

Benz tricycle 1896



Stanley Steam car 1905



Railton 1935



London B type bus - 1910



Ford Model T 1913

An Introduction to Automobiles



Jaguar 1955

Pictures taken from Smith (2002)



Czech Tatra 1937

Lincoln continental 1960s



Ford Sierra 1980s



Lotus Eclat

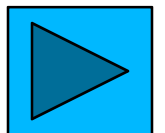


Aims

- Introduce the wide range of skills required for vehicle design and manufacture.
- Briefly set the historical scene and development of vehicles and their design.
- Introduce the vast range of possibilities for vehicle design.
- Demonstrate the interactivity of processes within the design and manufacture of vehicles

Steps in Automobile History

- Innovations and Inventions
- Mass production
- Development of World Motor Industry
- Streamlining
- Commercial vehicles



Inventions and Innovations

- Steam power to Internal Combustion engine
 - Steam engine used till late 1940s
 - Petroleum “spirit” used by Dr. OTTO in 1870s was a useless by-product of naptha used for lamps
 - Dr. Gottelib Daimler improved OTTO engine using petroleum vapour and in parallel Karl Benz also produced tri-wheel carriage in 1885



Mass production

- Cars were developed from horse carriages.
- Henry Ford -> “mass production” of Model T, 1909



- Concept from rifle manufacture of civil war
- Model T first car with design for manufacture
- Engine 2898 cc was built by Ford and various independent bodybuilders from buses to elegant family cars
- Hand-built cars to interchangeable parts

Picture taken from Smith (2002)

Mass Production

- Moving workers -> moving vehicle during manufacture , Highland park Detroit, 1913



Picture taken from Smith (2002)

Mass Production

- In 1970s, Volkswagen “Beetle” was sold in large numbers though style was antiquated as it was
 - Non rusting car
 - Mechanically reliable
- Toyota's contribution:
 - Production was flexible
 - Quality paramount, getting right first time - LEAN
 - Shorter production runs, wide variants



Development of World Motor Industry

- 1920s -1930s : small coach builders co-exist with large companies
- By end of second world war only few specialized manufacturers remain – Rolls Royce
- Large conglomerates like British Motor Corporation (BMC) , British Leyland (BL) faced problem of large stock
- Americans and Japanese moved parts of operations around the world
 - Because of export restrictions and to use facilities all over the world

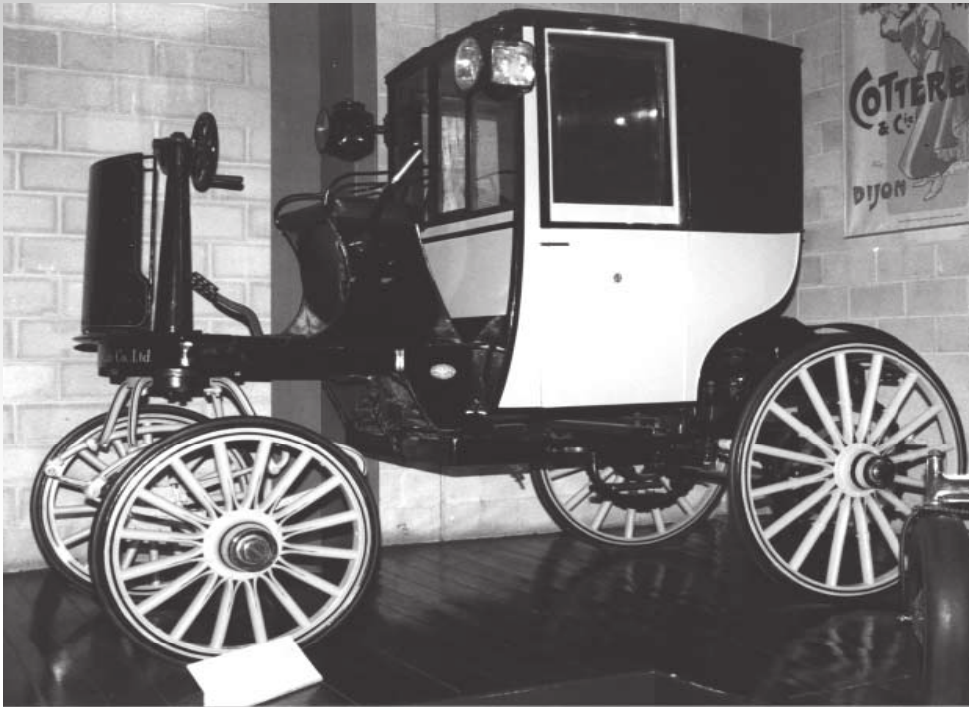
Development of World Motor Industry

Construction Development:

- Till 1930s wooden frame with fabric or wood skin used to build coaches
- Late 1930s onwards, pressed steel plates for skin
- Multiple curvature added more strength and body panels shared the load
- Recent cars have shell structure with aerodynamic structures

Development of World Motor Industry

- Wooden / Steel chassis frame was done away and replaced by stiff floor “pan” by spot welding
- By 1950s, “unitary” construction was universally followed for mass produced cars
- Composite body for lesser weight and corrosion free body – started after WWII (Lotus)
- Wheels progressed from wooden spokes to metal spokes to metal hub construction to metal spokes (Alloy)



Early car evolved from carriage , electric powered
Bersley 1897

Sports car with streamlined
composite body , Lotus



Development of World Motor Industry

Styling Development:

- Powered versions of horse carriages
- Engine was placed below vehicle by Daimler – hard maintenance
- 1890s, Panhard-Levassor created the concept of having engine in front with clutch and gear box ‘système Panhard’
- Windscreen was invented in 1920s with increasing speed of vehicle

Development of World Motor Industry

- By the 1930s, excessively elongated engine covers had become ‘de rigueur’ for powerful cars with sporting aspirations.
- Luggage was strapped in rear of vehicle and it became integral in european cars. It grew in '50s,'60s and '70s to larger volume
- Till '50s “open top” was preferred as inspired from horse carriages



Streamlining

- In 1890s, Amédée Bollée the younger produced first torpedo shaped designs with raked windscreen
- Americans did not like the air-streamlined design



Czech Tatra of 1937 V8



Chevrolet Air-flow

Streamlining

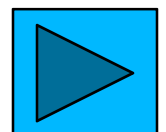
- Aerodynamics was considered impediment to styles due to angles
- Box type was more cheaper and easier to produce
- Became more popular only after the 70's when oil prices went up & fuel economy was considered important

Ford Sierra 1980



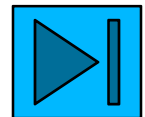
Commercial Vehicles

- End of 19th century, first lorry and trucks were steam powered – challenged by petrol vehicles
- Threats of world wars led to increase in roads, commercial vehicle sales and haulage in Europe
- IC engine led to the development of motor bus.
- Autobahns in 1930s Germany led to development of good road transport along with railways.
- Buses replaced electric trams, challenged railways in USA, Britain.



Construction Configuration and Styling

- Engine Development
- Transmission and System Layout
- Steering
- Suspension
- Brakes
- Interior Design
- Safety
- Too much Innovation



Engine Development

- Daimler and Benz invented IC engine automobiles in 1895
- Daimler developed Vee twin engines in 1898
- Ettore Bugatti, 1910 created first engine with Overhead Cam shaft in Model 13, capable of achieving 100 kmph speed with 1327 cc.
- Side valves were more preferred till WWII
- Improvements in materials led to other developments.

Engine Development

Diesel Engine:

- Main competitor to petrol engine – spontaneous combustion unlike petrol ignition
- It eliminated two weak points carburettor and spark plugs hence more reliable
- It had inferior power to weight ratio, hence restricted to heavy engines
- With turbo-charging and refinement, performance at par with petrol engines with cleaner emissions and higher efficiency.

Engine Development

Super charging and Turbocharging:

- When air is compressed at inlet, power to weight ratio of engine improved
- Compressors combined to engine shaft
- Used from 1930s in racing cars
- Compression with power from exhaust using turbine is turbocharging
- Turbochargers improve torque characteristics and smoother engine running

Engine Development

Two Strokes and Unconventional petrol engines:

- Two stroke (2S) has one firing stroke per revolution, theoretically twice efficiency
- 2S in unsupercharged always has fuel-charge loss during scavenging
- Intake needs to be mixed with lubricating oil resulting in smoky exhaust
- Applications restricted to motor-cycles and small cars like three cylinder SAAB car.

Engine Development

- Two stroke diesel is still preferred in large marine and railway engines
- Wankel engine had a semi-rotary than a reciprocating type of engine
- It had a problem with seals of rotor and inherent two-stroke emissions
- Gas turbines had good efficiency and thrust to weight ratio but not efficient in low speeds.

Engine Development

Electric and Hybrid propulsion:

- 1899, Jenatzy's "La Jamais Contente" was first vehicle to cross 100kmph
- Initial cars restricted to short distances but has considerably increased in recent times
- Improvements in Lead-Acid battery technology allowed increased range and even buses to operate in Urban areas on electric power to reduce smog.

Engine Development

- Limitations in battery led to hybrid vehicles of present day
 - Ultracapacitors or flywheel used
 - Smaller petrol engine is used
 - Regenerative braking
- *Not same as petrol-electric vehicle in past with pure electric operation for step-less operation



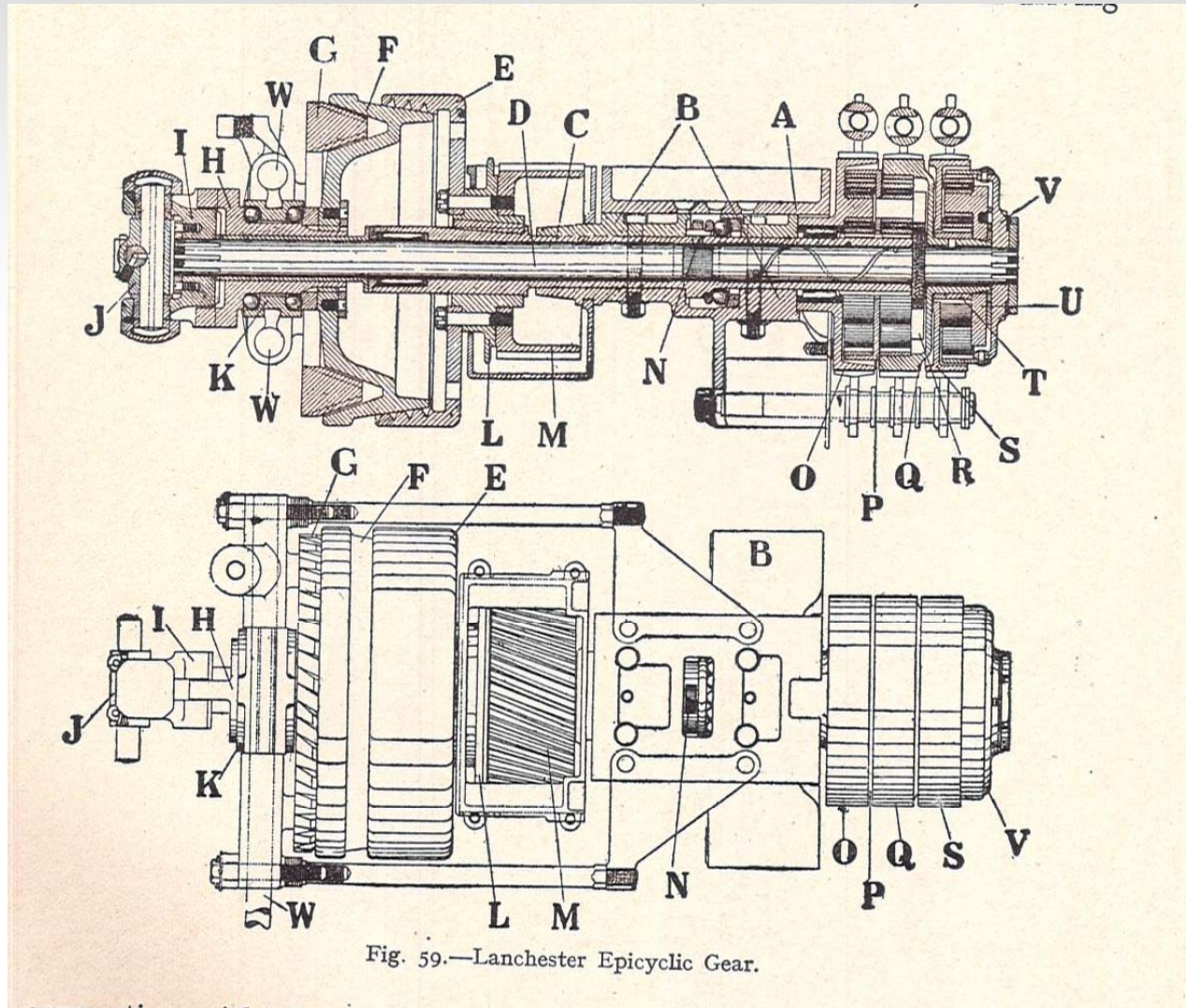
Transmission System Development

- Some of the drawbacks of petrol engines over steam engines were
 - Non-availability of full power at the start
 - Noisy operation
 - Non-instant stop – restart
- Clutches have evolved from belts and settled predominantly with plate clutch.
- Gear box evolved from shifting gears to constant mesh with moving dog clutches “crash” gear box.

Transmission System Development

- F.W. Lanchester and British Daimler created epicyclic gear box with bands and planetary rings
- Epicyclic gears used in ford model T , used in buses for ease of operation
- In 1940's, “preselector” gearbox was developed with fluid torque converter becoming a Constant Variable Transmission system (automatic)
- Earlier automatics had poor efficiency

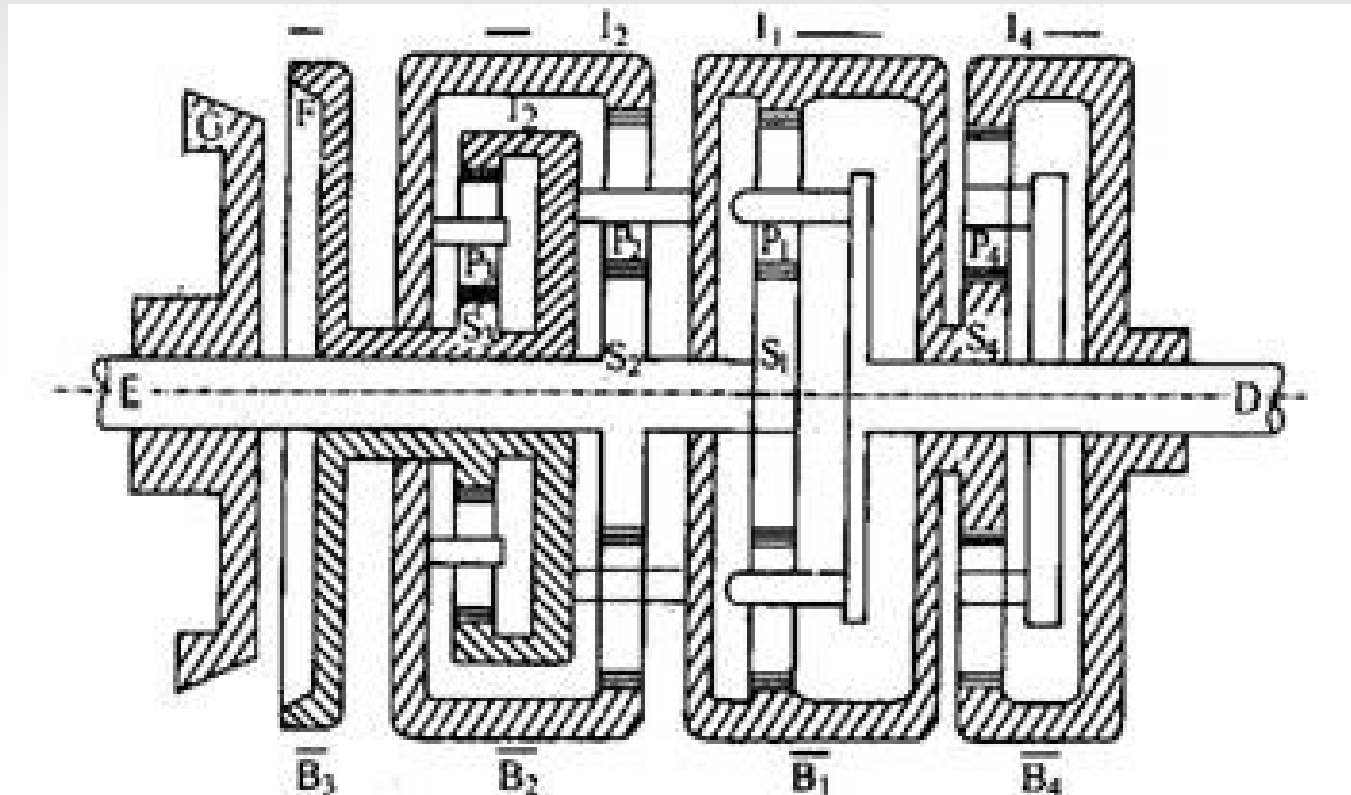
Lanchester Gear box



http://commons.wikimedia.org/wiki/File:Lanchester_epicyclic_gearbox.jpg



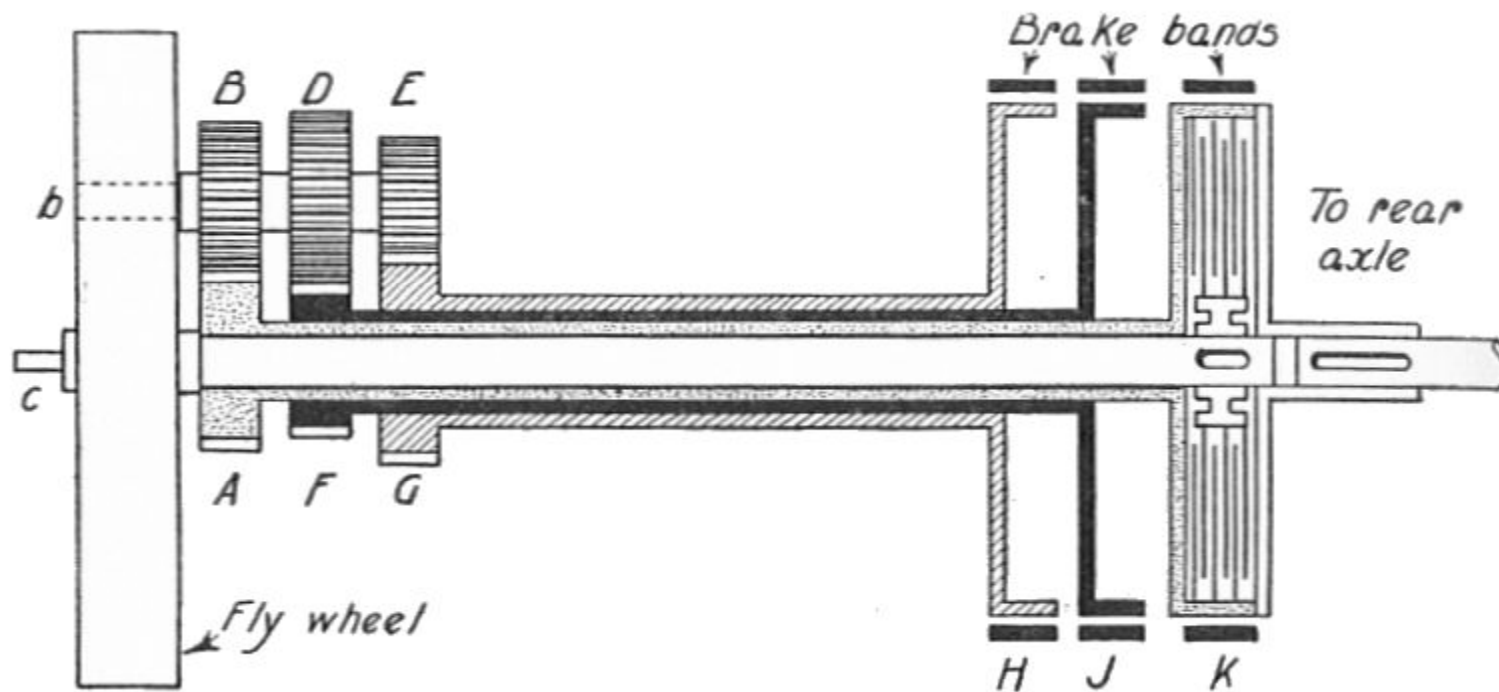
Pre-selector gearbox



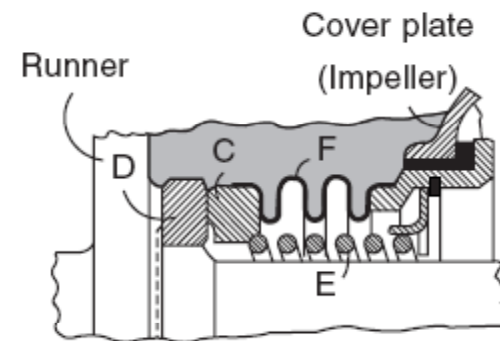
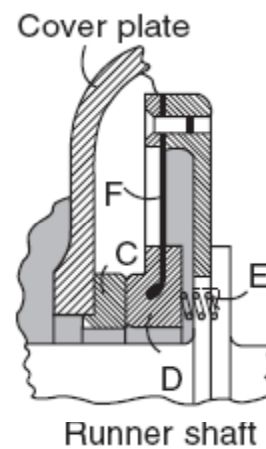
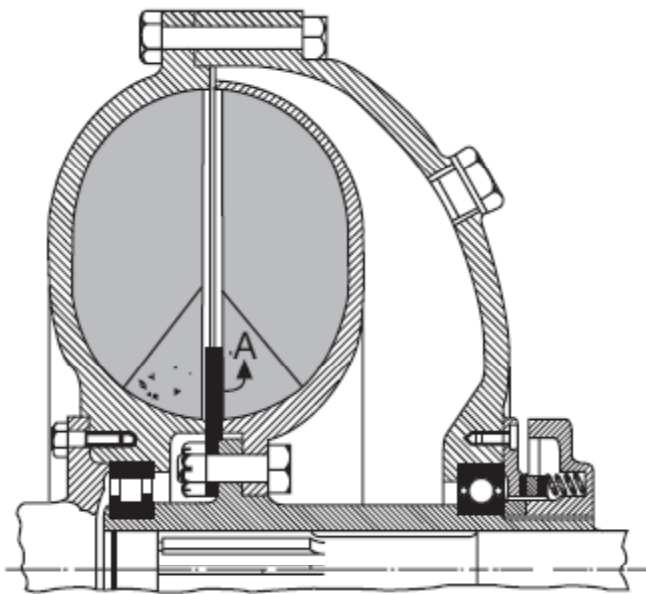
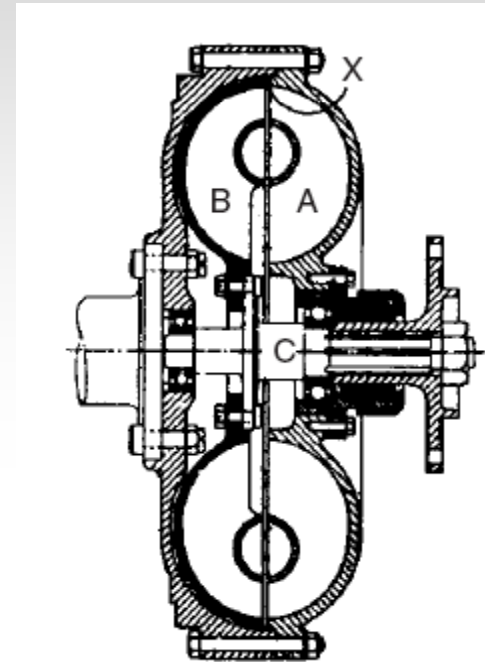
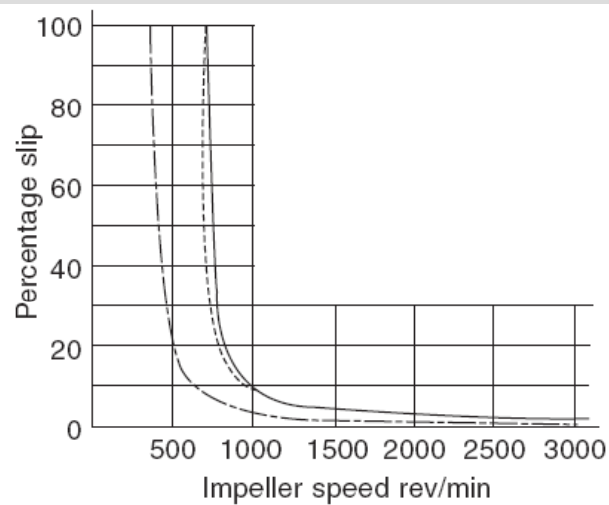
Wilson's Gearbox



Model T gear box



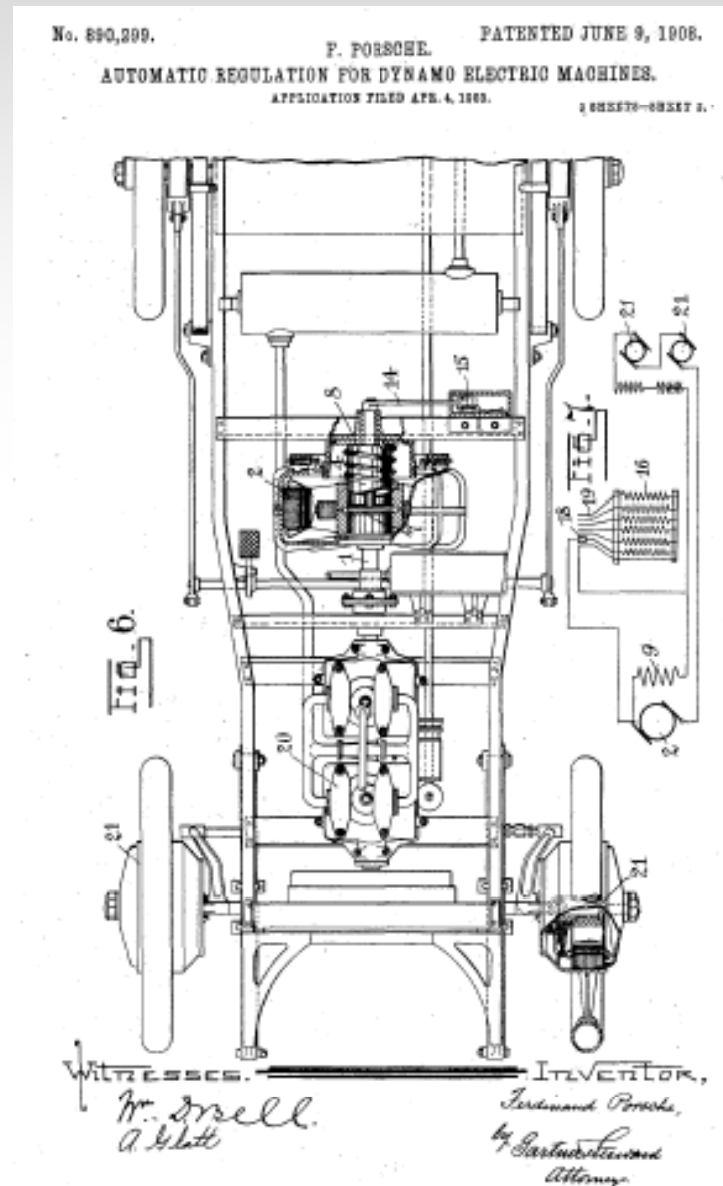
Fluid Torque Converter



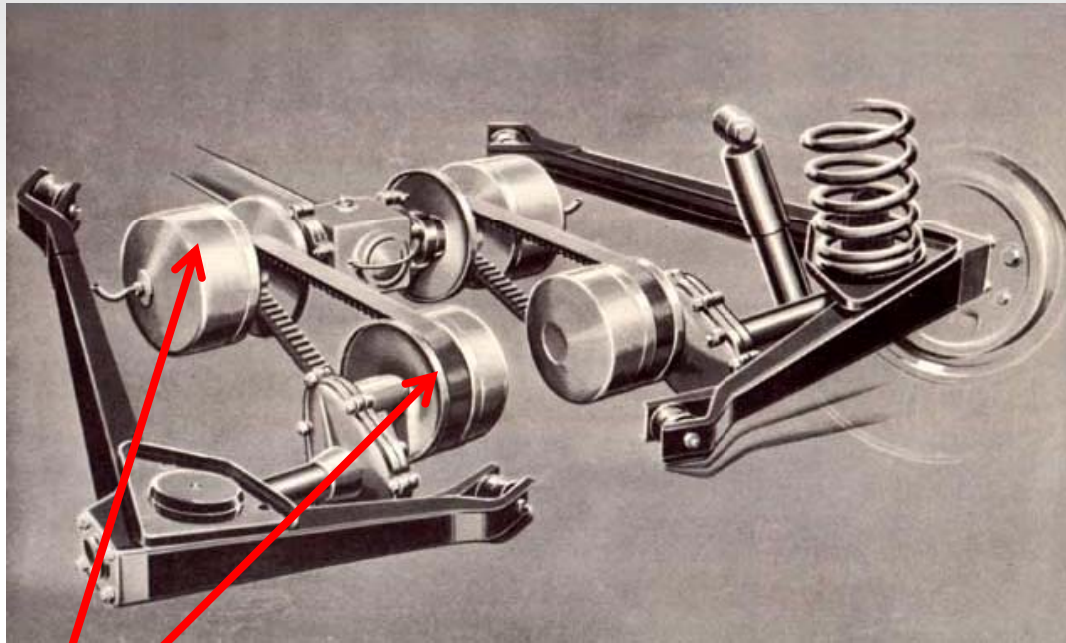
Transmission System Development

- Ferdinand porsche had first patent in 1908 for a electric transmission system ([890299](#)) first step towards CVT
- Semi-stepless was achieved using fluid-torque converters in 1940's
- DAF [variomatic](#) type CVT were used in dutch DAF cars (1959-63)

Porsche transmission



DAF variomatic



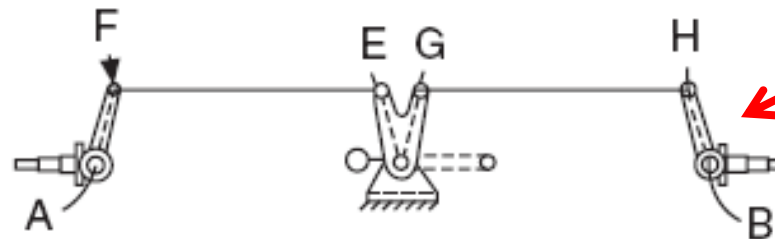
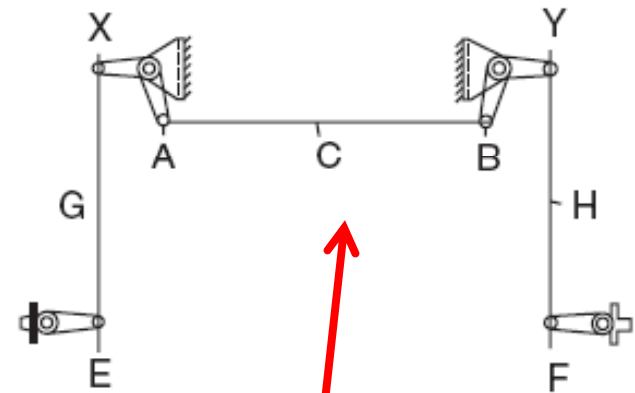
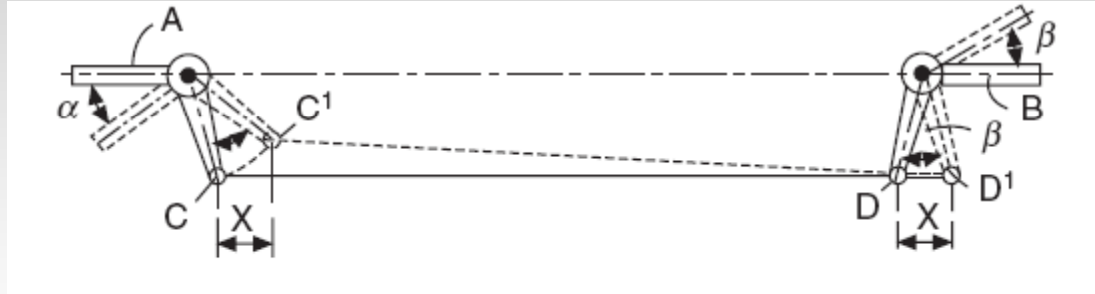
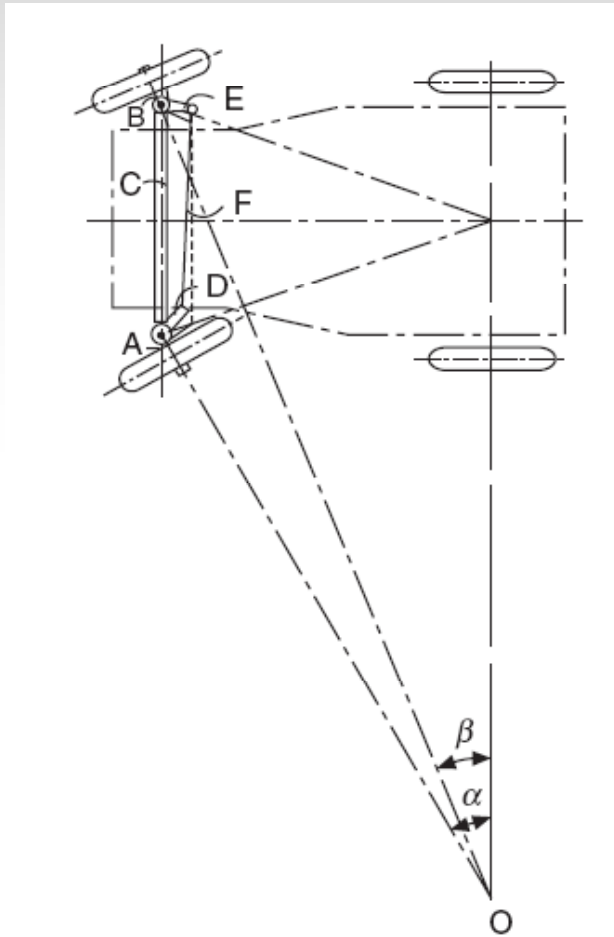
Double pulleys



Steering

- Earlier cars borrowed axles similar to horse carriages with unstable pivoting axles as horse is not present to stabilize the vehicle
- Ackerman's arrangement of pivoting wheels about individual axes allowed rotation at varied angles / speed during turn
- Tiller was replaced with steering and linkages and major development came after power steering.
- Four wheel steering is now available but restricted to a few models

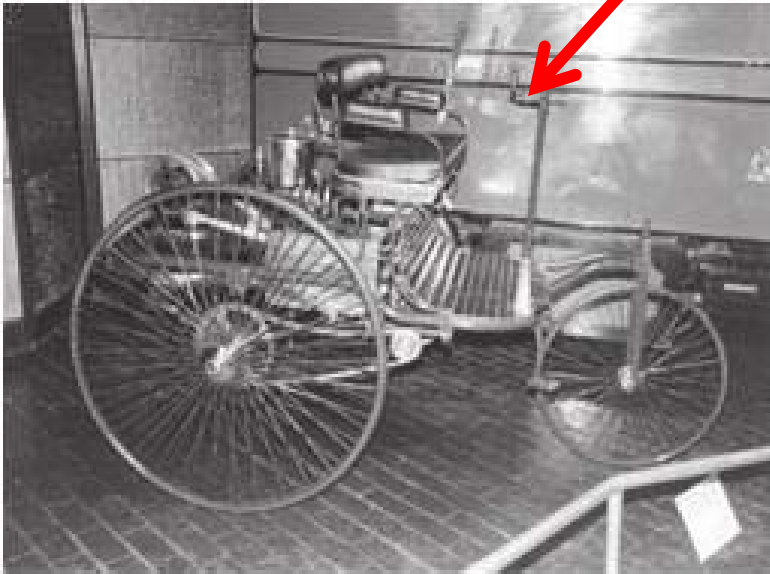
Ackermann Linkage



Ackerman
linkages for
Independent
Suspension



Tillers



Benz tricycle 1896



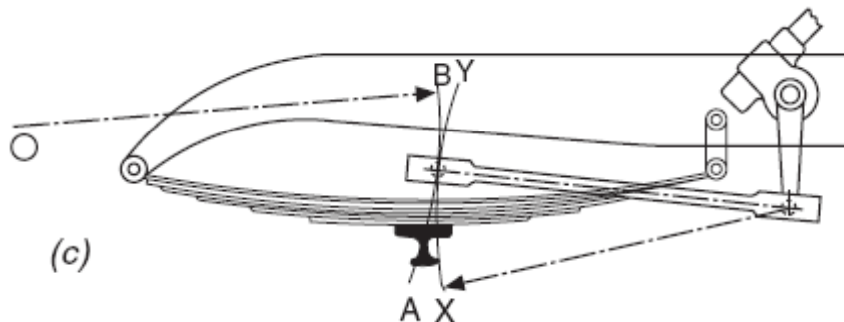
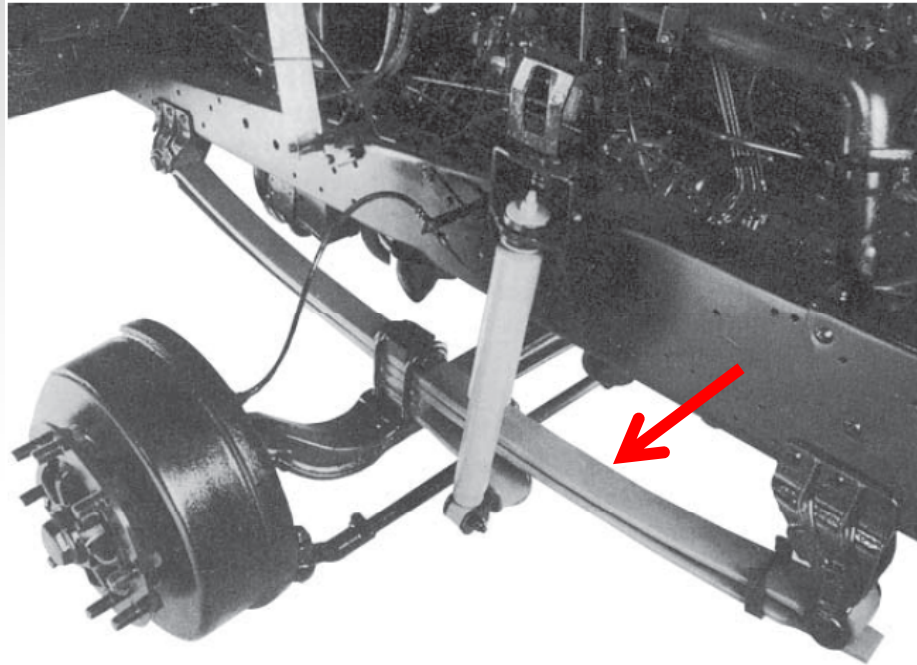
Panhard Levassor 1890-95



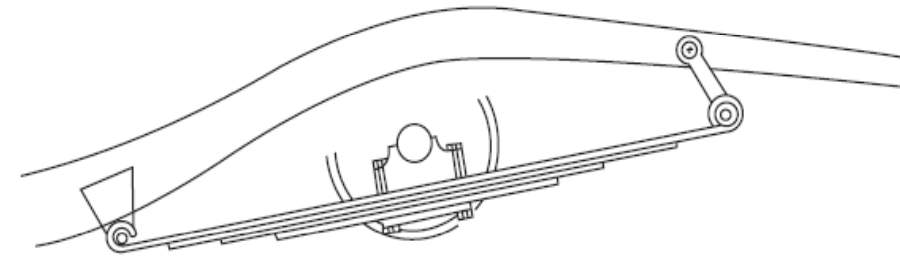
Suspension

- Elliptic springs adopted from carts – problems during braking and starting -need to be restricted
- Springing developed by torsion bars and further by pneumatic variable height suspensions
- Independent wheel suspensions developed
- Simple coil springs were used for front suspension alone and then used in rear also
- Active suspensions have vehicle lifted by power jacks controlled electronically

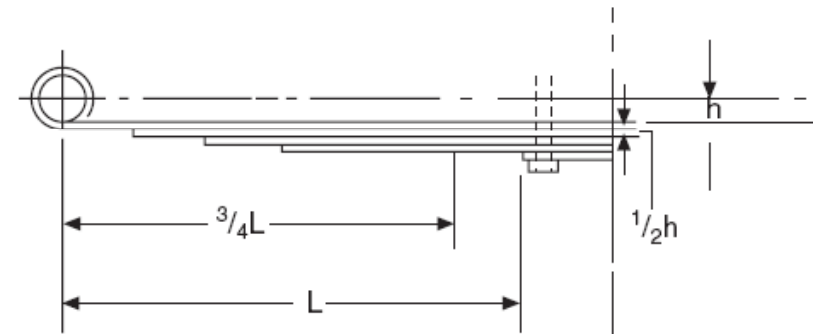
Elliptic Springs



AXle guidance interferes with steering



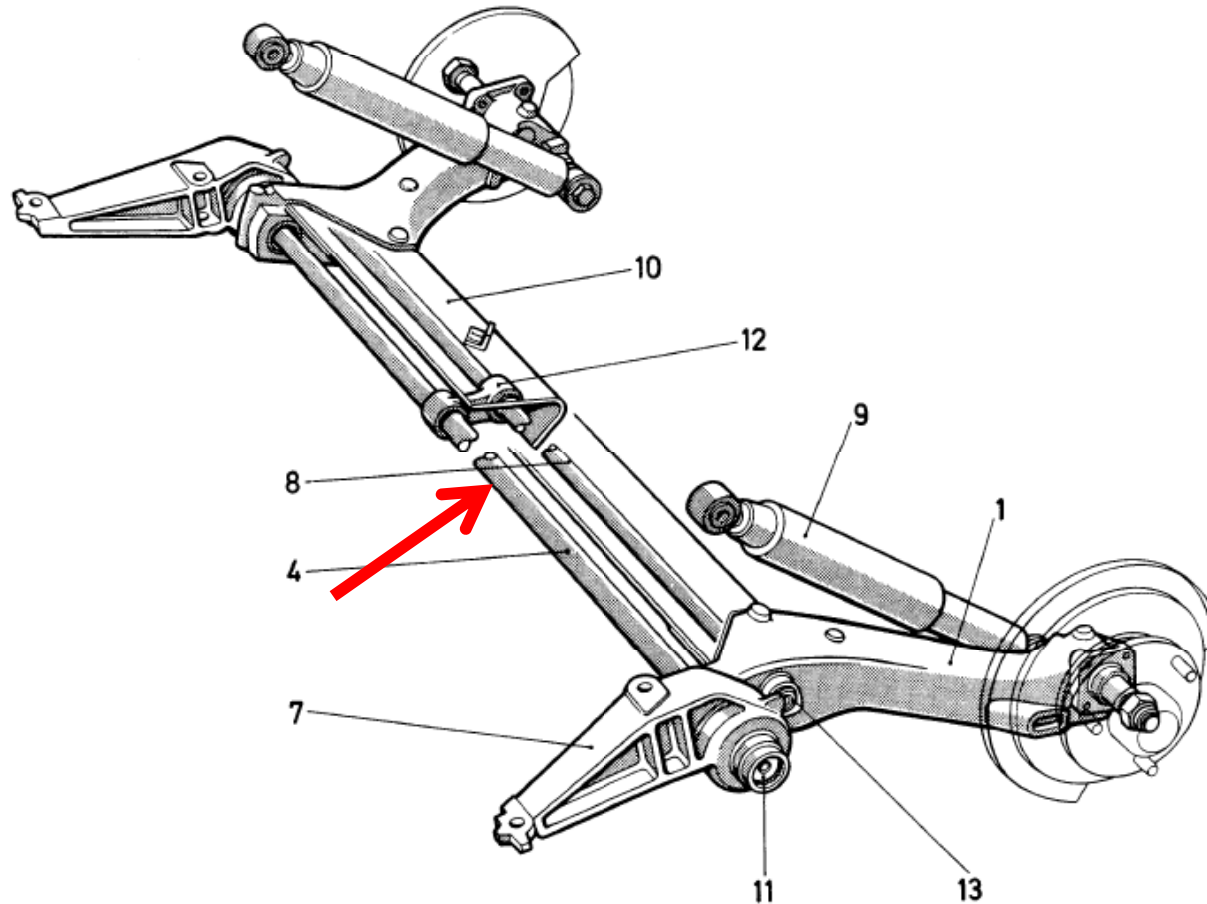
Mounting to reduce Squat



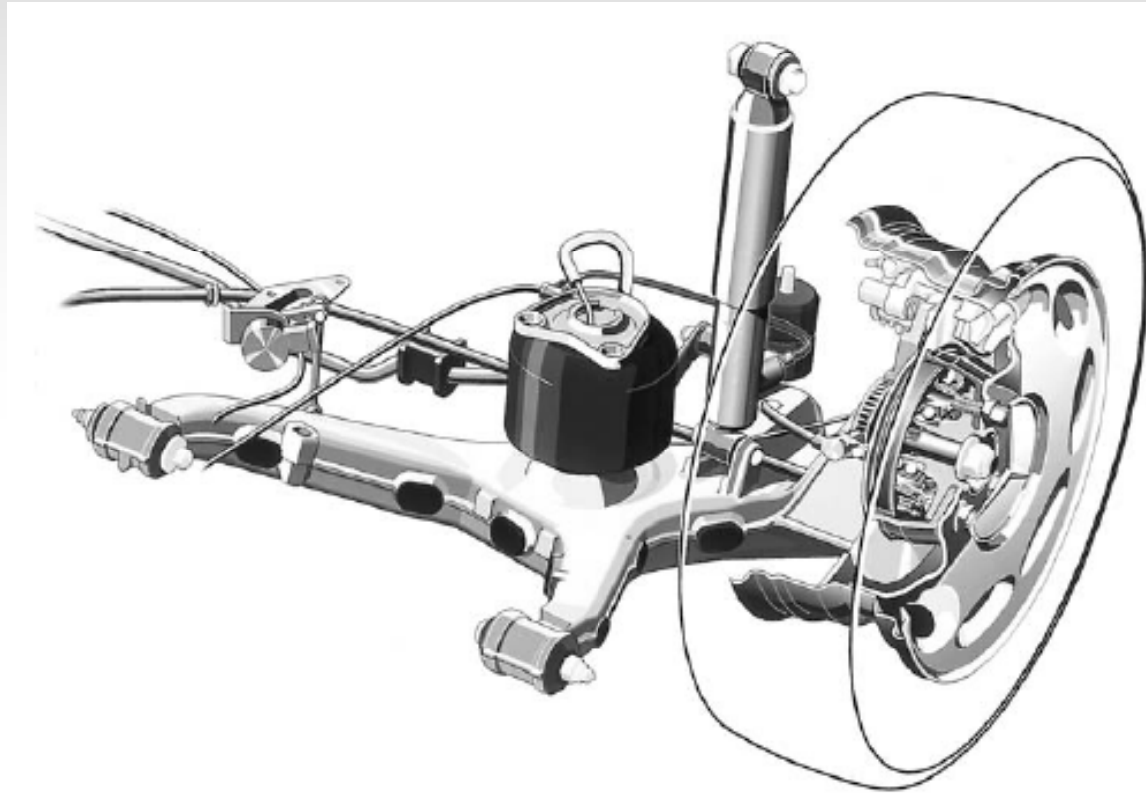
Mounting to function as anti-roll bar



Torsion bar



Pneumatic Suspension



Flat, non-driven air-suspended semi-trailing-arm rear axle of the Mercedes-Benz V class



Suspension

- Independently moving wheels improved road-grip
- Independent suspensions became popular by 90s.

Jaguar 3.4 was with independent suspension in '55



Pictures taken from Smith (2002)

Suspension

Wheels and Tires:

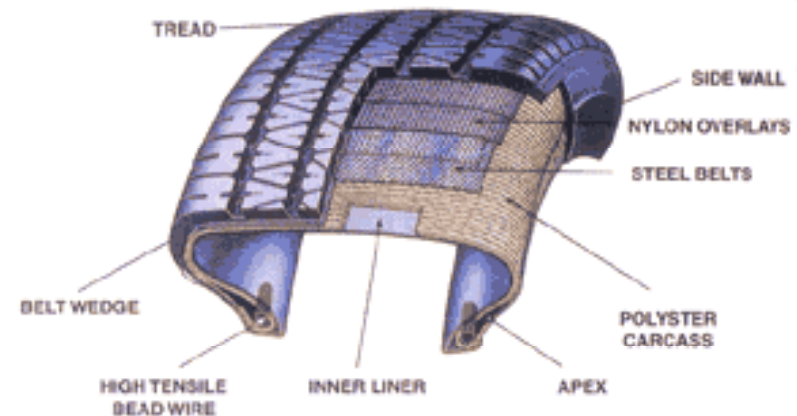
- Wooden spoked wheel with metal outer was unsuitable for higher speed
- 1895, Michelin brothers fitted Dunlop tires on peugeot cars for racing and it started
- Pneumatic tires had problems of puncture
- Large tires were good for poth-rudded roads, with roads improving size is reached to standard size.

Suspension

- Smaller tires improved ride and suspension dynamics
- Wider tires had better road grip
- Tubeless tires were introduced after WWII
- Radial ply was introduced
- “Low profile” tires – ratio of outer to inner diameter increased

Tubeless tires

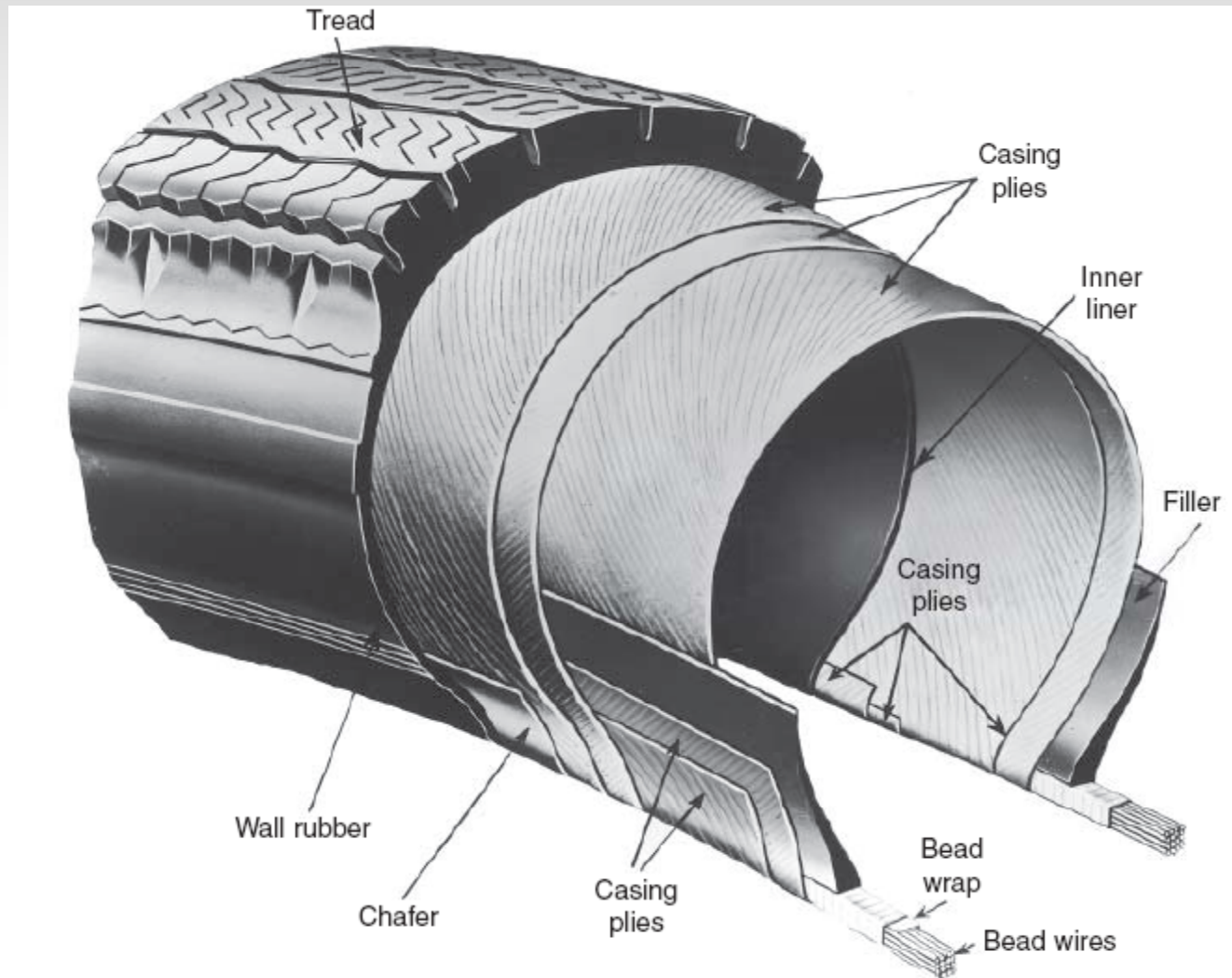
- Introduced in 1947 by Goodridge
- An air-tight layer to inner layer of carcass
- Soft inner layer of highly viscous material to fill in punctures
- Retain air-pressure longer than others vehicles can be controlled longer



http://www.indiacar.com/infobank/tlt_const.htm



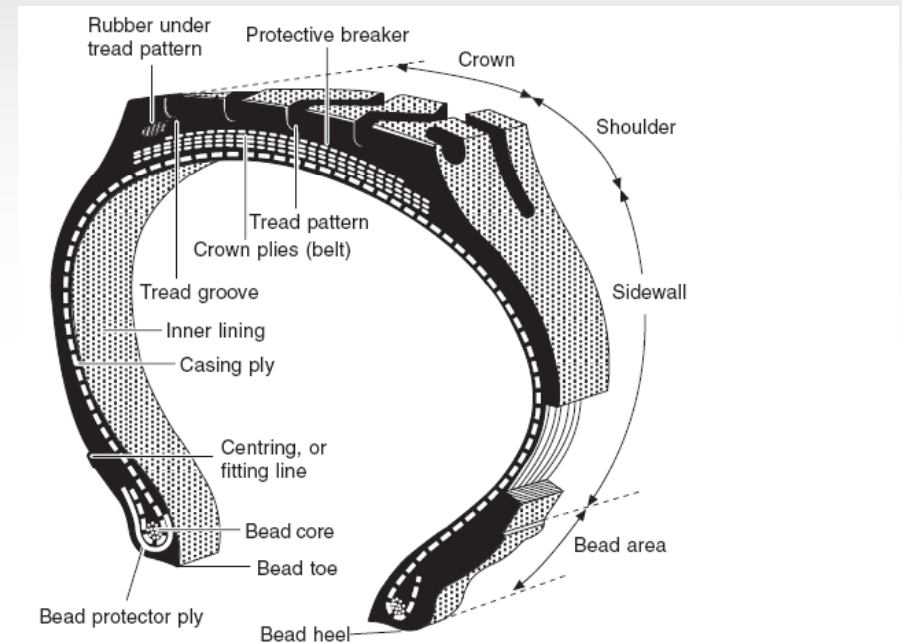
Tires



Relative flexure of the plies laid alternately at 45° to each other in crossply tyres tends to generate more heat than do those in the radial ply type

Radial Tires

- Since there is no cross ply, lesser heat generated hence more life
- 4 to 6 “bracing plies” of metal / rayon provides better contact grip and stability against deformation in higher speeds
- Stiffer in resisting lateral loading hence reduces under/over steer.

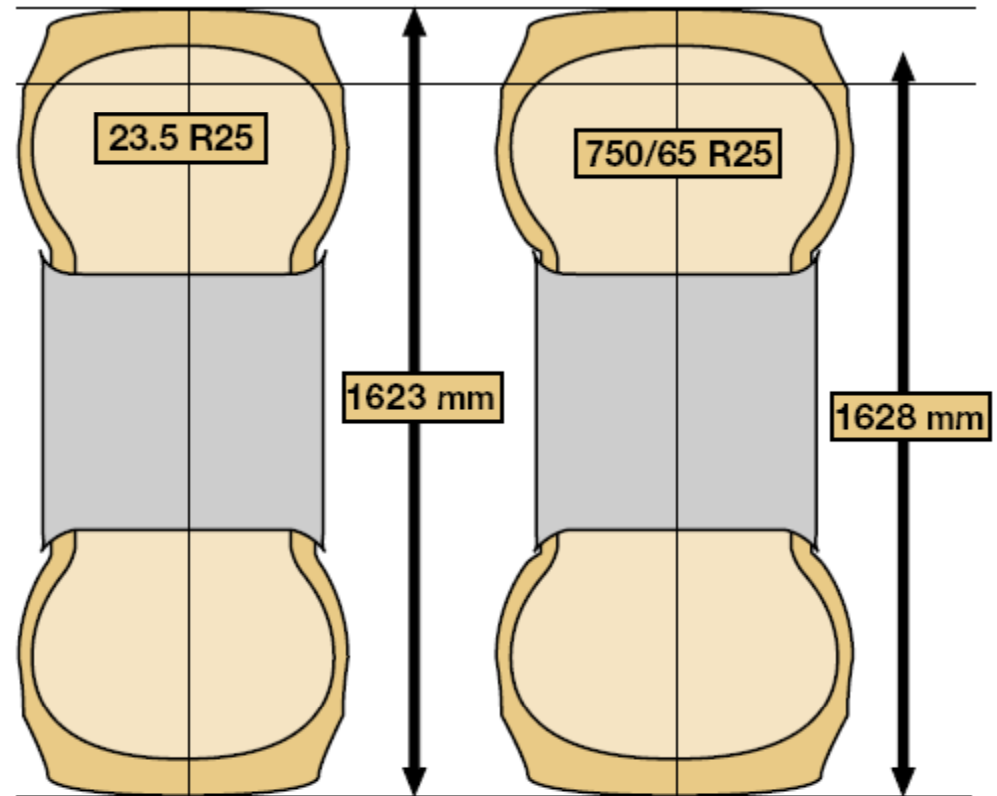


Beneath the treads of radial ply tyres are usually two or three steel or four or six textile cross braced bracing plies. These support the tread against centrifugal force, stabilise the contact patch and increase resistance to punctures



Low profile Tires

- Wider tires for same diameter
- Improvement of radial tires
- Larger chamber allows operation in lower pressure hence smooth ride or increase in comfort
- Increased traction as more area in contact



Brakes

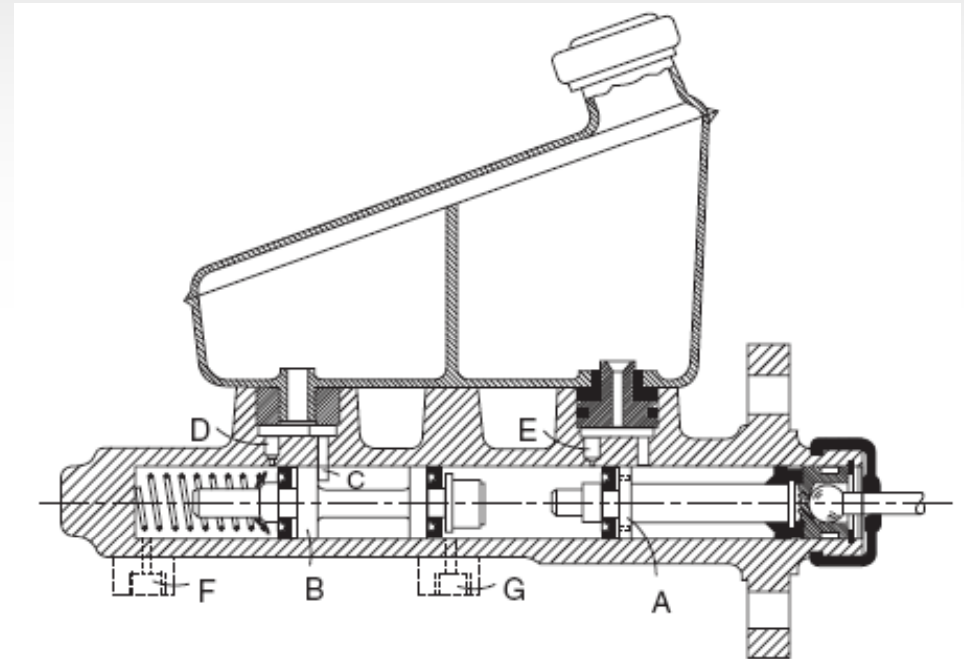
- Horse carriages were essentially stopped by horses
- Drum brakes with pair of internal shoes emerged as dominant
- Until 1920s brakes only in rear wheels
- With drum brake problem of fading due to overheat, emerged disc brakes in 1952.
- Disc brakes were used in front wheels and not in rear brakes as they required mounting of parking drum brakes

Brakes

- Brakes operated by mechanical rods and cables required skilled adjustment or cars would “swing”
- 1930s hydraulic power assisted brakes introduced
- 1960s, Dual hydraulic circuit introduced to overcome leaks
- Heavy vehicles required servo arrangement - Vacuum assist
- Anti Lock Braking introduced from aircrafts. British Jensen FF, 1960 was first passenger car to have it.

Dual hydraulic braking

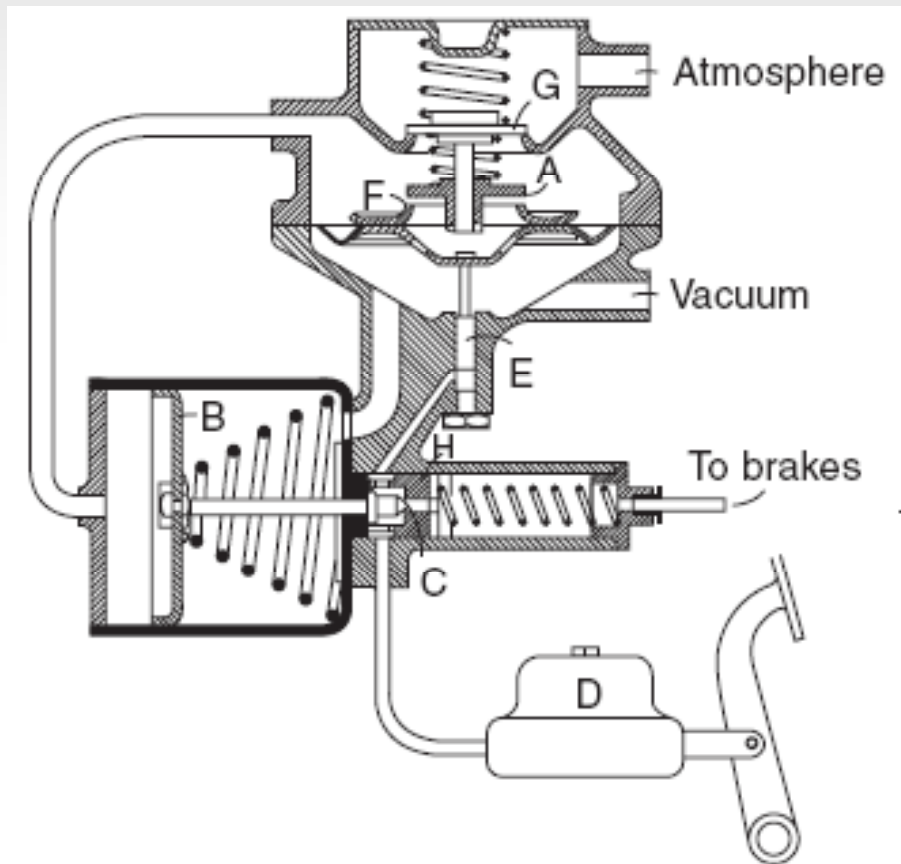
- Dual master cylinder
- Both actuating different circuits
- Failure of one is not affecting another
- At least one circuit operational



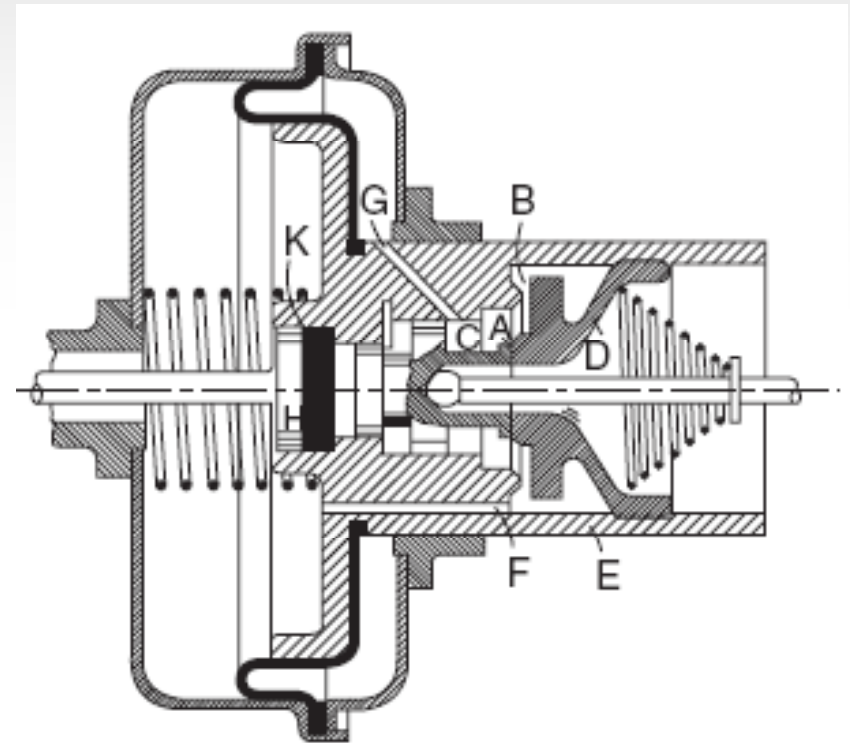
AP tandem master cylinder



Vacuum Assist braking



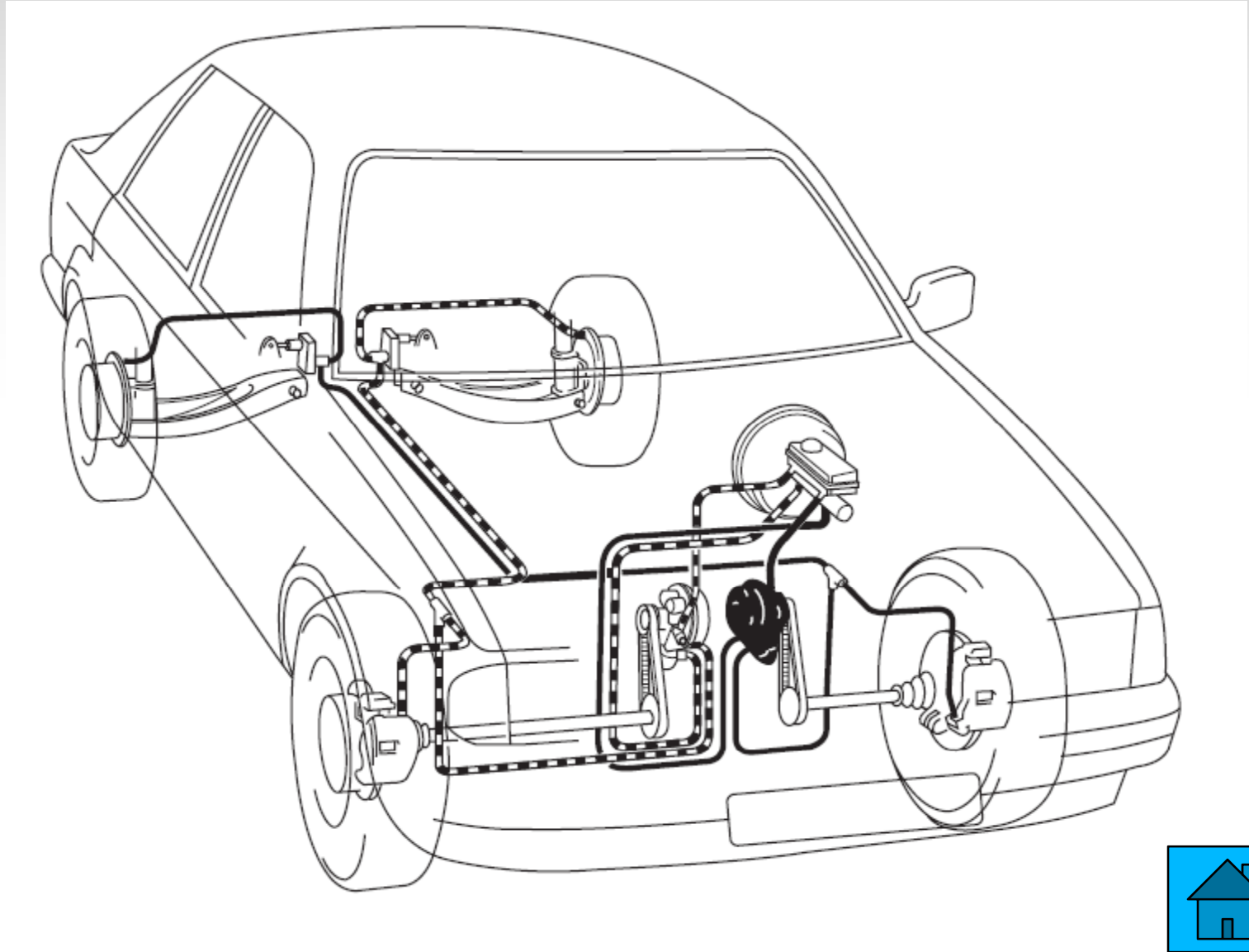
Bendix Hydrovac



AP direct-acting vacuum servo



Anti-Lock Braking



Ford Escort and Orion Anti-lock Braking System

Pictures taken from Steeds and Garrett (1983)

Interior Design

- Modern family cars not superior to high performance cars of 1930s.
- Essential dynamic analysis and design to improve quieteness
 - Direct belt between engine and cooling fan replaced by intermediate electrical
 - Vibration isolation
 - Mathematical analysis of the design
- Air conditioning, power windows, windows demisting added.



Safety Design

- Invention of motor cars produced more deaths than any other invention.
 - No. of civilian deaths per month in USA during WWII greater than deaths due to war
- 1930s “unitary” Chevrolet airflow body construction was more resistant to impact with another car.
- No significant work till 1950s and 60s as it was not a selling point

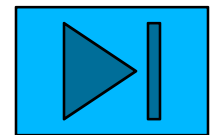
Safety Design

- Pre-war cars had steering columns like spears to the heart of drivers in case of frontal impact
- Collapsible steering introduced by 1960s
- Seat belts appeared around 1950s for front seat occupants and slowly spread to rear
- Airbags came later
- Vehicle is now designed with energy absorbers in front, rear and sides.



?? Too much Innovation ??

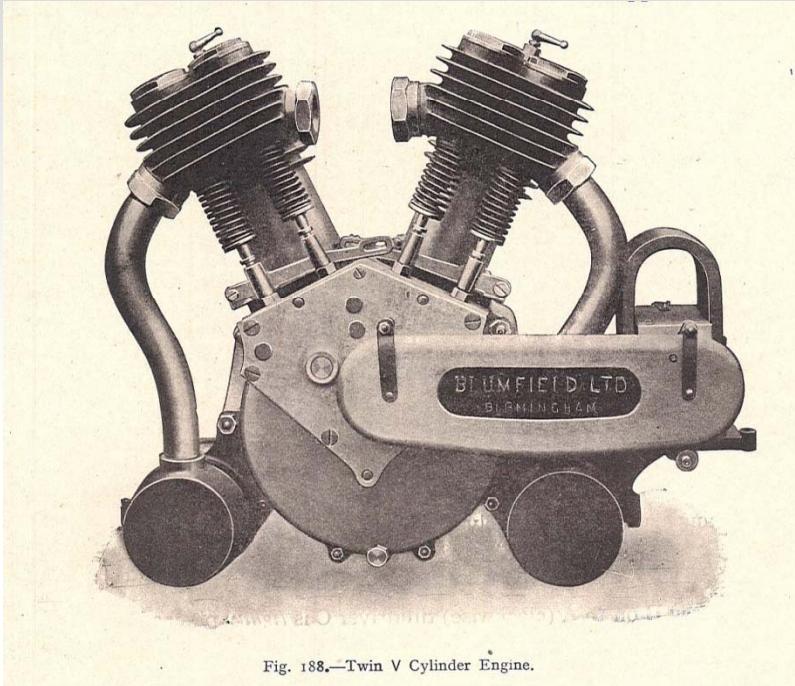
- Innovation not always a key to financial success
 - Alec Issigonis's revolutionary Mini with rubber bush suspension was famous but not with advanced hydro-elastic systems
 - Wankel engine
- Important to choose winners at right time
 - Disc brakes
 - Power Steering



Further Reading

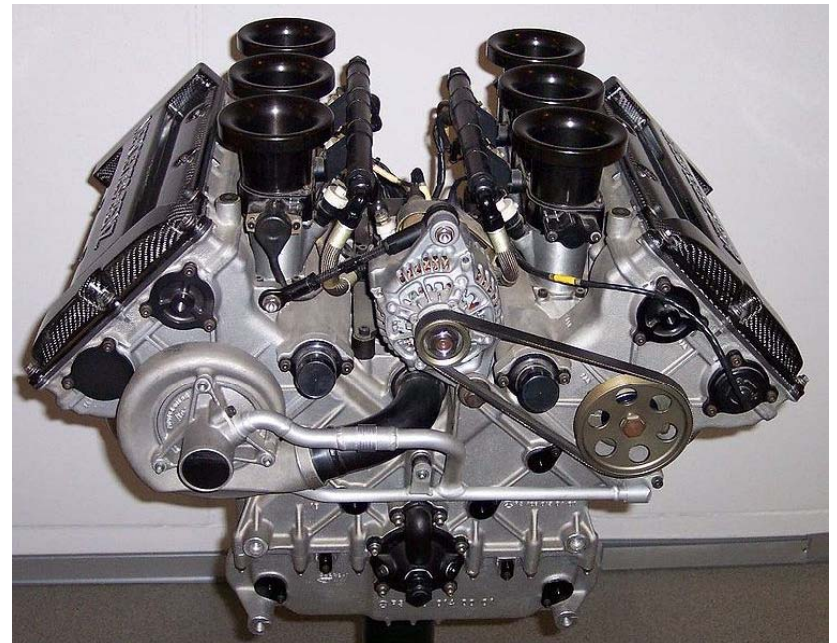
- Julian-Happian Smith (2002), An Introduction to Modern Vehicle Design, Butterworth-Heinmann (ISBN 0-7506-5044-3)
- Newton, K., Steeds, W. and Garrett, T.K. (1983), The Motor Vehicle (10th edn). Butterworths (ISBN 0-408-01118-1 (hard cover) and 0-408-01157-2 (soft cover)).
- Jörnsen Reimpell et al (2001), The Automotive chassis (Second edition), Butterworth Heinman (ISBN 0-7506-5054-0)

Vee-Twin



Blumfield V twin engine 1913-14
with Overhead Cam Shaft

http://en.wikipedia.org/wiki/File:Mercedes_V6_DTM_Rennmotor_1996.jpg

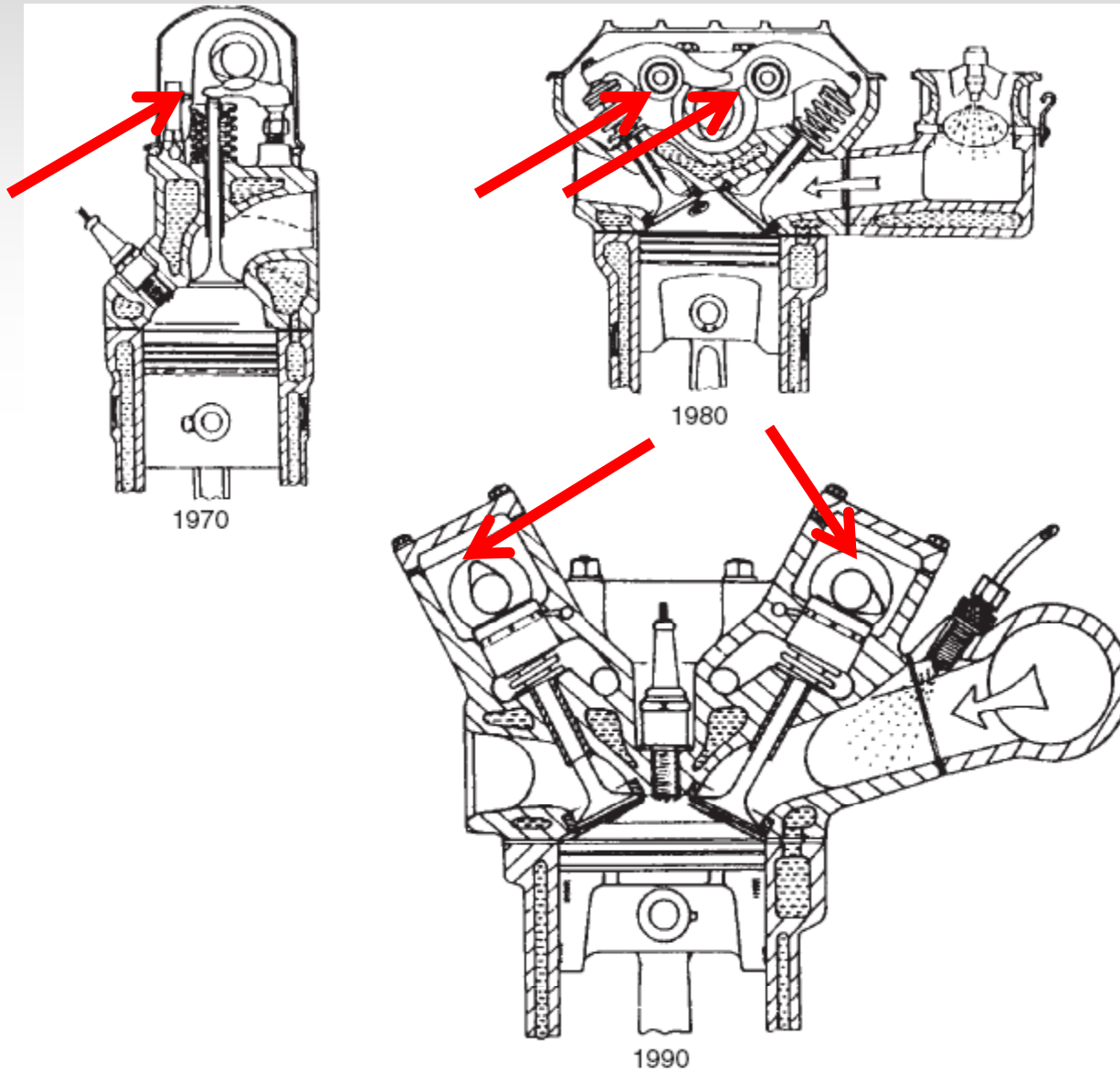


http://en.wikipedia.org/wiki/File:Blumfield_V-twin_motorcycle_engine.jpg

Mercedes Benz V6, 1996

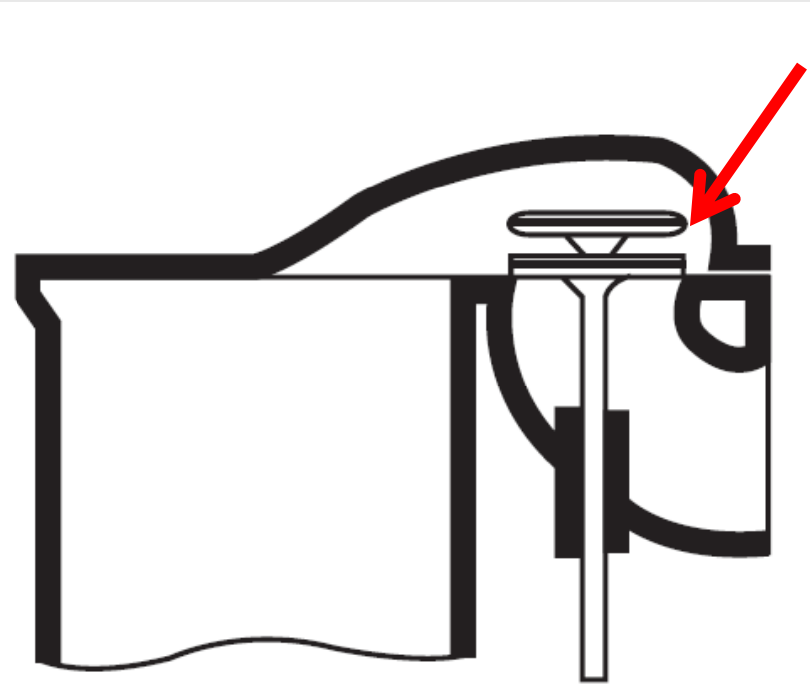
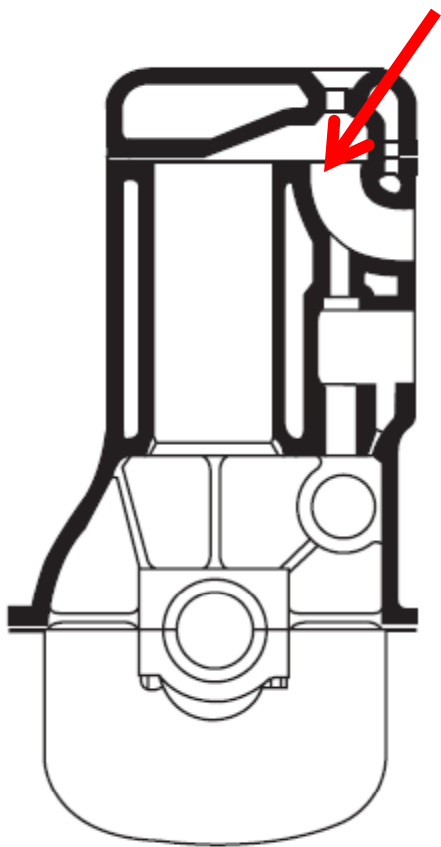


Overhead Cam Shaft



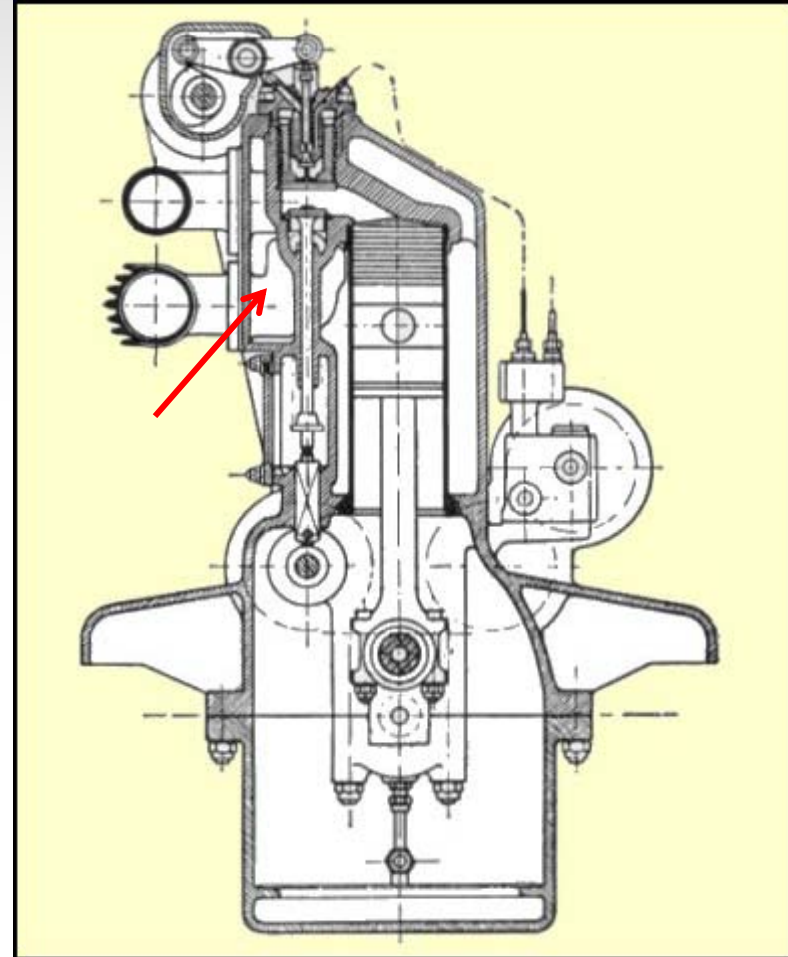
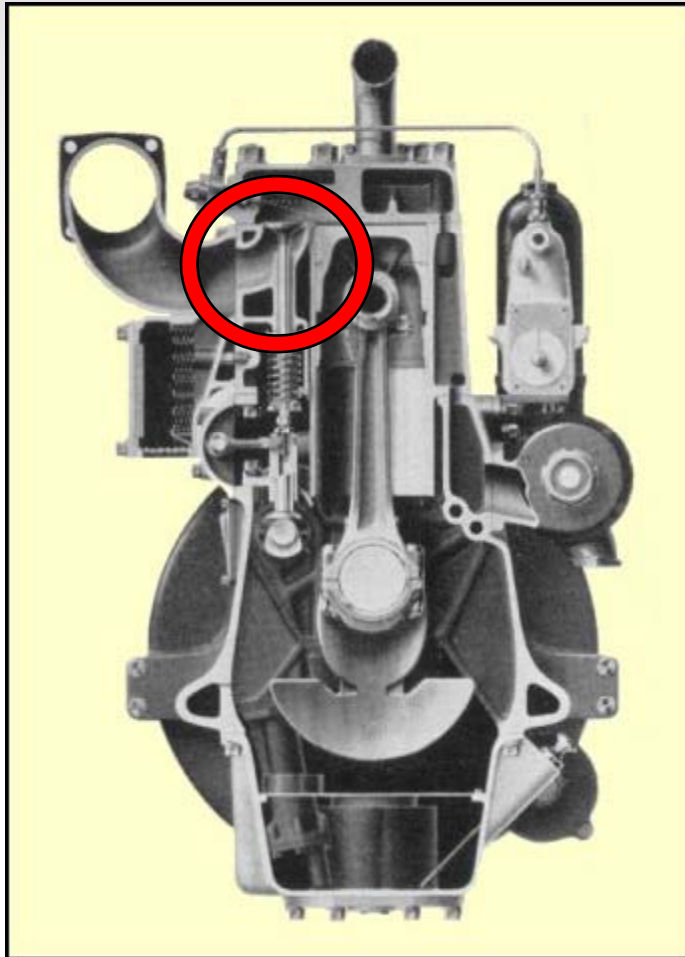
Pictures taken from Steeds and Garrett (1983)

Side Valve Engines



Pictures taken from Steeds and Garrett (1983)

Side Valve Engine



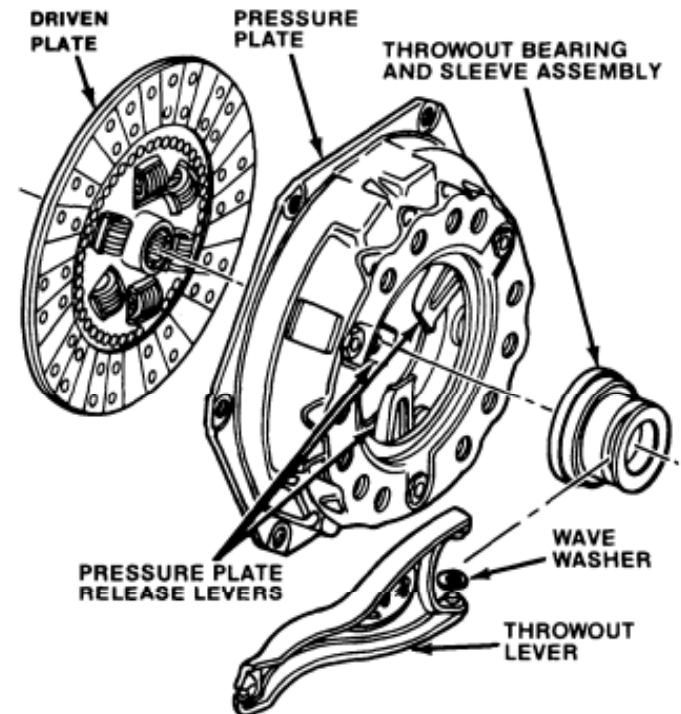
“Biefeld” Diesel engine of 1930s



Plate clutch



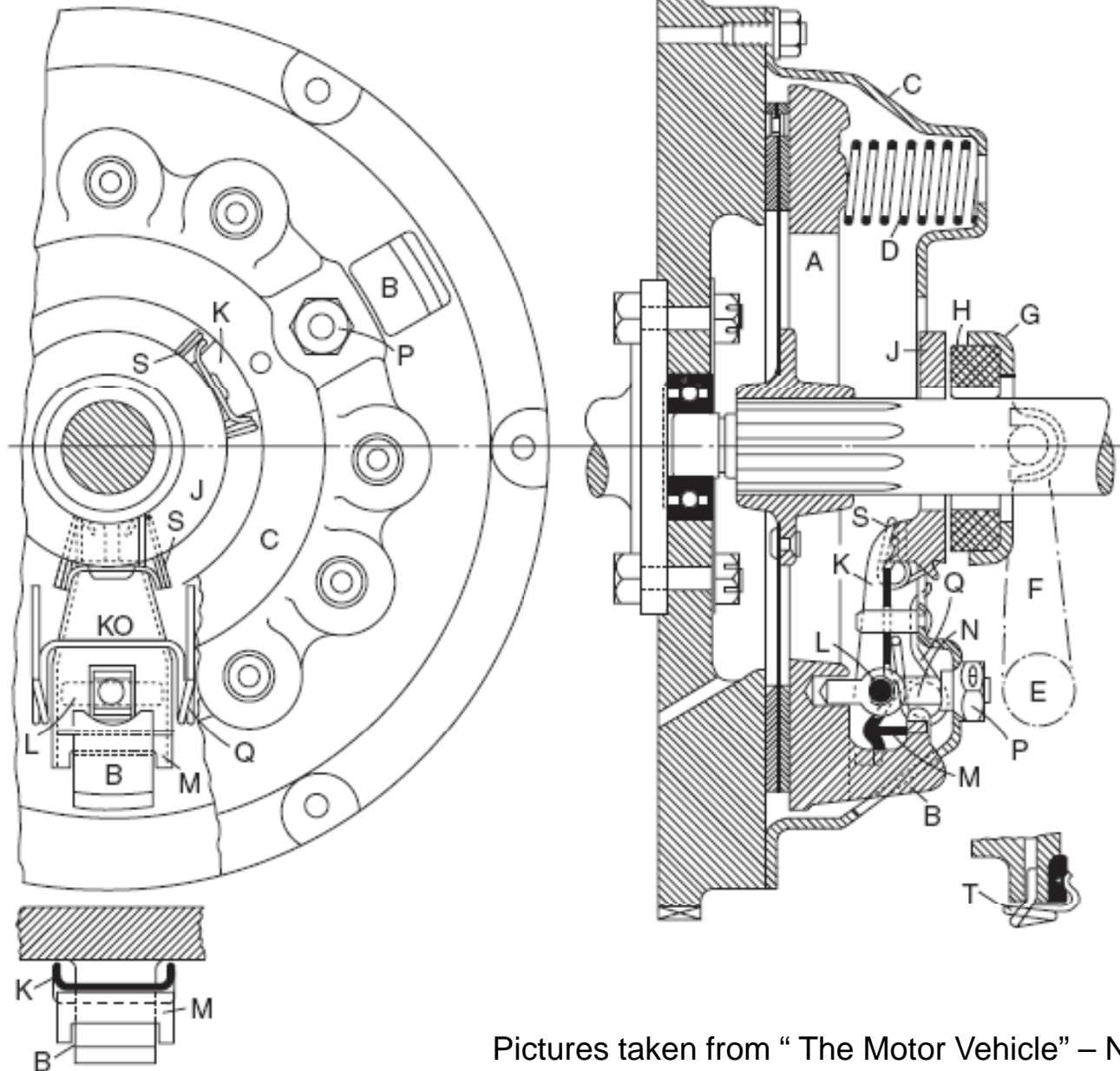
<http://gtmotorsports.com>



http://www.novak-adapt.com/knowledge/clutches_etc.htm

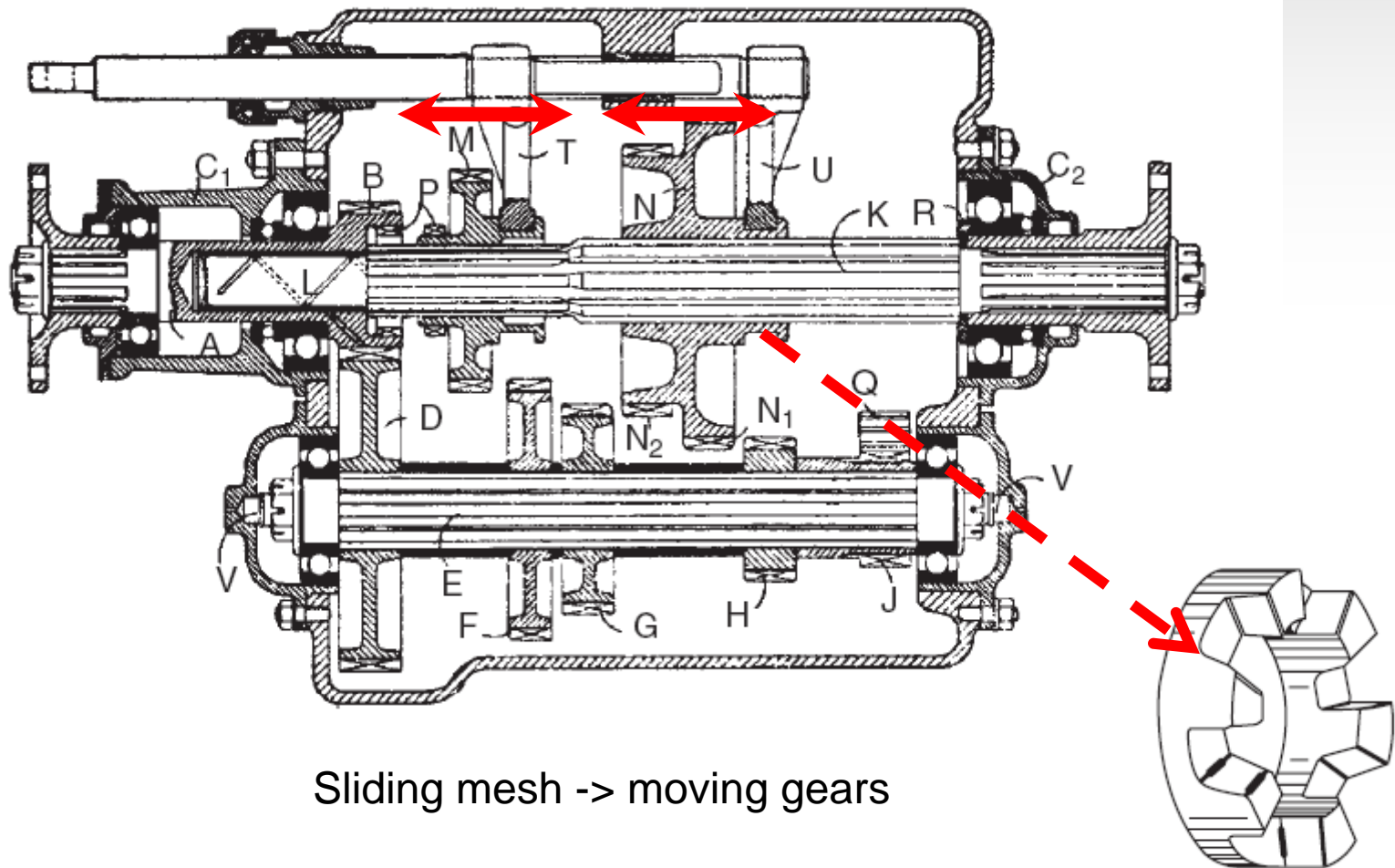


Plate Clutch



Pictures taken from "The Motor Vehicle" – Newton Steeds

Gear box

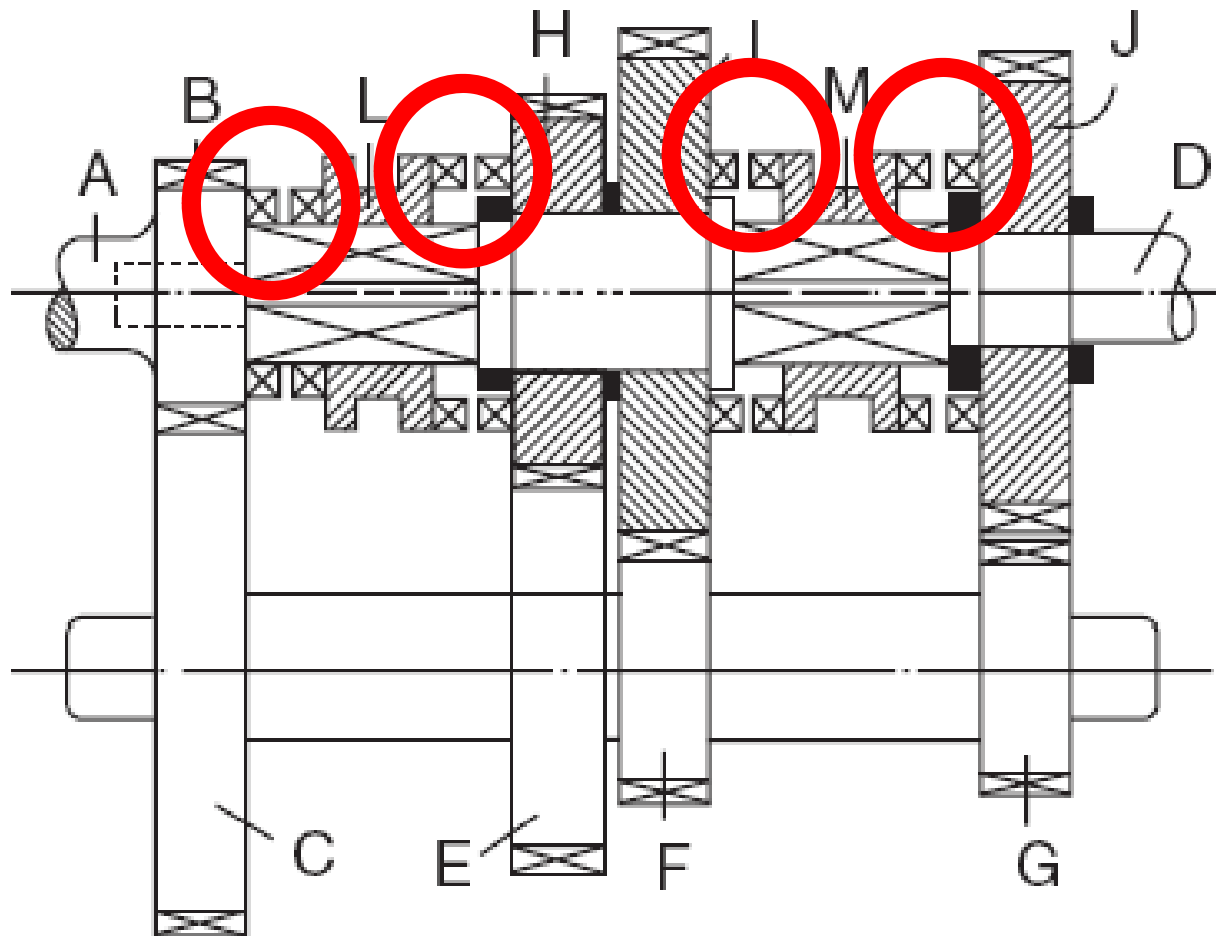


Sliding mesh -> moving gears

Dog clutch

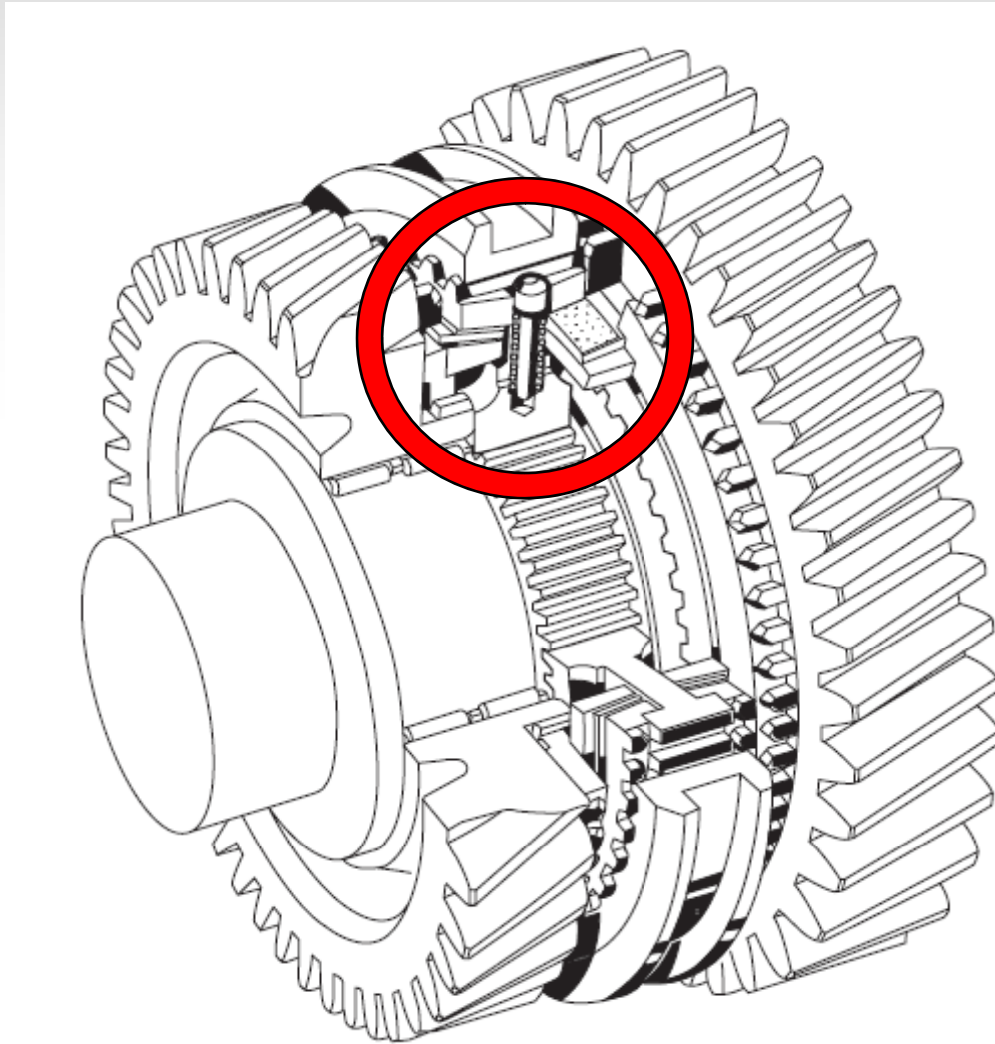


Gear box – Constant mesh



Pictures taken from Steeds and Garrett (1983)

Gearbox - Synchromesh



Synchromesh have “synchronizers” for smoother gear shifting

