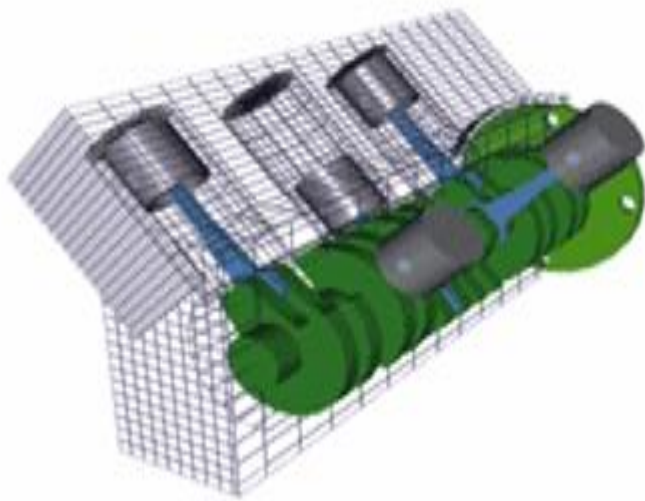# Internal Combustion Engine

ENG. MALIK RAIHAN

2019

Introduction Internal Combustion Engine

Divide of general engine to:
1- External combustion engine
2- Internal combustion engine
Internal combustion engines require ignition of the mixture, either by
1- spark ignition (SI)
2-compression ignition (CI)

The internal combustion engine is an engine in which the combustion of a fuel in a combustion chamber. In an internal combustion engine, the expansion of the high-temperature and high -pressure gases produced by combustion apply direct force to some component of the engine. This force is applied typically to pistons. This force moves the component over a distance, transforming chemical energy into useful mechanical energy.

The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines,   and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion,

Classified internal combustion engine according to :

1- according ignition cycle.

a- the two-stroke cycle

b- the four-stroke cycle

2- according to the type of the fuel used from combustion
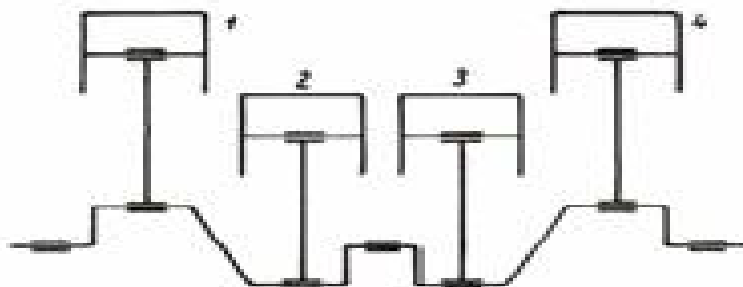
A – engine used diesel fuel.

B - engine using gasoline as a fuel .
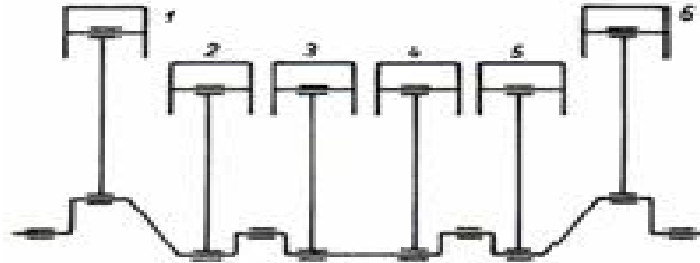
3- according to the combustion way to the fuel

A -a spark plug ignition engines.

B - a compression ignition engines.

4- according to the number of cylinder.
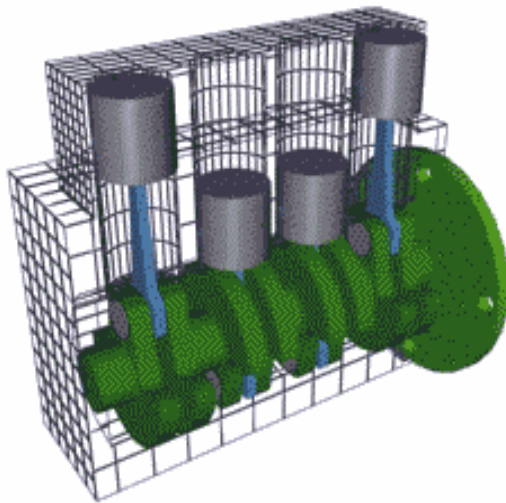
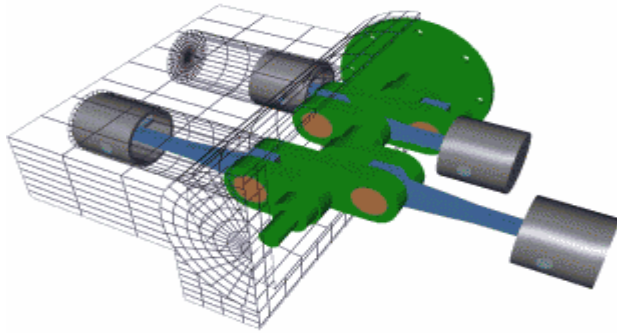A – single number.

B –double number .

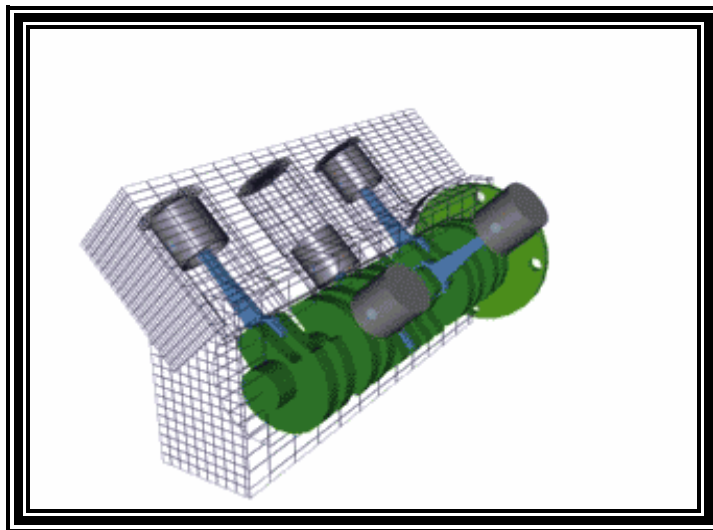# 5- according to the order cylinder.
A –upon straight order line(vertical).

B – upon straight order line(horizontal).

C - according to the(v) type of.

6- according to valve .

A –side of valve .
B –main of valve.
C – according of valve.

7- according the number stroke internal combustion engines
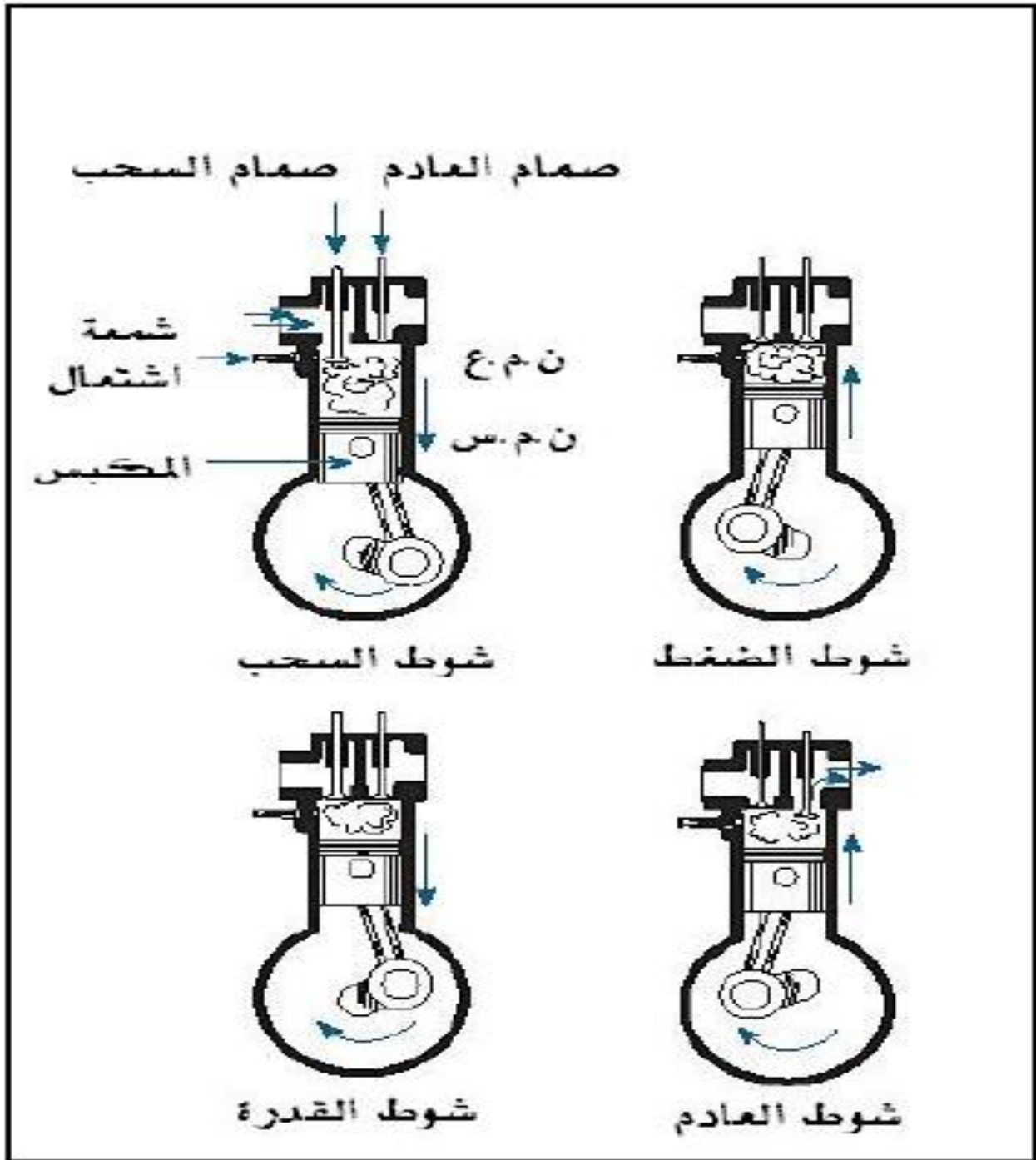
A - four-stroke internal combustion engines.
b-tow stroke internal combustion engines.

8- according the caver head cylinder.

A –single mass

B –block.

Mathematic contents in engine

صمام العادم   صمام السحب

شمعة
اشتعال

المكبس

ن.م.ع

ن.م.س

شوط السحب

شوط الضغط

شوط القدرة

شوط العادم

Basic engine nomenclature

1-cylider bore

2- piston area

$A = r^2 * Л$

$Area = (radius)^2 * Л$

3- top dead center :-
It is the highest point can the piston reached.

4-bottom dead center
It is the lowest point can the piston reached.

5- stroke:-
It is the distance between the top dead center and the bottom dead center

6- swept volume or displacement :-

$Vs = A * L = m^3$

$A = Л (D/2)^2$ A= area

$A = Л /4*D^2$ r = radius

$A = r^2* Л$ d = diameter

7- clearance volume (vc)

8- cylinder volume

$Vt = vs + vc$

Vt = volume total

9- compression ratio

R = Vt / Vc

horse power:-
It is a range of time to making work .

Power = force * distance/time

P = f * d / t

P = power   kw
F = Force   n
D = distance   m
T = time   sec

The Types power In engine.

A- Indicated horse power I.H.P

I.H.P = imep* A * L * N * n/60   tow stroke

I.H.P = imep * A* L * N* n/120   four stroke

Imep = Indicated mean effective pressure
n= the number of rounds
N= the number of cylinder

B - Brake horse power

B.H.P = bmep* A * L * N * n/60   tow stroke

B.H.P = bmep * A* L * N* n/120   four stroke

bmep = Brake mean effective presser
n= the number of rounds
N= the number of cylinder

C - Friction horse power

I.H.P = B.H.P + F.H.P

Mechanic efficiency

ηm = B.H.P / I.H.P
ηm = b.m.e.p / i.m.e.p
ηm = B.H.P / B.H.P + F.H.P

Thermal efficiency Divide to:-

A - Indicated Thermal efficiency

$\eta I = I.H.P / MF * C.V$

B - Brake Thermal efficiency

$\eta_B = B.H.P / MF * C.V$

$\eta_m = \eta_I / \eta_B$

mf = mass of fuel   kg/sec
c.v = Thermal value of fuel   kj / kg
I.h.p- b.h.p = power   kw

Specify fuel consumption
actuating of principle The Brake horse power

f.c = b.s.f.c * i.h.p

actuating of principle The Indicated horse power

f.c = i.s.f.c * b.h.p

Example :-

:- Engine produces (10h.p) I.H.P and the mechanical efficiency of 80% Calculate the B.H.P – F.H.P .

Salutation :-

η_m =b.p / i.p

80/100 = b.p/10

b.p=800 / 100

b.p = 8 h.p

f.p = i.p - b.p

f.p = 10 - 8 = 2 h.p

Example :-

:- Four-stroke diesel engine with four cylinders diameter cylinder (11 cm) stroke length (13 cm) the rotation speed of 2250 rpm Engine amount of b.m.e.p (704.5 kn/m2) Calculate the B.H.P

Salutation :-

B.H.P = b.m.e.p * A * L * N *n /120

B.H.P = 704.5 * 0.13 * Л (o.11/2)^2 * 2250 * 4 / 120

B.H.P = 48 h.p

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Example :-

:- Four-stroke diesel engine with sex cylinders diameter cylinder (82.55mm) stroke length (79.5mm) the   compression ratio (7.8) . Calculate the clearance volume and the capacity of the engine.

Salutation :-
Vs = A * L

VS = Л/4 * D^2 *L

VS = Л / 4 (82.55)^2 * (79.5)

VS = 425.5 m^3

Vt = vs * n

Vt = 425.5*6

Vt = 2553 cm^3

R = vt / vc

7.8 = 425.5 / vc

Vc = 425.5 / 7.8

Vc = 62.58 cm^3

Example :-

:- Engine with a four-stroke spark result in the brake horse power of (48 h.p) and(80%) mechanical efficiency consumes (0.3 kg) of fuel per horse power single calorific value of fuel(42000 kJ / kg) . Find horse power indicated and friction .
and thermal efficiency indicated and brake.. and calculate fuel consumption and air per hour.

Salutation :-

η_m = B.H.P / I.H.P

80/100 = 48/i.h.p

i.h.p = 4800/80

i.h.p = 60 h.p

f.h.p = i.h.p + b.h.p

f.h.p = 60 – 48

f.h.p = 12 h.p

η_B = B.H.P / MF * C.V

η_B = 48 * 750/0.3 * 42000

η_B = 0.7457 kw

η_I = I.H.P / MF * C.V

η_I = 60 * 750 / 0.3 * 42000

η_I = 21.3 kw

f.c = i.s.f.c * b.h.p

f.c = 0.3 * 48

f.c = 14.4 kg/h

ac = 14.4 * 14
ac = 202 kg / h

Example :-

:- Diesel engine results in the b.h.p of 5 .indicated thermal efficiency of 30%. mechanical efficiency of 75%. Calculate the fuel consumption in units liter/ hr. kg/hr and (I .s .f .c)(b .s .f . c)note that the calorific value of fuel 42,000kj/kg. fuel density 0.87 kg/lit

Salutation :-

$\eta_{m} =$ B.H.P / I.H.P
75/100 = 5 / i.p
i.p = 500 / 75
i.p = 6.666

η_{I} = I.H.P / MF * C.V
30 /100 = 6.666 * 0.745 / (mf /3600) * 42000
m.f = 1.419 kg/hr

density = mass / volume
0.87 = 1.1419 * v
V = 1.63 lit/hr
f.c = b.s.f.c * b.p
1.1419 = b.s.f.c *5
b.s.f.c = 0.283kg/hr/bp
f.c = i.s.f.c * i.p
1.1419 = i.s.f.c * 6.66
i.s.f.c = 0.213 kg/ hr/ip

Example :-

:- Machine with a four-stroke swept volume is (0.003 m3) If b.m.e. p is (7.42 kn/m2) the and number of cycles (4230 rpm) Calculate the B.H.P And the I.H.P and F.H.P. if you know that the mechanical efficiency is (76%).

Salutation :-

B.H.P = bmep * A* L * N* n/120

B.H.P = 7.42 * 0.003 * 4230 / 120

B.P = 78.466 kw

$\eta_{m\,=}$ B.H.P / I.H.P

76/100 = 78.466/i.p

i.p = 103.24 kw

F.P = I.P – B.P

F.P = 103.24 – 78.466
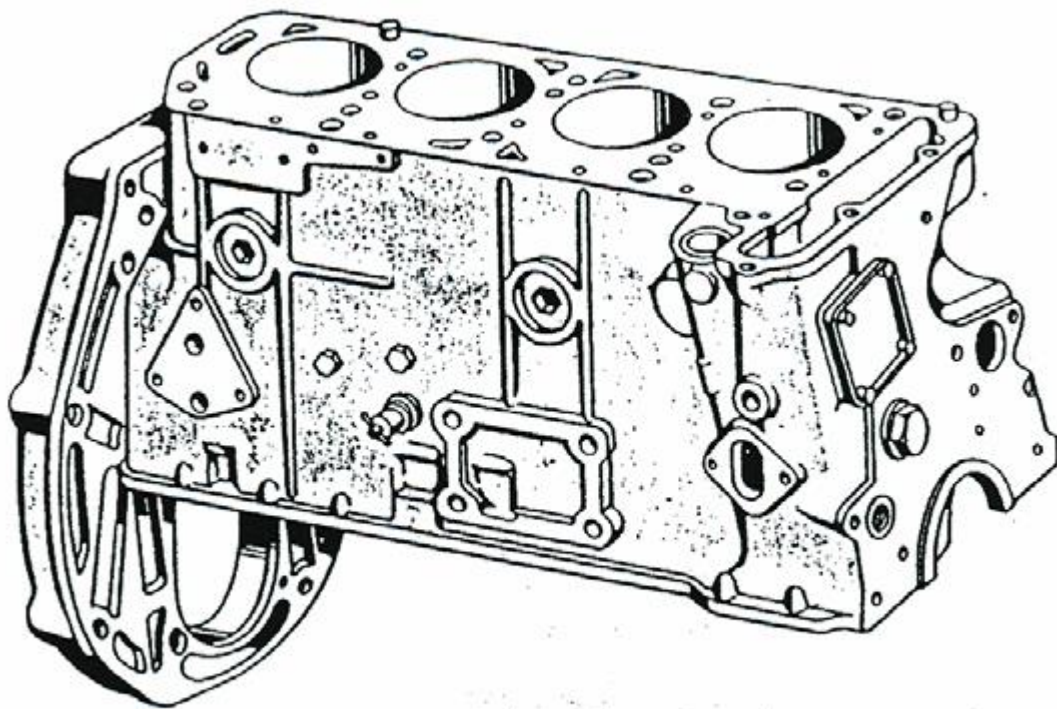
F.P =24.77 KW

Fixed parts in the engine and moving parts

.

Fixed parts. Consists of the following

1 - cylinder block

2 - cylinder head cover

محامل عمود الكامات   أدلة الصمامات

فتحات شمعات الاشتعال
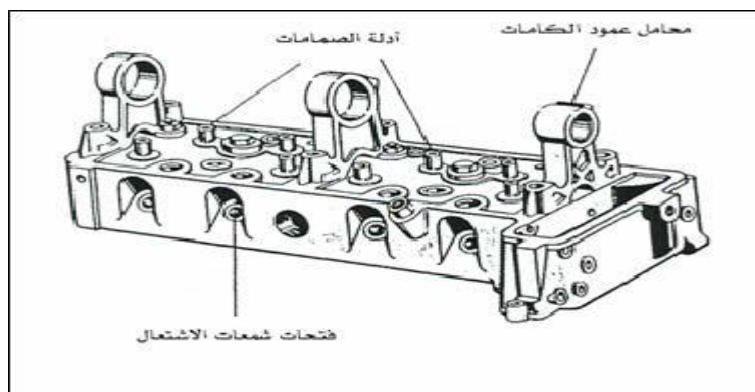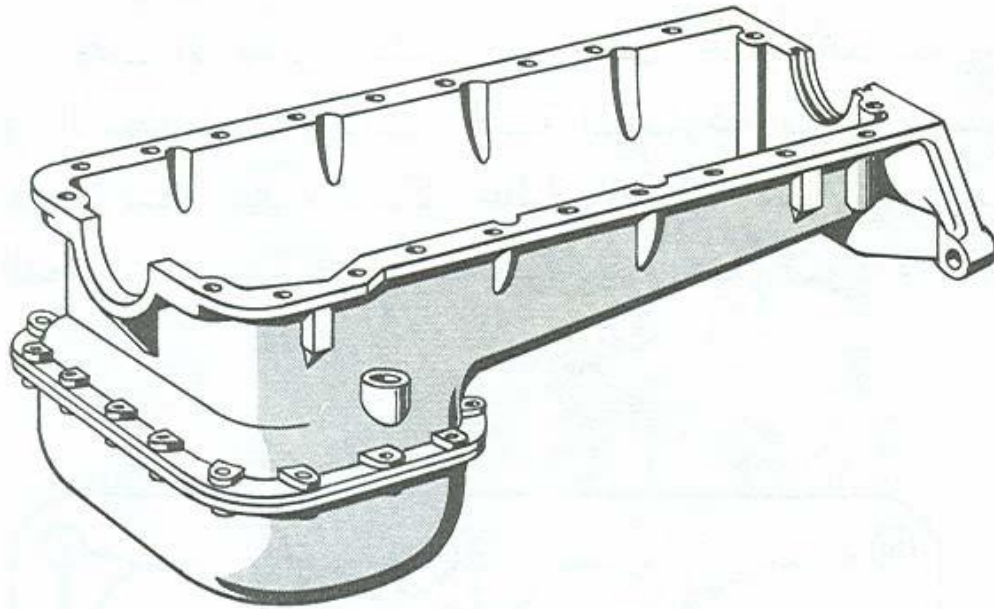
3 – crank shaft case
4- oil case

Cylinder block is made up of.
1 - cavity of the cylinder.
2 - pockets of water
3 - manifold pipes
4 - boards valves
5 - slot Candle Mug

Cylinder head cover.
Made of aluminum metal to speed heat loss and increase cooling
 crank shaft case.
making with the cylinder block in one piece and contains: -

1 – bearing big end
2 - slot full of oil
3 - bearing of camshaft
4 - Side slot to fill the oil.

oil case And contains.
1 - slot discharge oil
2 - There are oil pump in it.
3 - and sheets in a cross-sectional
4 - spins the axle dump
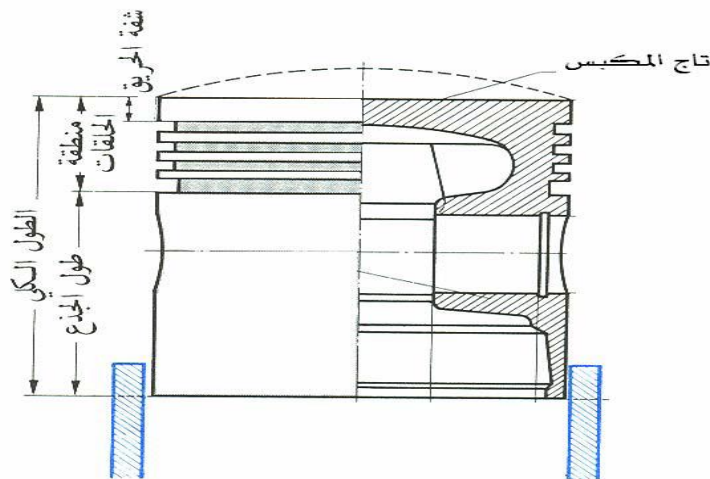5 - where there are fins for cooling.

Moving parts: -

1 – piston.
 The three functions.
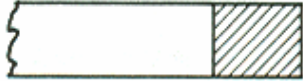A - receive the power of the combustion
B - the power of combustion is transferred to the crankshaft
T - carries piston rings.

2 - piston rings –
 and are of two types.
A - pressure rings

B - Oil rings

3 - piston pin.
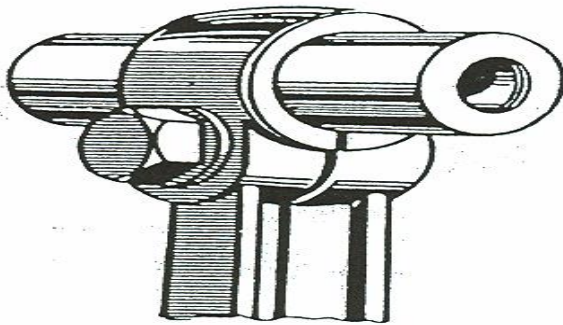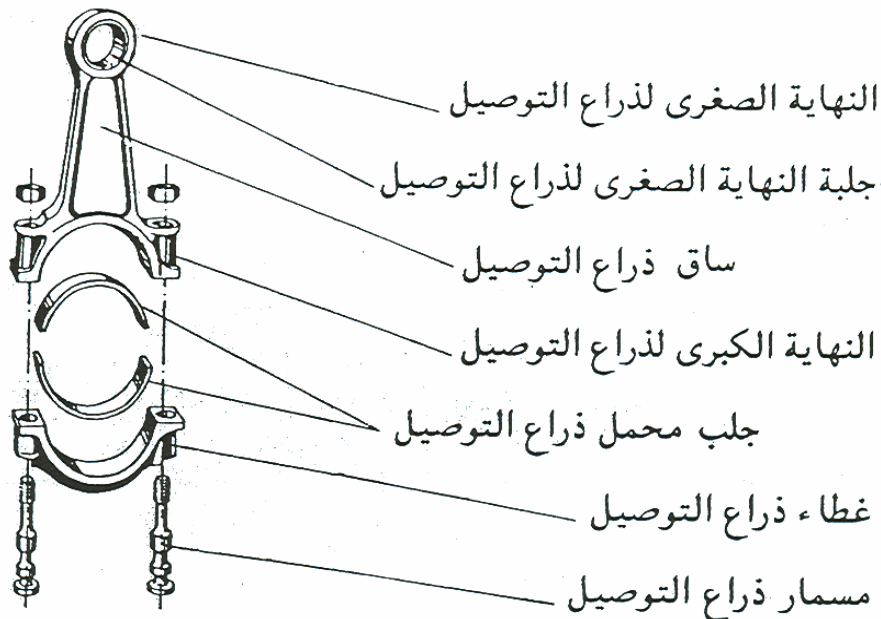

4 – connecting rod consists of the following

النهاية الصغرى لذراع التوصيل

جلبة النهاية الصغرى لذراع التوصيل

ساق ذراع التوصيل

النهاية الكبرى لذراع التوصيل

جلب محمل ذراع التوصيل

غطاء ذراع التوصيل

مسمار ذراع التوصيل

A - Minor end

B - end the Great

T - body connecting rod

W - screws

C - big end shells.

5 - crankshaft: - consists of the following: -

محمل ارتكاز   محامل ارتكاز   مرفق العمود   ثقب تزييت

ذراع التوصيل
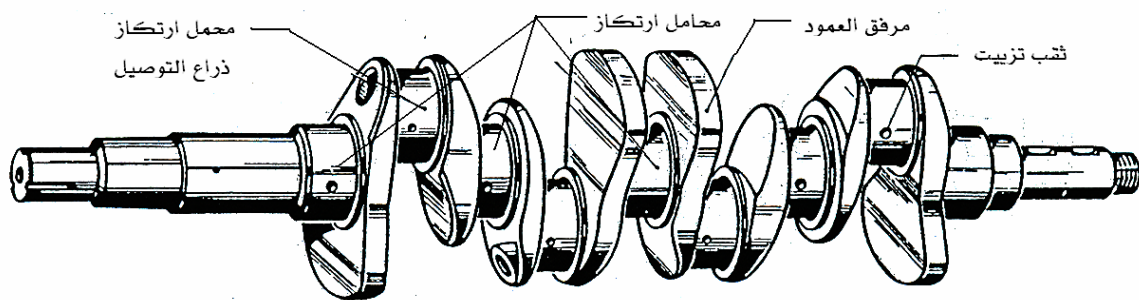
a- main bearing

b-connecting bearing

c- balance

6 - camshaft. The functions of the.

A - open and close valves

B - Run pump oil

T - Turn on fuel pump

W - Run distributor sparks

7 - fly wheel. The following functions.

1 - energy storage
2 - power transmission
3 - Rotate the engine
4 - Consistency of engine speed
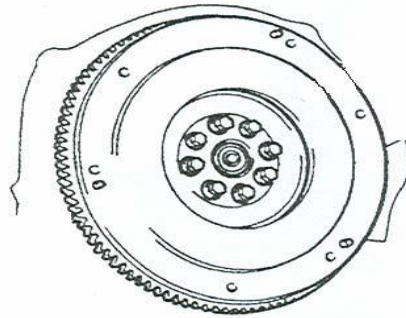
8 - valves. And be of two types

رأس الصمام

عنق (تقوس)

تقوية

الساق

نهاية الساق
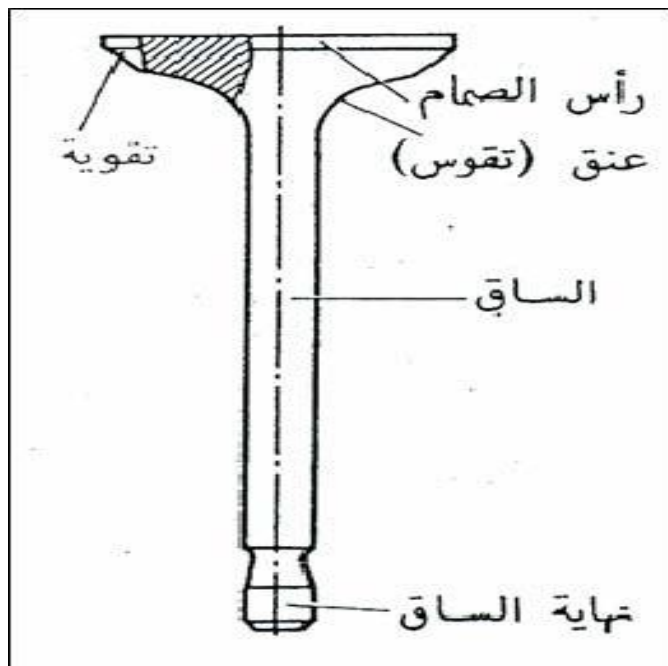
A – intake Valves

B - exhaust valves

valve in general consists of the following

1 - valve leg

2 – guide   valve

3 - head of the valve consists of the following

A - the face of the valve

B - the valve seat

9- Timing gears.

A Timing gears. control the organization of open and close valves to dissuade stroke.

Thermal cycles.

Thermal cycles for the four-stroke engine
For the purpose of the engine, the
specific process that must get sequentially

1 – discharge cylinder mixture flammable
2 - press the mixture into a smaller size
3 - to ignite the mixture, which causes the
production power.
4 - the expulsion of gases resulting from
combustion.

The laws of thermal dynamics.

1 - Boyle's law.
 If the temperature remained constant in the ideal
  gas, the volume of the mass of gas is inversely
        proportional to pressure.
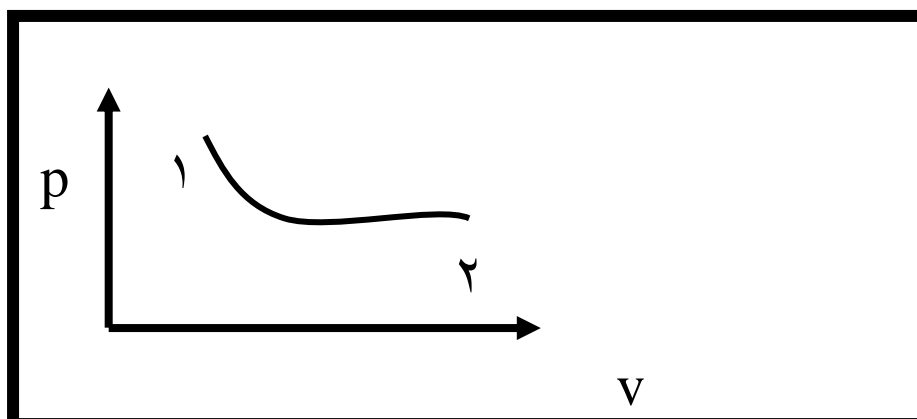
2 - Charles Law.

If the gas pressure remained constant, the ideal size is directly proportional to temperature,
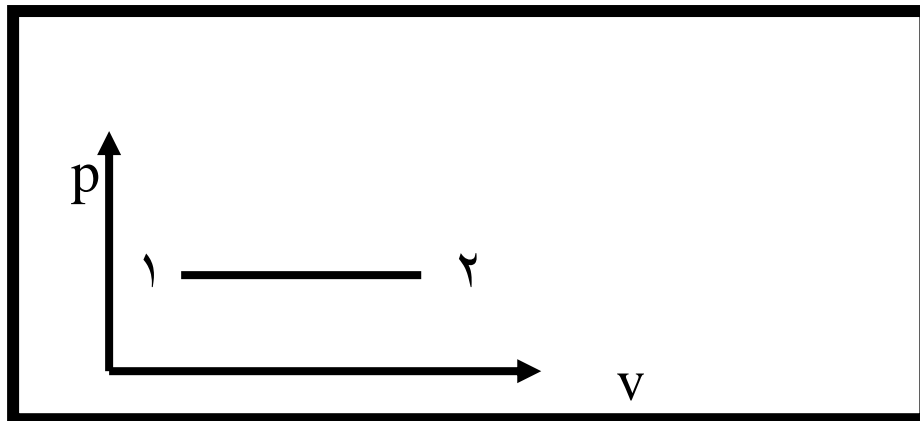
Ideal Otto cycle (constant volume).

(or Otto cycle)Four-stroke cycle
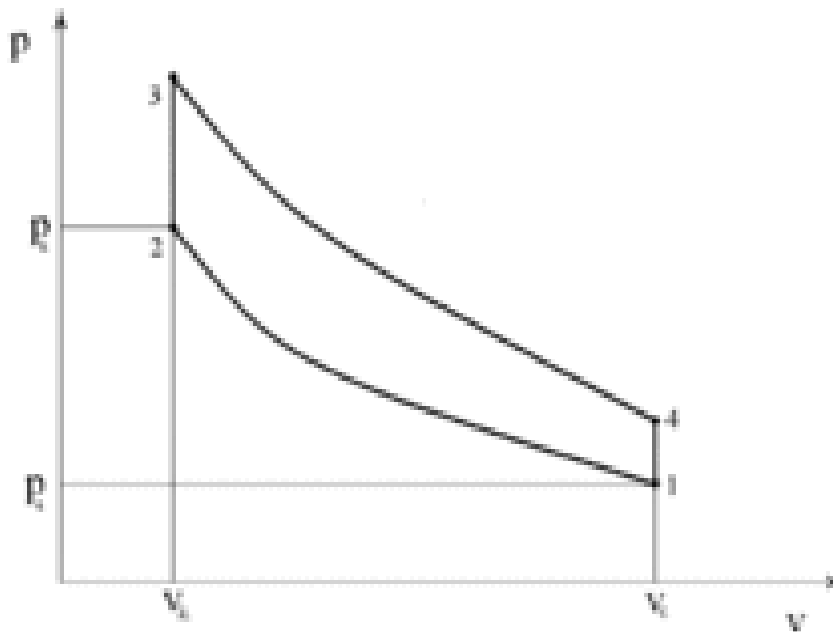
Otto cycle is four runs and can be found in gasoline engines, and enables a planner to clarify N. pressure - Size

1 - gas pressure of(1 ---- 2) increases the pressure and less volume and increases its temperature

2 - increase the gas pressure used in conjunction with evidence of the size of(2 ----- 3) Bakedzabh heat

3 - Gas spreads of(3 ---- 4) In this case the gas does not gain or lose any amount of heat

4 - low gas pressure with evidence of the size of (4 --- 1), therefore, lose the amount of heat to get back to the first case

Ideal diesel cycle (constant pressure).

 (or diesel cycle)Four-stroke cycle
diesel cycle is four runs and can be found in diesel engines, and enables a planner to clarify.
N. pressure – Size

Cycle diesel

1 - gas pressure of (1 ---- 2) increases the pressure and less volume and increases its temperature

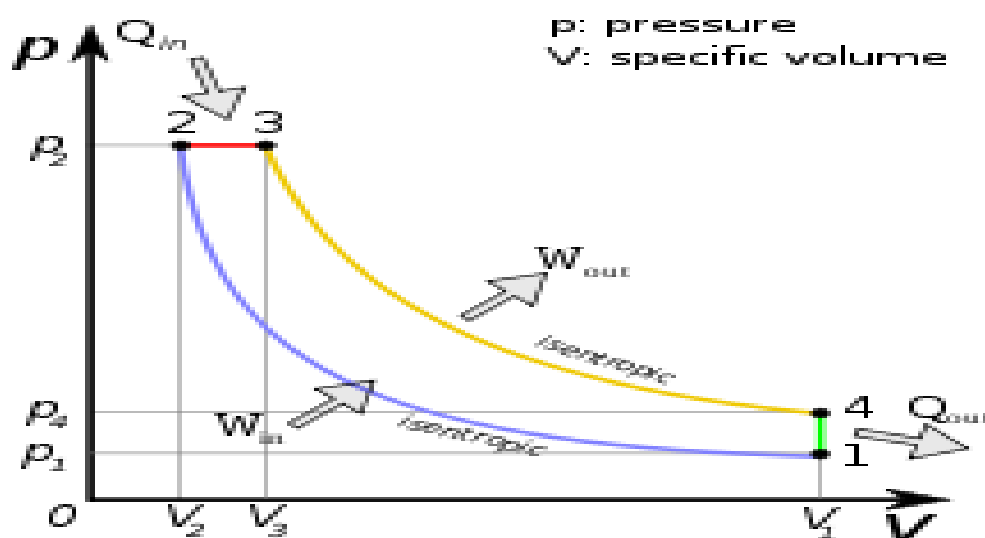2 - increase the volume of gas pressure with proven (2 ---- 3) increase in temperature

3 - Gas spreads of (3 ---- 4) In this case the gas does not gain or lose any amount of heat

4 - low gas pressure with evidence of the size of (4 --- 1), therefore, lose the amount of heat to get back to the first case

Real Otto cycle

1. Intake stroke:-
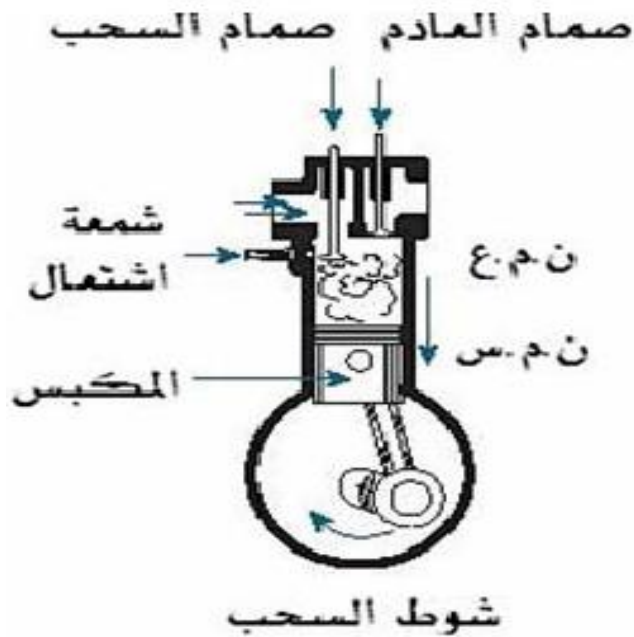
The first stroke of the internal combustion engine is also known as the suction stroke because the piston moves to the maximum volume position . The inlet valve opens as a result of piston movement, and the vaporized fuel mixture enters the combustion chamber. The inlet valve closes at the end of this stroke.

2. Compression stroke:-

شوط الضغط
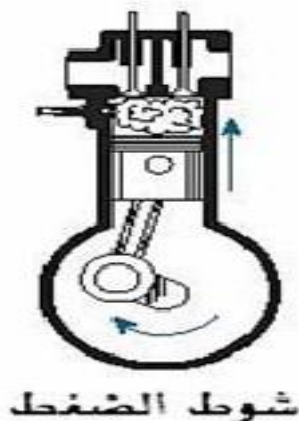
In this stroke, both valves are closed and the piston starts its movement to the minimum volume position and compresses the fuel mixture. During the compression process, pressure, temperature and the density of the fuel mixture increases.

3. Power stroke:-

شوط القدرة
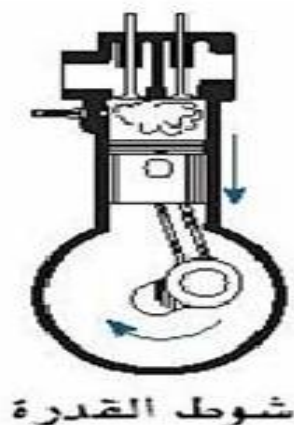
When the piston reaches the minimum volume position, the spark plug ignites the fuel mixture and burns. The fuel produces power that is transmitted to the crank shaft mechanism.

4. Exhaust stroke: -

شوط العادم
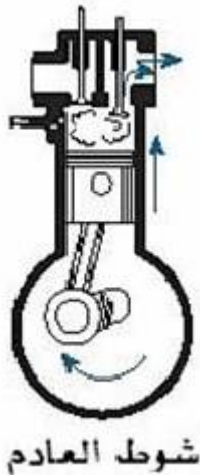
In the end of the power stroke, the exhaust valve opens. During this stroke, the piston starts its movement in the minimum volume position. The open exhaust valve allows the exhaust gases to escape the cylinder. At the end of this stroke, the exhaust valve closes, the inlet valve opens,

 and the sequence repeats in the next cycle. Four-stroke engines require two revolutions.

For two-stroke engines:-

Is clear from the study-stroke engines Quartet that the machine works half the time (during the two halves of the compression and the

ability) as the engine heat the other half is working the air pump only.
This is to benefit fully from the circuit in the engines that meet the thermal cycle runs through two games of a piston two-stroke engines
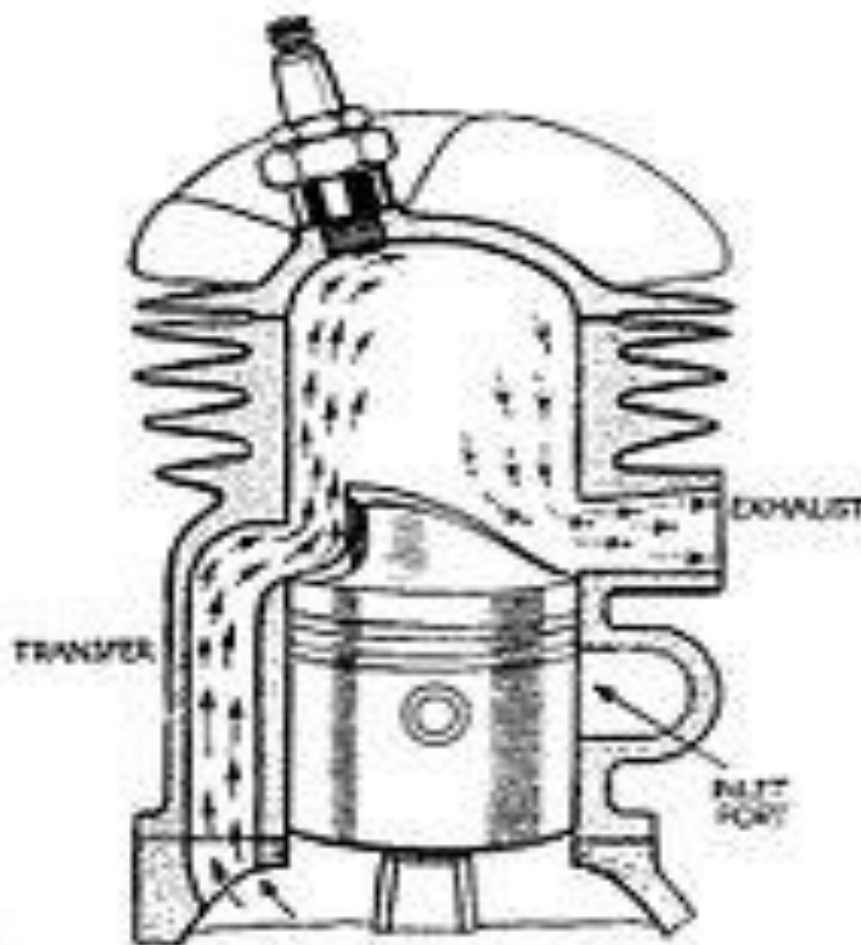
Characterized by tow stroke engines. Four stroke engines. in the processes of cleaning and shipping of the cylinder does not Taatman result of absorption-and-drop caused by the

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movement of the piston, but by Compressed air or the mixture in advance, the mixture is compressed flammable or exchange the air in the pump either independently or in a vacuum procedure of the drive tray as a result the movement of the piston in the cylinder.

Advantages of tow stroke engines.

Cylinder is characterized by the presence of two-stroke engines openings or windows are distributed on the walls as the opening and closing these windows depends mainly on the movement of the piston and Odeith at that moment.

and stroke are as follows: -
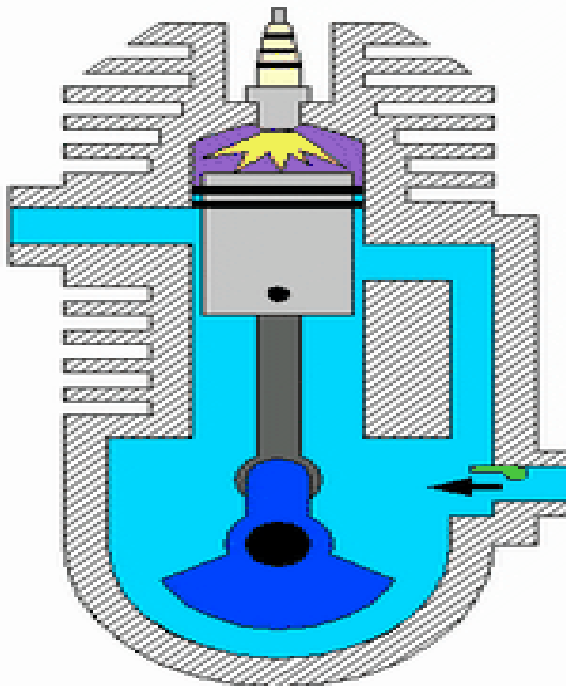
1 - intake -and-Compression stroke: -

means that the piston moves up and compresses the mixture in the combustion area and within a delirious process enters the batter's New) gasoline and oil, mixing and air) from the bottom of the piston (withdrawal) before the arrival of the piston to the dead zone upper a little and go this mixture to the area can annex) crankshaft area) and at the completion stage, delirious crankshaft house half a roll ..

2 - power stroke and exhaust: -

 ignition (explosion) before the point of dead
And pay a little higher pressure of the gases burnt

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piston down (and here is
Employment and capacity) and then is
compressed mixture from inside the Karnak to
the area of combustion, a pressure prior and be
the clouds closed and before the arrival of the
piston to the area of dead lower slightly exposed
at the end of the piston top slot exhaust to allow
the gases burnt out (exhaust) and replaced by a
mixture new and here is Karnack second half of
the session.

Comparison between the Four-stroke cycle and tow-stroke cycle

The most important features of two-stroke
engines are: -
1 - increased power resulting from increasing the
number of rotors
2 - it is simply characterized by bilateral motor
design, especially the lack of need for the
installation of valves and timing mechanisms of
the complex and its affiliates.
3 - and is characterized by its small size and ease
of maintenance.

Fuel system for diesel engines

Diesel engines in cars took to spread because of the
economics of operation in this type of motor does not

use the sparks to ignite the mixture ignites, but when he arrived to the point of self-ignition and reach the air temperature inside the cylinder diesel engine by the fuel injection to about 540 ° m.

diesel fuel

Produced and diesel fuel in varying degrees is 1-D, 2-D ,4-D. The types 1-D, 2-D two types for use in cars.

The system of public
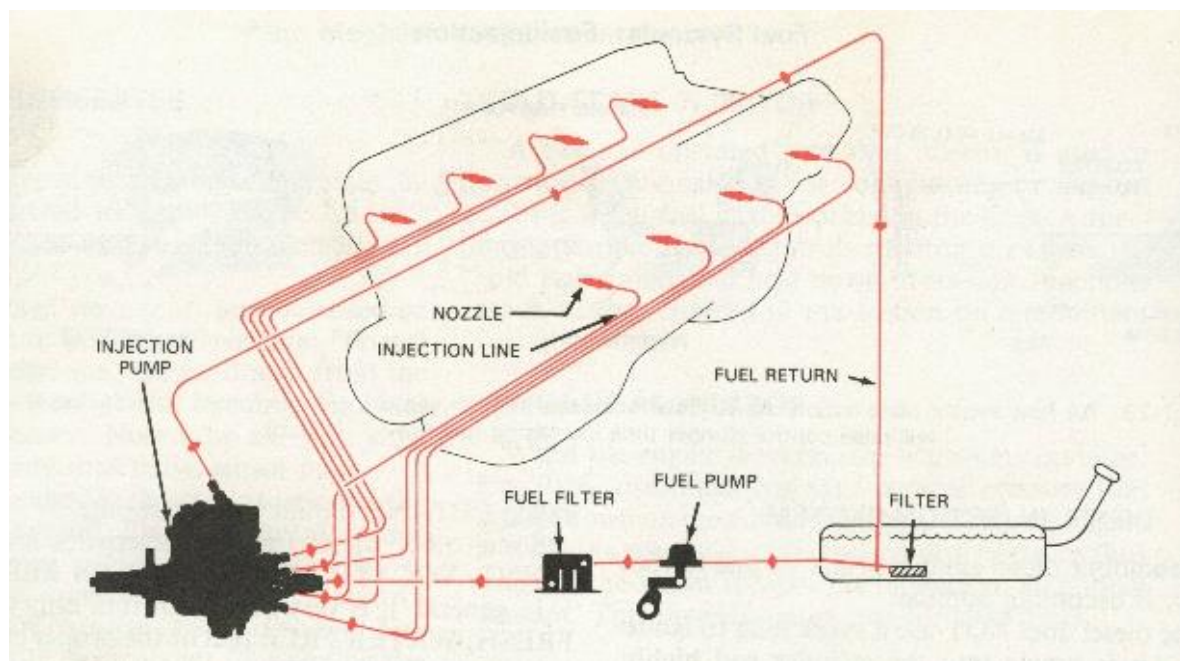
Form shows a diagram of the diesel injection system is composed of
1-Fuel tank,
2-primary Fuel Filter
3-Feed pump
4- secondary Fuel Filter
 5-Injection pump,
 6-injector

7-Conductors necessary high-pressure

8-Conductors with the necessary low pressure.

Parts of the system.
1 - fuel tank,

Made of sheet metal has a hole and filling unit send the amount of fuel.

2 – primary Fuel Filter

You clean the fuel from the dust and impurities and water molecules

3 - Feed Pump

You connect the fuel from the tank to the rest of the parts of the system pressure of (15 bar)

4- Fuel Filter secondary

Final cleaning of the fuel pump before entering the main

5 - and the injection pump,

Of the most important parts of the system and accurate you raise fuel pressure to 250-300 bar and perfusion inside the combustion chamber and the production power in the engine

6 - injector

In the process of fuel injection perfusion inside the combustion chamber without the payment of fuel in the form of drops, leading to the non-burned.
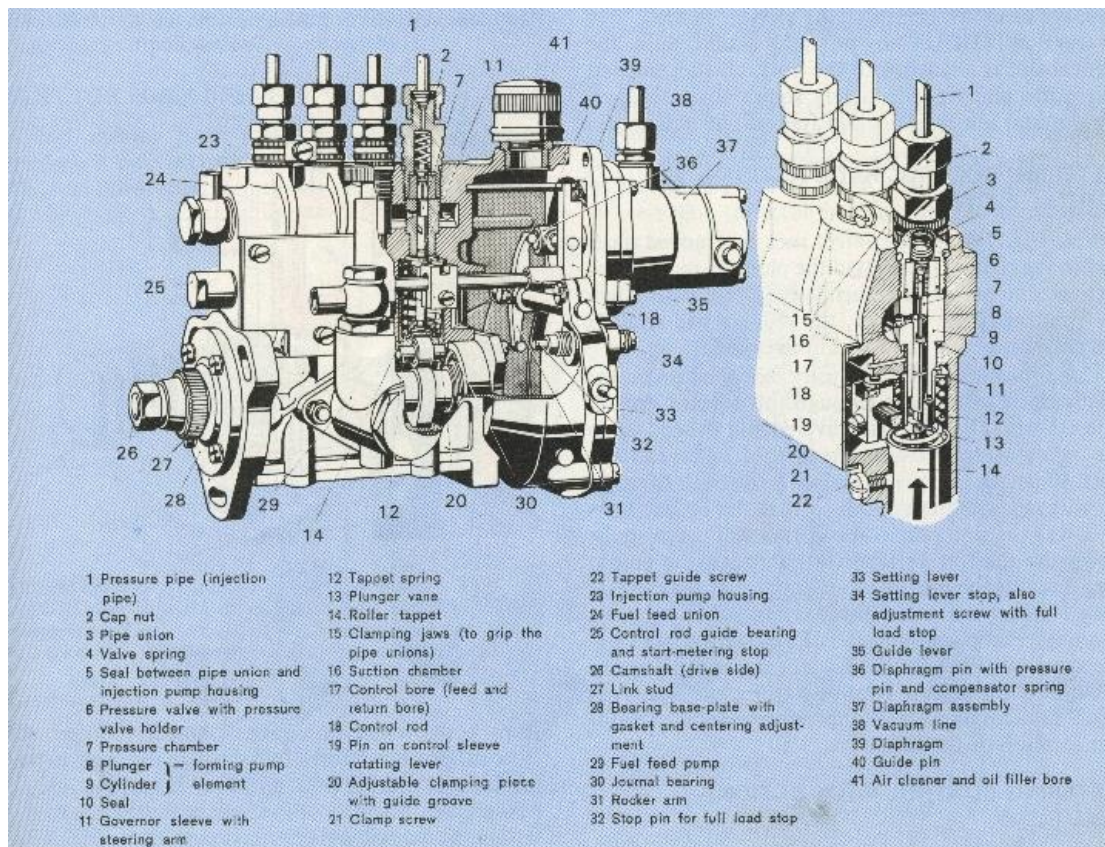
7 - conductors necessary high-pressure

They are made of iron pipes bear the high pressure link between the injection pump and injector

8 - the necessary connectors with low-pressure

They are made of plastic pipe intended for low pressure

Injection pump,

1 Pressure pipe (injection pipe)
2 Cap nut
3 Pipe union
4 Valve spring
5 Seal between pipe union and injection pump housing
6 Pressure valve with pressure valve holder
7 Pressure chamber
8 Plunger } forming pump
9 Cylinder } element
10 Seal
11 Governor sleeve with steering arm
12 Tappet spring
13 Plunger vane
14 Roller tappet
15 Clamping jaws (to grip the pipe unions)
16 Suction chamber
17 Control bore (feed and return bore)
18 Control rod
19 Pin on control sleeve rotating lever
20 Adjustable clamping piece with guide groove
21 Clamp screw
22 Tappet guide screw
23 Injection pump housing
24 Fuel feed union
25 Control rod guide bearing and start-metering stop
26 Camshaft (drive side)
27 Link stud
28 Bearing base-plate with gasket and centering adjustment
29 Fuel feed pump
30 Journal bearing
31 Rocker arm
32 Stop pin for full load stop
33 Setting lever
34 Setting lever stop, also adjustment screw with full load stop
35 Guide lever
36 Diaphragm pin with pressure pin and compensator spring
37 Diaphragm assembly
38 Vacuum line
39 Diaphragm
40 Guide pin
41 Air cleaner and oil filler bore

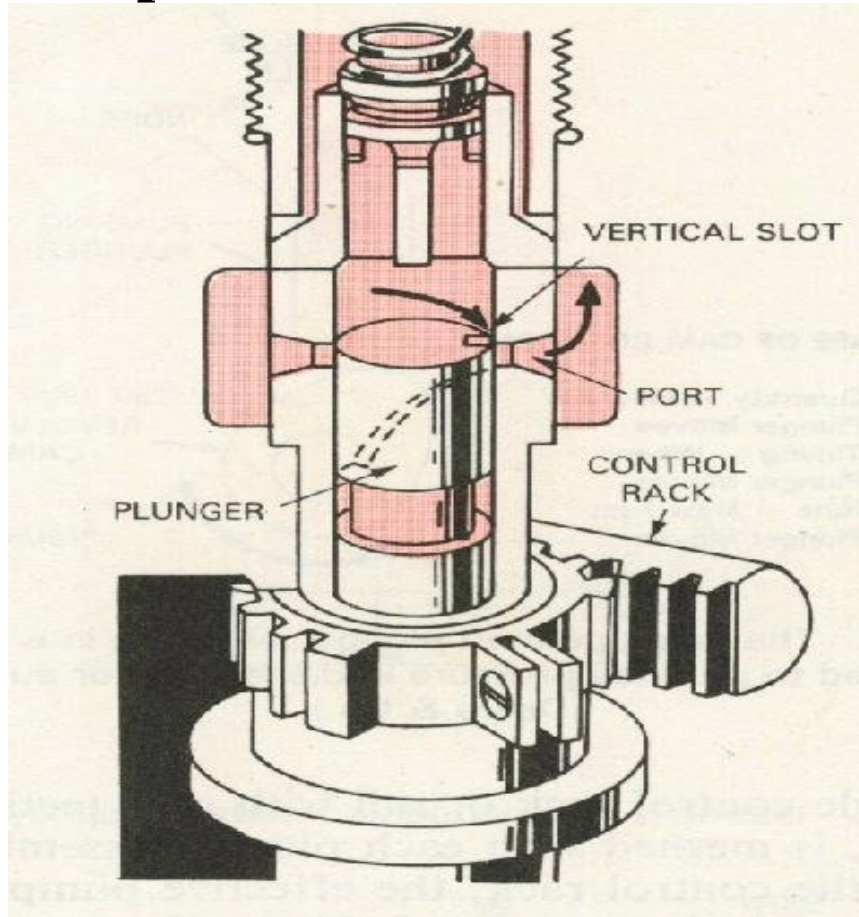The functions of injection pump.
1 - Calibration of the amount of fuel injected.
2 - the timing of fuel injection.

3 - regulation of injection.

4 - and fuel atomization minutes split into very small.

Pump consists

1 – crankshaft pump

2 – plunger which has a spiral slot

3 – barrel

4 – Tapti

5 - spiral spring

6 - valve fuel discharge

7 –control rack

8 - slot entry of fuel and out present on the cylinder

The mechanism of action

When the piston at the bottom enter the fuel into the cylinder walls and fill the vacuum above the piston and at his movement towards the top due to the movement of cam up the piston to the top and pay the fuel under high pressure and fill slots force the high-pressure valve discharge to the opening and push the fuel to spray and a guest slot spiral to determine the amount Fuel paid for by the part that controls the helix Bay through the control rack.

injector

The injected fuel inside the combustion chamber perfusion

Work injector

Raise the needle valve on the seat under the influence of upward pressure fuel pump of the hole exposed after needle fuel pressure drop due to the needle seat spring effect

Lubrication system

The purpose of the lubrication process

Is to put a thin film of oil between two surfaces in close proximity

Viscosity:

Property is the amount of coherence express the inner layers of liquid with each other.
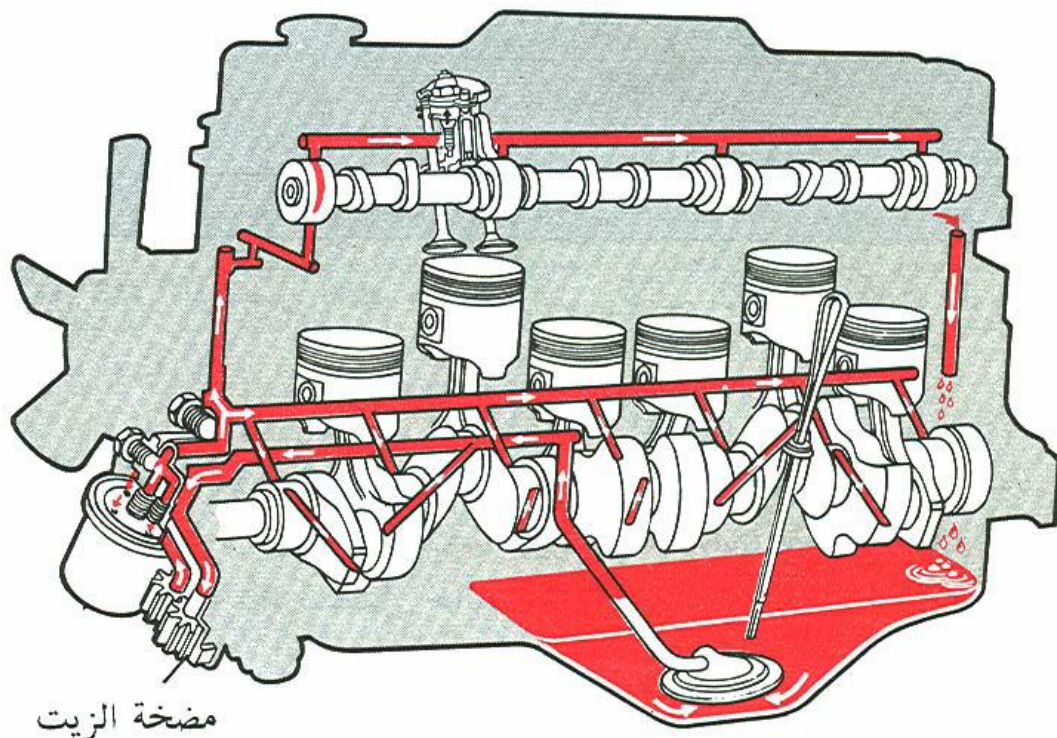
The functions of lubricating oil:

1 - Lubrication
2 - Cooling
3 - knitting and Conditions
4 - Cleaning
5 - Increasing the power.
6 - to deter shocks.
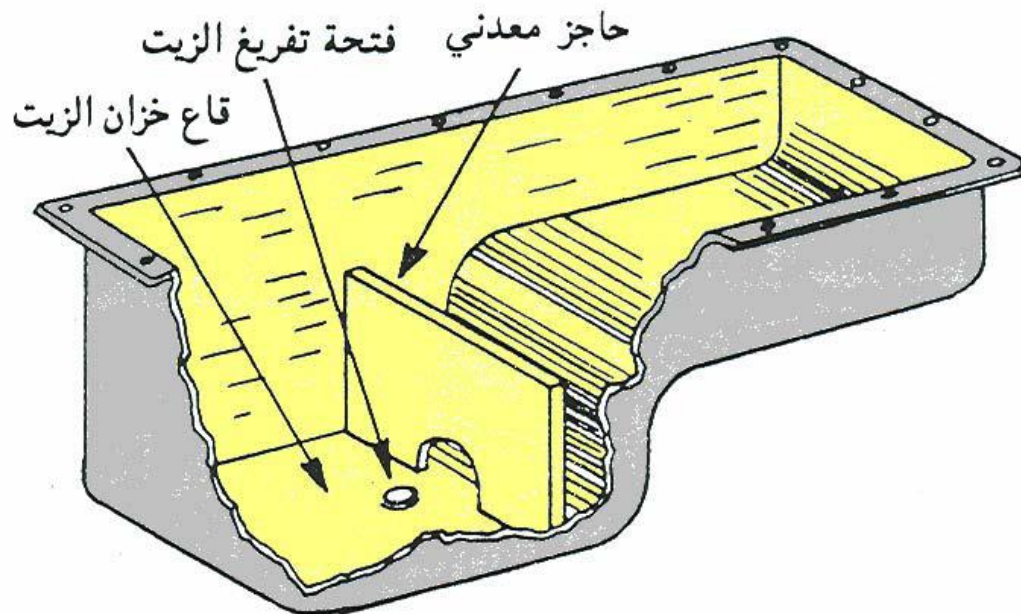
Characteristics that must be met in lubricating oils:

1 - a suitable Viscosity for a fixed

2 - with a considerable resistance to combustion
3 - resistant to oxidation
 4 - a-resistant foam

# Components of lubrication:

مضخة الزيت

1 - Oil pan

A container that collects the oil lubrication of the engine and the purpose is to work a reservoir for a certain amount of oil depending on the requirements of the engine and maintain the oil level so that it is consistent and appropriate for the pump to dissuade drop or rise of heights, so the base with two different levels also contains plug discharge at the lowest point of the Even can dump the engine oil after the lifting of the jaw or stopper.

2- Oil Strainer
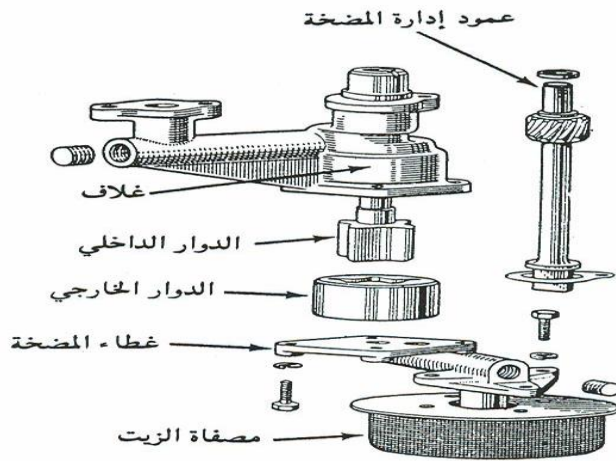
Is a wire mesh metal minutes gaps are placed in the casing connecting the bottom of the oil pump so that they are at a distance suitable from the bottom of the pot of oil in order to avoid capture mineral deposits generated during the operation of the engine and that accumulate inside the container and thus operate the refinery to purify the oil from the exotic materials large.

3 - Oil Pump
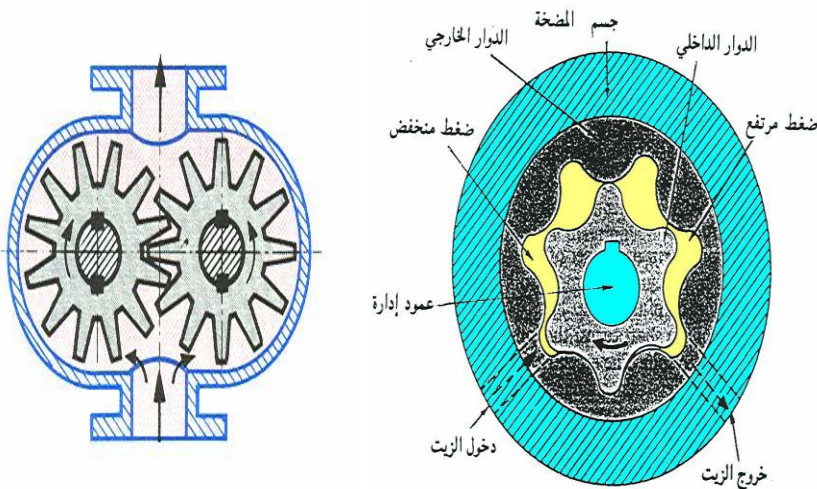
Used several types of oil pumps in the group of

lubrication for engine parts such as pump with feathers - the pump rotor - pump leg immersion - pump gears which derive their movement usually of different types of camshaft engine and sometimes crankshaft and the purpose of the pump is pulling oil from the vessel and then pay in the Department of lubrication distributor under a certain pressure suit pressure needed to reach the oil to various parts of the engine and the pump is supplied to the pressure regulator (valve safe) ride with them at the mouth of the oil out.
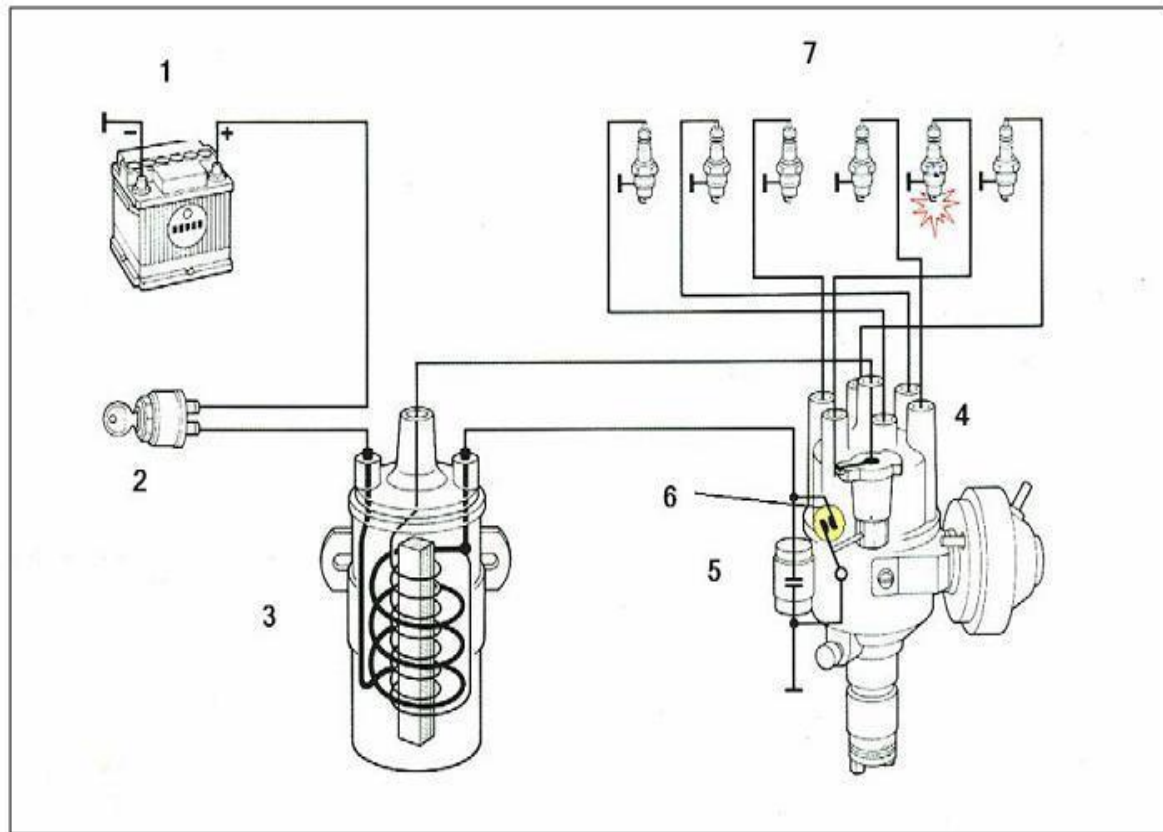
4 - Oil Filter

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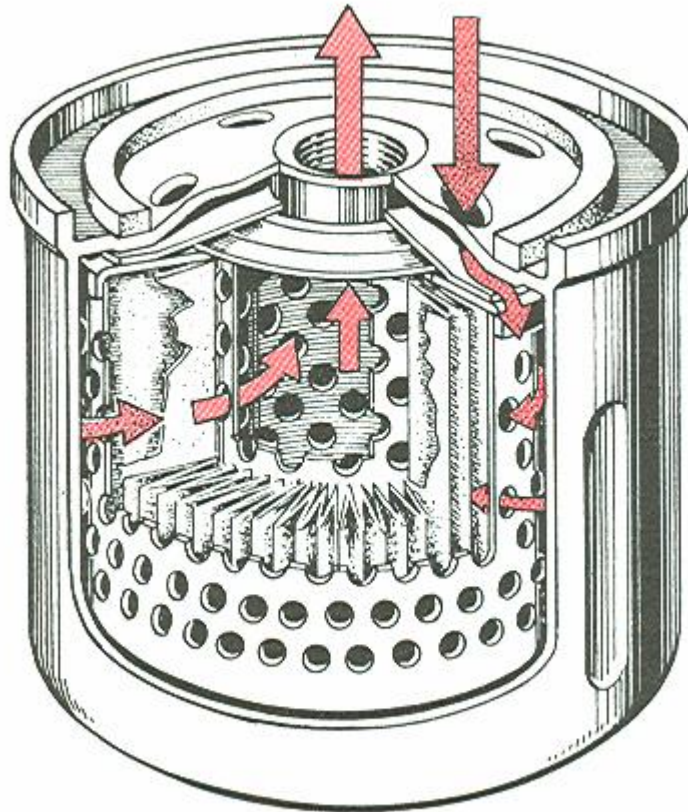
Installed in the engine lubrication circuits are two
main types of filters (filters), oil and purpose of
the book is outstanding minute impurities in oil
and prevent their passage in the Department of
lubrication to clean up the engine moving parts to
eat decreases and long life operation.

Ignition system
Ignition system

Ignition system.

Ignition system: - the ignition system is divided into two parts.

A - primary circuit.

B - Secondary circuit.

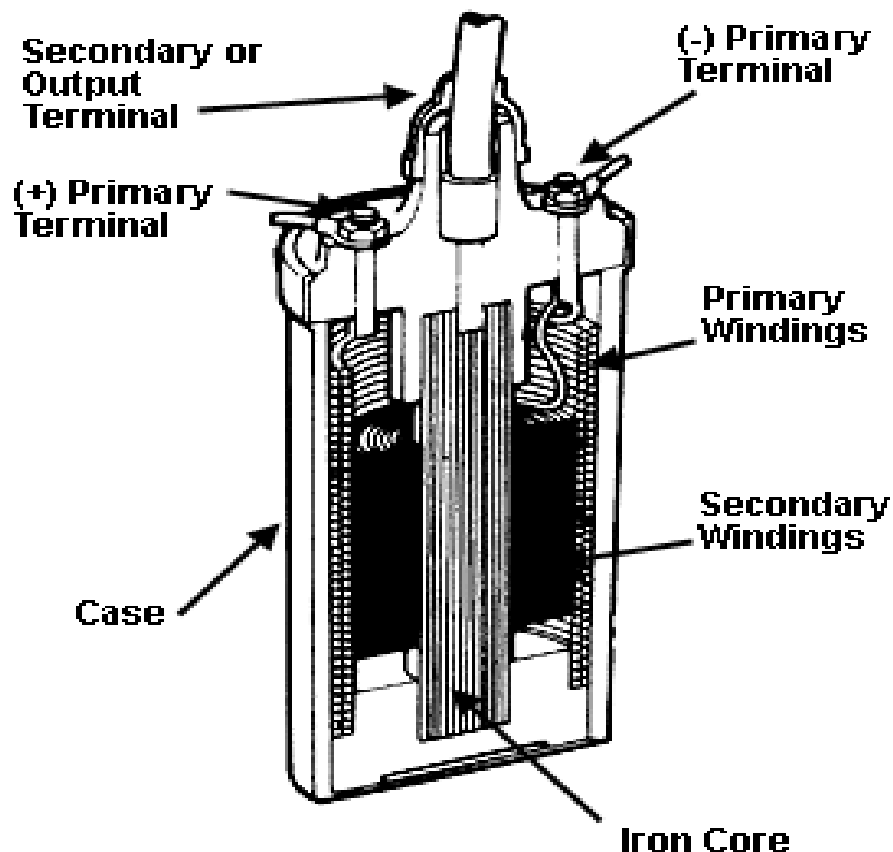primary circuit: - consists of the following: -

1 - battery.
Tank capacity 12-volt
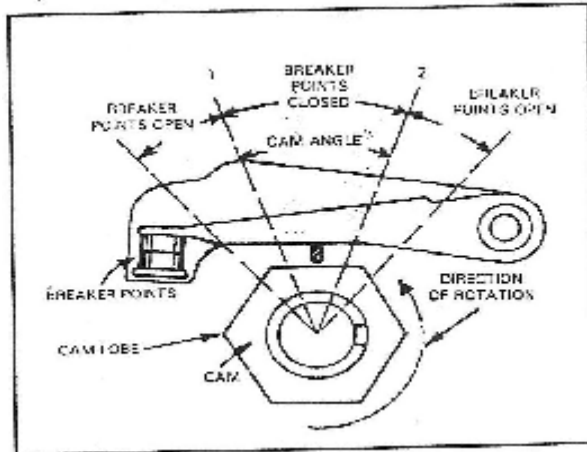2 – switch
3 - to resist the succession of (fuse)

4 – coil ignition of primary
Converts the voltage from 12 volts to 15000 volts and with the help of contact breaker

5 – contact breaker
Consists of two parties, one fixed and the other takes a moving movement of the cam on the distributor shaft.

6 – condenser
Has the following functions
A - to prevent electric arc
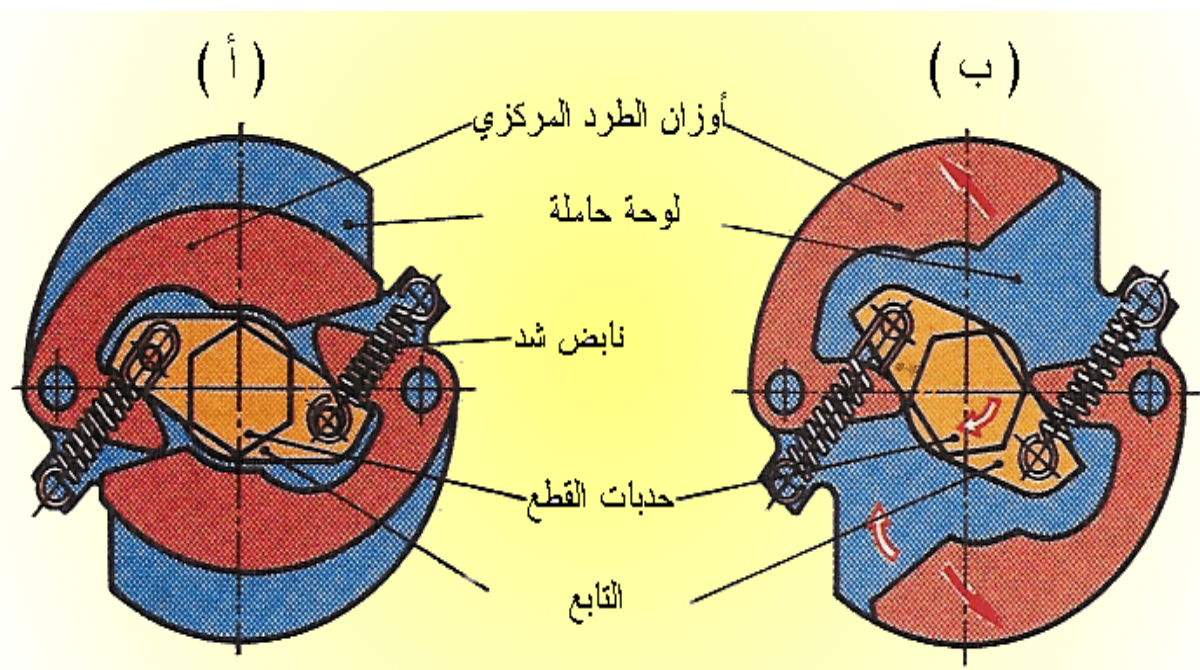# B - help to the collapse of the magnetic field

7 – body machine a cathode

8 - Low voltage wire

9 - and delay the provision of equipment sparks
Group used crowbars and weight in a centrifuge

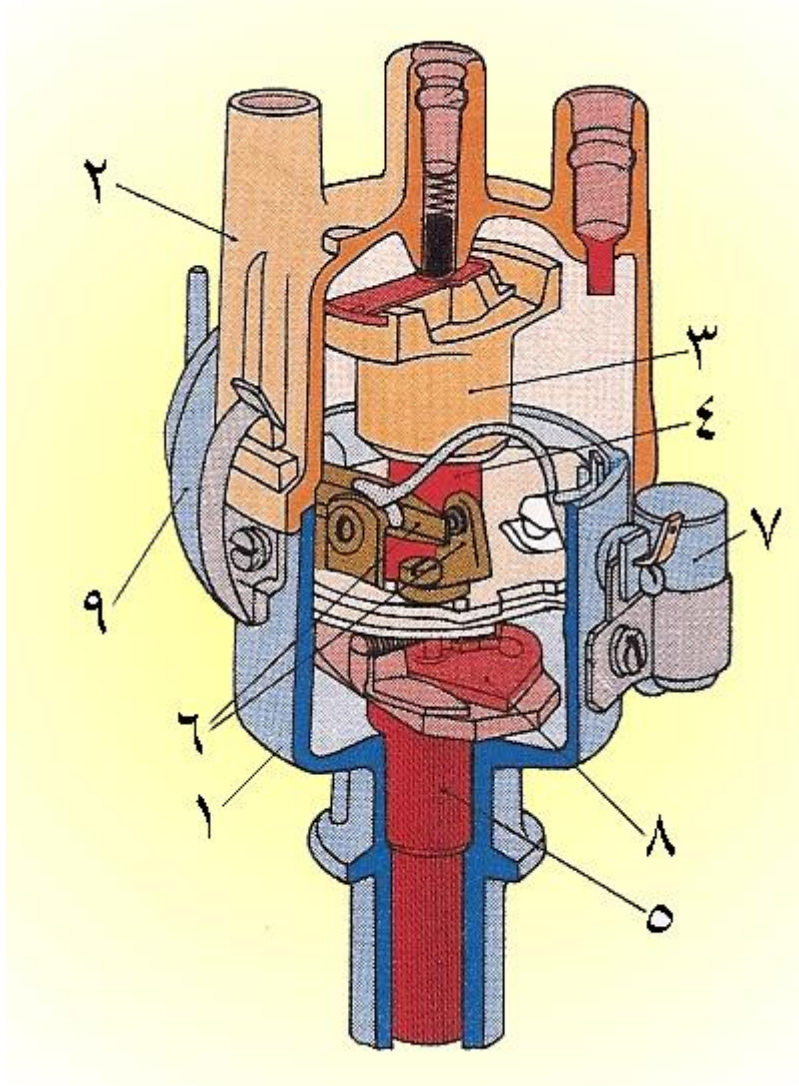# Secondary circuit: - consists of the following: -
1 - secondary coil
Converts the voltage from 12 volts to 15000 volts and with the help of contact breaker

2 - Distributor sparks

Has two main

A - closing and opening of the primary circuit.

B - distribution of voltage high-pressure through the secondary circuit
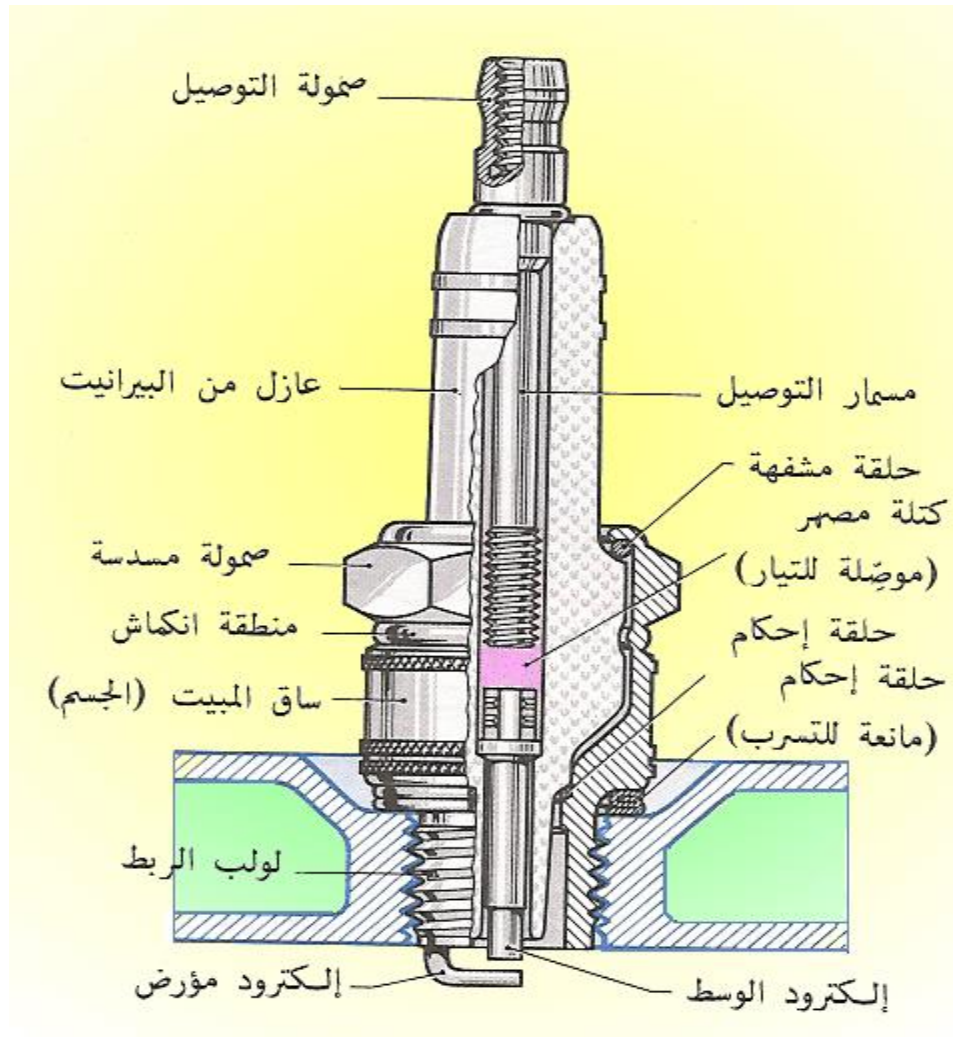
3 - Distributor cap
Contains four slots arranged in a circular motion and is made from industrial and melanin in the middle slot receive the spark through the spring and black charcoal to connect

4 - the rotor electrode
Made with industrial resin containing a metal blade to distribute the spark

5 – spark plug

Contain negative and positive poles, and through them produces electric spark
6 - high voltage wires