



Design Guideline for Ignition Distributor

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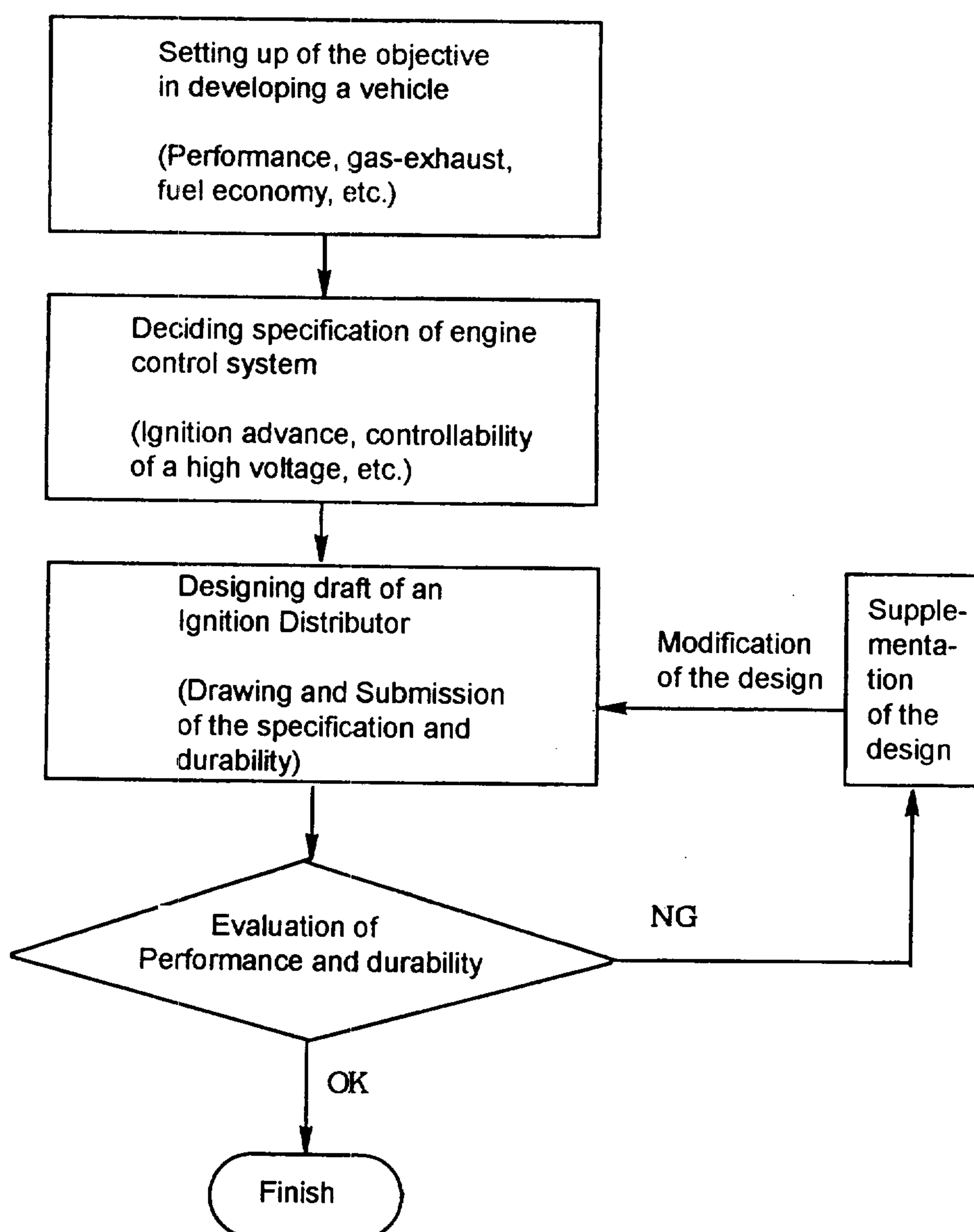
1. Scope of application

This standard shall specify the Ignition Distributor loaded in 4-cycle gasoline engine.

2. Purpose

This standard shall guarantee appropriate quality in designing an Ignition Distributor by defining the method and standard of the design.

3. Designing procedure



4. Scope of the guide

This standard shall specify the level and criteria of performance of Ignition Distributor and some points to be considered in setting up design standard to achieve the development targets such as improving exhaust power and torque of engine, increasing fuel economy of a vehicle and reducing exhaust gases. However, it doesn't specify the design standard of sub-components in Ignition Distributor for guarantying its productivity and durability so that it should be discussed with the enterprise in taking the enterprise's approval application or sample for approval.

5. Contents of a specification document

The specification document should contain the size and required performance level of Ignition Distributor.

Generally, contents in the section 「6.10 Required performance to improve durability」 are not included in the specification, except when Ignition Distributor needs some special requirements to fit into the using condition or external environment.

6. Design standard

6.1 Setting up of the objective in Design.

Classify the functions assigned from Engine Control Module (Users only) (or the functions that should be carried out by Ignition Distributor) and set up the objectives by head. An exemplified setting is given in parentheses.

- Function of generating high voltage for ignition (Method : Transistor ignition system)
- Function of controlling ignition energy (Controllability of Dwell Angle)
(Larger than 24kV at normal temperature, 12V of voltage of battery, 24rpm of rotating speed of engine)
- Function of controlling ignition timing (Centrifugal advance : Advance characteristic curve, retard function)
(Vacuum advance : Advance characteristic curve, number of diaphragm plate)
(Adjusting range of advance control on idling : BTDC $6^{\circ} \pm 30^{\circ}$)

- Function of distributing high voltage (Distributing order 1-3-4-2)
 - (Drop of ignition voltage : smaller that 1kV)
 - (Maximum allowed advance of rotor : BTDC 48° ~ ATDC 12°)

6.2 Deciding the mounting position

Generally, the position that Ignition Distributor is mounted on shall differ according to driving method of the vehicle (Front or rear wheel drive), position of engine hanger and operating system of intake and exhaust valves (SOHC, DOHC).

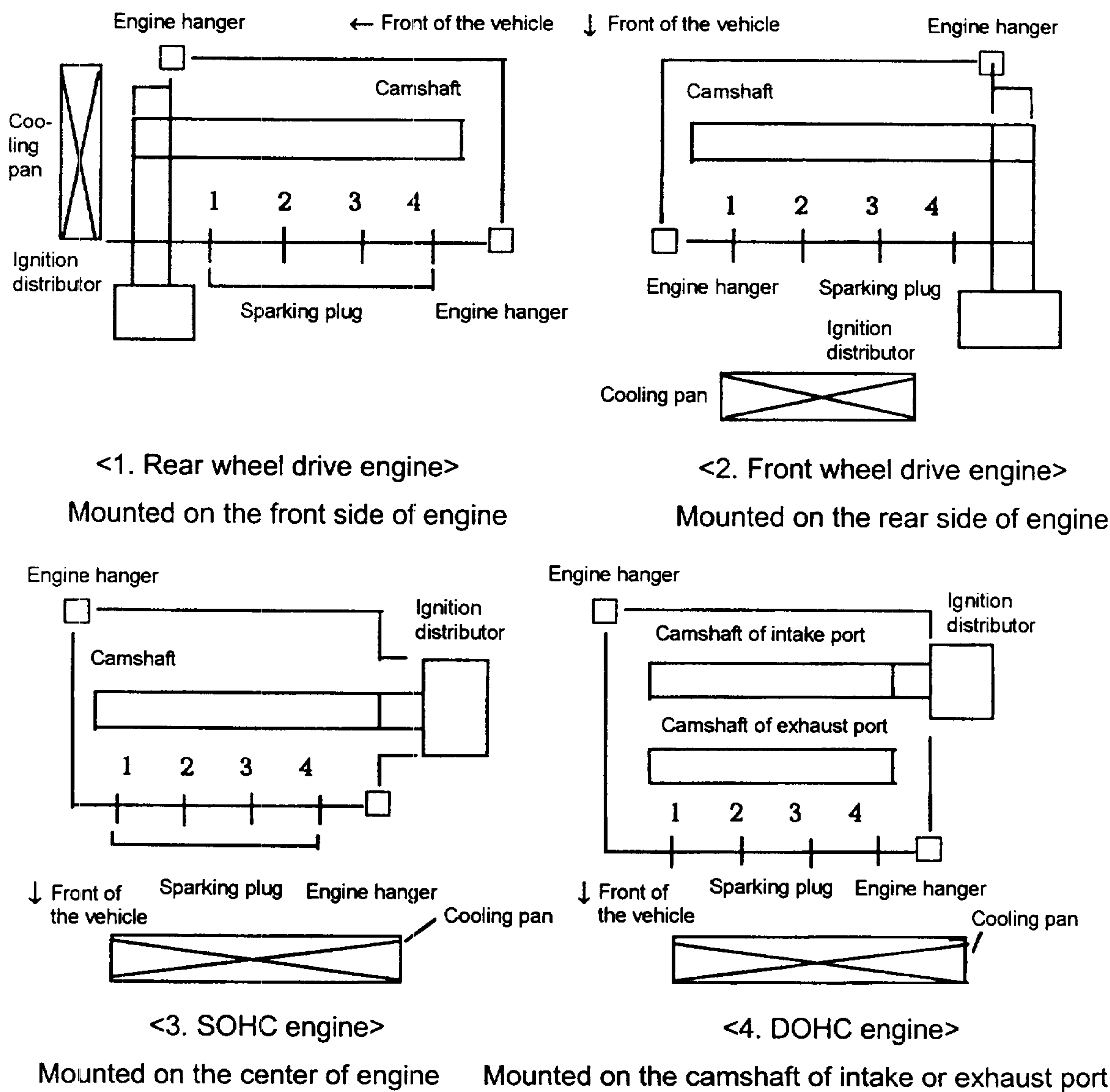


Figure 1 Mounting position of Ignition Distributor (example)

However, it's better to mount Ignition Distributor on intake port to prevent the damage by heat since electronic components such as Ignition generator (Ex. Igniter) and sensor are built in the distributor.

6.3 Design of the mounting shape.

Design the shape of a flange considering advance control comparing with when the piston of engine is on Top dead point, and also consider the interference with neighboring components for adjusting minimum or maximum advance in designing the distributor or the vacuum advance.

The vacuum advance should be designed to locate in the opposite side of exhaust port considering damage by heat on the rubber insulation (Diaphragm) of the vacuum advance, especially the pressure tube of exhaust port should be taken out to be protected from the exhaust heat.

6.4. Design of high voltage generator

6.4.1 Securing ignition energy

(1) Required voltage

The required ignition voltage of the engine for burning out air/fuel mixture in a combustor can differ according to the specification of igniter, operational condition of the engine and the fuel.

(a) Gap in spark plug, Compression pressure in a combustor

As shown in equation (1), which represents the law of Pasen, the required voltage increases in proportion to the product of the gap in ignition plug and the compression pressure in a combustor, that is, as the gap in plug increases.

$$V_r = K \cdot P_d + C \dots\dots\dots \text{Equation (1)}$$

- Here, V_r is required voltage (kv)
- P is compression pressure in a combustor (ata)
- D is gap in plug (mm)
- K is a coefficient (kv/ata*mm)
- C is a constant defined by electric pole temperature, density of gases in a combustor and the shape of the electric pole in the plug.

(b) Ignition timing

If ignition timing is changed, the pressure in a combustor will be varied resulting in different required voltage.

(c) Rotating speed of engine and Acceleration condition

The required voltage gets lower by a rise of electric pole temperature as rotating speed of engine gets faster but gets higher as the mixture per cylinder and per cycle increases and compression pressure rises in acceleration.

(d) Fuel economy on engine idle

As the fuel economy on engine idle is lower, the required voltage gets higher

(e) Pressure in intake pipe

As negative pressure rises, pressure in a combustor gets down resulting in lower required voltage.

(f) Recycling of exhaustion gas.

When exhaustion gas recycles, the required voltage gets lower because lowered combustion temperature decreases the temperature of ignition plug.

(2) Generated voltage in Igniter.

The secondary high voltage generated in Igniter should exceed much the required volts in (1) in any condition. If not, heat will be leaked out causing serious problems such as large amounts of exhaustion of toxic gases (Hydrocarbon, carbon monoxide), decrease of fuel economy, backfire, the pre-ignition of the tertiary catalyzer.

Generated voltage is determined by primary saturated electric current and the ratio between the numbers of turns of primary and secondary windings, but it should be generated enough because it can be lowered by resistance in distributing process and by stray capacity.

If an equivalent circuit is composed as shown in figure (2), the generated voltage in this circuit is like equation (2).

$$e_2 = I_1 \cdot \sqrt{\frac{L_1}{C_1 \cdot (n_1/n_2)^2 + C_2}} \cdot K \quad \text{----- Equation (2)}$$

Here, $e_2(v)$ is the generated voltage of secondary winding,

$I_1(A)$ is saturated electric current of primary winding,

$$I_1 = V_b/R_1$$

$V_b(v)$ is voltage of battery,

$R_1(\Omega)$ is internal resistance of primary winding,

$L_1(H)$ is inductance of primary winding,

N_1 is the number of the turns of primary winding,

N_2 is the number of the turns of secondary winding,

$C_1(F)$ is constant capacity of primary winding,

$C_2(F)$ is constant capacity of secondary winding,

K is loss coefficient

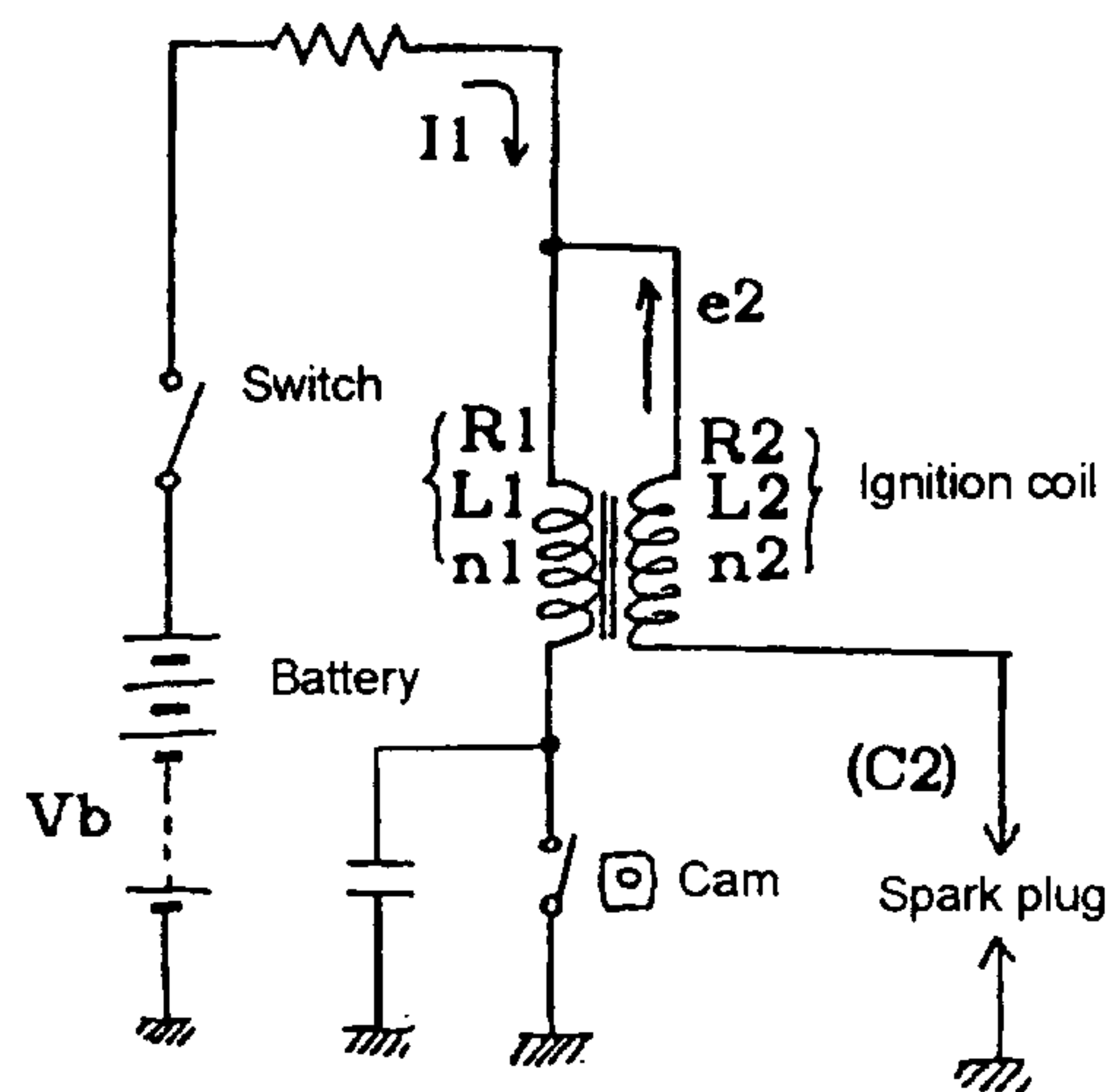


Figure (2) Circuit of igniter

Thus, the generator should be designed to generate more volts than required voltage of engine considering some factors such as voltage dropping of battery, time constant and the number of the turns of primary and secondary windings, surrounding temperature, leakage resistance, stray electrostatic capacity and load resistance of secondary winding and Dwell Angle of primary winding, which affect the generated voltage.

6.4.2 Design of high voltage generator

At first, decide the specification of ignition coil (Primary and secondary resistance, inductance, the number of the turns), which are the most significant factors in generating high voltage in secondary winding. It is followed by the decision of the specification of the high voltage generator in distributor as below, which controls the passing time of current flow in primary winding of ignition coil.

(1) Conventional distributor

(a) Decision of Dwell Angle of the cam.

In conventional distributor, the shape of the cam and the plug gap decide Dwell as

shown in figure (3) so that it is important to keep constant Dwell Angle on any condition of operating engine. For example, for 4 cylinder engine (1), Dwell ratio is constant on 58% ($52^\circ/90^\circ$, i.e., current flows during 58% of a cycle and doesn't during 42%) if Dwell Angle of the cam is fixed on 52%). Besides, Dwell angle gets smaller as a vehicle drives, stepping down the ignition energy because the wear in cam and contact point as well as Elasticity change of the spring that snugly-fits contact point alters the plug gap. Thus, for protecting Dwell Angle from getting smaller within warranted period of the high voltage generator, it's necessary to adapt wear tolerance materials in operating parts, prevent elastic change of the spring even under heat and humidity and keep sufficient contact pressure.

Note (1) Dwell Angle is 52° for 4 cylinder engine (Calculate as Dwell Angle/a cycle, Dwell ratio is $52^\circ/90^\circ = 58\%$. Here a cycle equals $360^\circ/\text{the number of cylinders}$), 41° for 6 cylinder engine (Dwell ratio is $41^\circ/90^\circ = 58\%$). But the passing time of current for 6 cylinder engine is 0.67 times ($4/6 = 0.67$) that for 4 cylinder engine so that you must be careful that the secondary voltage for 6 cylinder engine will be lowered.

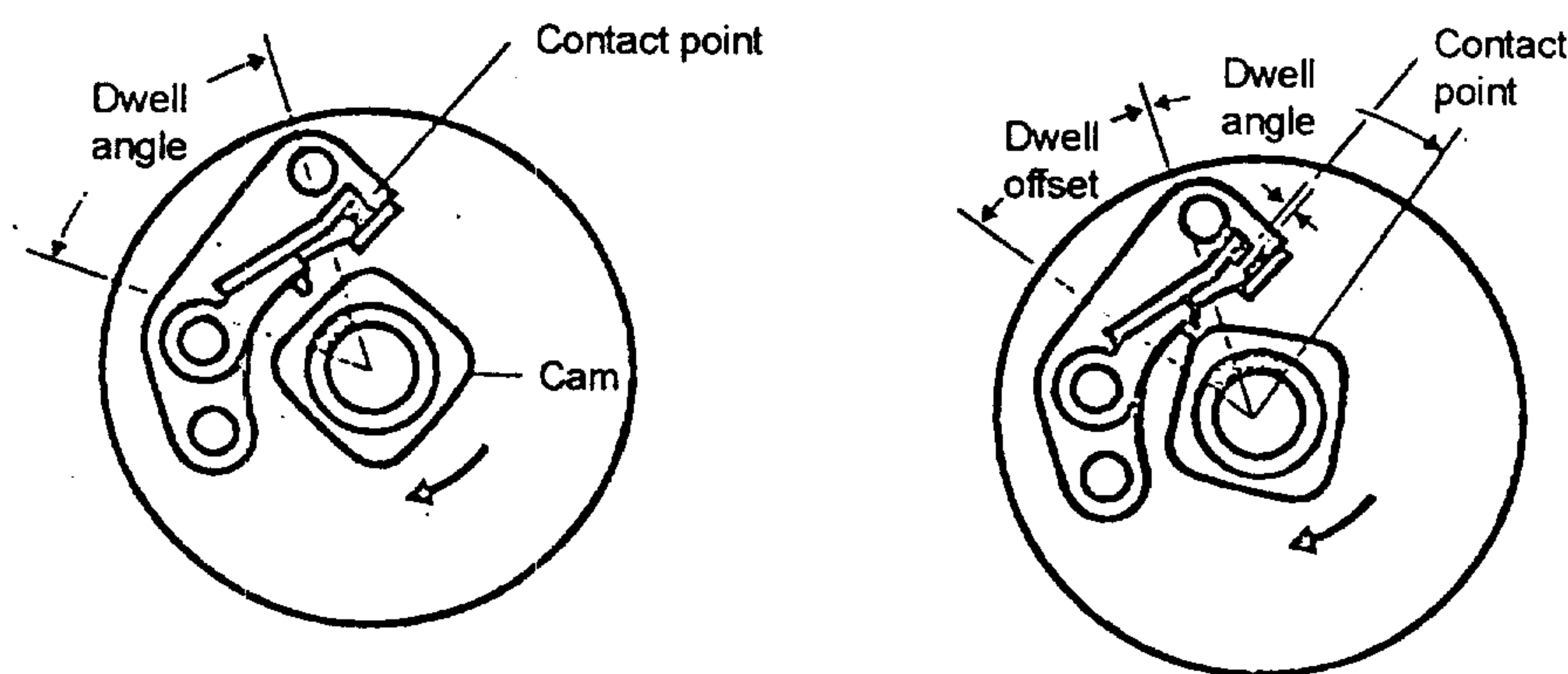


Figure (3) Dwell Angle of the cam in conventional distributor

Since constant Dwell Angle shortens the recharging time of a battery while the engine operates at high speed, ignition energy is sharply lowered as shown in figure (4). Therefore, ignition energy must be generated sufficiently not to be lower than the required voltage at high speed (2). However, Dwell Angle should not be too large because large Dwell Angle increases current flows, weakening the durability of contact point.

Note (2) Although Dwell Angle should be kept small at low speed, large at high speed, this control is nearly impossible for mechanical contact point. Thus, you can adapt a general alternative to change the time constant of the primary winding of ignition coil.

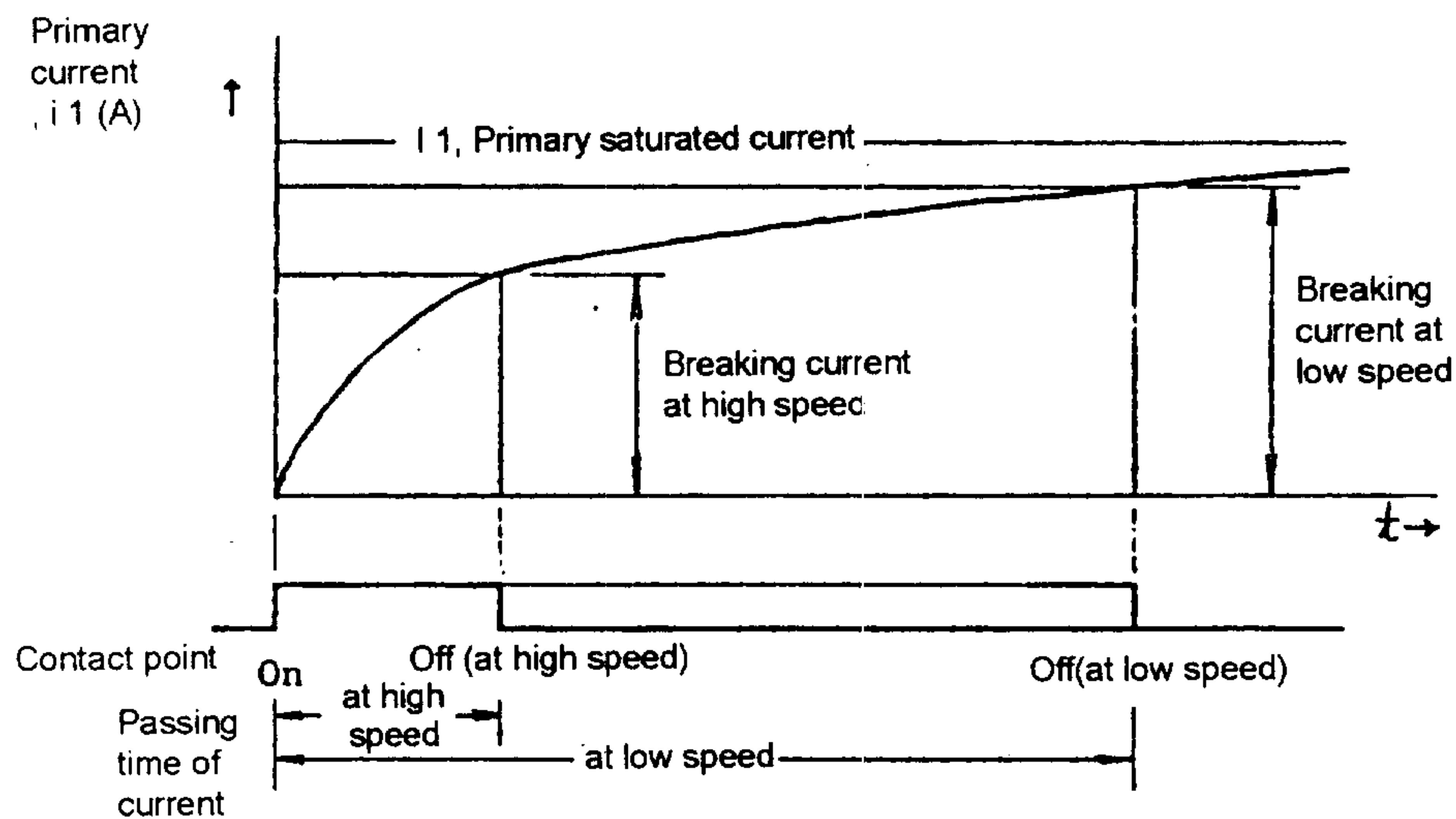


Figure (4) Difference of braking current and energy between high and low speed.

(b) Decision of the capacity of the condenser

When the break contact interrupts the primary circuit, a high voltage is induced in secondary winding, which voltage is applied to the sparking plug, causing it to produce arc on contact point as shown in figure (5) and equation (3). Especially at low speed, much high voltage is induced causing intense arc and weakens the durability of the contact point, finally resulting that the contact point is burned and ignition doesn't occur.

Therefore, the condenser should be equipped arranged in a row by the contact point to absorb the arc current. As the capacity of the condenser is large, the time to recharge it is shorter and prevent the arc.