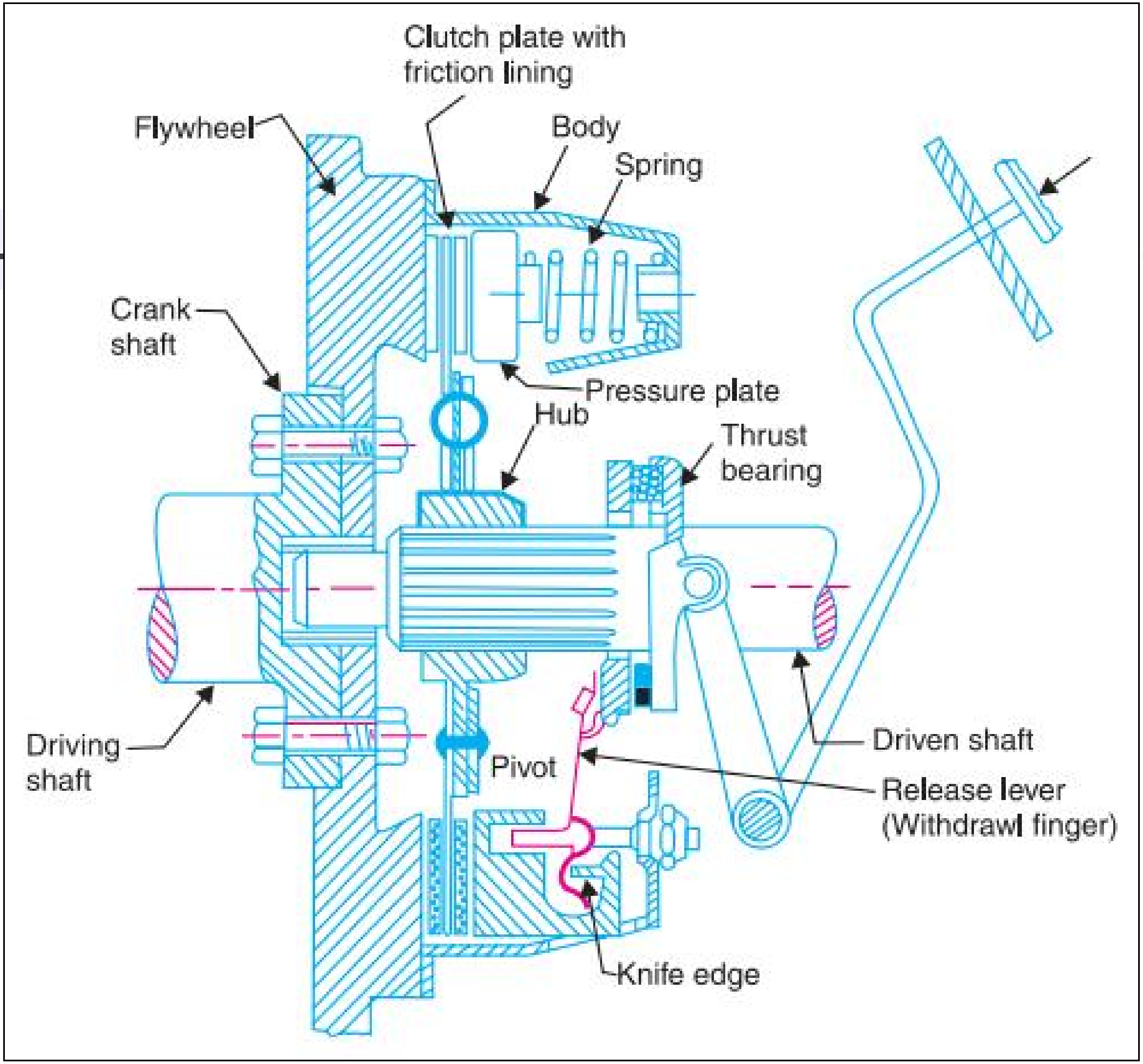
(friction disk) splined to transmission Input shaft

(throw-out bearing *T/O bearing*) allows to push on rotating clutch fingers

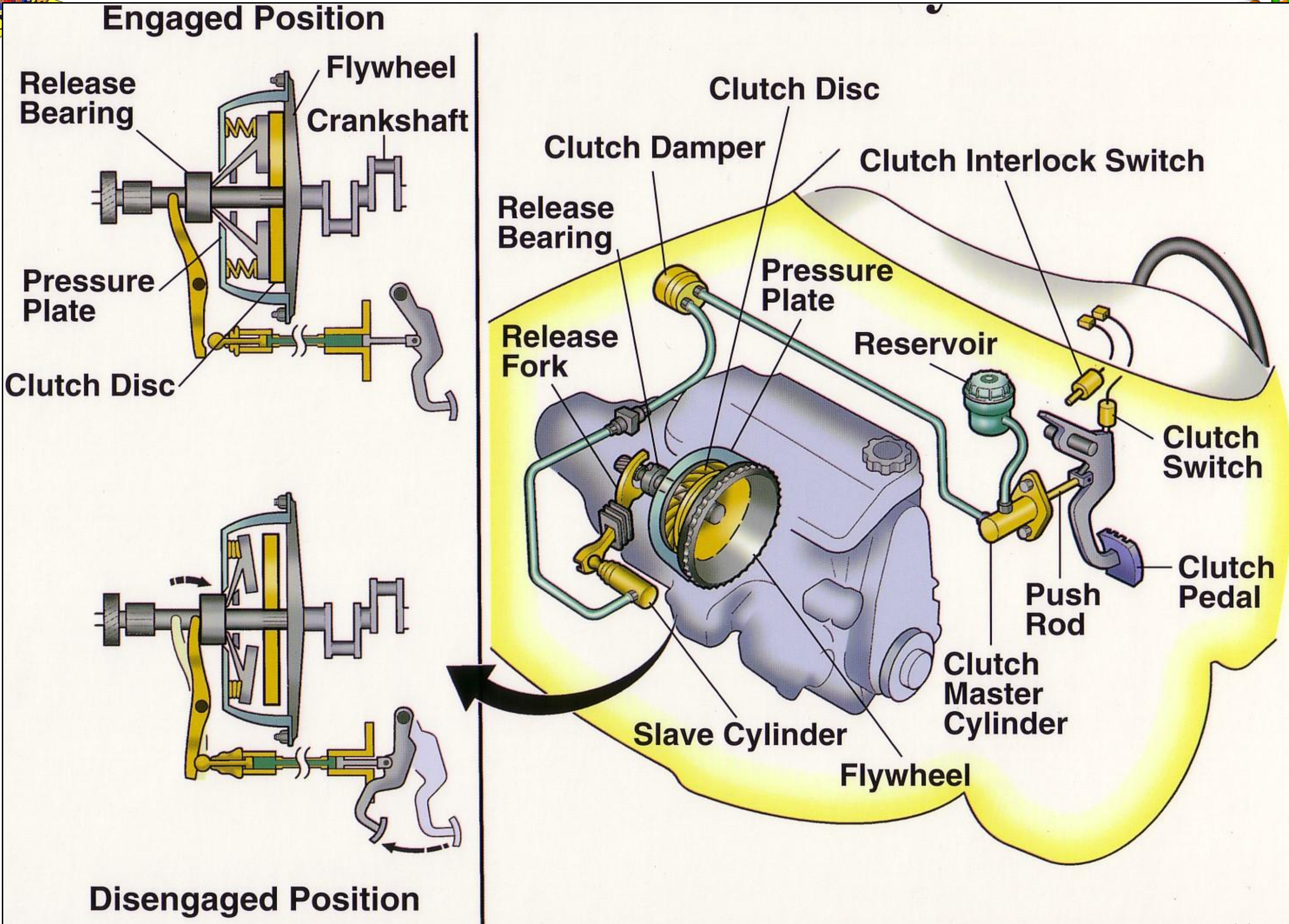
Flywheel: Bolted to Crank

Pressure Plate: Bolted to flywheel - Applies the spring force to clamp the friction disk to the flywheel

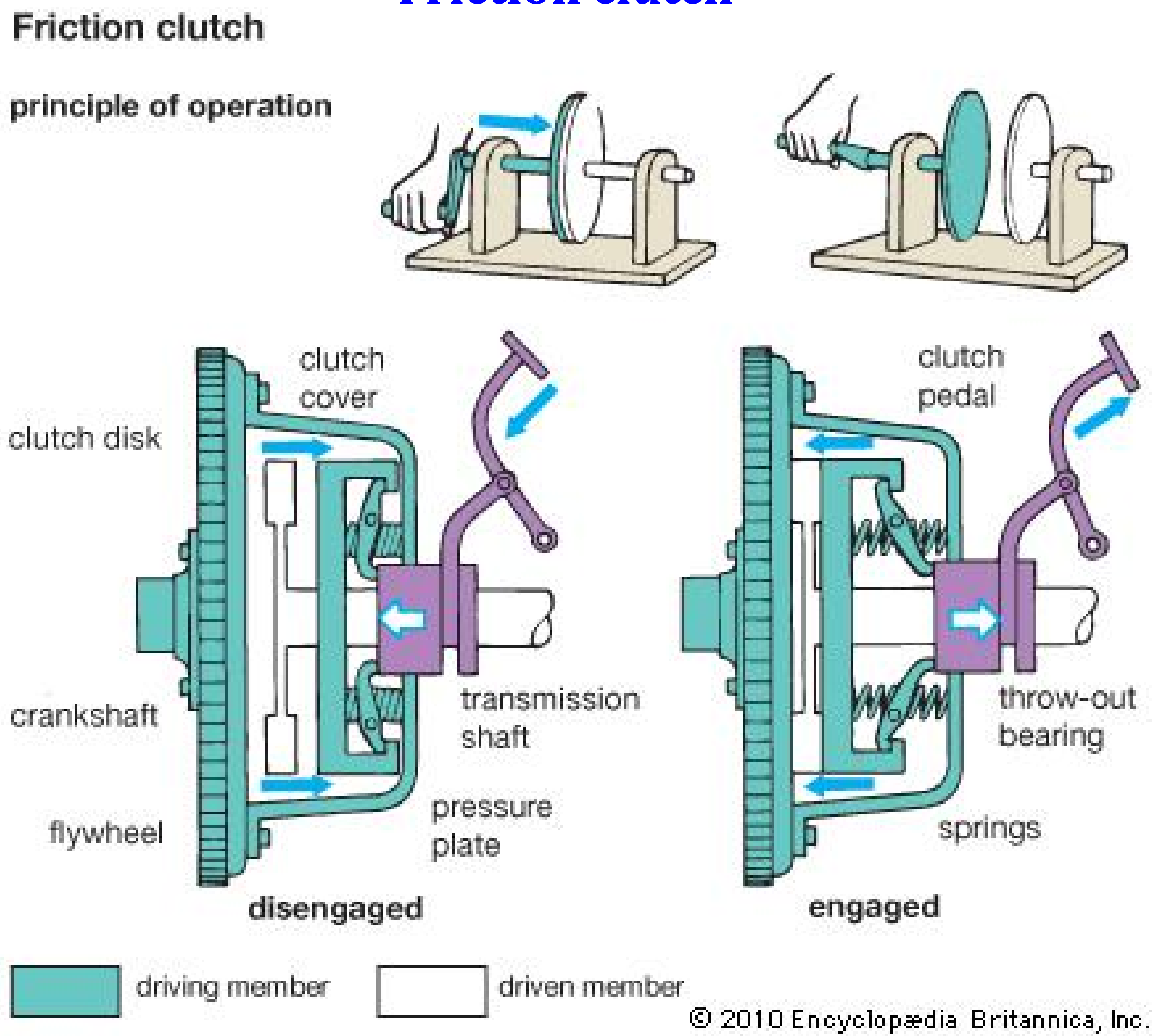
Release Fork: (clutch fork) pushes T/O bearing to release rotating clutch



Clutch plate with
friction lining
Flywheel
Body
Spring
Crank
shaft
Pressure plate
Hub
Thrust
bearing
Driving
shaft
Pivot
Driven shaft
Release lever
(Withdrawl finger)
Knife edge


Engaged Position
Release Bearing
Flywheel
Crankshaft
Pressure Plate
Clutch Disc
Disengaged Position
Clutch Disc
Clutch Damper
Clutch Interlock Switch
Release Bearing
Pressure Plate
Reservoir
Release Fork
Clutch Switch
Clutch Pedal
Push Rod
Clutch Master Cylinder
Slave Cylinder
Flywheel

Friction clutch



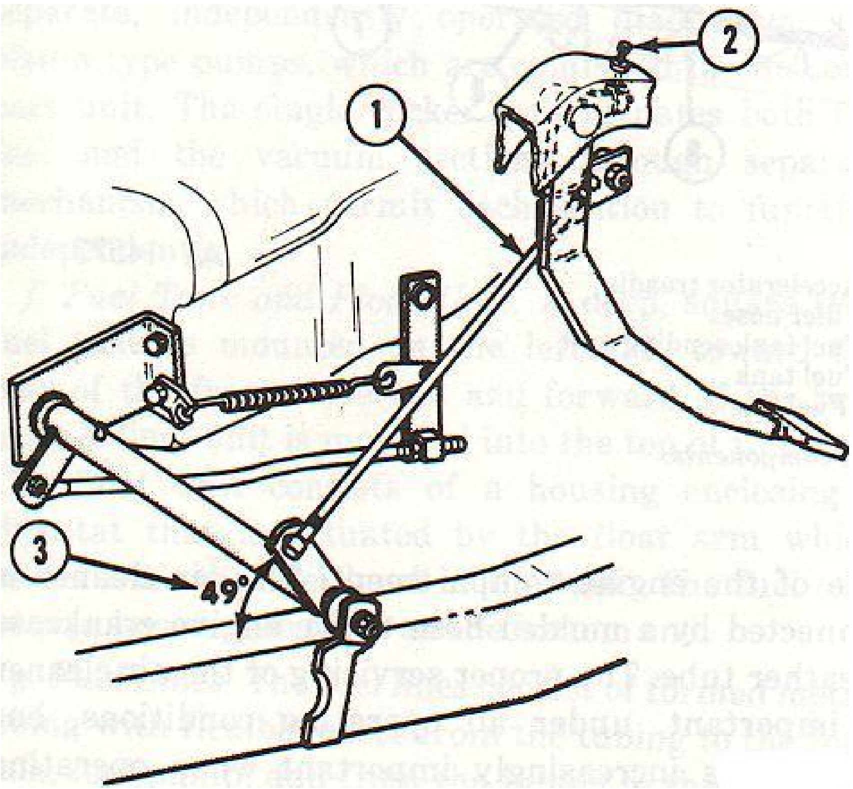
CLUTCH PLATE

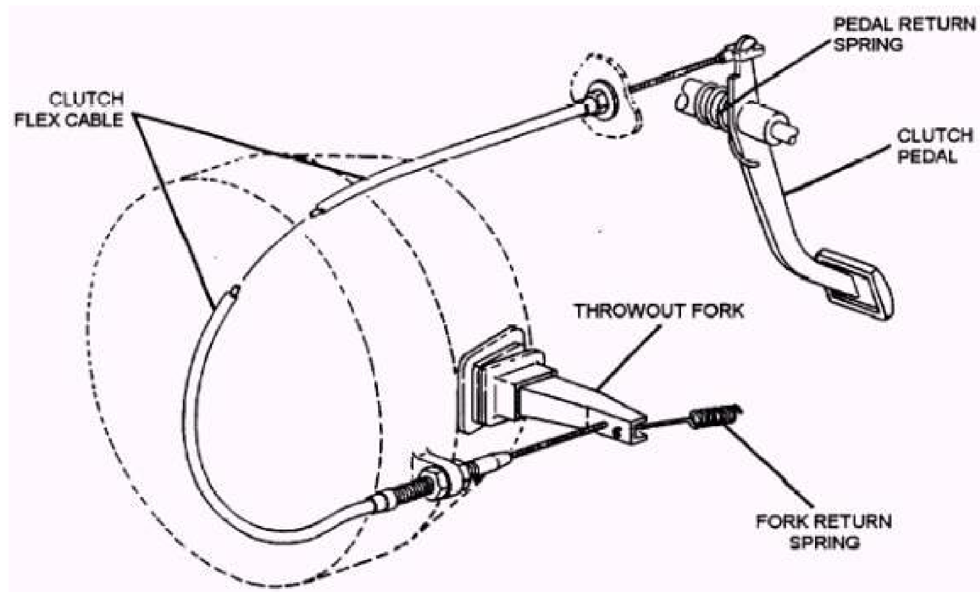

MOPAR
MUSCLE

Release Systems

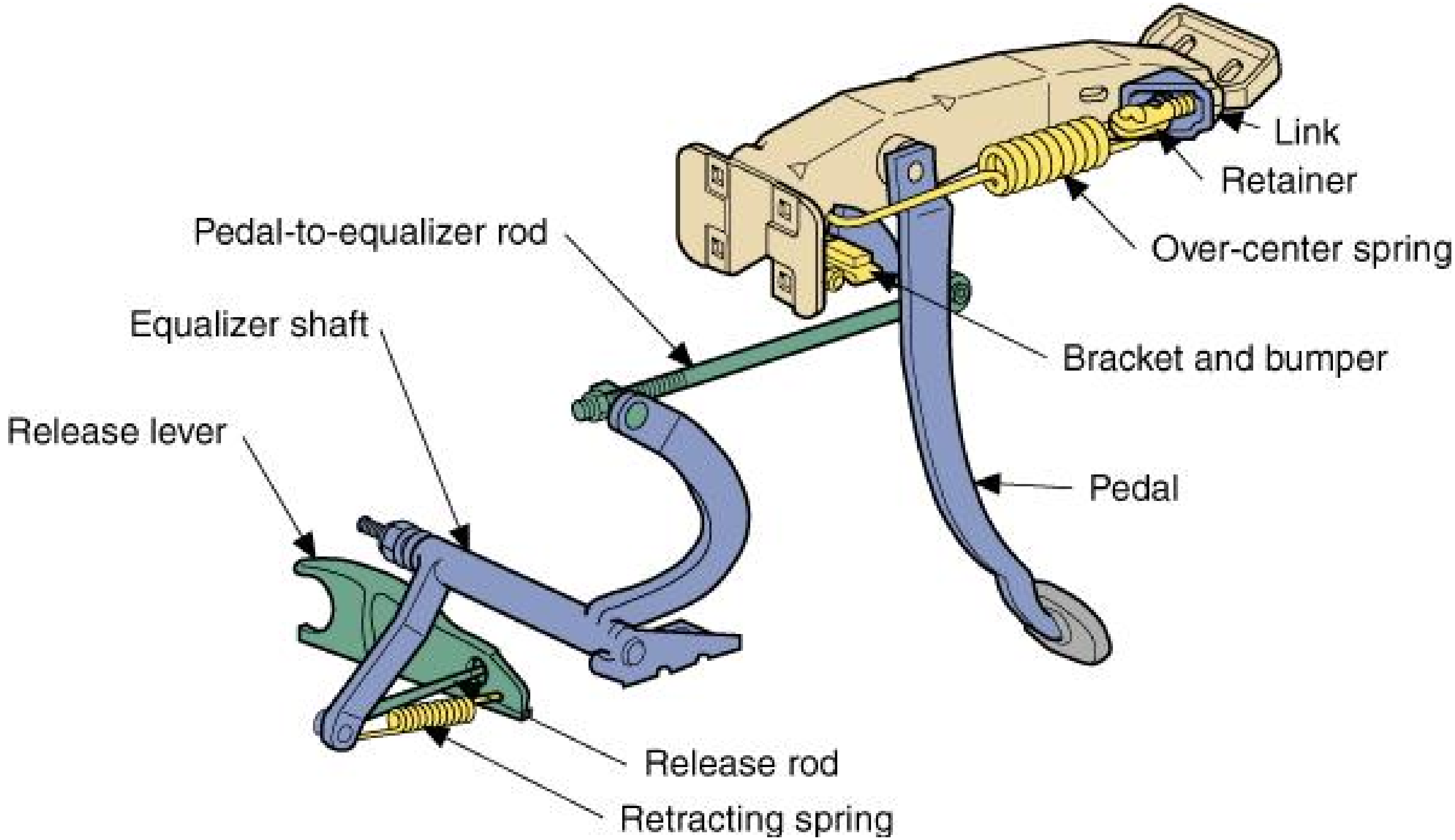
- Mechanical
  - A system of levers and linkages and/or cables connecting the clutch pedal with the release fork
- Hydraulic-Mechanical
  - A hydraulic master cylinder is used to transmit force to the slave cylinder which pushes on the release fork
- Hydraulic
  - A hydraulic master cylinder is used to transmit force to the slave cylinder which is located in the bellhousing and pushes directly on the throwout bearing

Mechanical Release

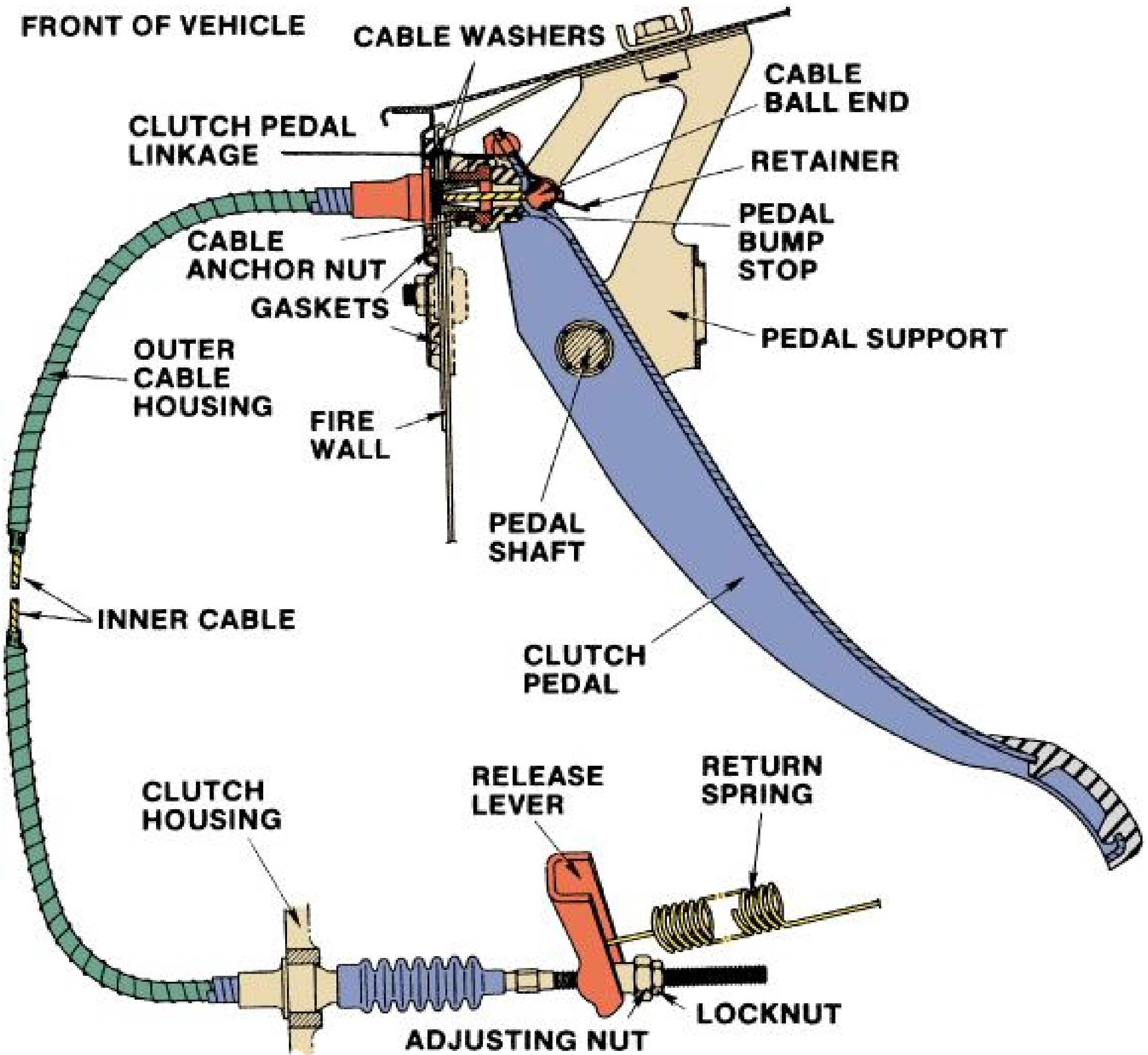




Mechanical Release

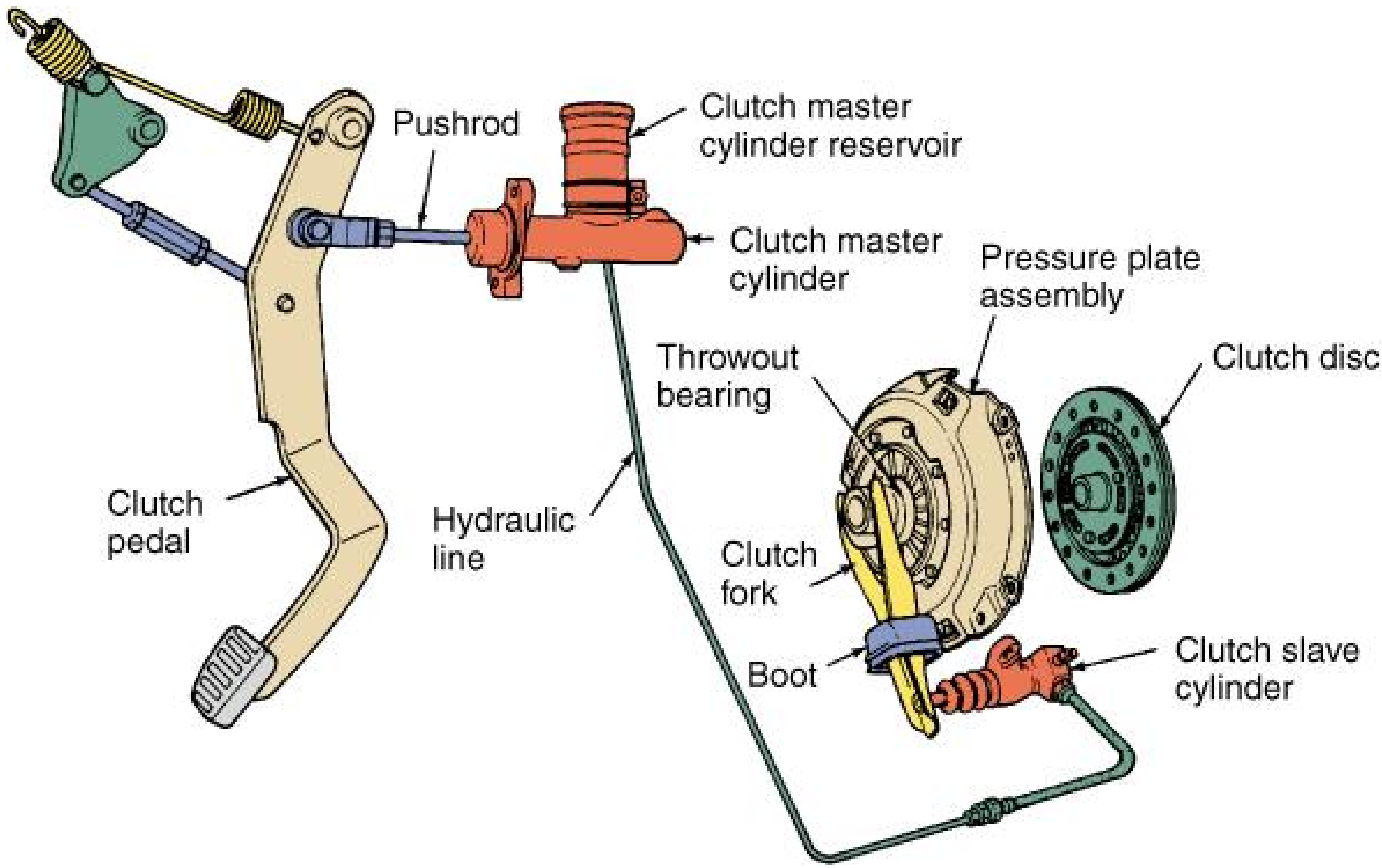


Cable Release

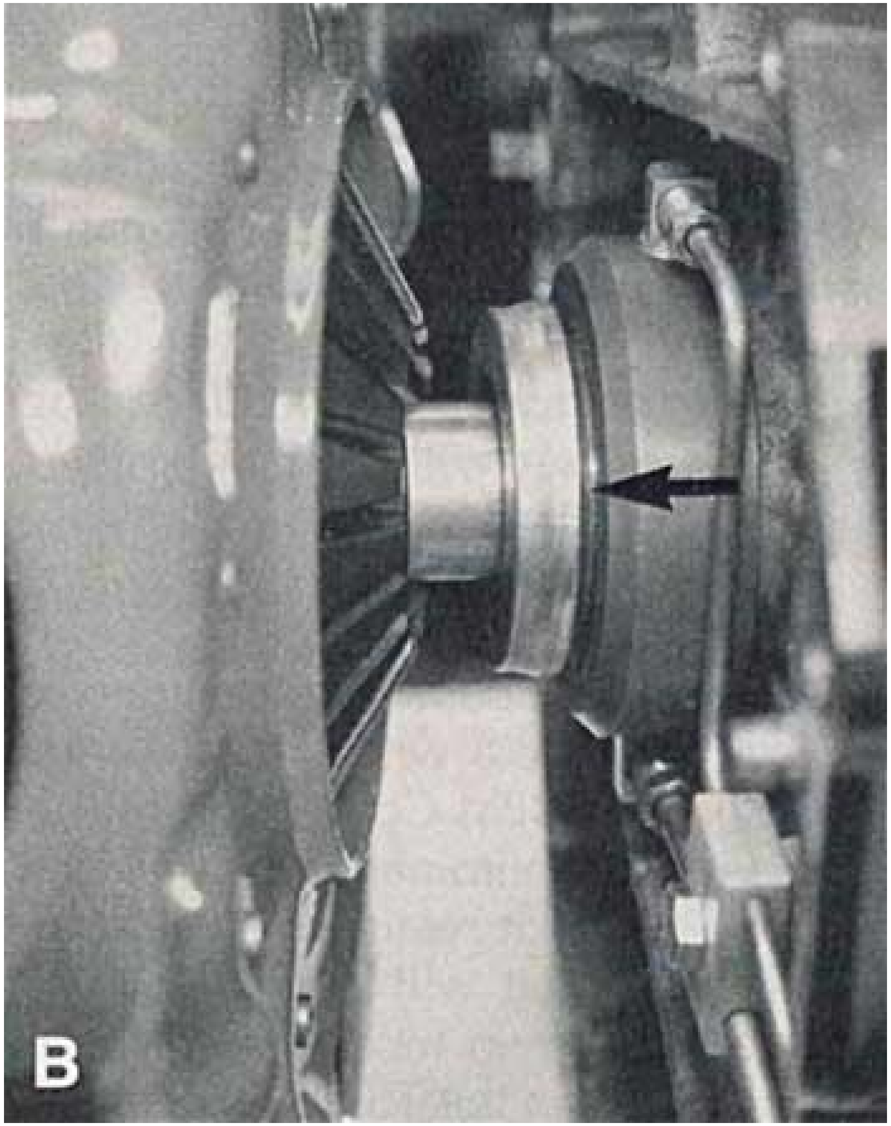


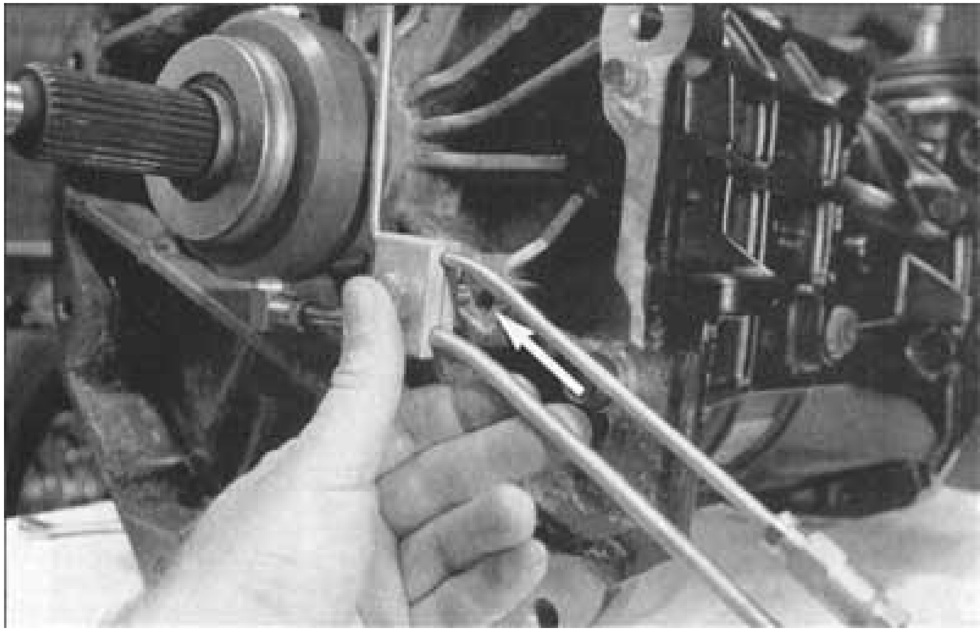
Mechanical-Hydraulic Release

Mechanical-Hydraulic Release



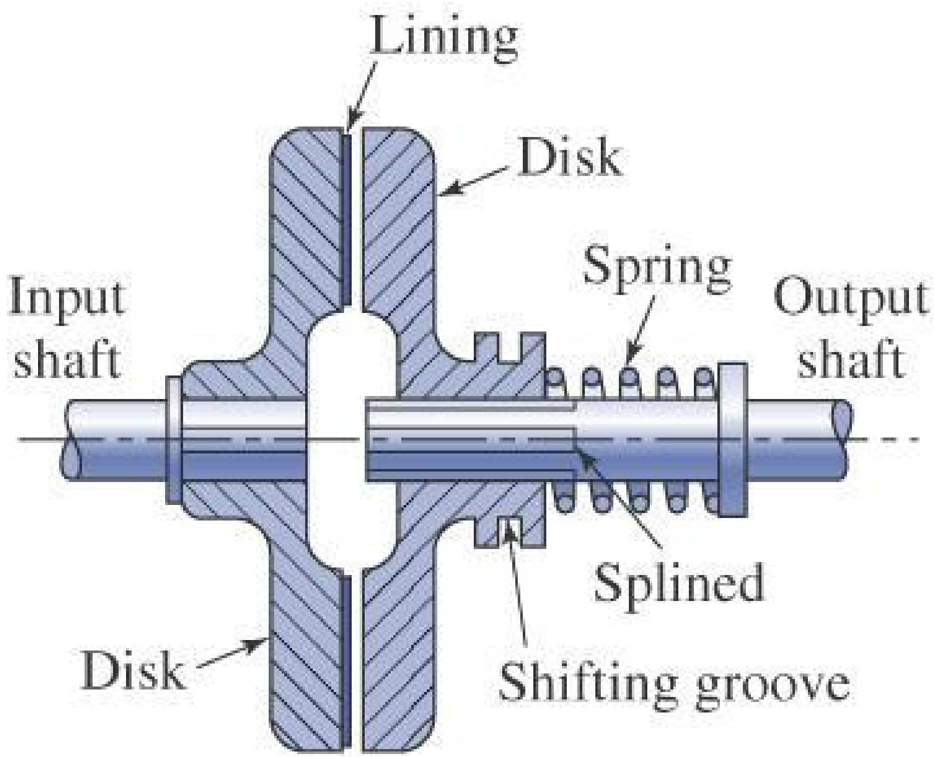
Hydraulic Release



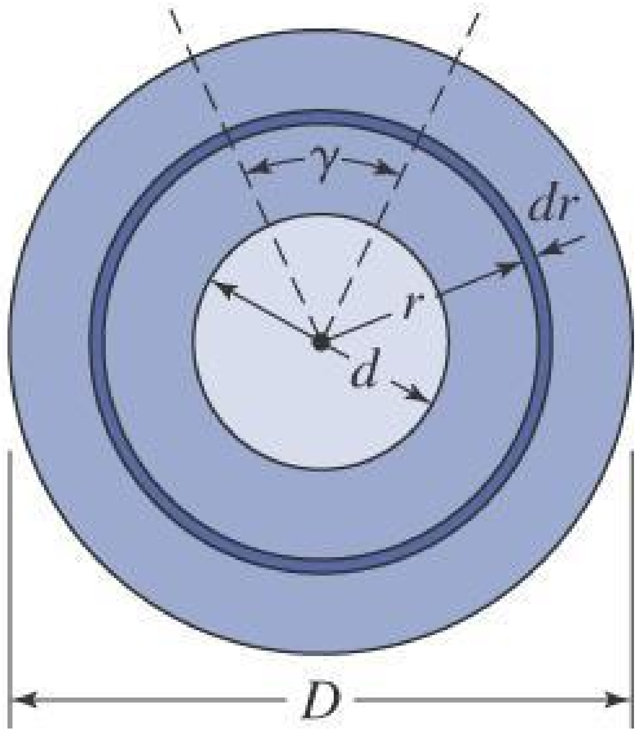


How a Clutch Works

Clutches

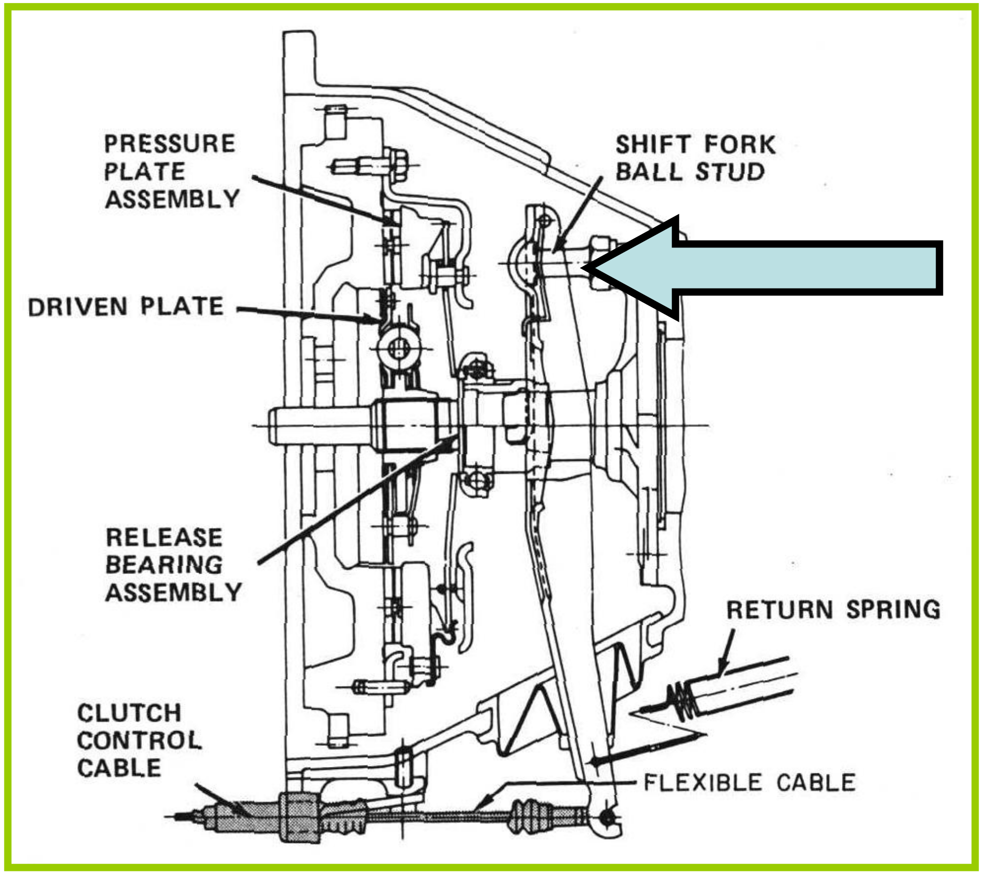


Lining
Disk
Spring
Input shaft
Output shaft
Splined
Disk
Shifting groove



γ
dr
r
d
D

Cable clutch



- No complicated linkage
- Flexibility
- No motor mount problems

CONE CLUTCH

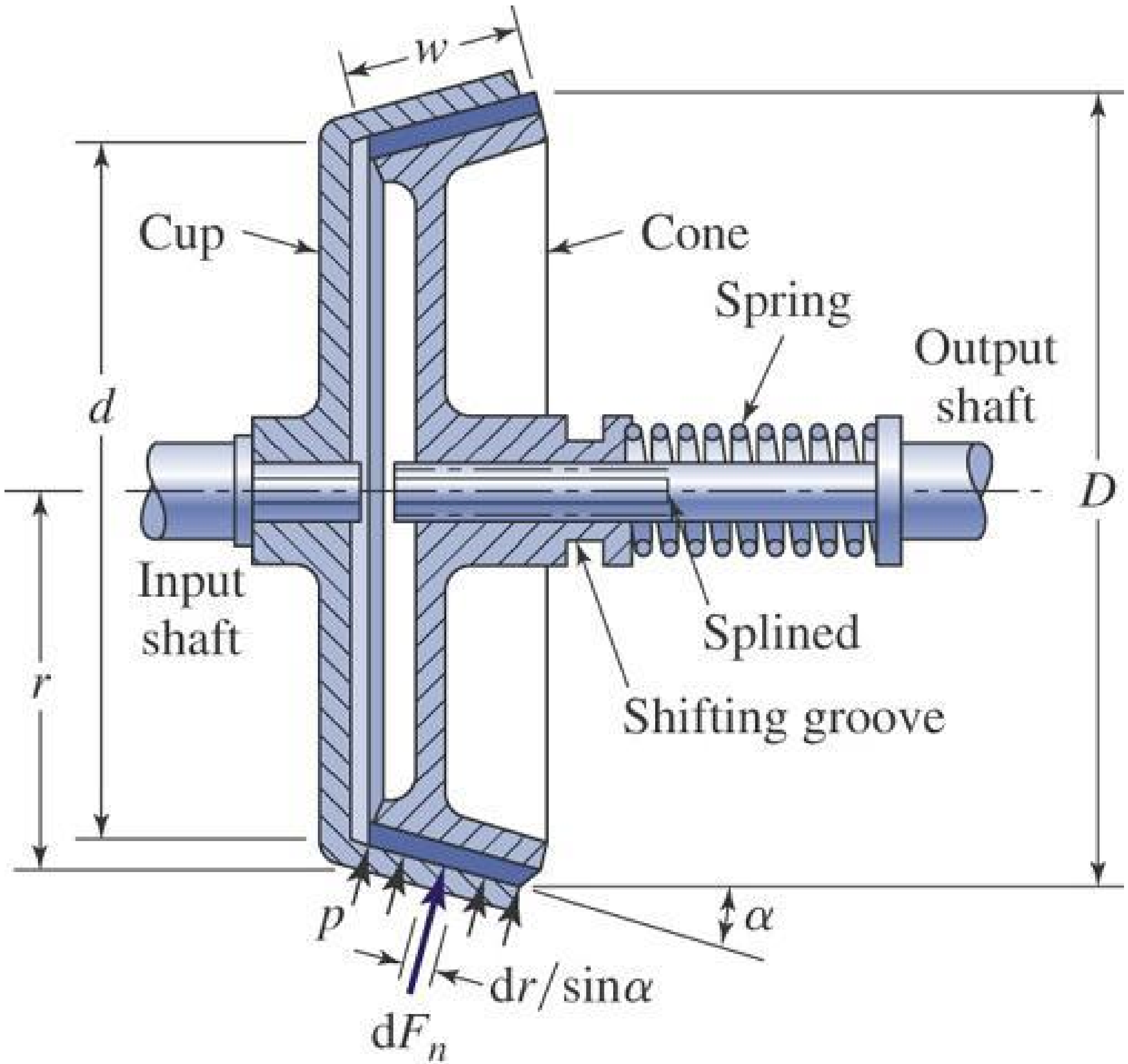

w
Cup
Cone
Spring
Output
shaft
d
D
Input
shaft
Splined
r
Shifting groove
p
α
dr/sinα
dF_n

Plate or Disk Clutches

- The plates shown in figure below shown as **A** are usually **steel** and are set on splines on shaft **C** to permit axial motion (except for the last disk).
- The plates shown as **B** are usually **bronze** and are set on splines on shaft **D**.
- The number of pairs of surfaces transmitting power is one less than the sum of the steel and bronze disks.

$$n = n_{steel} + n_{bronze}$$

The capacity:

$$T = F \cdot f \cdot R_f \cdot n$$

Where:
T = torque capacity, Nm
F = axial force, N
f = coefficient of friction
R_f = friction radius
n = number of pairs if surfaces in contact

The axial force (F):

$$F = p \cdot \pi \cdot \left(R_o^2 - R_i^2\right)$$

Where:
p = the average pressure

$$R_f = \frac{2}{3}\left[\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right]$$

If the contact pressure is assumed uniform

OR:

$$R_f = \frac{R_o + R_i}{2}$$

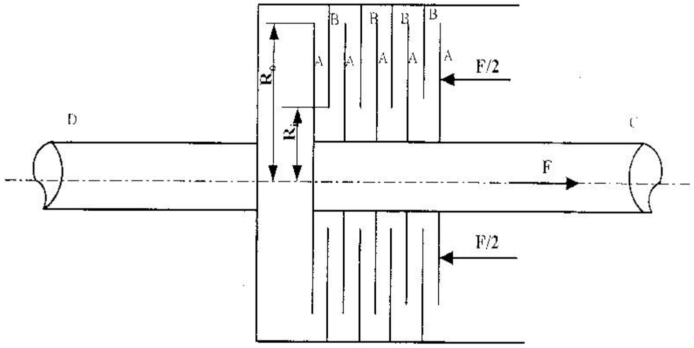
If wear is assumed uniform

Where:
R_o= outside radius of contact of surfaces, m
R_i= inside radius of contact of surfaces, m

The power capacity:

$$P = T \cdot N \cdot \left(\frac{2\pi}{60}\right), \quad \text{Watt}$$

Where:
T = shaft torque, Nm
N = speed of rotation, rpm



Multiple Disk Clutch

Cone Clutches

- A cone clutch achieves its effectiveness by the wedging action of the cone part in the cup part.

A) The torque capacity (based on uniform pressure):

$$T = \frac{F \cdot f}{\sin\alpha} \cdot \left(\frac{2}{3}\right)\left[\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right]$$

Alternate form:

$$T = F \cdot f \cdot \left[\frac{R_o^3 - R_i^3}{3R_m \cdot b \cdot \sin^2\alpha}\right]$$

Where:
R_m = mean radius = 0.5 ($R_o + R_i$)
b = face width, m
α = pitch cone angle

OR:

$$T = F_n \cdot f \cdot \left(\frac{2}{3}\right)\left[\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right] \quad \text{where } F_n = p(2\pi \cdot R_m) \cdot b$$

Power

$$P = T \cdot N \cdot \left(\frac{2\pi}{60}\right) = F_n \cdot f \cdot \left(\frac{2}{3}\right)\left[\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right]\left(\frac{N}{9.550}\right) = \frac{F \cdot f}{\sin\alpha}\left(\frac{N}{9.550}\right)\left(\frac{2}{3}\right)\left[\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2}\right], \text{ Watt}$$

B) The torque capacity (based on uniform wear):

$$T = \frac{F \cdot f \cdot R_m}{\sin\alpha} = F_n \cdot f \cdot R_m$$

Pressure variation

$$p = \frac{F}{2\pi \cdot (R_o - R_i) \cdot r}$$

Maximum pressure

$$p_{max} = \frac{F}{2\pi \cdot (R_o - R_i) \cdot R_i}$$

At smallest radius

Minimum pressure

$$p_{min} = \frac{F}{2\pi \cdot (R_o - R_i) \cdot R_o}$$

At largest radius

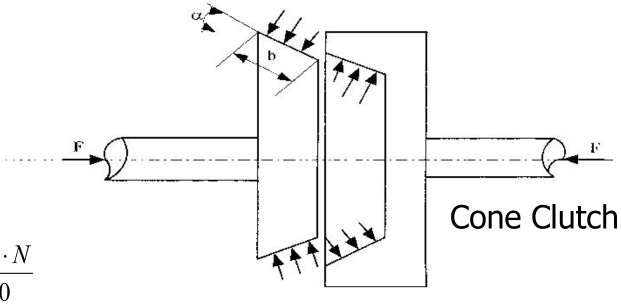
Average pressure

$$p_{av} = \frac{F}{\pi \cdot (R_o^2 - R_i^2)}$$

Power

$$P = T \cdot N \cdot \left(\frac{2\pi}{60}\right) = \frac{F_n \cdot R_m \cdot N}{9.550}$$

$$= \frac{F \cdot f \cdot R_m}{\sin\alpha}\left(\frac{N}{9.550}\right), \text{ Watt}$$



Cone Clutch

Problems on single plate clutch

A plate clutch consist of a pair of contacting surface with inner and outer diameter 100 mm and 200mm. Take μ = 0.2 , Permissible pressure is 1N/mm^2. Assuming uniform wear criterion . calculate the power transmitting capacity at 750 rpm. Assuming data given above , calculate power transmitting capacity using uniform pressure criterion .

Problems on single plate clutch

- STEP 1: GIVEN DATA
- No.of contact surface, i=2
- Inner diameter d_{min} = 100 mm . , r_{mim} = 50 mm
- Outer diameter d $_{max}$ = 200 mm ., r $_{max}$ = 100 mm.
- Co efficient of friction, μ = 0.2
- Speed, n = 750 rpm
- Axial pressure, p_a = 1 N/mm^2.

Problems on single plate clutch

I - FOR UNIFORM WEAR CRITERION :

STEP 2: CALCULATION OF DESIGN TORQUE

$b = r_{max} - r_{min} = 50$ mm

$r_m = (r_{max} + r_{min})/2 = 75$ mm

$i = [M_t] / 2\pi p_a b \mu r^2_m$

$[M_t] = 2\pi p_a b \mu r^2_m \times i$

$= 2 \times 3.14 \times 1 \times 50 \times 0.2 \times 75^2$

$= 706.858 \times 10^3$ N-mm

Problems on single plate clutch

STEP 3 : CALCULATION OF NOMINAL TORQUE

WKT, $[M_t] = k_w . M_t$

$M_t = [M_t] / k_w$ = 282.743 ×10 ^3 N-mm .

M_t = 282.743 ×10 ^3 / 100

= 2827.43 kgf -cm .

STEP 4 : POWER TRANSMITTING CAPACITY :

$M_t = 97400\ k_w / n$

$K_w = M_t \times n / 97400$

= 21.77 kW

Problems on single plate clutch

II - FOR UNIFORM PRESSURE CRITERION :

STEP 2: CALCULATION OF DESIGN TORQUE

WKT, $i = [M_t] / 2\pi p_a b \mu r^2_m$

$b = r_{max} - r_{min} = 50mm$

$r_m = 2/3 [r^3_{max} - r^3_{min} / r^2_{max} - r^2_{min}]$

$= 77.78$ mm

$[M_t] = 2\pi p_a b \mu r^2_m \times i$

$= 760.23 \times 10^3$ N-mm .

Problems on single plate clutch

STEP 3 : CALCULATION OF NOMINAL TORQUE

WKT, $[M_t] = k_w . M_t$

$M_t = [M_t] / k_w$

$= 760.23 \times 10^3 / 2.5$

$= 304.092 \times 10^3$ N-mm.

= 3040.92 kgf.cm .

STEP 4 : POWER TRANSMITTING CAPACITY :

$M_t = 97400\ k_w / n$

$K_w = M_t \times n / 97400$

= 23.41 kW

Problems on multiple plate Clutch

A multiple-disc wet clutch is to be designed for a machine tool driven by an electric motor of 12.455 KW running at 1400 rpm. Space restrictions limit the outside disc diameter to 100 mm. determine appropriate values for inside diameter, total number of discs, an clamping force.

Problems on Design of Cone Clutch

A leather faced conical clutch has cone angle 30°. The intensity of pressure is 6×10^4 N/m^2 and breadth of conical surface is not to be greater than 1/3 of mean radius . if μ = 0.2 and clutch transmits 37 KW at 2000rpm . Find dimensions of contact surface, assume service factor of 2.5.

Problems on Design of Cone Clutch

- STEP 1: NOTE THE GIVEN DATA:

Cone angle $2\alpha = 30^0$.

Semi cone angle $\alpha = 15^0$.

Intensity / axial pressure $p_a = 6*10^4\ N/m^2$

$= 0.06\ N/mm^2$.

Face width $b = 1/3\ r_m$. $r_m = 3b$.

Co efficient of friction $\mu = 0.2$.

Power transmitted, P = 37 KW .

Speed, n= 2000 rpm .

Service factor, $k_w = 2.5$.

Problems on Design of Cone Clutch

STEP 2 : CALCULATION OF NOMINAL TORQUE

WKT, $M_t = 97400\ k_w / n$

$= 97400 \times 37 / 2000$

$= 180.16 \times 10^3$ N-mm.

STEP 3 : CALCULATION OF DESIGN TORQUE

WKT, $[M_t] = k_w . M_t$

$= 450.475 \times 10^3$ N-mm.

STEP 4 : CALCULATION OF DIAMETER OF CLUTCH

$d = (49500 \times k_w \times kw / n \times \tau)^{(1/3)}$; $\tau = 300$ kgf / cm^2

$= 4.24$ cm

$= 42.4$ mm.

Problems on Design of Cone Clutch

STEP 5 : CALCULATE MEAN RADIUS AND FACE WIDTH

$$I_{min} = [M_t] / 2\pi p_a b \mu r^2_m$$

$$1 = 450.48 * 10^3 / (2\pi * 0.06 * 0.2 * r^2_m * r_m/2)$$

[I =1 for cone clutch]

$$r_m = 261.7 \text{ mm.}$$

Face width $b = r_m/3 = 261.7/3$

$$b = 87.23 \text{ mm}$$

Problems on Design of Cone Clutch

STEP 6 : CALCULATE OUTER&INNER DIAMETER

W.K.T , $r_{max} = r_m + b \sin\alpha/2$

$= 261.7 + 87.23 \times \sin 15°$

$= 272.98$ mm

$d_{max} = 2 \times r_{max} = 545.96$ mm .

$r_{min} = r_m - b \sin \alpha /2$

$= 261.7 - 87.23 \sin 15^0 /2$

$= 250.41$ mm.

$d_{min} = 2 \times r_{min} = 500.82$ mm.

Problems on Design of Cone Clutch

STEP 7: DETERMINE THE CLAMPING FORCE

$$a = \pi\sigma(r^2_{max} - r^2_{min})$$

$$= 2226.68 \text{ N}$$

STEP 8: FORCE REQURIED TO ENGAGE THE CLUTCH

$$Q_e = Q + 0.25\, Q\, \mu \cos\alpha$$

$$= 2334.2 \text{ N}.$$