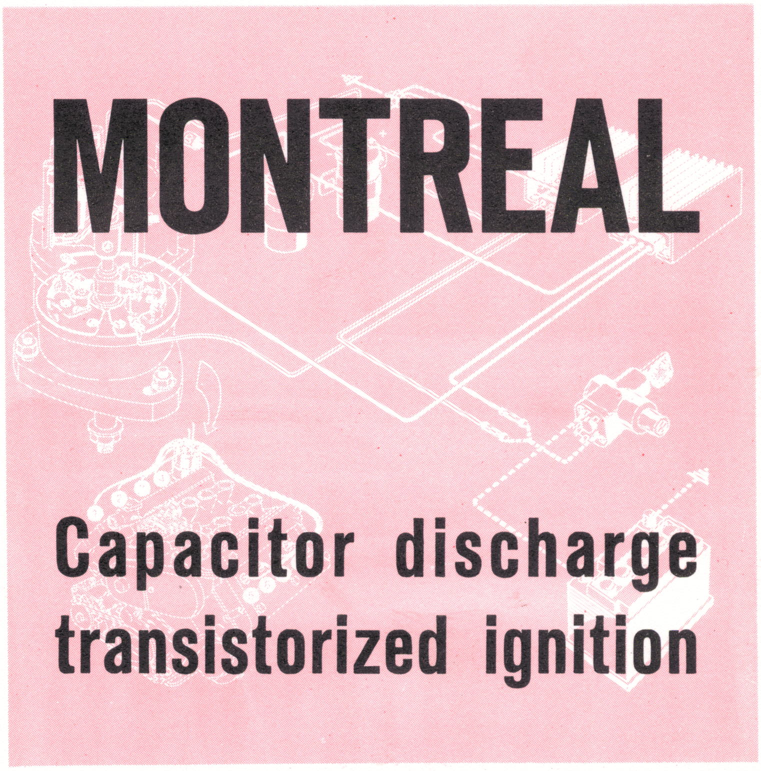
Alfa Romeo

DIREZIONE ASSISTENZA

MONTREAL



Capacitor discharge transistorized ignition

C O N T E N T S

FOREWORD

In the following pages the fundamental operating principles of the capacitor discharge transistorized ignition system as installed on the Alfa Romeo Montreal model are described.

As introductory notes to the transistor assisted and capacitor discharge systems, a brief treatment about the characteristics and limitations of the conventional ignition is given.

Maintenance directions are also outlined to the purpose of putting emphasis on those precautions an operator should take when testing or repairing this system.

THEORY OF SEMICONDUCTORS

Before examining in details the transistor action, let us consider some phenomena, occurring in the atomic structure, on which the functioning of the transistor is based.

Matter is composed of an inconceiveable number of particles called molecules. Such molecules, although very small, are in turn made up of other particles called atoms.

The atom is the smallest particle into which a substance can be divided without changing its identity that is instead lost if the division is carried out further.

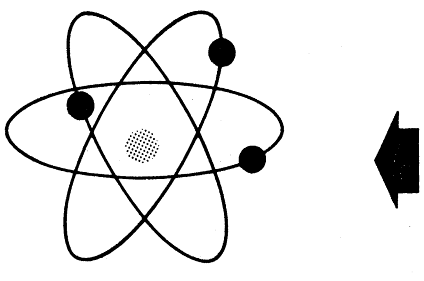
In other words, if iron is fragmented in smaller and smaller particles (so tiny that it would take something like a hundred thousand billion of them, side by sidy, to measure an inch) the process will ultimately lead to the iron atom, which is still iron with all its properties.

If the iron atom is divided further, iron will no more be found, but particles having no longer the properties of iron.

The atom consists of an equal number of protons and electrons. All the protons are concentrated in the central portion of the atom, which is called the nucleus.

The electrons whirl about the nucleus in definite paths or orbits as the planets revolve about the sun. Proton has a charge of positive electricity while the electron has a charge of negative electricity.

Electrons are all alike and protons also are all alike; in an atom there is an equal number of electrons and protons although varying atom by atom. For example: copper has 29 electrons and 29 protons, iron 26 and 26, aluminium 13 and 13, and so on.



MODEL OF AN ATOM

When subjected to some external action (heat,electromotive force,etc.) electrons tend to increase their orbiting speed until, due to the effect of the centrifugal force, they overcome the attraction of the nucleus and fly away toward another atom.

This movement of free electrons explains how a current of electricity takes place.Since free electrons move through metals more easily than through any other substance they are called conductor;electricity can therefore be held as a flow of electrons through conductors.

Good conductors, such as copper or aluminium, have large numbers of free electrons, while nonconductors or insulators (e.g.rubber or air) have very little free electrons.

There are also a few substances, which are halfway between conductors and insulators, that are called semiconductors.

These substances, such as germanium, are usually nonconductors, but, if combined with atoms of other elements, arsenic or indium for instance, become conductors.

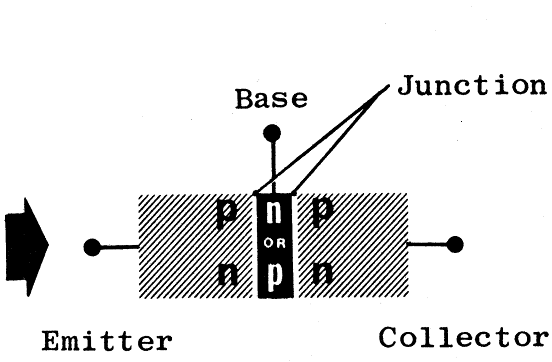
According to the combination, different sort of conducting material will result.

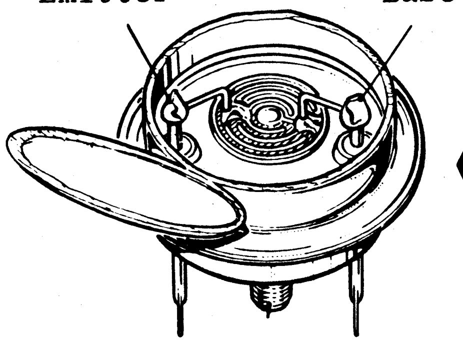
If a little arsenic is mixed with the semiconductor, the combination acts as conducting material of the sort known as N, or negative type, because of the extra electrons whose charge is negative.

A somewhat different sort of material results if gallium is added; in this material there is shortage of electrons and this shortage leaves "holes"; then the absense of electrons or "holes" results in a positive charge. This combination is known as P, or positive type.

A transistor is made up of three sections of a semiconductor material fused to form a three layer unit. The method of stacking the material gives the transistor its polarity. The three layers can be arranged either as "NPN" or as "PNP" and are called emitter,base and collector. The joining surface between layers is called junction.

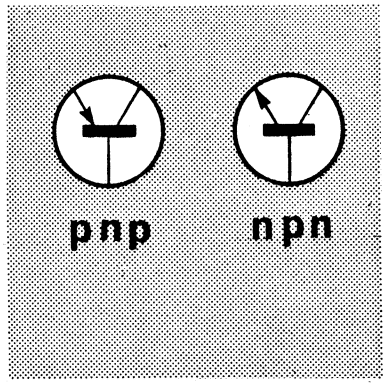
TYPICAL TRANSISTOR STRUCTURE





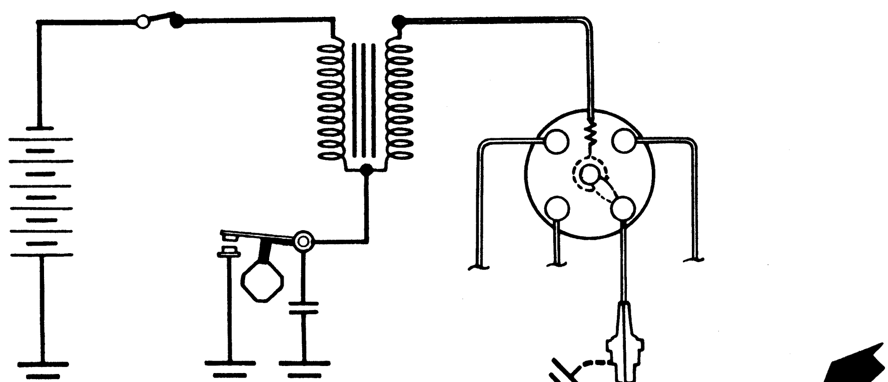
SKETCH OF A TRANSISTOR

TRANSISTOR SYMBOLS



CONVENTIONAL IGNITION SYSTEM

The conventional ignition system is shown in the following schematic drawing:

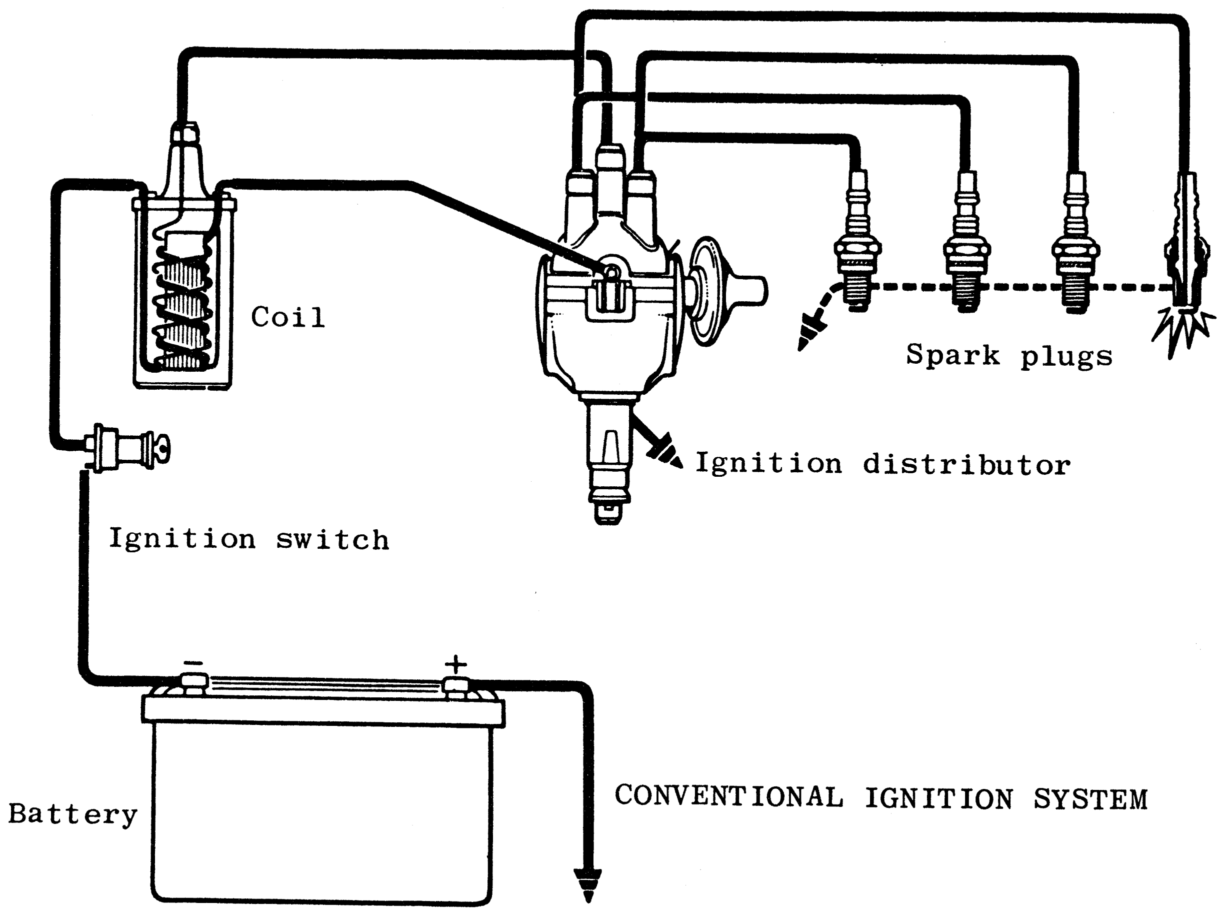


CONVENTIONAL IGNITION SYSTEM

The direct current drawn from the battery at low voltage is converted into pulsating current by the breaker arm and points (components of the ignition distributor) and is fed to the primary winding of the transformer (coil); because of the inductance of the primary winding, the opening of contacts produces the high voltage surge at the primary terminals; the main purpose of the capacitor is that of reducing the arcing between contact points as they begin to separate from each other; such arcing would prevent the primary voltage to collapse rapidly and would burn the points.

The high voltage surge may reach peak values of about 300 - 400 volts; the voltage required to jump the spark gap is built up in the coil through a secondary/primary turn ratio of about 80.

Since the breaker cam is driven by the crankshaft the system provides also for the ignition timing.



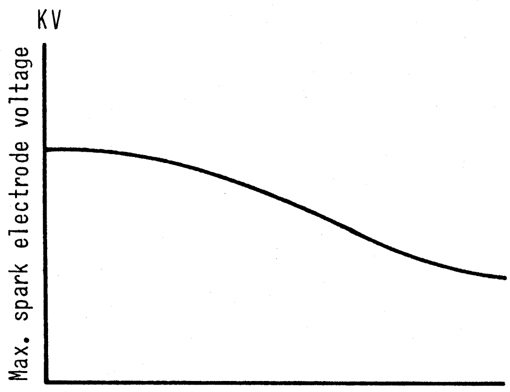
CONVENTIONAL IGNITION SYSTEM

LIMITATIONS OF THE CONVENTIONAL IGNITION SYSTEM

The extraordinary simplicity of the conventional ignition system has on the other hand well defined limits.

They are:

1) - A decreasing in voltage available at the spark plug electrodes at high RPM range as shown below:



In fact, as the RPMS increase, the time in which the points remain closed is reduced even if the dwell angle remains unchanged.

It is however well known that the strength of the magnetic field in the coil core is a function of the current flowing through the coil primary.

If, due to excessively high RPMS, the current flow cannot reach its maximum value since the build-up time is not enough, the magnetism also will not arrive at the maximum ideal strength.

In terms of energy, the equation $E = \frac{1}{2} LI^2$ shows that, when the current decreases, even the energy involved in a complete cycle is lower than the theoretically ideal value.

2) - Spark plug fouling. Today this is a very tough problem.

The modern engines are handicapped by a rather unsuitability to a prolonged operation at idle speed or at low RPM range as frequently occurs in town traffic and in weekend queues: this causes the engine to miss and eventually to stop and makes re-starting very difficult.

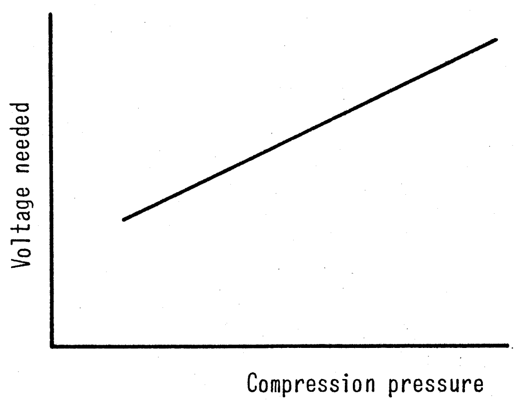
Such a phenomenon is exclusively due to a progressive fouling of plugs caused by insufficient temperature when operating at idle speed or at low load.

On the other hand, resorting to plugs with a different heat range, i.e. hotter plugs, is not advisable since they will impair the performance at full throttle or with heavier load and will cut down engine life.

The graphs below depicts the factors affecting the voltage required to fire the spark.

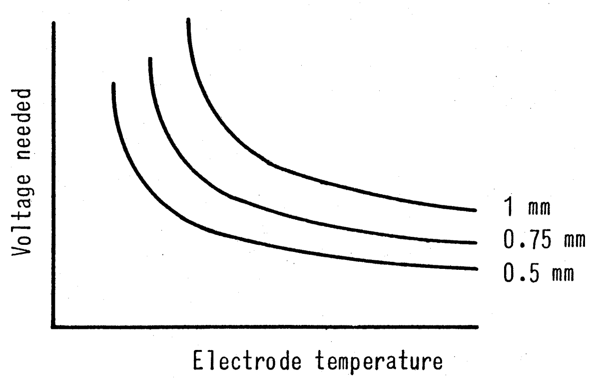
a) Compression pressure

This graph shows clearly that the voltage required for the spark to jump the gap is in direct proportion to the pressure of the fuel/air mixture in the compression chamber.



b) Electrode gap and temperature

For a given electrode gap, as the electrode temperature increases the voltage needed diminishes while, for a given temperature, the voltage increases as the electrode gap widens.



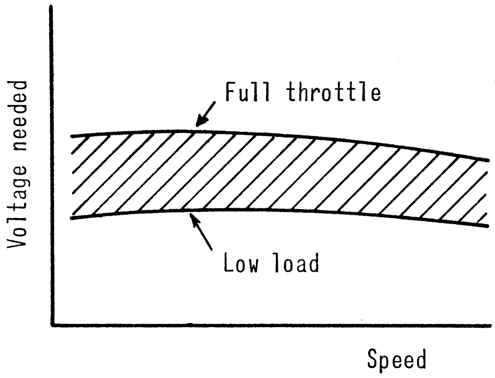
c) Speed and load

This graph shows the effects of speed and load in a typical four-stroke cycle car engine.

The slight decrement which occurs at high speed range is attributable to:

1) increment of spark plug electrode temperature

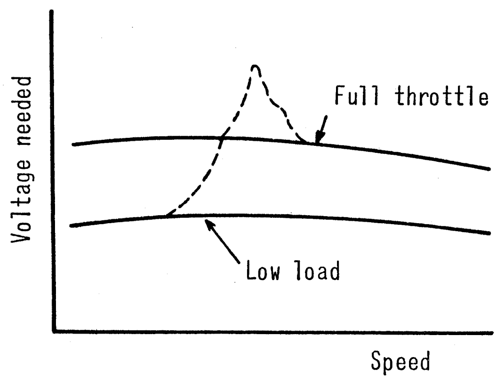
2) decrement of compression pressure resulting from a decreasing volumetric efficiency.



d) Acceleration

A quick opening of throttles causes a peak in the ignition voltage as shown.

Such an increment can be attributable to the increase in compression pressure which takes place in this condition. This is a transient phenomenon and can be detected only with oscilloscope testers. Such a supplementary need for voltage is the cause of engine misfiring that can be experienced on fast getaway.

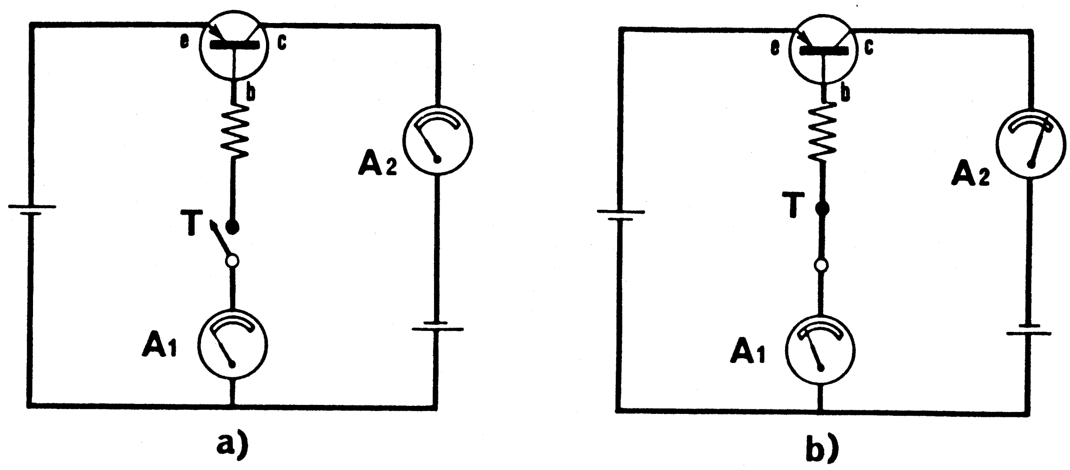


3) - Poor operation reliability since contact points and condenser have to be tested regularly.

A more sophisticated ignition system was therefore developed to overcome the limits imposed by the conventional ignition system and to meet the requirements of higher power output engines.

USING TRANSISTORS AS ELECTRICAL RELAYS

The first attempt to introduce electronic devices into the ignition system has been the use of a transistor as a switch in place of the contact-breaker points that is to transistorize the conventional ignition system.



A TRANSISTOR USED AS A RELAY

A switch in a circuit controls the current flow through the circuit; with a conventional switch the full current flow passes across the switch contacts.

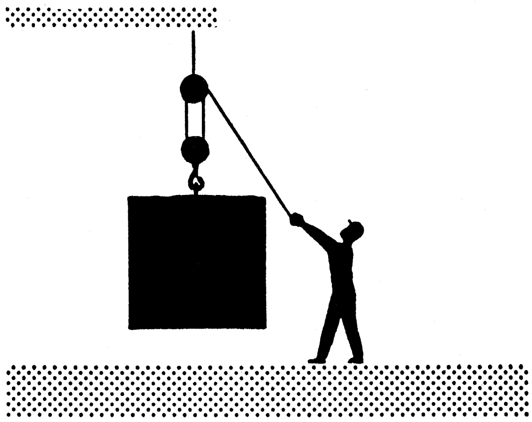
If the switch is connected to the base of a transistor as shown above, the transistor performes as a relay, that is, when excited by a weak current, it triggers the very large current flow of the main circuit.

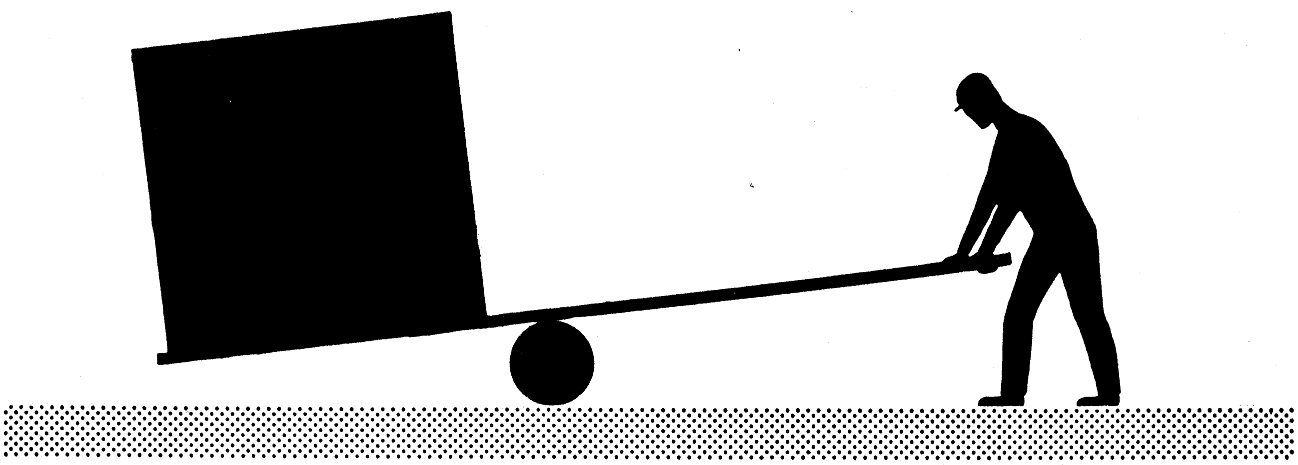
The two diagrams on page 8 show two instruments marked A1 and A2 for measuring current.

It can be noticed that in the diagram "a" the switch "T" is open and the instruments are reading no current flow both in the emitter/base circuit and in the emitter/collector circuit.

In the diagram "b", conversely, the switch "T" is closed and current flows through both circuits and specifically the dial A1 shows a weak current flow I1 (in the range of mA) while the dial A2 shows a much higher current flow I2 (in the range of Amperes). The switch "T" is nothing but the contact breaker points; this depicts very well how a transistor allows to trigger the current "I2" by means of the remarkably weaker current "I1".

As previously mentioned,this is just the sort of operation of an electrical relay, which, energized by a weak current, opens or closes a circuit subjected to a stronger current load, or that of a lever or a tackle which enable man to raise or hoist heavy loads with little effort.

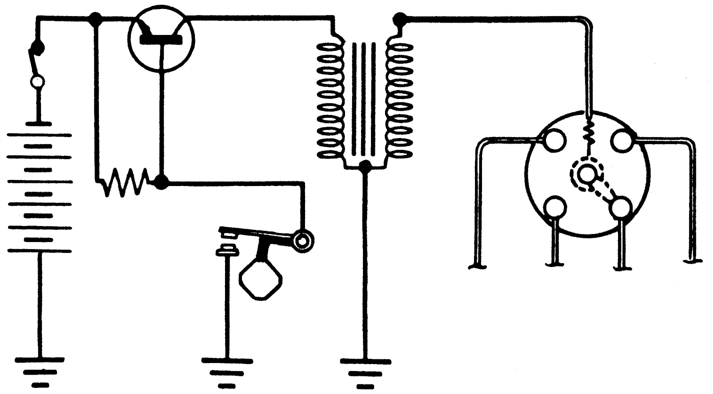




BASIC TRANSISTORIZED IGNITION CIRCUIT

Many transistorized ignition circuits are not of breakerless type but retain the contact points; for the purpose of our treatment, let us hold the breaker type as basic circuit.

Contact-breaker points are connected to the emitter/base circuit of a transistor while the primary coil is connected to the collector-emitter circuit.



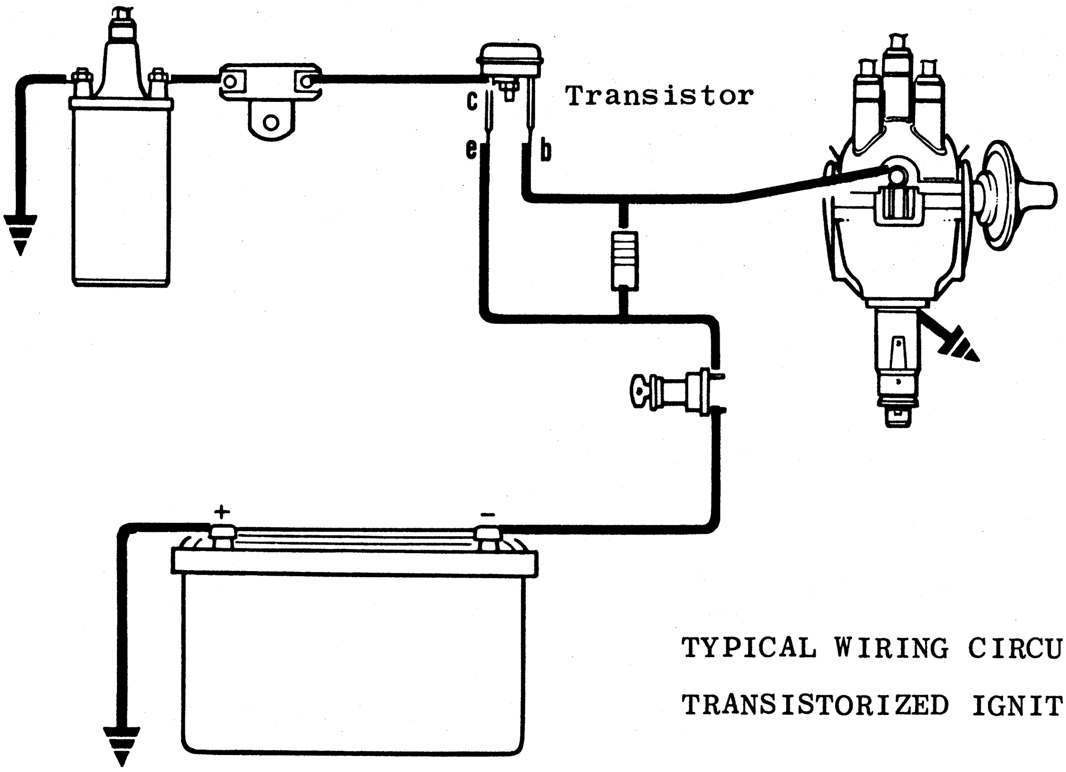
BASIC TRANSISTORIZED IGNITION CIRCUIT

As previously seen a small current variation in the emitter/base circuit is enough to switch off the large current flowing through the collector/emitter circuit. In other words, a small current flows across the contact points and controls the current passing through the primary circuit.

When the points open, the transistor cuts off the primary circuit and the current flow drops to zero. The magnetic field rapidly collapsing induces a high voltage in the secondary winding which is delivered to the spark plugs in the usual manner.

No more arcing occurs at the contact points since no more current in the range of amperes flows through them but only very small currents.

Such an arrangement does away of the capacitor but retains the other components of the circuit with their mechanical and electrical characteristics.



TYPICAL WIRING CIRCUIT OF A TRANSISTORIZED IGNITION SYSTEM

OPERATING PRINCIPLE OF BOSCH CAPACITOR DISCHARGE TRANSISTORIZED IGNITION

The capacitor discharge transistorized ignition consists of:

a) converter
b) transformer } capacitor charging circuit

c) capacitor

d) trigger circuit

e) thyristor

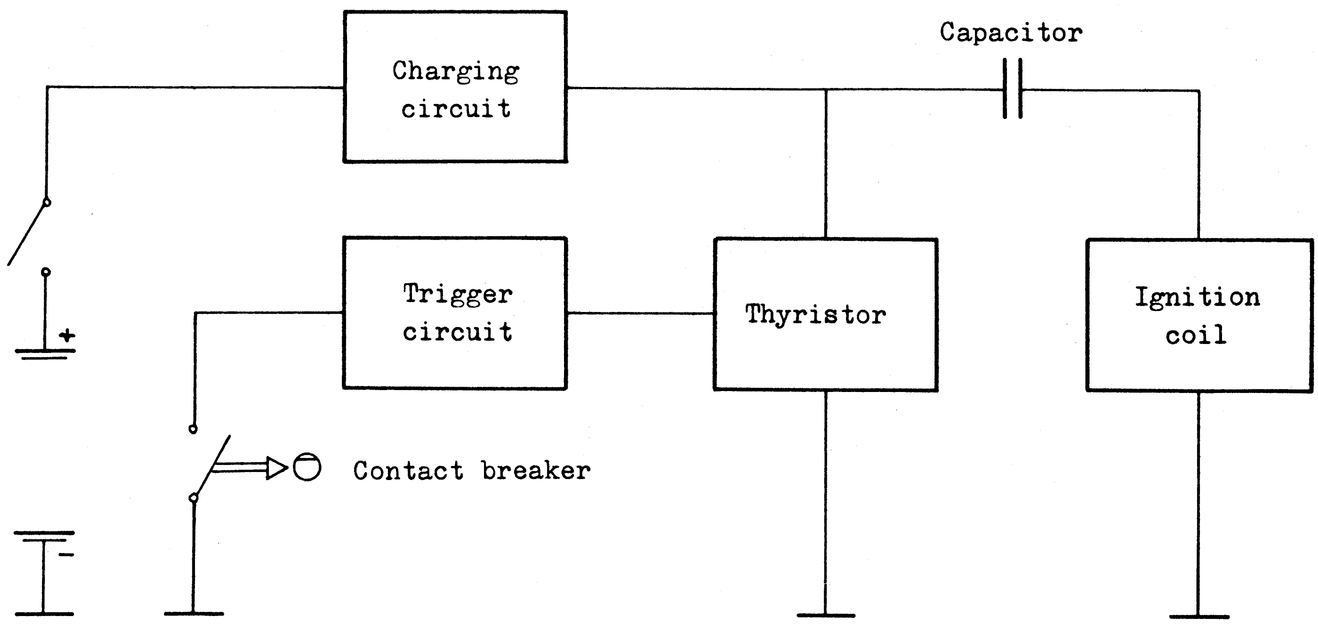
f) coil

The system operates as follows:

The capacitor charging circuit draws current from the car's electrical system at 12 volt.

The direct current from the battery is made pulsating by an oscillatory circuit and the voltage increased with a transformer.

The increase in voltage is required firstly to allow the use of a conveniently sized capacitor and also for the reason that energy is stored by condensers in direct proportion to the square of the voltage.



After the voltage has been brought up to 300-400 Volts, the current is again rectified and released to the capacitor which stores it to fire the spark plugs.

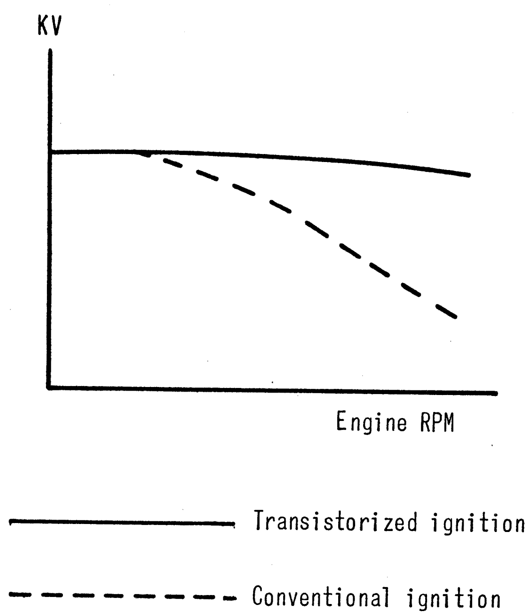
The precise moment in which the capacitor must discharge through the coil primary winding is determined by the breaker points that, energizing the trigger circuit, make the thyristor trigger the capacitor thus firing the spark plugs.

The thyristor, a modern development of the transistor, is one of the fundamental components of the system and operates like a relay as outlined in the section describing the transistor-assisted ignition.

The main advantage of this system over the standard ignition system or the transistor-assisted ignition is that the capacitor discharges on the coil in a very short time boosting the spark to jump the plug gap even with fouled electrodes; moreover,current draw is limited and the electrodes are subject to less wear.

ADVANTAGES OF THE BOSCH CAPACITOR-DISCHARGE IGNITION SYSTEM

1) Unaffected by spark plug fouling due to the capacitor - discharge feature.



2) Greater voltage available on cold starting and at high RPM range.

3) Reduced current flow at the contact breaker points; parts will be subject to mechanical wears only.

4) More accurate ignition timing.

5) Longer spark plug life.

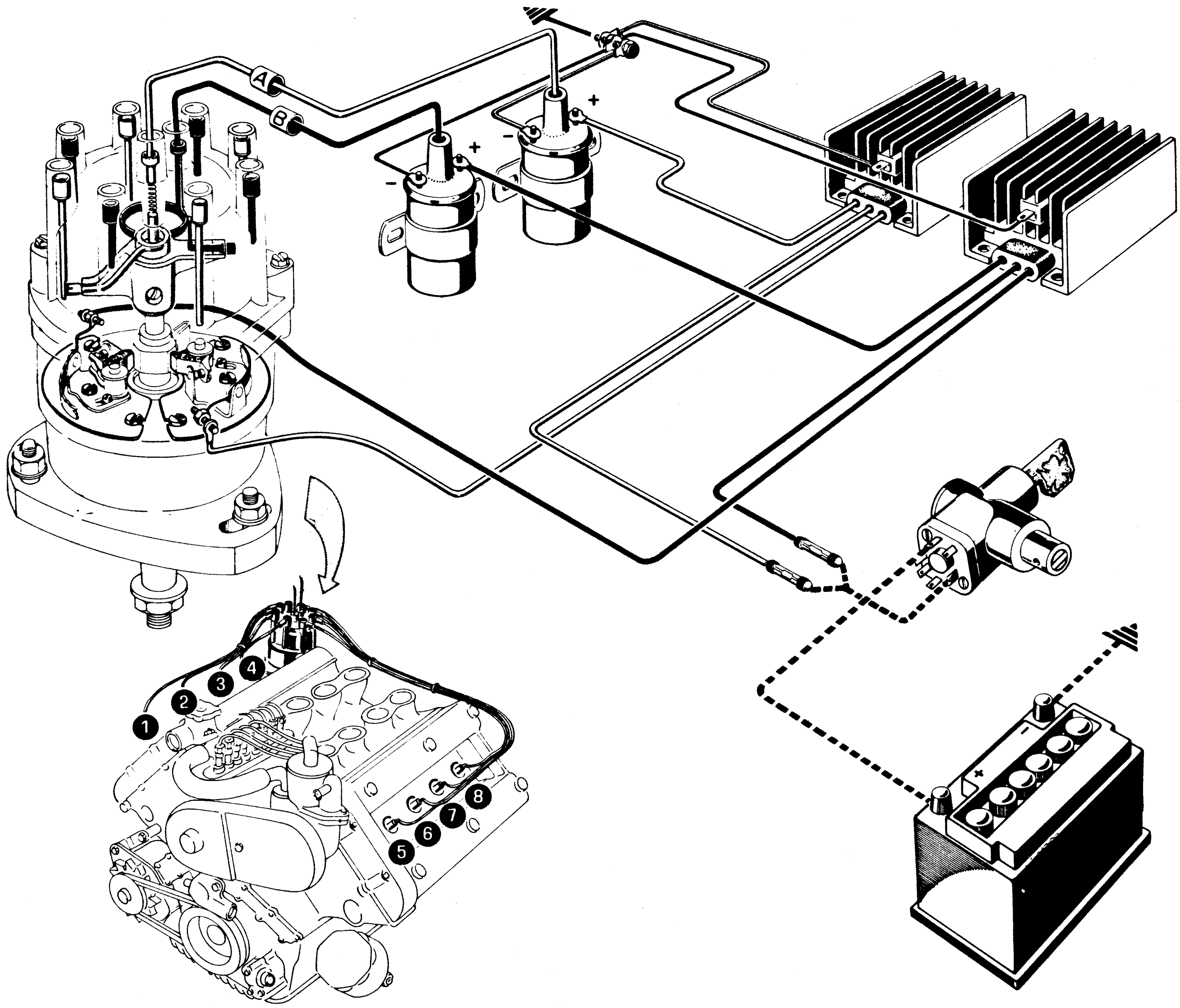
6) Reduced pollutant emissions since the engine operates on leaner mixtures.

DESCRIPTION OF THE MONTREAL IGNITION SYSTEM

a) Transistor control unit

b) Ignition coil

c) Ignition distributor



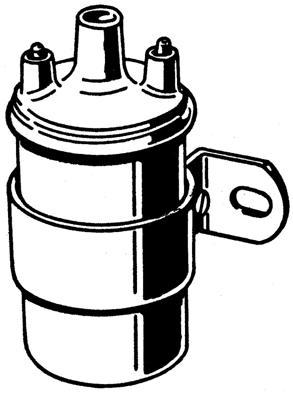
Let us consider in detail the ignition system components.

a) Transistor control unit

The control unit body is of elektron casting construction finned for better cooling.
The electronic components (affected by temperature) are installed on an aluminium plate for heat dissipation. Converter, capacitor and resistors are directly fitted to the body casting.
The remaining wiring components are on a printed circuit.
Connections are made through a 3-blade built-in connector.
The casting bottom is closed with an aluminium cover.

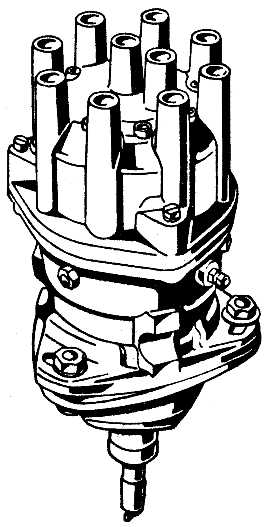
b) Ignition coil

Externally it resembles a conventional coil; the windings instead are of special construction to suit the requirements of the use with the transistor control unit.



c) Ignition distributor

It is of the same type as fitted to the V-8 sports car and competition models.



Aluminium alloy body, two breakers, automatic advance governor and a 4-lobe cam, two ball-bearings, rotor arm and cap.

Warning (from Bosch literature)
Before performing any repair work on the ignition system, the following should be kept in mind:

1) Never connect condensers, radio interference suppressors, timing lights, etc., to the coil terminals; also make sure the grommet is properly fitted to the terminal so that accidental contacts and grounds are prevented.

This type of coil cannot be replaced with a standard coil not be connected with the convential hook up.

2) Works such as disconnecting or connecting wires of the ignition system shall always be performed with the ignition circuit off.

3) Before using a quick charger, disconnect the battery from the car's wiring harness.

Never use a quick charger as a battery booster when trying to start a misfiring engine.

4) When installing a battery, check connections for proper polarity (negative terminal grounded).

5) Failure to comply with these directions will seriously damage or even destroy the control unit.

IN-CAR TESTS

Testing the transistor control unit

Switch on the ignition.

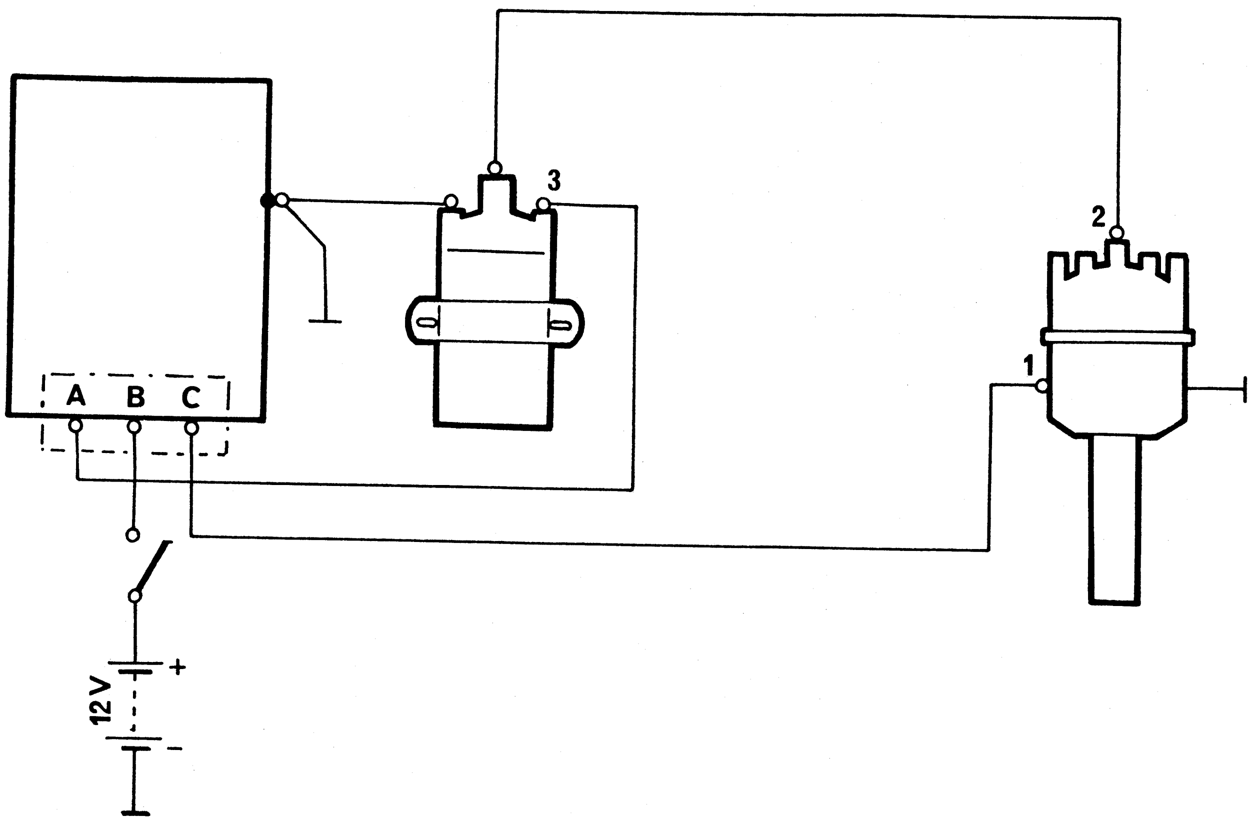
In the transistor control unit a light buzzing sound will be heard. If not so, a check of the current draw of the control unit should be made by connecting an ammeter across the ignition switch and the control unit terminal B.

Disconnect the distributor terminal 1 and switch on the ignition.

The current draw of the control unit should fall between 1.2/1.6 Amp. at about 11.5 Volts.

Reconnect the cable to the distributor terminal 1. If the current draw is within the specified tolerance, disconnect the wire 2 from the distributor not from the ignition coil and connect it to an ignition tester set to a 5 mm contact gap.

Crank the engine with the starter motor: if the sparks jump correctly the system is OK. If misfiring is experienced, the ignition coil must be checked on bench for it is impossible to test the coil in car. Should the ignition coil operate properly, then the control unit must be renewed.



In-car ignition timing

Setting the ignition distributor on installation:connect a test light (12 V., 3 W) to the distributor terminal 1.

Timing the ignition with a stroboscopic light. Do not connect the stroboscopic light to the ignition coil terminal 3 but only to one of generator terminals.

EMERGENCY MEASURES IN THE EVENT OF A DEFECTIVE CONTROL UNIT

If the control unit fails to operate and replacement parts are not available, the engine may notwithstanding be set in motion by carrying out the following:

a) cut off feeding to the defective control unit by disconnecting the feed wire;

b) remove from the distributor cap the wire coming from the coil of the defective control unit;

c) connect by a jumper the distributor high voltage terminals and the two contact-breaker feed terminals.

Caution. It is essential to limit the operation of the ignition system in such a condition to the minimum, positively avoiding to exceed 5000 RPM to prevent damaging the operating control unit.

Oscilloscope ignition tester

Since the Bosch capacitor discharge transistorized ignition system has voltage characteristics different from those of conventional ignition system, oscilloscope-type ignition testers must not be used for testing this equipment.

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