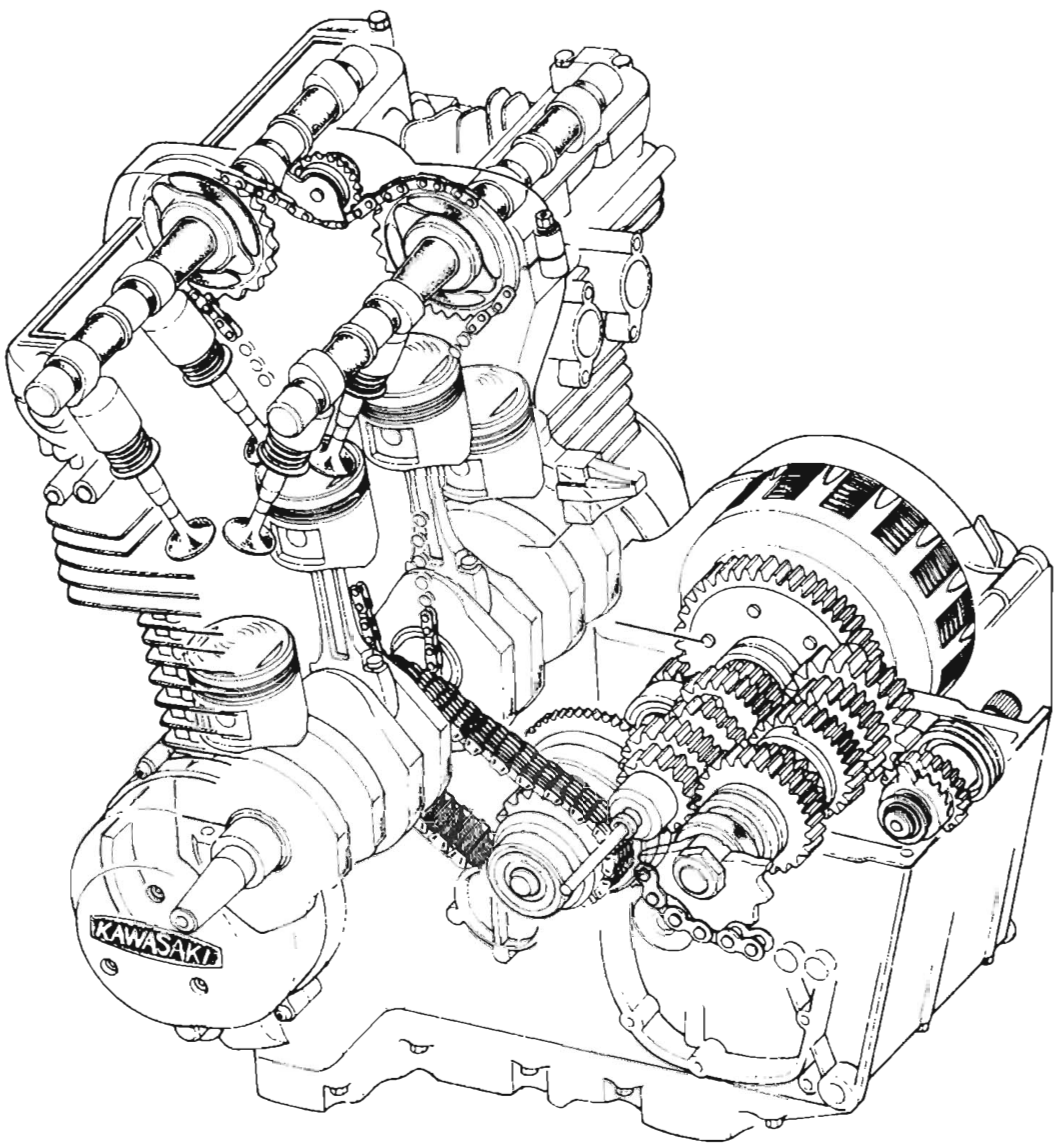
Kawasaki

TRAINING CENTRE



709 Banbury Avenue, Trading Estate, Slough SL1 4LH. Tel: Slough (0753) 76476 Telex 849978

Electronic Fuel Injection System

This electronic fuel injection system takes the place of conventional carburettors and provides an electronically controlled fuel/air mixture to the engine. The system operates on the principle of continuous direct air flow to determine the correct fuel/air mixture.

Sensors in this system continually monitor engine speed and temperature, and intake air flow and temperature. This information is sent to the electronic control unit, which process these signals and determine the fuel requirements of the engine.

The control unit then generates an electric signal which is sent to the fuel injection valves. The electro-magnetic injection valves open and inject the exact amount of fuel needed in front of the intake valves. The injection valve nozzles are designed to deliver a finely atomized fuel charge, which promotes even and complete combustion.

The electronic system consists of the following basic components, air intake system, fuel delivery system and electronic control system.

The air intake system works as followers, incoming air charge passes through the air cleaner to the air flow meter. This is where the air flow rate and temperature are measured. The air then goes to the surge tank where it is distributed to the four intake ducts. A throttle valve in each intake ducts controls the air flow to each cylinder.

The surge tank has two functions. The first is to reduce the influence of air flow pulsation on the air flow meter, and the second is to distribute the incoming air to each cylinder.

There is a separate throttle valve for each cylinder, and they must be synchronized just as on a normally carburetted engine.

Electrical signals are sent to the control unit from various sensors, engine speed is picked up at the ground sides of the primary windings of the ignition coils. Air flow rate which is measured by the air flow meter, start signal is picked up at the positive side of the starter relay. The throttle valve shaft has a switch which signals the idle position and the full load position of the throttle valves. Engine temperature is picked up by the engine temperature sensor on the cylinder head. Air temperature is picked up by a sensor built into the air flow meter.

The control unit receives these signals as input data and processes them in accordance with a predetermined program. The control unit then computes the duration of fuel injection required to meet the needs of the engine, and sends a signal pulse to the injectors. Each fuel injector opens its valve according to the pulse received, and the correct amount of fuel is injected into each intake manifold.

The major advantages of this "air flow sensitive" system is that the air flow is measured before it reaches the cylinders. This allows the control unit to compute the proper amount of fuel before it is needed.

Benefits of this system is:-

a) Driveability:

The system provides superior cold start performance with virtually no throttle lag or hesitation. Accelerator pumps are not needed since the signal generated by the air flow meter precedes charging of the cylinders. Fuel/air mixture is always correct; throttle response is excellent.

b) Better Fuel Economy:

System delivers the precise amount of fuel needed over the entire engine speed range. When compared to a normally carburetted engine of the same power output, the electronic system equipped engine delivers better fuel economy.

c) Low Exhaust Emissions:

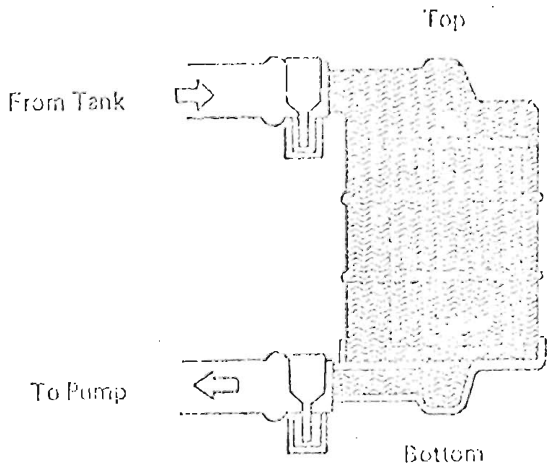
Continuous maintenance of the correct fuel/air mixture over the entire engine speed and load range results in low exhaust emissions. Compared to carburetted engine designed to meet the same emission levels, an electronic system engine can be optimized for better performance, driveability, and fuel economy.

d) Low Maintenance:

This system automatically takes into account and compensates for all changes occuring during the normal service life of the engine (cylinder/piston wear, combustion chamber deposits, valve clearance etc). The system always delivers the correct fuel/air mixture.

Fuel Filter

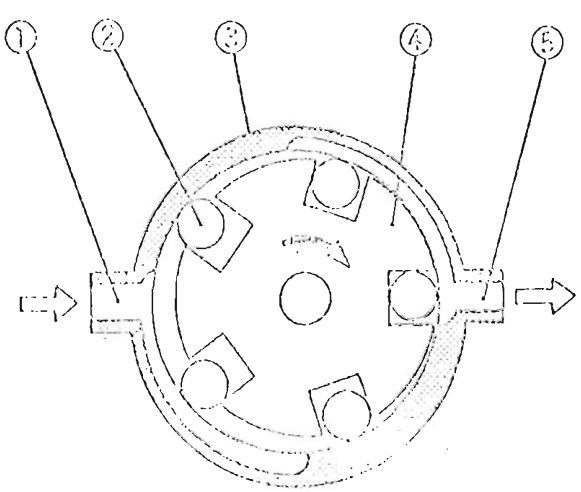
The fuel filter removes impurities from the fuel as it makes its way to the fuel pump. If the fuel was not in the system impurities would damage the pump and injectors. Periodic filter replacement is required.



Fuel Pump

The fuel pump is gravity fed and the pump is of a wet type. This means the fuel goes through the pump while lubricating and cooling the motors. The pump supplies pressurized fuel to the injectors, this is done by the roller cell mechanism pushes fuel through a reduced outlet diameter. The pump rate is 2 litre per minute or between 120-140 litre per hour. The pressure in this part of the circuit to injectors and regulator is 2.55kg (33psi approximately).

Fuel Pump



1. Inlet
2. Rollers
3. Pump Housing
4. Pump Rotor
5. Outlet

FUEL INJECTION SYSTEM

Fuel System

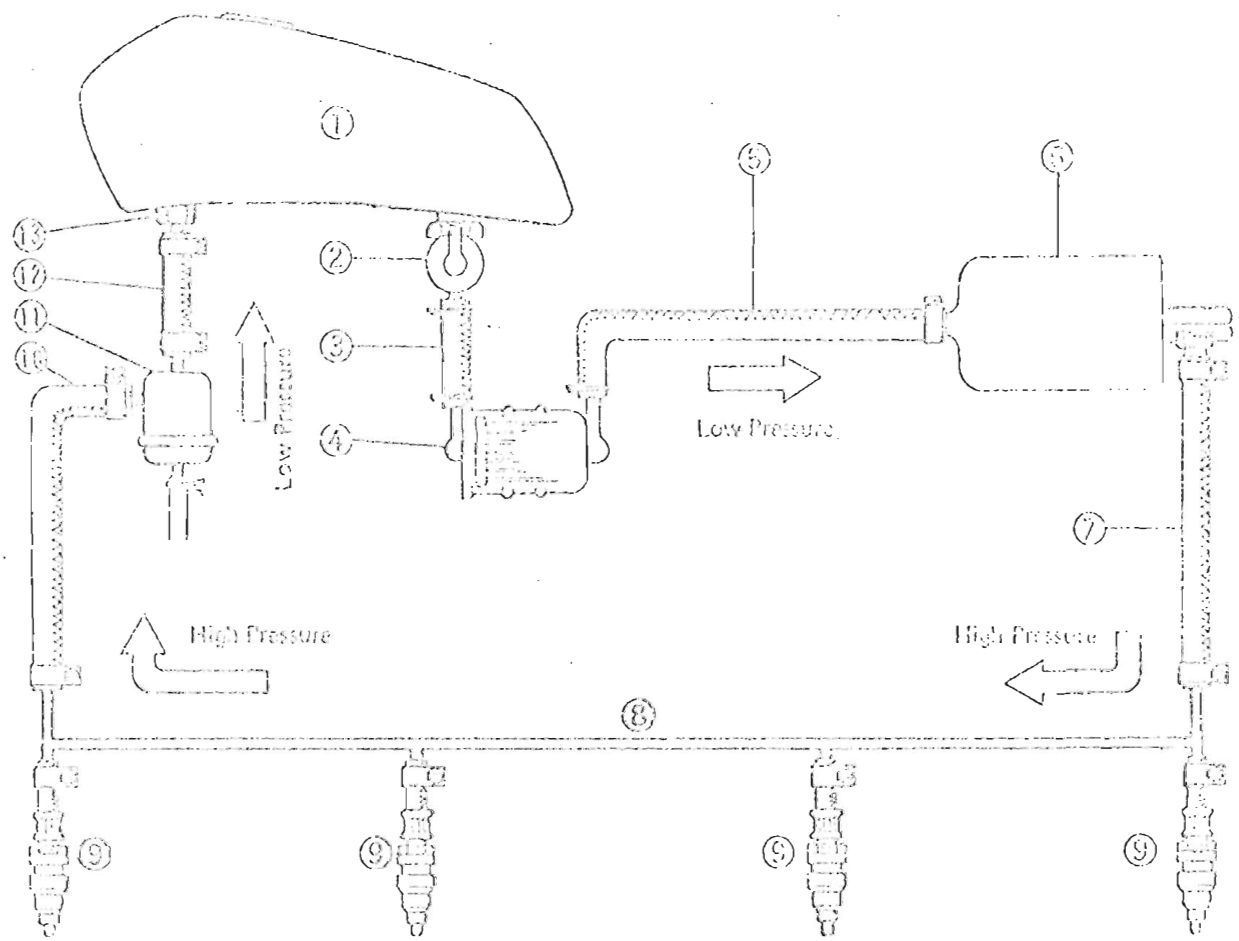
Fuel is contained in the tank and has an inlet and outlet for the fuel to flow.

The outlet is via the fuel tap the inlet which allows excess fuel to return to the tank is controlled by a check valve. The check valve operates under pressure and allows fuel to pass one way only.

Once the fuel has left the tank it flows down the hose to the fuel filter and then onto the fuel pump. From the fuel tank to the inlet of the fuel pump, this part of the circuit is of low pressure.

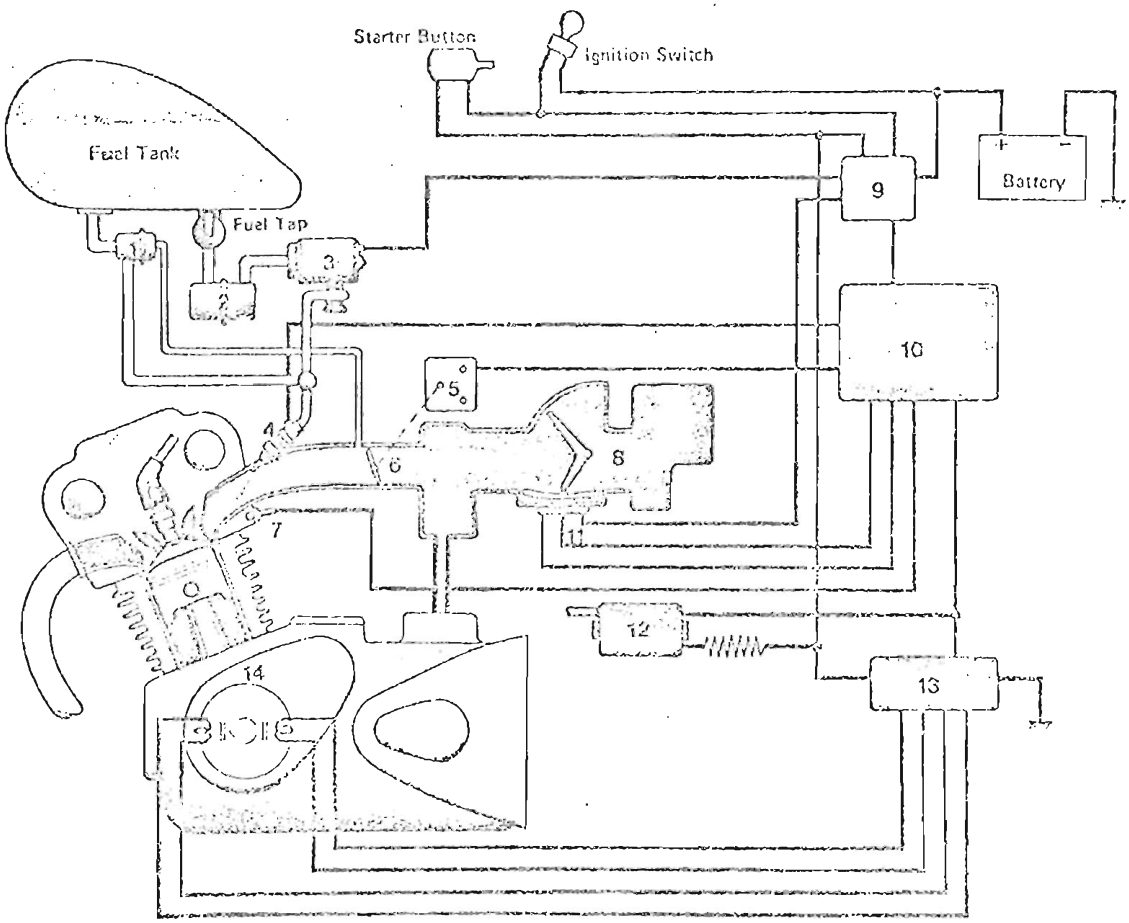
Fuel in the pump is then pushed through the outlet onto the injector feed line. Any excess fuel that is not required goes onto the pressure regulator. The regulator controls the quantity of fuel to be fed back into the tank.

Fuel System



1. Tank
2. Tap
3. Hose (Low Pressure)
4. Filter
5. Hose (Low Pressure)
6. Pump
7. Hose (High Pressure)
8. Distributing Pipe
9. Injectors
10. Hose (High Pressure)
11. Pressure Regulator
12. Hose (Low Pressure)
13. Check Valve

Schematic Diagram of Electronic Control Fuel Injection System



1. Pressure regulator: controls pressure in fuel line.
2. Fuel filter: removes impurities from fuel.
3. Fuel pump: draws fuel from tank and delivers pressurised fuel to fuel line.
4. Injectors: inject atomised fuel against inlet valves upon signal from control unit.
5. Throttle valve switch: is located on one end of throttle valve shaft, and signal idle and full-load positions of throttle valves to control unit.
6. Throttle valves: control rate of air flow drawn into engine.
7. Cylinder head temperature sensor: signal engine temperature to control unit.
8. Air flow meter: measures rate of air flow drawn into engine, and signals control unit; contains air temperature sensor and fuel pump contacts.
9. Relay: controls power supply to fuel pump and control unit.
10. Control unit: receives various signals from sensors, and computes and controls opening time of injectors.
11. Air temperature sensor: measures temperature of air flowing through air flow meter, and signals control unit.
12. Ignition coil.
13. IC igniter.
14. Timing rotor.

Digital Fuel Injection System

This system is a new electronic fuel injection system that has been developed by advanced Kawasaki technology and uses a more advance digital micro computer. The D.F.I. system features that a single micro computer in the control unit controlling both the quantity of injected fuel and the fuel pump operation. The sensors send signals that show environment and engine operating conditions to the computer. The computer processes these signals following the control programs in the memory and determines the optimum quantity of injected fuel. At the same time the computer judges whether the pump continues to run or not and stops the pump if the pump operation is not required. The D.F.I. system had advantages over the electronic system with smoother throttle response, reduced intake resistance and simplified configuration.

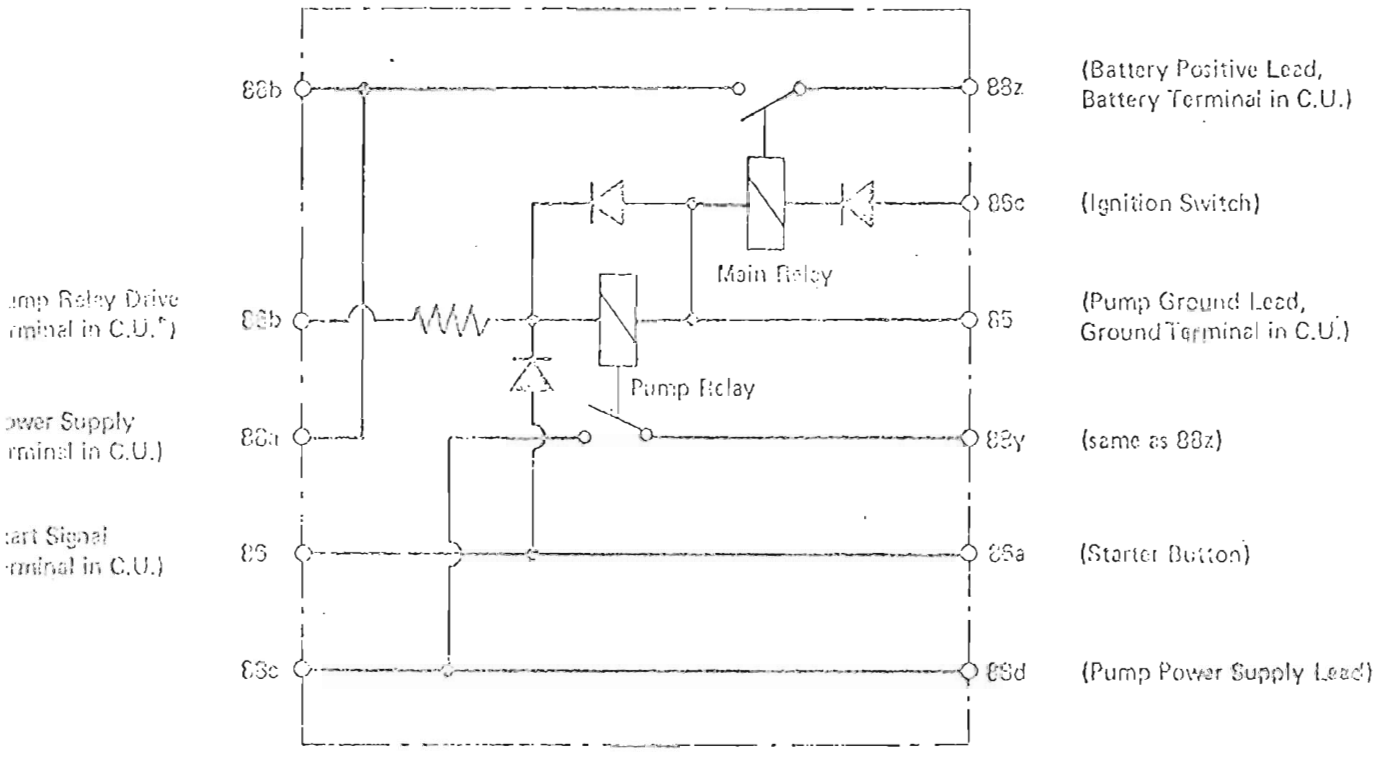
Operation of Component Parts

The throttle sensor is installed on the throttle valve assembly. The sensor has potentionmeter in it and provides the throttle-valve-opening angle information by altering the output voltage. The sensor needs no adjustment unless it is removed from the throttle valve (4 cylinder) for replacement or unless its position is altered by loosening the sensor screws.

Main/Pump Relay

Two relays are contained in a single case; one is a main relay to control power supply to the control unit, and other a pump relay to control power supply to the fuel pump.

Main/Pump Relay

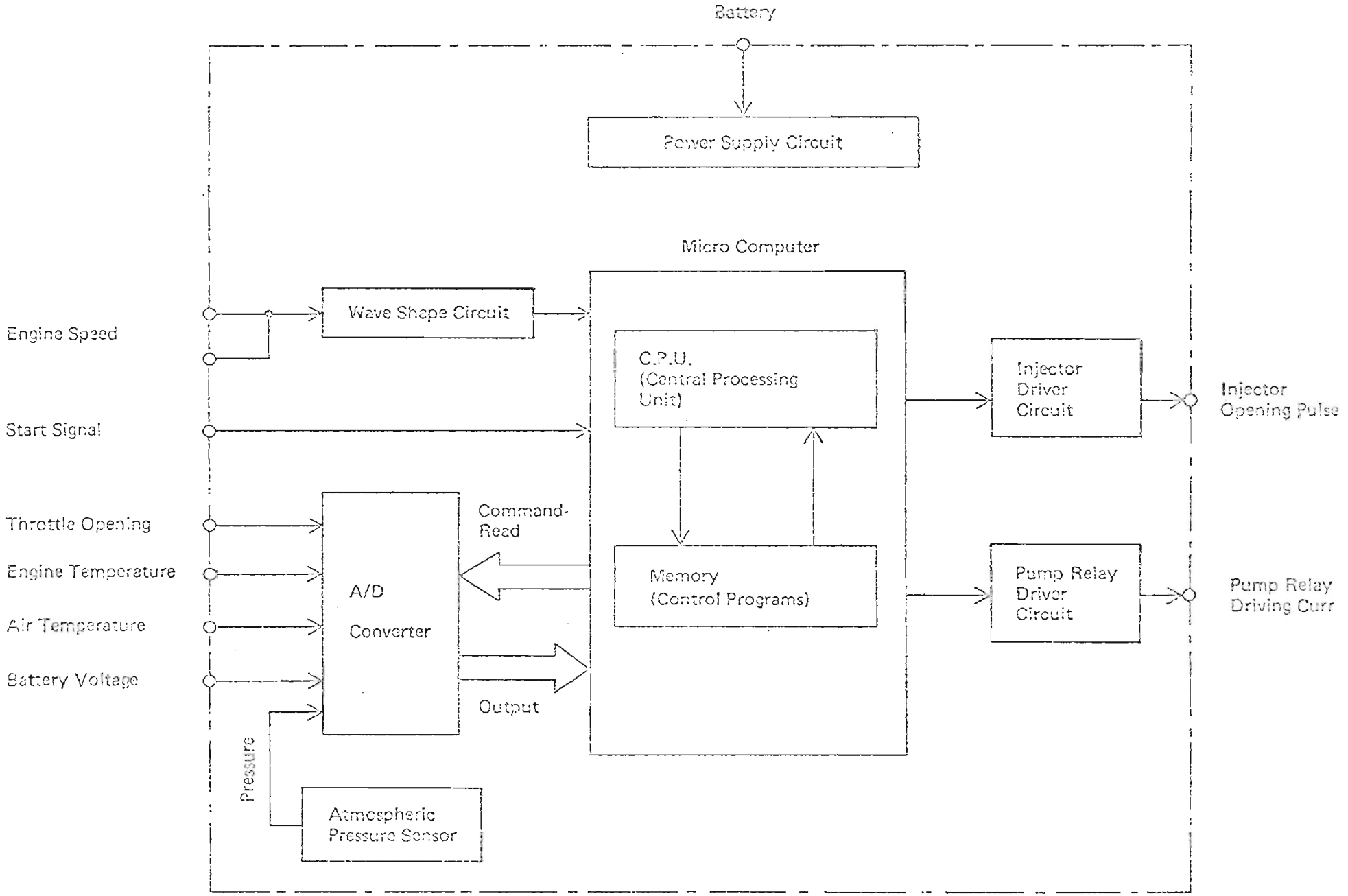


*C.U. means control unit.

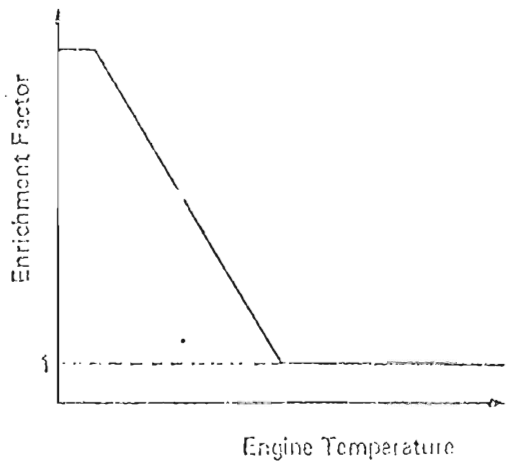
INJECTION CORRECTION ITEMS

. Cold start enrichment: The fuel-air mixture is enriched during the following two conditions are satisfied:

- When the engine is cold.
- When the starter motor is in use.


Battery
Power Supply Circuit
Micro Computer
Wave Shape Circuit
Engine Speed
Start Signal
C.P.U.
(Central Processing
Unit)
Injector
Driver
Circuit
Injector
Opening Pulse
Throttle Opening
Engine Temperature
Air Temperature
Battery Voltage
A/D
Converter
Command-
Read
Output
Memory
(Control Programs)
Pump Relay
Driver
Circuit
Pump Relay
Driving Curr
Pressure
Atmospheric
Pressure Sensor

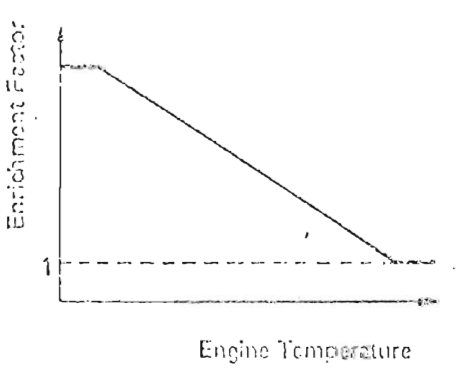
Cold Start Enrichment



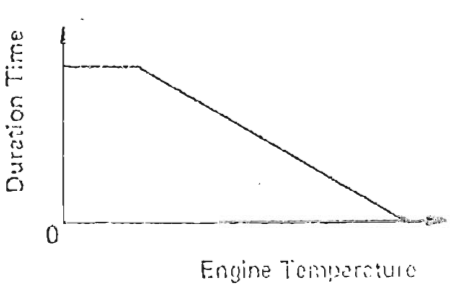
After start enrichment: The after start enrichment bigins at the instance the following two conditions are satisfied, and continues for a while:

- When the engine is cold.
- When the starter button is first turned off after the ignition switch is turned on.

After Start Enrichment



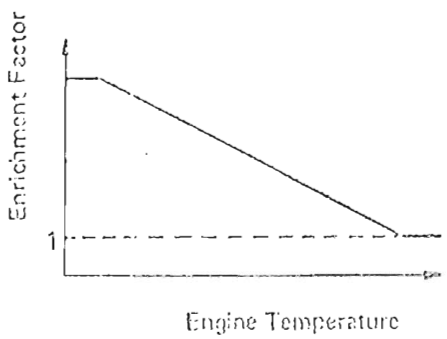
After Start Enrichment Duration Time



Warm-up enrichment: The fuel-air mixture is enriched during the following two conditions are satisfied:

- When the engine is cold.
- When the engine is running (not cranked over).

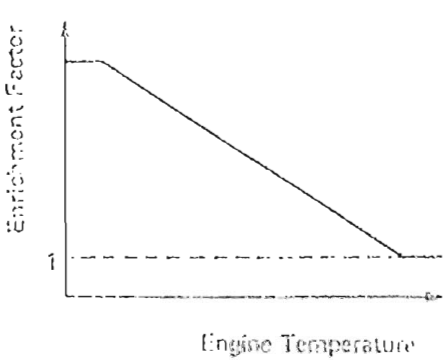
Warm-Up Enrichment



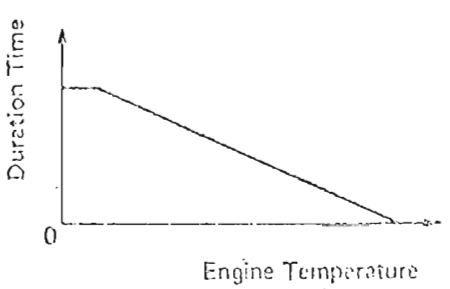
Acceleration enrichment: The acceleration enrichment begins at the instance the following two conditions are satisfied, and continues for a while:

- When the engine is cold.
- When the throttle opening speed (quantity of opening angle increase during a unit time interval) becomes greater than a predetermined level.

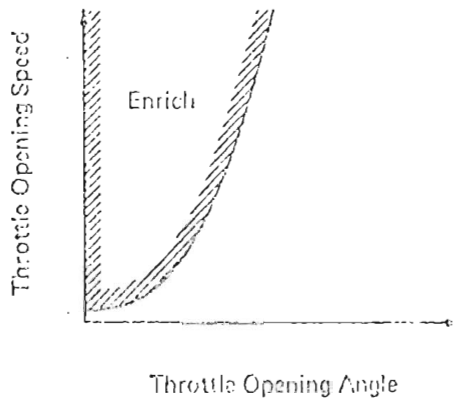
Acceleration Enrichment



Accelration Enrichment Duration Time



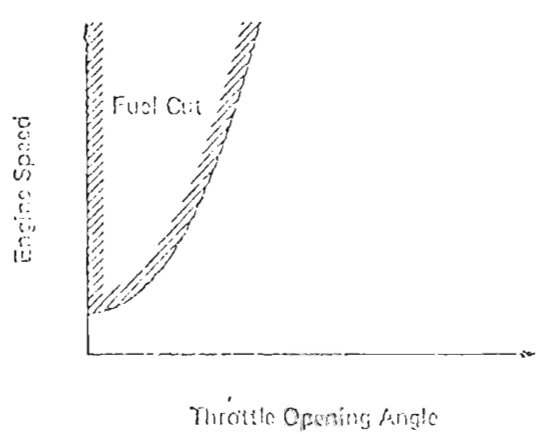
Acceleration Enrichment Zone



Fuel cut: Fuel injection is stopped during the following two conditions are satisfied:

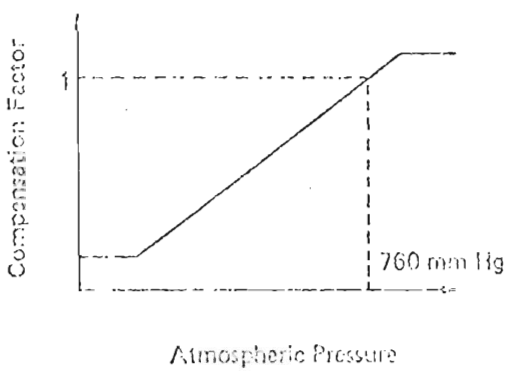
- When the engine is warmed up.
- When the combination of the throttle valve opening angle and the engine speed satisfies the predetermined conditions.

Fuel Cut Zone



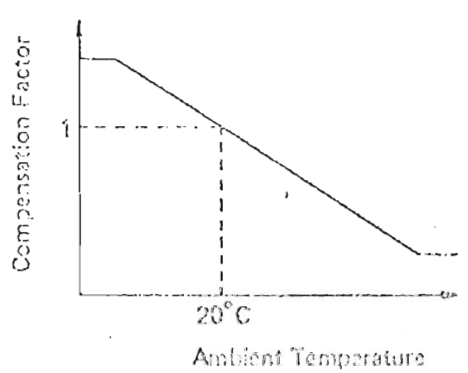
Altitude compensation: The higher the motorcycle goes up, the thinner the air becomes because of lower atmospheric pressure. This causes a relatively richer fuel-air mixture at high altitude. To compensate for changes in air pressure, the pressure sensor in the control unit monitors the atmospheric pressure. The result is better engine performance, fewer fuel consumption, and fewer emissions at high altitudes.

Altitude Compensation



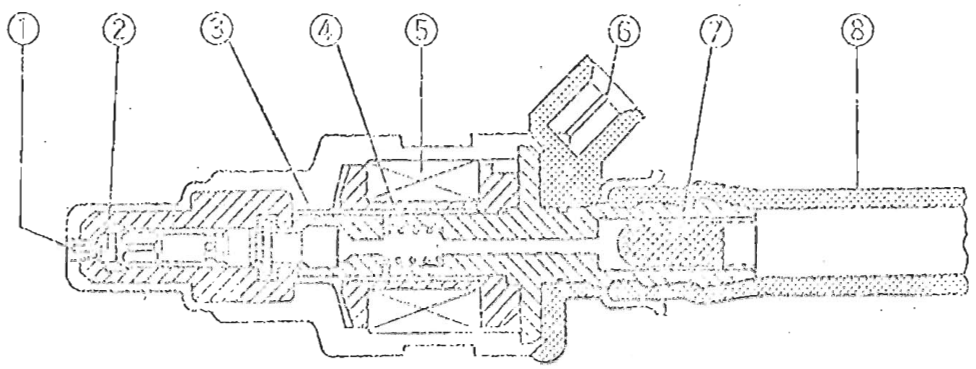
Air temperature compensation: The air density depends also on the air temperature. The change in air density caused by change in air temperature is compensated for by monitoring the intake air temperature.

Air Temperature Compensation



Injectors

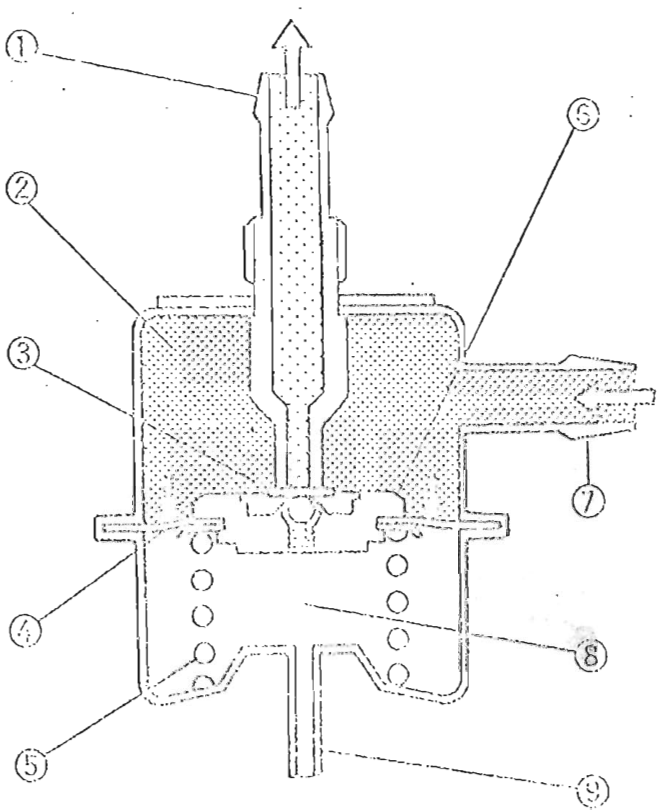
The injectors are of a solenoid-operated-valve type, and inject the fuel when the solenoid is energized. Both valve opening time and fuel pressure influence the amount of injected fuel. Fine atomization of the fuel charge is achieved through the design of the injector nozzle. The result from the injector is a very homogenous fuel/air mixture which promotes even burning and more complete combustion. Fuel injection occurs once very 360° of crankshaft rotation, which means that the injectors inject fuel twice for each cylinder combustion cycle. In other words one fuel injection supplies 50% of fuel required for one complete combustion cycle.



1. Nozzle
2. Valve
3. Core
4. Spring
5. Solenoid
6. Electric Terminal
7. Filter
8. Fuel Hose

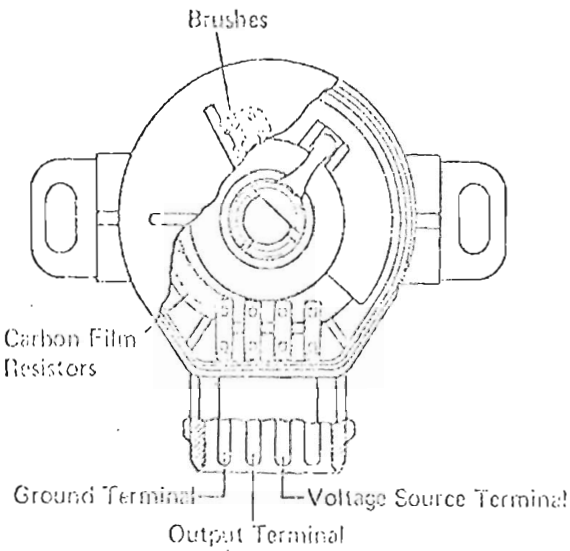
Pressure Regulator

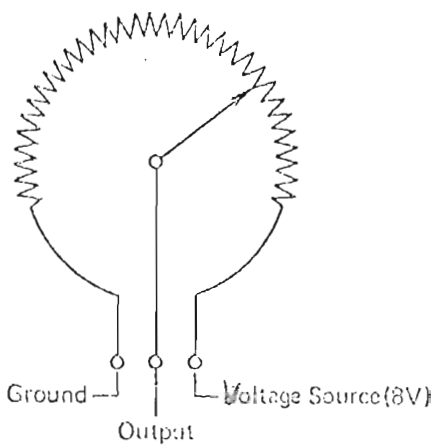
The overflow-type pressure regulator keeps the pressure difference between the fuel line and the intake manifold constant (2.55 kilograms per square centimeter). Therefore, the amount of fuel injected from the injectors is controlled by changing the valve opening time of injectors.



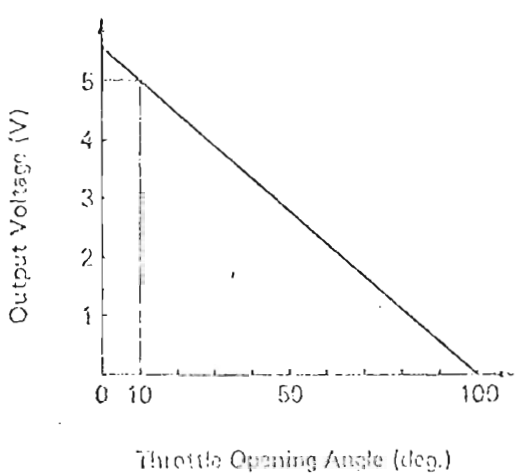
1. Outlet
2. Fuel Chamber
3. Valve
4. Diaphragm
5. Spring
6. Valve Support
7. Inlet
8. Spring Chamber
9. Vacuum Hose Connection

THROTTLE SENSOR





Throttle Sensor Output



Control Unit

Control Unit Internal Circuit

The control unit consists of the major circuits shown

Function of Each Circuit

Power supply circuit: The battery voltage changes as the electrical loads change and the battery charge condition changes. The power supply circuit changes the electric current from the battery to stable 5-volt and 8-volt currents, and supplies either of the currents to each circuit.

Wave shape circuit: Engine speed signals sent from the ignition coils contain various noises in them. The wave shape circuit removes these noises from signals, and change the shape of signals into a rectangle.

Analog-to-digital (A/D) converter; The A/D converter translates continuous analog signals into proportional discrete digital signals.

Micro computer: The micro computer is a brain of the DFI system, and has following two control functions—

- To determine the amount of fuel injected from the injectors.

All informations that show the engine running conditions are sent to the micro computer. The computer processes synthetically these informations according to the programs stored in the memory, and calculates an optimum amount of fuel to be injected for the engine condition at the time.

- To control fuel pump operation.

The computer controls the pump operation through the pump relay so that it works only under the following conditions:

(1) For about 5 seconds after the ignition switch is turned on.

(2) When the starter motor is in use.

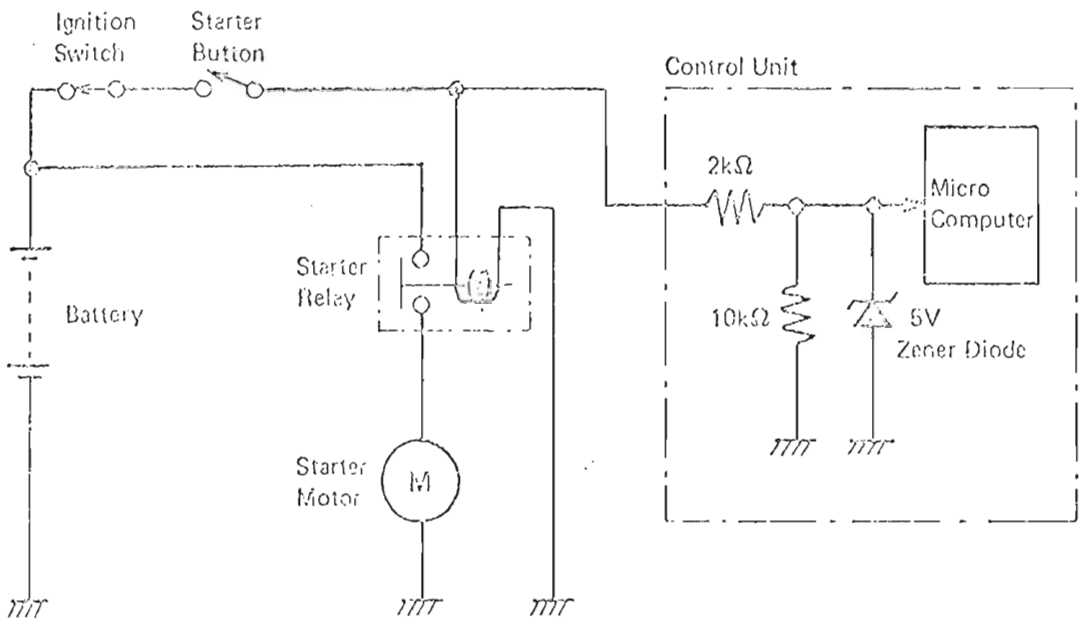
(3) When the engine is running.

Injector driver circuit: The injector driver circuit supplies injector opening pulses to the injectors at the computer command.

Pump relay driver circuit: The pump relay driver circuit supplies pump relay driving current to the relay to control pump operation.

Starter button: The voltage of the starter-relay positive lead jumps up to the battery voltage when the starter button is pushed on to crank over the engine. This voltage becomes start signal.

Start Signal Circuit

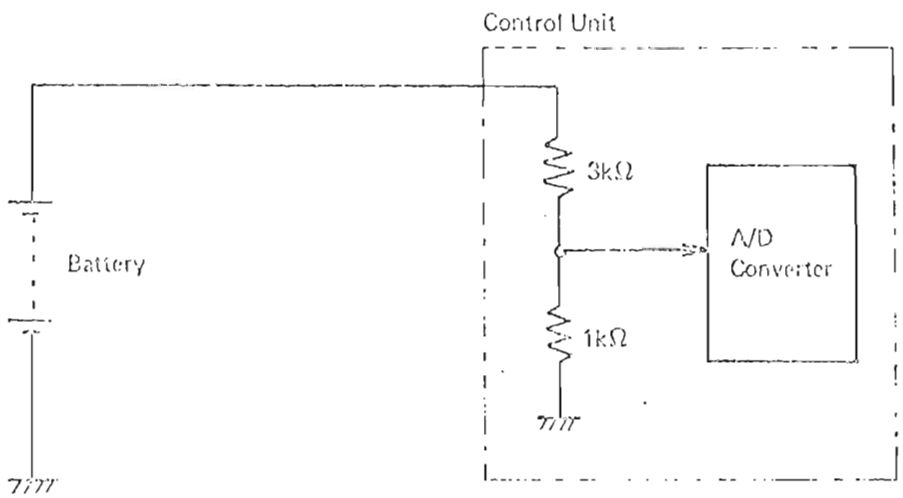


Ignition switch: When the ignition switch is turned on, the battery power reaches the power supply terminal in the control unit. This power surge becomes ignition-on signal.

Air temperature sensor: The air temperature sensor is installed on the air duct between the air cleaner housing and the surge tank. Its appearance differs from that of the engine temperature sensor, but the senser resistance and the sensor circuit are the same as that of the engine temperature sensor.

Battery voltage pickup: The battery voltage is picked up at the battery positive lead.

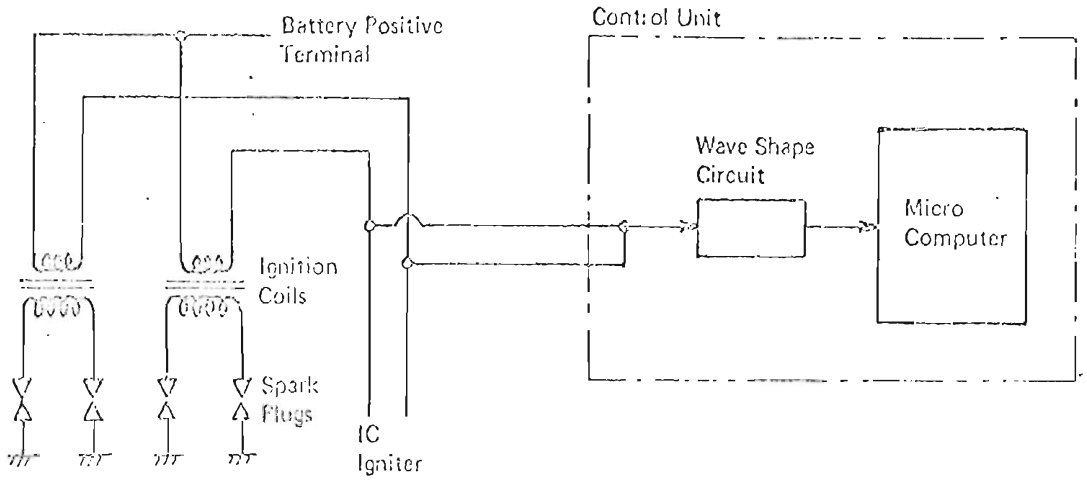
Battery Voltage Pickup Circuit



Atmospheric pressure sensor: The atmospheric pressure sensor is built in the control unit and is invisible from the outside. A semiconductor pressure sensor coverts exerted pressure into the electric signal. The output voltage of the sensor is sent to the A/D (analog-to-digital) converter after amplified.

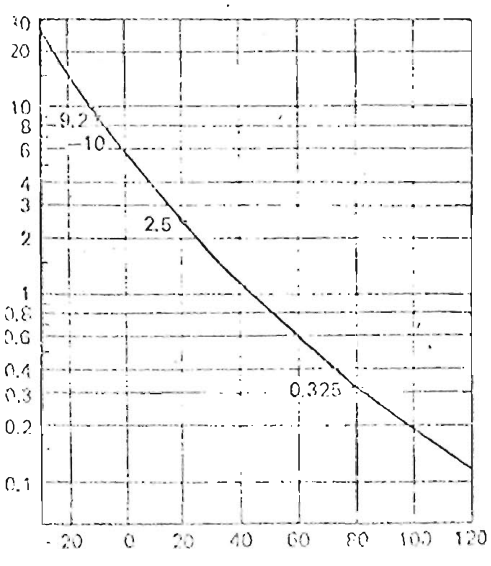
Engine speed pickup: Engine speed is picked up at the ground sides of the primary windings of the ignition coils. Two pulses per crankshaft revolution are sent to the control unit.

Engine Speed Pickup Circuit

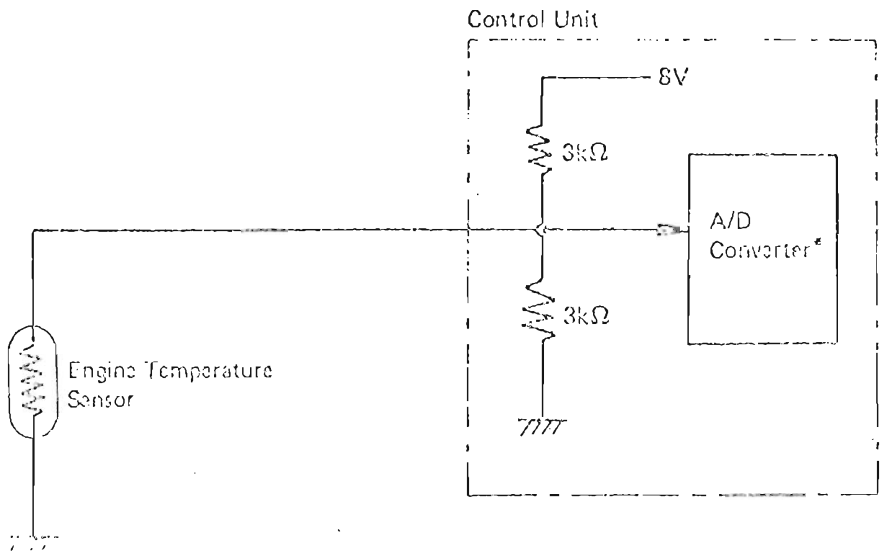


Engine temperature sensor: The engine temperature sensor is installed on the cylinder head. The electrical resistance of the thermistor in the sensor decreases as the temperature increases.

Engine Temperature Sensor Resistance



Engine Temperature Sensor Circuit



*Analog-to-digital converter

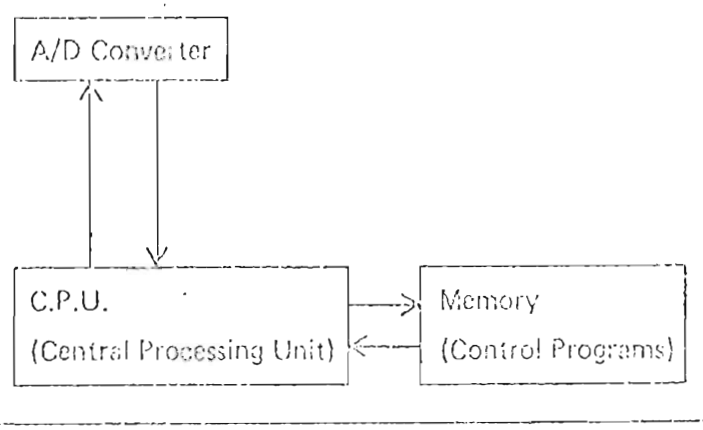
Control Unit Inputs and Outputs

SENSORS (Input Signals)

1. Ignition Coil (Engine speed)
2. Throttle Sensor (Throttle opening angle)
3. Starter Button (Starter signal)
4. Ignition Switch (Ignition ON signal)
5. Engine Temperature Sensor (Engine temperature)
6. Air Temperature Sensor (Air temperature)
7. Atmospheric Pressure Sensor (Atmospheric pressure)
8. Battery Positive Lead (Battery voltage)

Input

CONTROL UNIT



Ourput

ACTUATERS (Controled Items)

1. Injecters (Injected Amount of Fuel)
2. Fuel Pump (Operation- run or stop)

FUEL INJECTION.

i. L. Jetronic. (Bosch) Z1000 H1 First bike 1980
Z 1100 B1.

ii D.F.I. Digital fuel Injection Z1100 B2
2x1100 A1/2/3.
2x750 E1/2.
ZG 1300 A1/2.

MERITS.

i Quick response
ii Fuel consumption low.
iii Good engine response.
iv Easy starting.
v Stable idling
vi Fewer emissions.

Electrical Input signals + Fuel pressure + Time duration = Mixture.

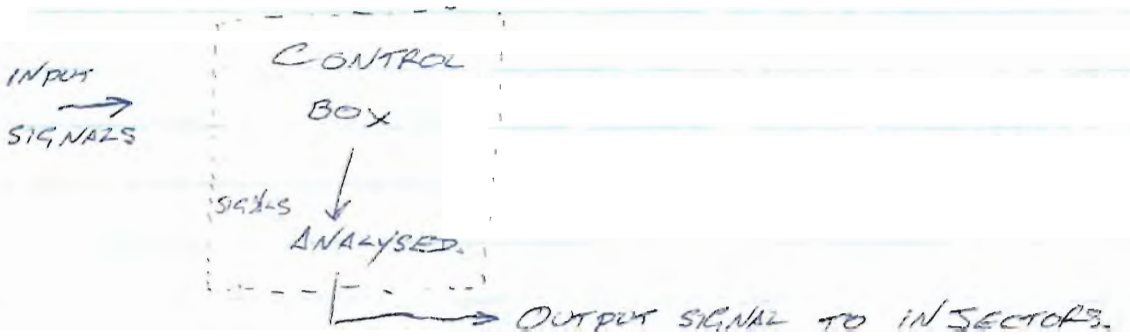
L. System. (Analogue Signals)

Input Signals

i Engine temperature. 2.0-3.0 KΩ @ 20°c
ii Engine Speed. Primary circuit (H.T. coil)
iii Throttle position Idle or full open.
iv Air temperature 2.0 - 3.0 KΩ.
v Air flow meter. Potentiometer. 8v → 1v idle full open.
vi Start signal. Starts fuel pump.

} To CONTROL BOX →

All the input signals go to the control box.



FUEL SYSTEM.

Tank.
Filter
Pump.
Pressure regulator.
Injector.

AIR SYSTEM.

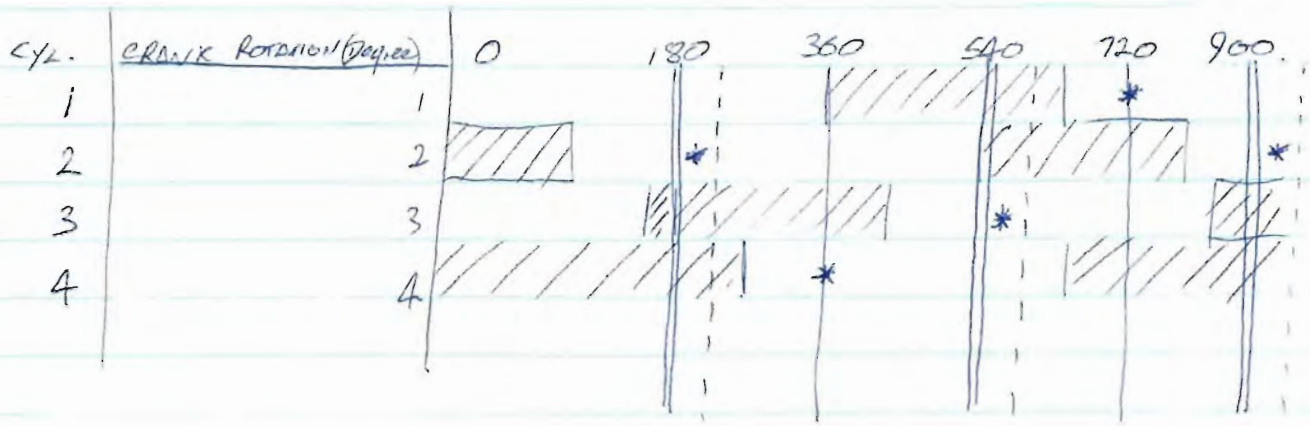
Air filter
Flow meter
Surge tank.

Tank → Pump Low pressure.
Pump → Injector → regulator high.
Regulator → tank low pressure.

TANK:- Gravity feed with a check valve. (½ full. No additives, No foreign matter)
FILTER:- Paper element. change every 3000 miles
PUMP:- wet type (immersed in petrol) 2 litres per minute.
PRESSURE REGULATOR:- Engine Vaccum 33 P.S.I. idle
36 P.S.I. full throttle.
INJECTOR:- Solenoid type. moves inwards. Stroke 0.15mm. ≥ 6 milli sec.

Check:-
Fuel Quantity or quality (4 star)
Oil filler plug. Breather hoses. Drain hoses.
Injector O rings.
Blown fuses.
State system works.
Cylinder compression 121 - 188 PSI (<140 psi gives problems)
Service items, valve clearance plugs. Ignition.
Electrical connectors.
External damage.
water in harness.

INJECTOR TIMING.



INLET VALVE DURATION.

INJECTION DURATION.

* SPARK.

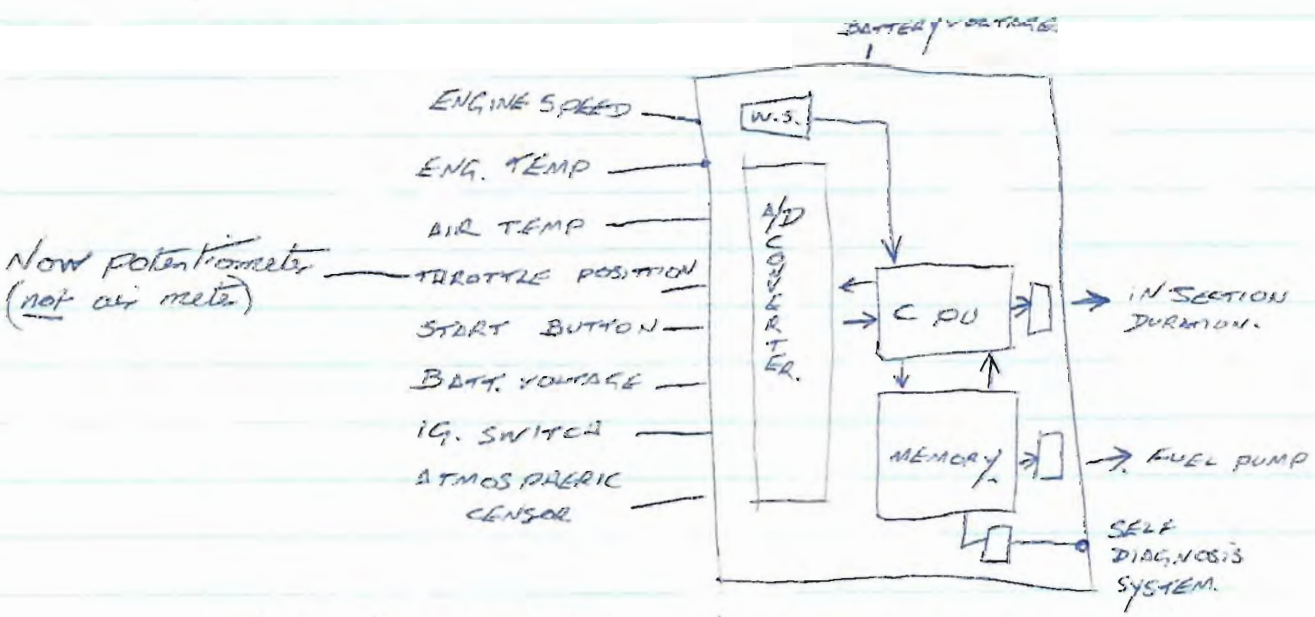
D.F.I. SYSTEM.

Advantages over E. Jectronic system:-

i Smoother throttle response

ii Reduced intake resistance.

iii Simplified configuration.



A/D CONVERTER = ANALOGUE/DIGITAL CONVERTER

W.S. = WAVE SHAPE CIRCUIT (~~)

C.P.U = Central processing unit.

Every 1-3 milli sec. DFI unit checks:- Throttle position 96 times.

Voltage	16 "
Altitude	8 "
Engine temp	4 "
Air temp	2 Times.