ELECTRONIC FUEL-INJECTION.

COMPONENTS.

1) General Feed Relay.
2) Electronic Control Unit.
3) Relay for Fuel Pump.
4) Fuel Pump.
5) Fuel-Pressure Regulator.
6) Thermal Switch (see "Cold-Starting" Diagram).
7) Throttle Spindle Switch.
8) Thermal Sensor.
9) Supplementary Air Control.
10) Impulse-Relay for cold-starting. Injector (see "Cold-Starting" Diagram).
11) Injector (cold-starting) (see "Cold-Starting" Diagram).
12) Ignition distributor (Triggering Contacts).
13) Injector, (main).
14) Pressure Sensor.
15) Full Load Switch.

NOTES:-

The following diagrams explain the operation of these items.

- The Cold Starting diagram includes items 6, 10 and 11.
- The last diagram shows the general operation of the ECU under acceleration and full-load conditions.

RELAYS

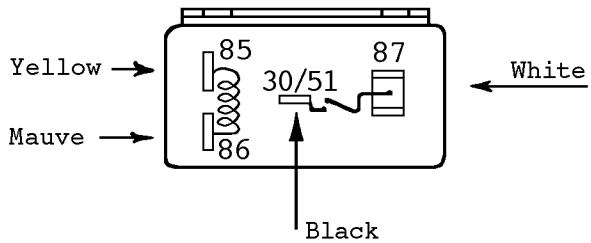
Relays (construction and fitting).

- The three Relays, fitted adjacent to the battery, are all of the same type; they have four blade-connectors (one double-bladed, no.87); two connectors (coded 85 and 86) are at the ends of the solenoid winding, the other two (coded 87 and 30/51) are the switching contacts; spring-leaded open, they close when the solenoid is energised.
- No. 30/51 is the live side of the switching contacts (feed from battery).
- The colour codings of the leads from the harness to these connectors are the same on all three relays:-

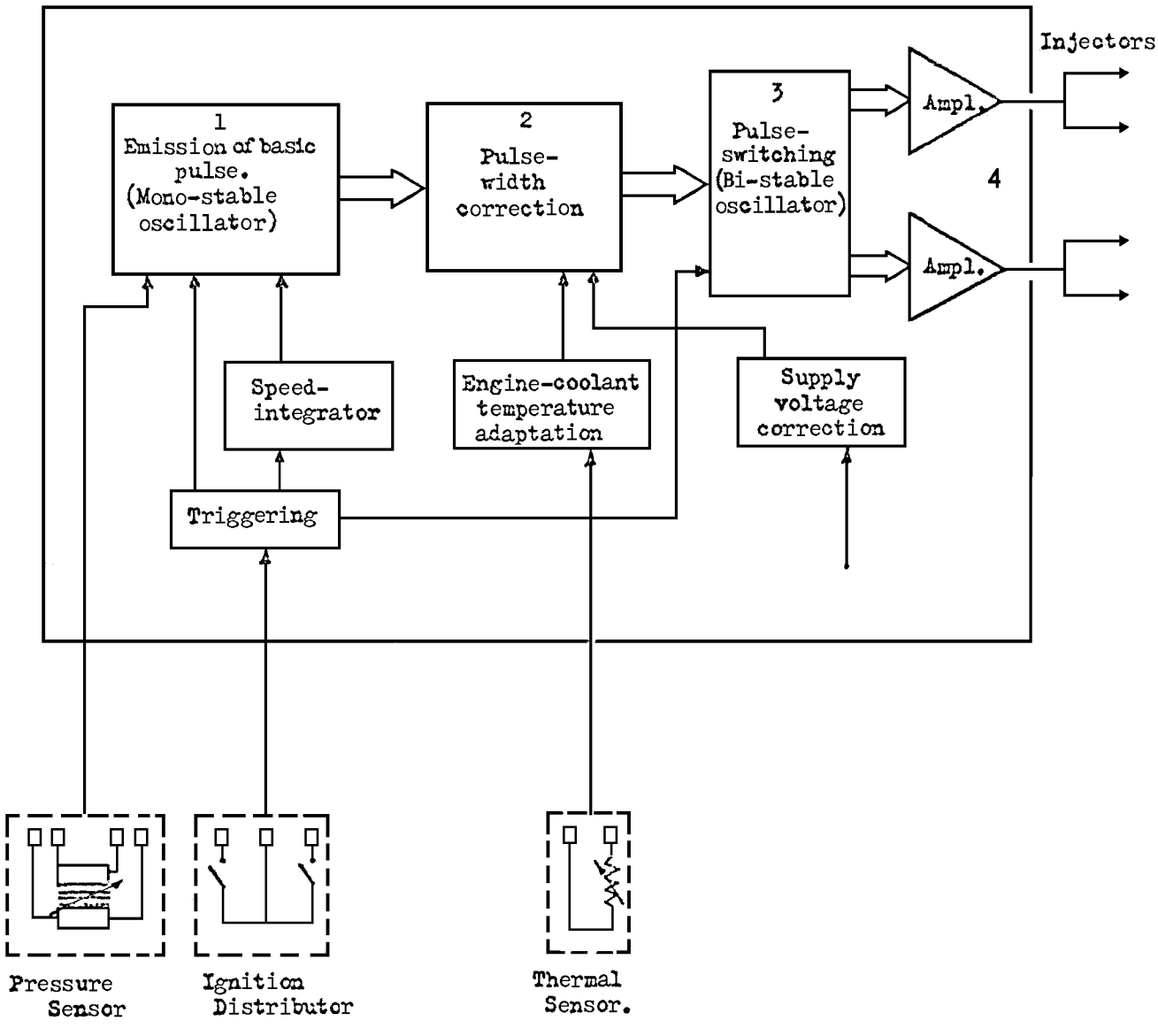
No. 85:- Yellow. No. 86:- Mauve,
No. 87 : - White. No. 30/51:- Black.

- As installed on the car, the forward relay is the General Feed Relay, the centre relay is the Fuel Pump Relay, the rearward relay is the Impulse Relay for the Cold-Starting Injector,

View from above.



ELECTRONIC CONTROL UNIT

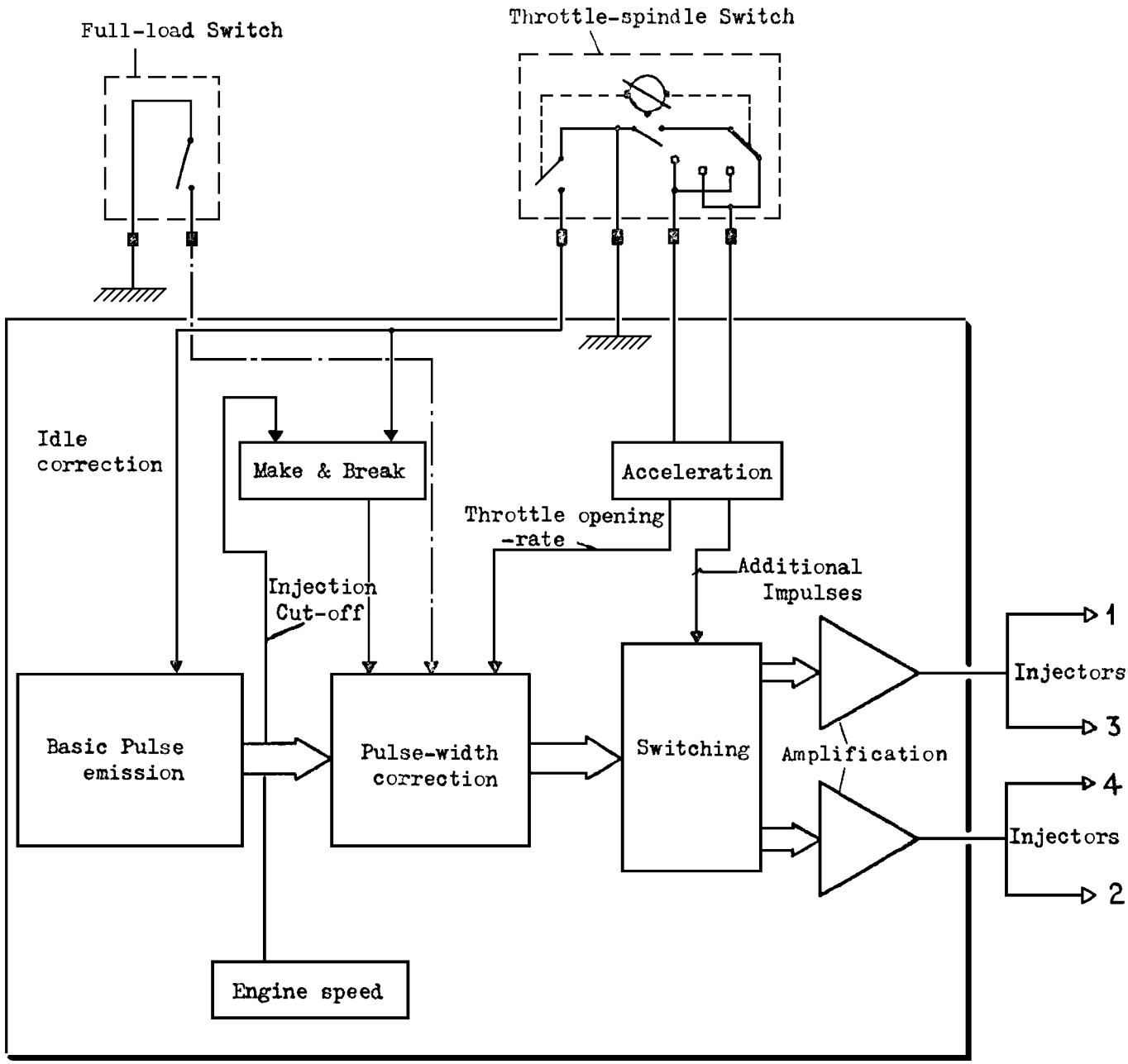


Electronic Control Unit (ECU):- receives signals from the various sensing elements, creates pulses, corrects the pulse-width, directs them to one or other pair of injectors, amplifying them to operate the injector solenoids at 3 volts. Also controls operation of Fuel Pump when engine starts and stops.

Voltage compensation (inside Electronic Control Unit):- senses battery voltage and alters pulse width if necessary; e.g. if battery voltage is low, injector solenoid will open valve slowly, compensator increases pulse width.

Fig: PRINCIPLE OF OPERATION OF ELECTRONIC CONTROL UNIT

ELECTRONIC CONTROL UNIT



OPERATION OF ELECTRONIC CONTROL UNIT, ACCELERATION & FULL-LOAD

Electronic Control Unit (ECU):- receives signals from the various sensing elements, creates pulses, corrects the pulse-width, directs them to one or other pair of injectors, amplifying them to operate the injector solenoids at 3 volts. Also controls operation of Fuel Pump when engine starts and stops.

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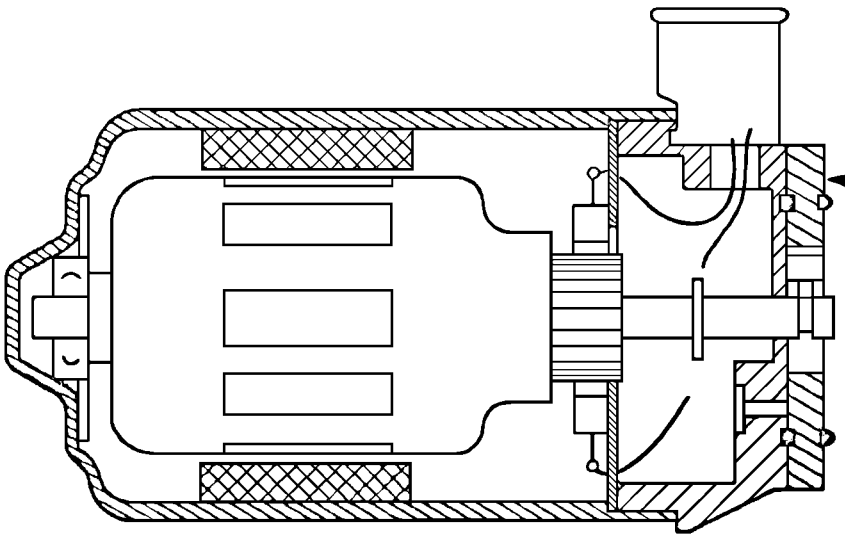
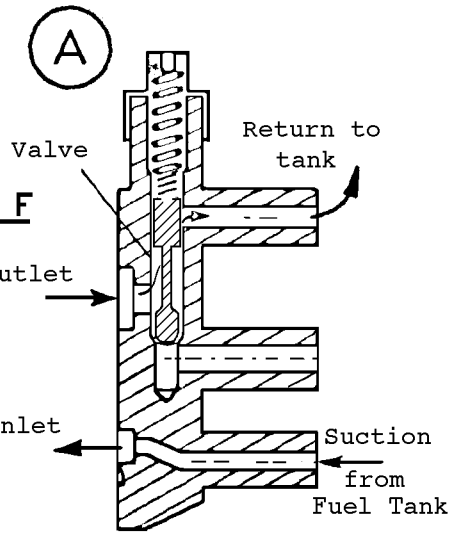
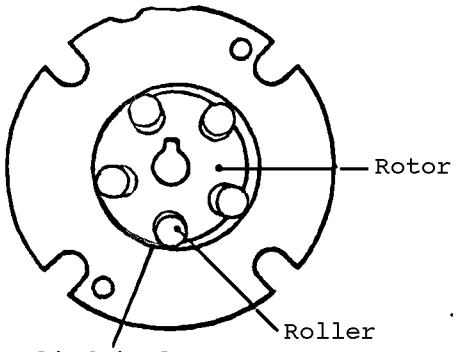
FUEL PUMP





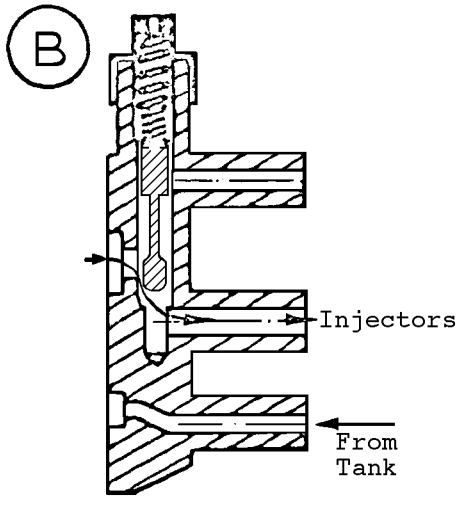
View F

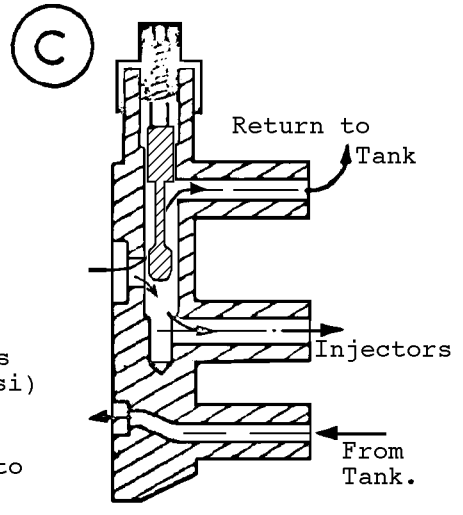


Starting de-aeration -: A

Normal Running -: B

High-pressure cutting-out -: C





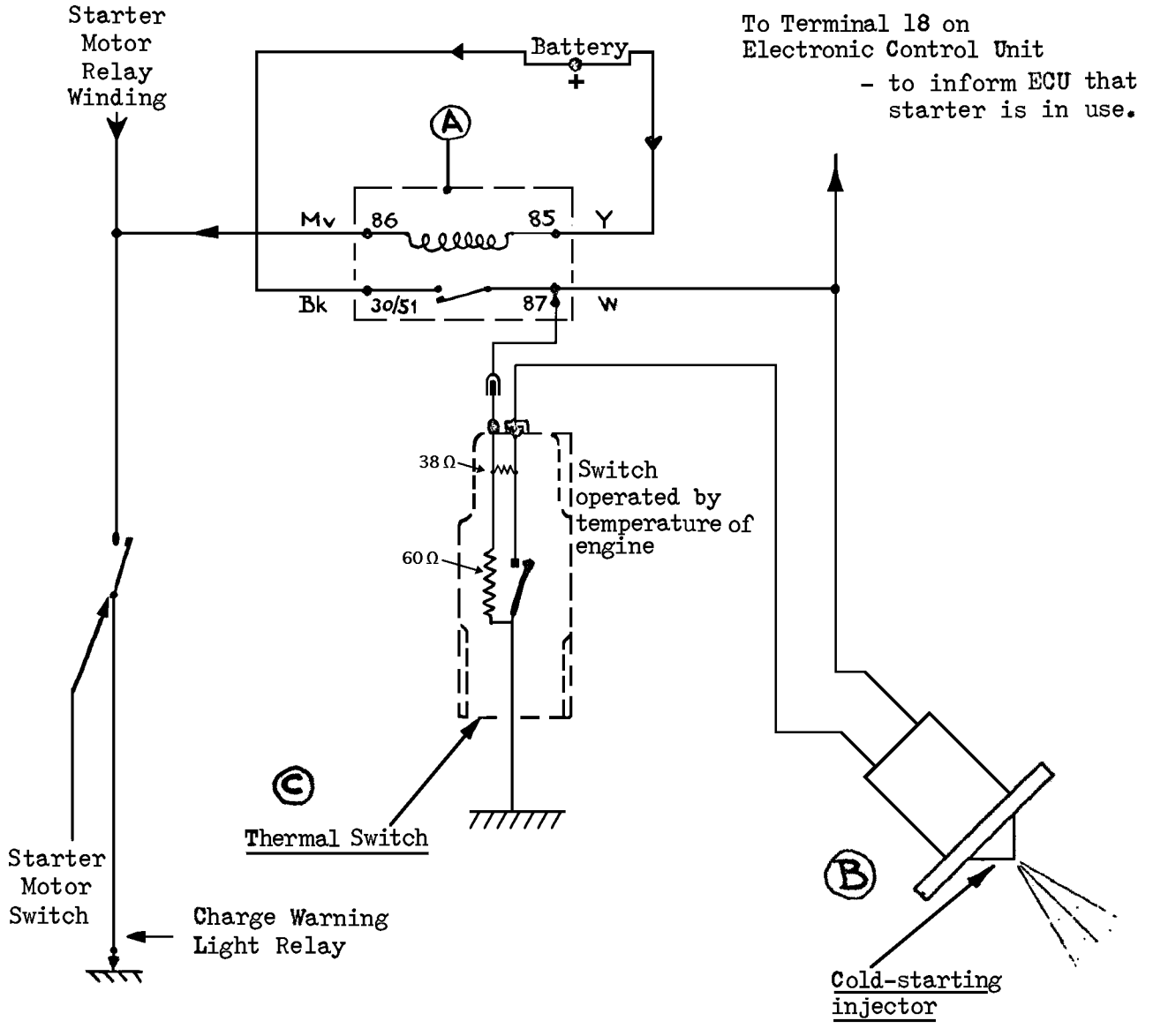
A cylindrical rotor on the pump shaft has five grooves along its periphery, and rotates inside a cylindrical housing; in each groove is a roller; inlet and outlet ports communicate with the space between the housing and the rotor 1 when the pump operates the rollers move outwards under centrifugal force and act as valves. A spring-loaded pressure-relief valve opens if the ring-main circuit pressure reaches 4 bars (58 psi) and fuel is returned to the tank (C).

This valve has a fine flat on it; when the pump starts (A) any air present escapes past the flat and returns to the tank; when the pump stops, the roller-vanes are no longer hold out by centrifugal force; fuel escapes from the ring-main along this flat until the line-pressure falls to 1.3 Kg/cm² (18½ psi) at which point the valve closes.

The pump is full of fuel at all times, eliminating shaft-seals and the friction they would introduce

The pump output of approx. 13 galls/hr exceeds the maximum requirements of the engine (9¼ galls/hr) and thus ensures that fuel circulates continuously.

COLD STARTING

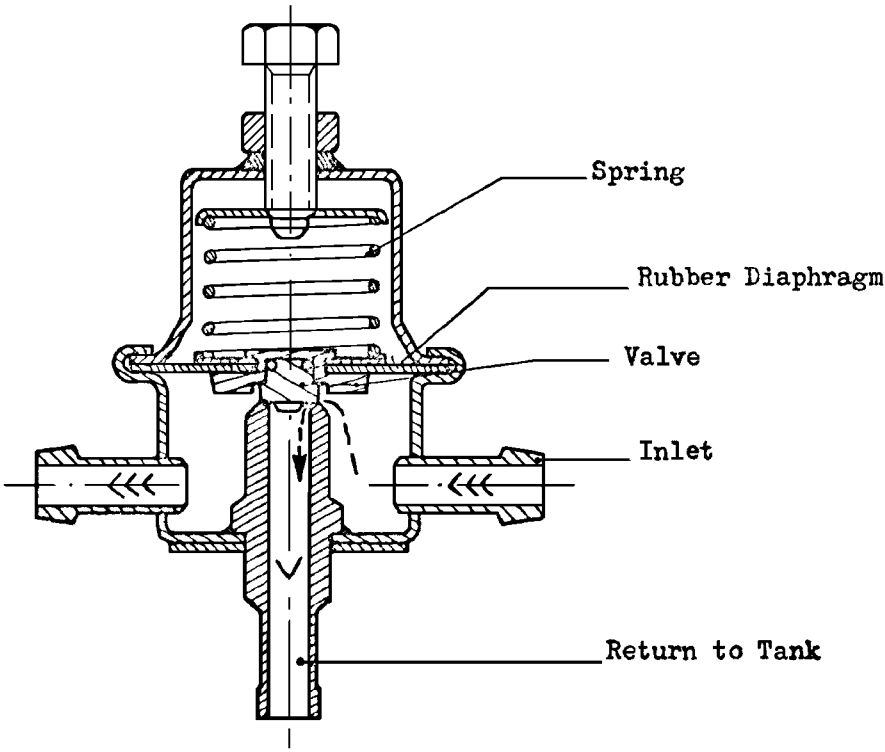


A. Relay, Impulse:- for cold starting injector, energised only when starter motor is in use.

B. Injector, Cold Start:- Energised by Impulse Relay, provided Thermal Switch is closed (below 20°C to 30°C (68°F to 86°F); only injects while Starter Motor is running. Operates at battery voltage, i.e. 9 - 10v while starter motor is in use.

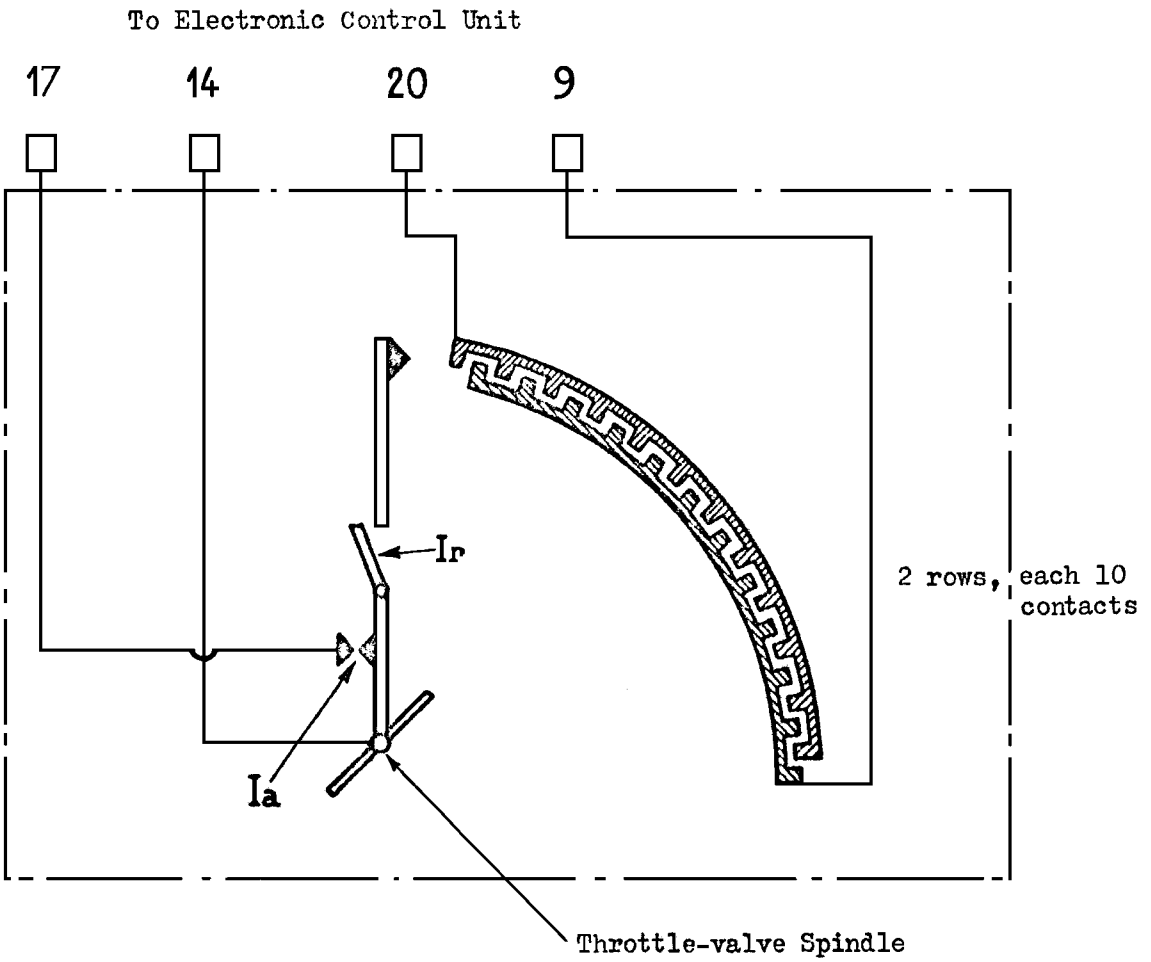
C. Thermal Switch:- responds to engine-coolant temperature if below 20°C to 30°C (68°F to 86°F), and allows cold-starting injector to open for the period of use of the starter motor; fuel condensed in manifold continues to evaporate giving reducing richness. Incorporates a resistance which heats the temperature-sensitive switch to avoid flooding engine if the starter motor is operated for long periods (timing 6 seconds at - 20°C, 1 second at + 15°C).

FUEL - PRESSURE REGULATOR



Fuel-Pressure Regulator:- Fitted into the Fuel-supply Ring-Main. A spring-loaded rubber diaphragm holds a valve closed until the fuel-pressure acting on the diaphragm is sufficient to compress the spring, lift the valve and allow fuel to return to the tank (2 kg/cm^2, 28.5 p.s.i.

THROTTLE-SPINDLE SWITCH

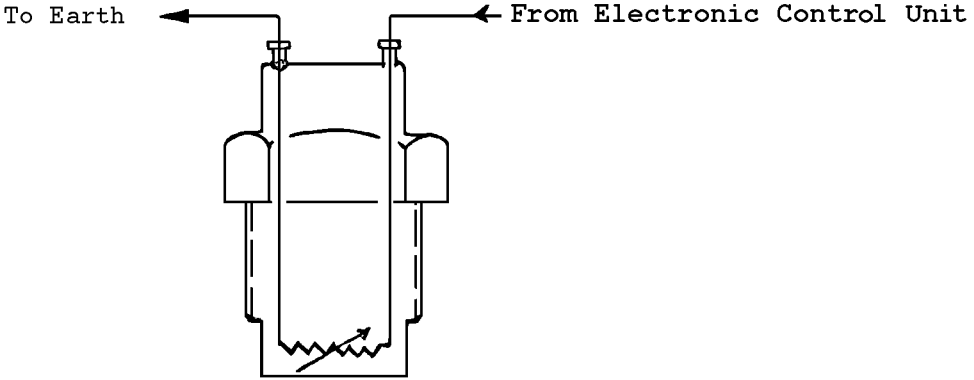


Throttle Spindle Switch:-

- Idling (throttle closed):- reduces length of pulse determined by Electronic Control Unit from Pressure Sensor Signal, otherwise mixture would be too rich. ("Throttle-closed" Switch Ia).
- Acceleration:- a slider rotating with the Throttle Spindle contacts alternate contacts and sends signals alternately to the bistable switching circuit and to the pulse-width correction circuit in the Electronic Control Unit. Those to the bistable switching circuit provide additional signals to the injectors, until the effect of the alteration of inlet manifold pressure on the Pressure Sensor results in a change of inductance (this is because the time lag of 150m/s at the Sensor would otherwise provoke a flat spot). The signals to the pulse-width corrector cause an appropriate change in the pulse width according to their frequency, i.e. as a function of the rate of opening of the throttle.
- Throttle-closing:- when the throttle is being closed, the connection to the slider is open-circuited and no pulses are supplied (Switch Ir)
- Fuel cut-off on over-run (engine-braking):- when the accelerator is released, Switch Ia causes fuel cutoff and the Electronic Control Unit recommences pulses when the engine speed has fallen to 1100 rpm; if the car then gathers speed down a slope with the throttle closed, fuel is cut off when the engine speed has risen to 1800 rpm. The difference is to prevent alternate power-on/power-off condition if engine speed is at about 1100 rpm.

THERMAL SENSOR

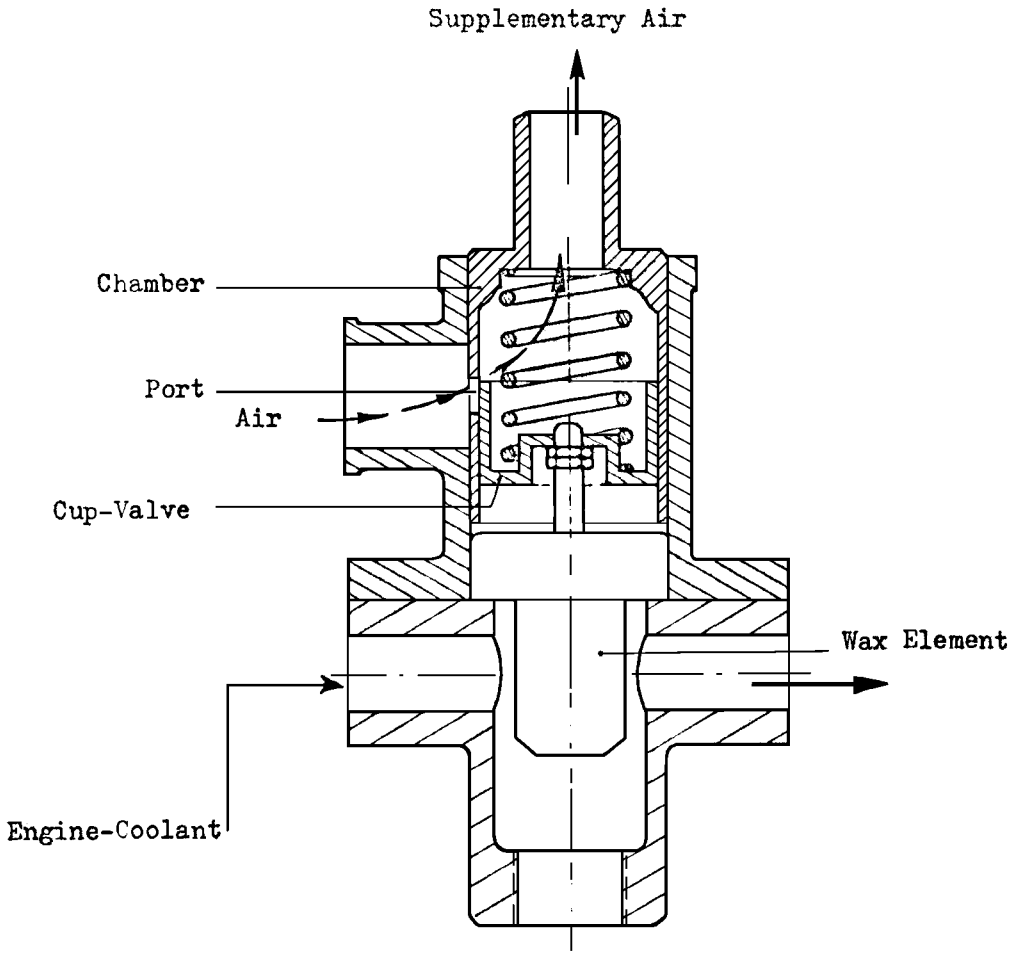
& INTAKE AIR SENSOR .



Thermal Sensor: - Resistance varies with engine coolant temperature; (Warm-up control) signal to Electronic Control Unit causes changes in pulse width (e.g. Temp. change from 50°C to 30°C causes pulse width to be multiplied by 2.5), until engine has reached normal operating temperature (70°C or above). R = 2100 - 3100 Ohms @ 20° C (68° F)

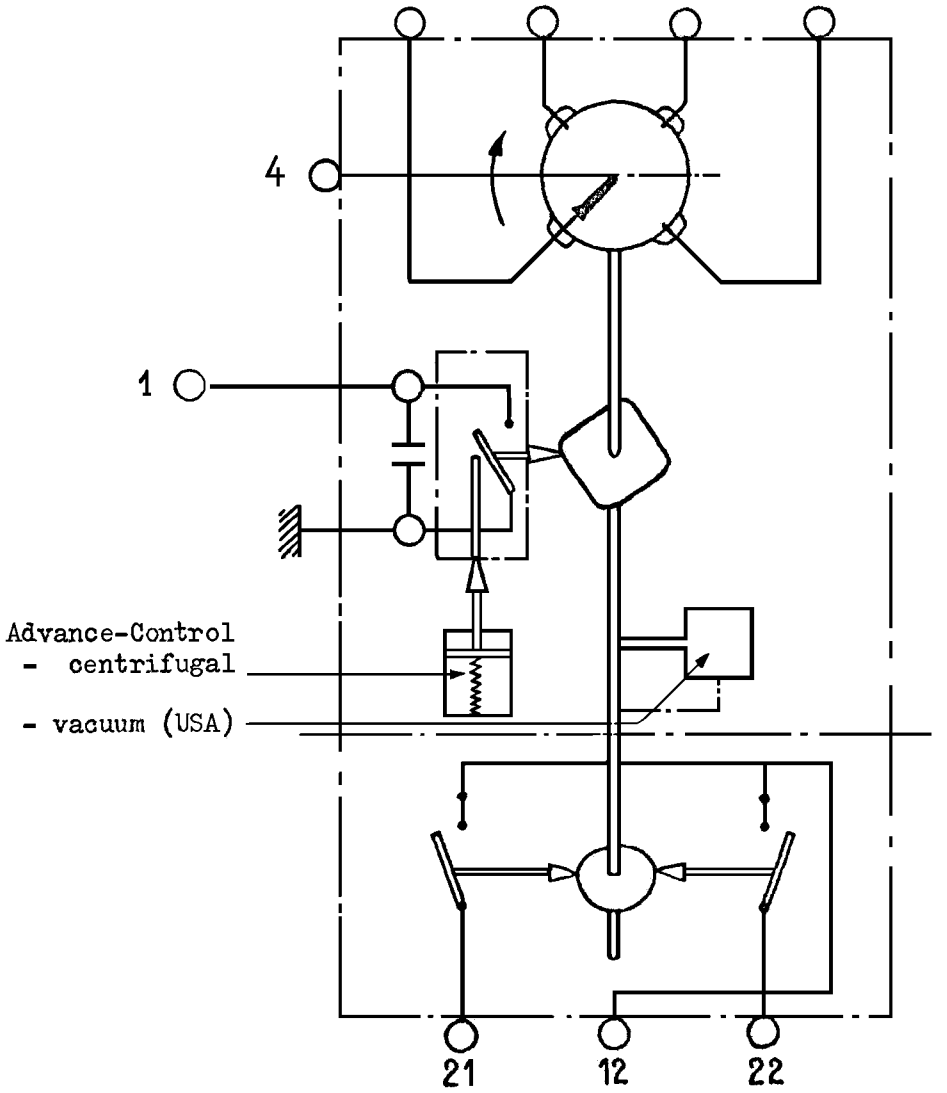
Intake Air Sensor: Resistance varies with intake air temperature; signal to ECU causes changes in pulse-width, balancing supply of fuel to mass (i.e. actual quantity of oxygen) of intake air. R = 260 - 340 Ohms @ 20° C (68° F)

SUPPLEMENTARY AIR CONTROL



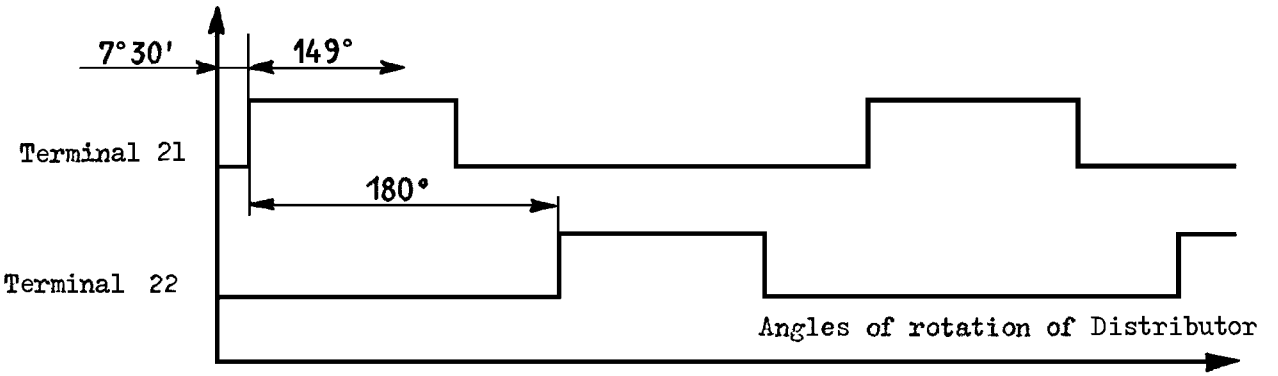
Supplementary Air Control (non-electrical):- in engine coolant circuit; a spring-loaded cup-valve operated by a temperature-sensitive wax element meters air passing through a port, reducing the volume of air as the coolant temperature rises; this supplementary air bypasses the throttle valve, and provides extra air during the warm-up period to balance extra fuel supplied in response to signal from Thermal Sensor. The air supply to this Supplementary Air Control comes from the engine-side of the Air Filter. When the coolant has reached 70°C the supplementary air port is closed.

IGNITION DISTRIBUTOR



Ignition-Distributor.

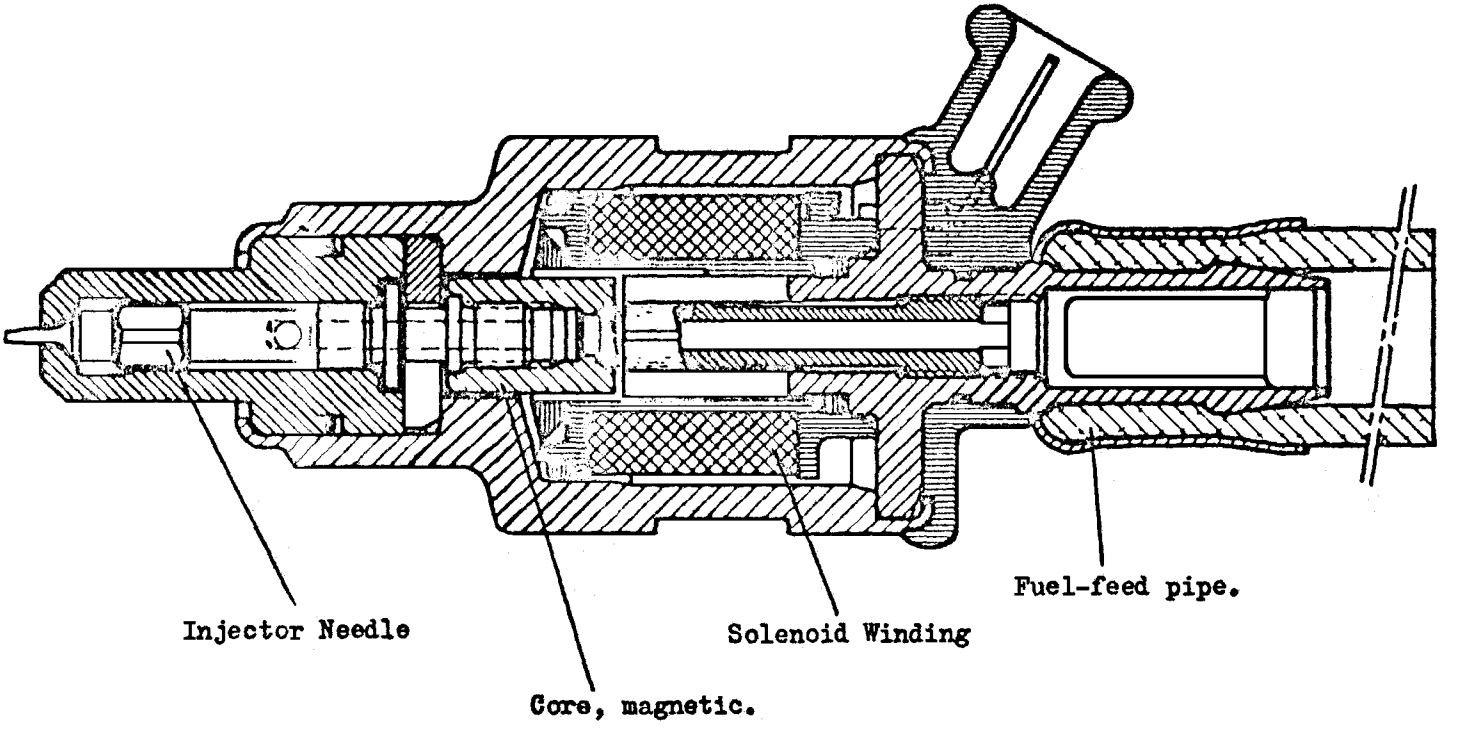
DIAGRAM OF IGNITION DISTRIBUTOR.



ORDER OF PULSE-TRIGGERING

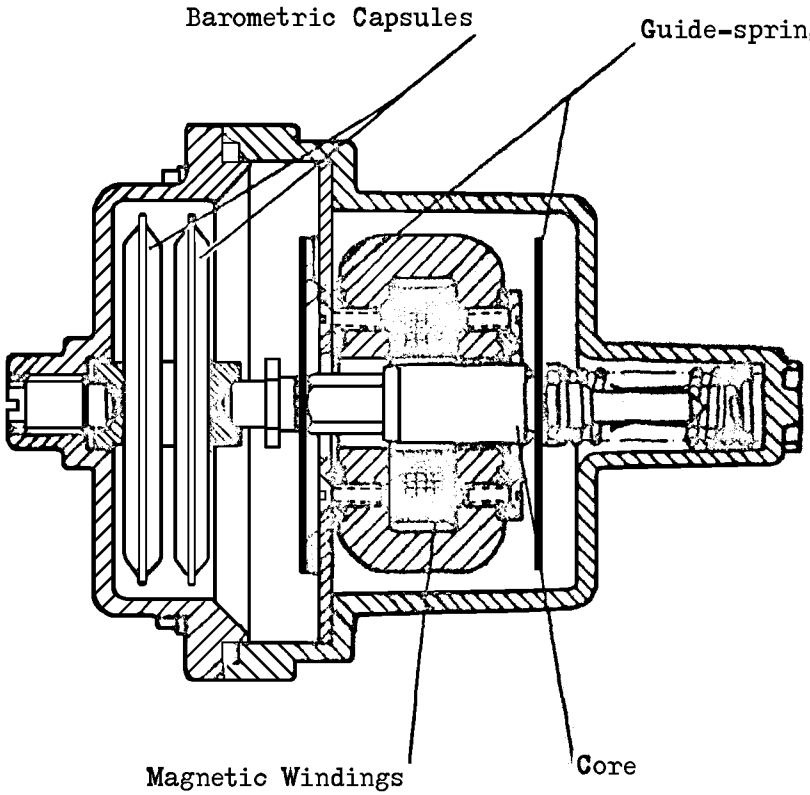
Ignition Distributor: Includes an additional cam on the shaft, with two contact-breakers at 180°; these contact-breakers which each close through 149° of rotation of the distributor shaft supply to the Electronic Control Unit, triggering - pulses which are the signals for the commencement of the pulses supplied by the ECU to the injectors, and the switching of pulses to alternate pairs of injector; the frequency of the pulses from the triggering contacts informs the ECU of the speed of the engine.
The contacts are non-adjustable.

INJECTOR



- Solenoid-operated in pairs (1 and 3, 4 and 2) by pulses emitted by Electronic Control Unit. Fuel supply is at constant pressure (28.5 psi) and injector has constant lift; the only variable is the duration of opening (corresponds to the pulse width). The solenoids operate at 3 volts, to avoid heating the fuel. Needle opening-time is approximately 1 millisecond. The duration of injection time varies from 2.5 milliseconds at idling to 9.7 milliseconds at full load.

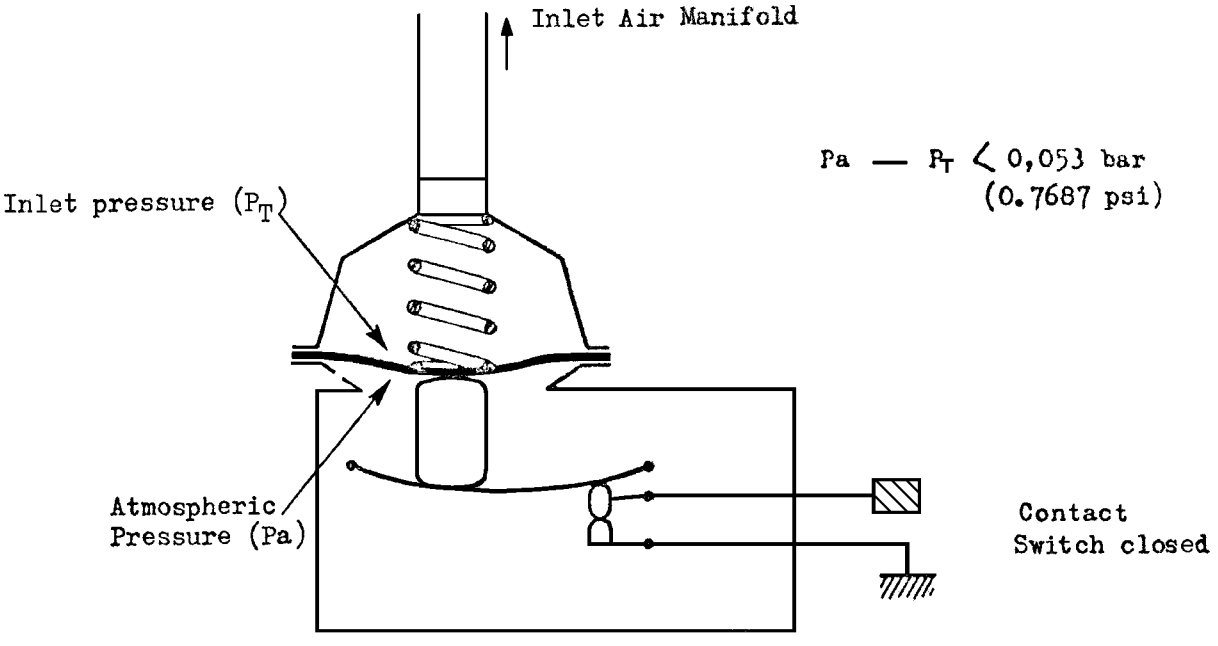
PRESSURE SENSOR



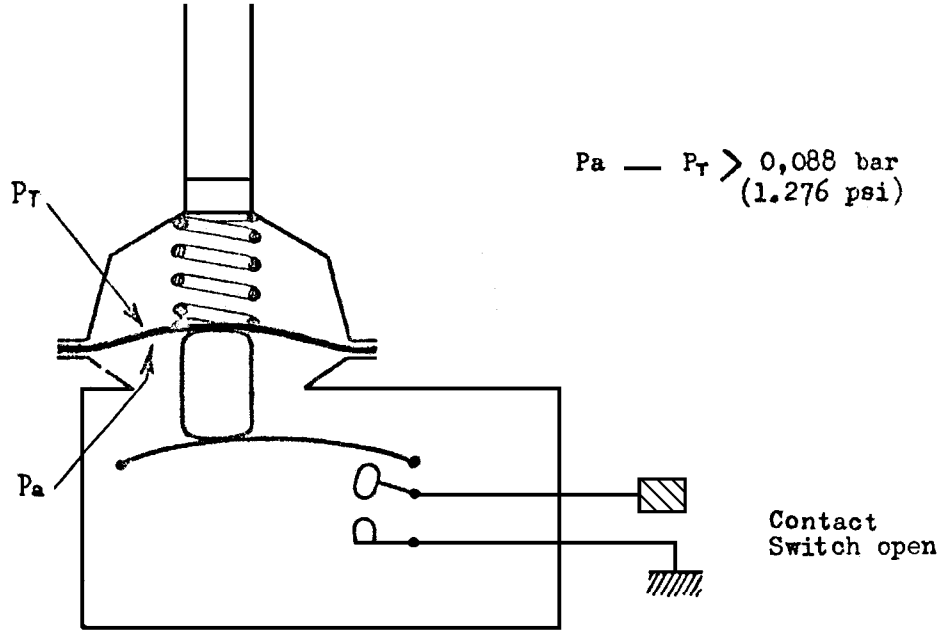
Pressure Sensor:- sends signals of varying inductance; controlled by inlet manifold pressure acting on two barometric capsules attached to a movable core in a choke of two windings (primary and secondary) which acts as a transformer. Value of inductance varies with the absolute pressure in the manifold; The ECU sends a signal through the primary and receives a response from the secondary, this response varies as the inductance changes.

The Pressure Sensor is damaged by excessive vibration or by being dropped. On the car it is mounted on the Scuttle Panel by a bracket with rubber bushes.

FULL-LOAD SWITCH



FULL-LOAD SWITCH CLOSED



FULL-LOAD SWITCH OPEN

Full Load Switch:- Senses difference between absolute pressure in manifold and atmospheric pressure: when pressure differential is less than 0.053 bar (0.7687 psi) i.e. when throttle is 2/3 open or more, a contact closes and sends a signal to the Electronic Control Unit which modifies the pulse width accordingly. An over-centre spring keeps the contact closed until the pressure differential reaches 0.088 bar (1.276 psi), to avoid fluttering and hesitation which could occur if the pressure oscillated slightly above and below a single operating level; the actual pressure of opening and closing varies with changes of atmospheric pressure, thus affording automatic altitude compensation. When the engine is stopped, the pressure differential is nil, therefore the switch closes; as soon as the engine starts to turn, with the throttle closed, the switch opens, but in the closed position its signal to the ECU contributes to a slight increase of pulse-width each time the engine is started, whether hot or cold.