Citroën

DS Electronic Injection
Course

1) Introduction:-

-Why Injection? To supply to the engine the exact quantity of fuel it requires in all the different conditions of use. The beet carburettors can only do this at certain points in the load curve, properly designed injection equipment can do it practically all the time.

Why electronic injection? Mechanical and electromechanical systems depend on moving rods and arms and levers, they therefore have a certain delay in their response—time; electronic circuits operate at practically the speed of light and respond without appreciable delay. Our system uses printed circuits, transistors and so on, practically no moving parts therefore very little wear. Furthermore, with this Injection system, the engine is smoother, more flexible, and its power output is increased; it has wore torque at lower speeds, better acceleration, and better fuel consumption, ‘when compared to a carburettor 1)3 driven in the same way, although if you use the extra power available you will burn more petrol. Average improvement 2 mpg.

2) With the introduction of Electronic Fuel Injection, a number of changes occur in the DS2l. EFI:-

SAE bhp :— increased from 115 at 5750 to :139 at 5500 rpm
DIN " :— increased from 106 at 5500 to 125 at 5250 rpm
SAE Torque :- increased from 125.8 ft lbs at 4000 to 144.6 ft lbs at 4000 rpm
DIN " :— increased from 122 ft lbs at 3500 to 135.25 ft lbs at. 2500 rpm

a) Engine:- Bore, stroke and capacity unchanged.

— Compression ratio 9 : 1.
— Piston crown marked "9"
— Oil-cooler added on LH side of crankcase, with air-intake duct in LH brake-disc cooling intake; pressure—relief bypass in cooler-spacer in case of matrix obstruction. Engine oil-pressure warning-light switch fitted to oil-cooler spacer.
— Crankcase:- mounting for oil-cooler (bolts and ring-seals, face to face mounting.)
— second oil-gallery takes oil-pump output direct to cooler, from where it passes up into main oil-gallery.
— Oil-pump same type but outlet modified to deliver oil into additional oil-gallery,
- Crankshaft:- specially treated, dimensionally as DS21 but marked “D.30" on front crank.
— Main bearings:- aluminium-tin.
— Big-end bearings:- Copper-lead.
— Radiator capacity increased to 23 pts; header tank added.
— Flywheel starter ring has 125 teeth, starter pinion 9 teeth.
— Cylinder head:— new fitting of 4 individual inlet elbows.
—Thermal Switch for cold—starting
Injector at rear L H side of cylinder head (between inlet elbows of cylinders nos. 3 & 4.

– Exhaust valves:- hollow; sodium–cooled.
– Valve cover:- Oil filler-neck extended.
– Distributor:- Bosch ref. JF UX4
- C/b gap 0.40mm (0.016”)
– Dwell angle 50° ± **3°**
- Triggering Contacts on shaft for signals to Electronic Injection Control Unit
- (Vacuum unit for USA only).
– Ignition Timing:- Static 8½° BTDC (slot in flywheel,in bell-housing).
– Strobe:- at 1800 rpm, 22° total crankshaft.
– 6¾° distributor (3⅜ graduations).
– Spark Plug :- SEV-Marchal 35B or
- Champion L87Y or
– Bosch W225 T35 or
– AC 42F.
- Gap 0.020" to 0.024".
– Plug-well caps :- New caps with plug-lead guides.
– Air filter :-. New position at RH side of radiator.
– Crankcase gas recycling:- New pipe layout.

b) Clutch:

– Ferodo, diaphragm type, 230 D.DATE; 18 fingers; Linings “755”, 6” X 8 7/8” dia., both faces.
– Clutch mechanism: riveted unit assembly.
- New clutch Fork, Thrust Race and Guide.
– Clutch clearance, 2 turns, as before.

c) Gearbox:

– Gearcase modified, Pressure Regulator now fitted to LH side.
– Gearbox cover :- Oil filler now at front.

d) Hydraulic System:

– Pressure Regulator: moved to LH side of gearbox, due to presence of oil cooler on crankcase. (with practise, pressure–release screw can be reached without moving radiator air-duct.)
– Centrifugal Regulator: bob-weights and levers modified on casing)
– Fast Idling Device. Clutch Re-engagement Control:– positions, shaped differently but operate as before. (Access to CRC through hole in Air Manifold web).

— Clutch Slave Cylinder:— greater diameter, additional return spring.

— Hydraulic Selector:-. New mounting angle.

— Suspension Spheres:- Shock—absorbers secured in tapped necks of spheres by **slotted bush**-nuts (27.5 ft lbs);) ft spheres and shock absorbers not interchangeable with non—injection cars. Pressures unchanged.

— Shockabsorbers. :— Body and discs secured by a central rivet, cannot be dismantled; slightly harder.
— Fitted either way up, i.e. damping is the. same on bump and rebound.
– constant-leak through central hole in rivet.
– Front:- visible additional damper discs under rivet heads.
- square edge to hole in rivet.
— Rear :- no additional damper discs,.
- counterbore on central hole (both sides)

– Fluid Flow:- From pressure-Regulator direct to front Brake Sphere, then to Priority Valve and other circuits.

– Ft. Brake Sphere:
— 5 pipe-attachments instead of two (added direct feed).

– Piping :— Numerous changes due to new positions of units.

e) Other changes.

— Petrol Tank:
— outlet filter eliminated.
— additional connection for return from fuel injection system.

– Tyres – 185 HR 380 XAS, front, rear and spare, for all markets.
— Fronts 29 psi; Rear 26 psi.

– Heights :— Front 235 ± 3; Rear 360±5

— Jackstay and Oilcan Carrier:- on board. in spare wheel.

— Basic settings:—

— Slow Idle:—	750 ± 25 rpm
— Clutch Clearance:—	2 turns
– Clutch Drag	925 + 25 rpm
— Fast Idle	1000 + 25 rpm

NOTE:
— Slow Idle Screw is on top of throttle valve housing, facing forwards.
— Fast Idle screw is adjacent to Supplementary Air Control on LH side of engine and faces upwards.
— There is no mixture screw or choke control.

The Slow Idle and Fast Idle adjustments, and adjustment of the Accelerator Cable guide and stop sore~i are the only adjustments which can be made to the Fuel Injection System; one other item, a Switch connected to the throttle spindle, can be adjusted as regards its position, but only with the use of a special Test Unit; all the components of the injection system are non-adjustable internally; if faulty they are simply replaced.

Bosch Electronic Fuel Injection

We have seen that the purpose of the injection system is to ensure the supply of the correct amount of fuel to the engine in all its varying conditions of use, i.e. from cold-starting, through warming-up, acceleration, normal running, full throttle, over-run, and idling conditions, in varying conditions of temperature and altitude.

The injection system is controlled by a device known as the Electronic Control Unit (abbreviated to E.C.U.). This is a box containing several transistorised printed circuits, which receives signals from various sensing devices attached to the engine, which reads and combines these signals, end then sends impulses to the injectors.

None of the units is adjustable; if faulty they are replaced. They are tested (except the ECU) by a Bosch Tester,EFAW 228.

There are two supply channels to the engine, one for air and one for fuel.

AIR CIRCUIT. (Illustration 1)

Air enters the air filter, to the right of the engine, passes through a. flexible hose to a metal housing in which is a single throttle-valve (butterfly) operated by a cam and a. cable from the accelerator pedal. From the throttle housing extend 4 air-tubes of equal length, this assembly is the Air Inlet Manifold. The four ends of the manifold pipes are connected by short hoses to Inlet Elbows secured to the cylinder head.

Adjustment of Idling:- screw adjustment affects airflow only, (there is no mixture screw); the idling-air channel bypasses the throttle-valve, in the throttle valve housing. (Screw facing forwards).

The Fast Idle on cars with hydraulic gearchange:- another air-channel bypasses the Supplementary Air Control (the S.A.C. at the lower LH side of engine, provides the necessary air supply during the warming-up period).

FUEL CIRCUIT. (Illustration 2)

From the Tank, (1), fuel is drawn through a paper Fuel Filter (2), fitted in the fuel line (change every 12000 miles) by the Electric Fuel Pump(3); the filter and pump are under the RH body sidemember.

The pump sends fuel along the supply line to the engine, and the fuel pressure is regulated to 28.5 psi (2 kg/cm^2) by a Fuel—Pressure Regulator (4) fitted to the LH side of the cylinder head. The output of the Pump is considerably more than the engine requires, and the surplus passes through the Fuel-Pressure Regulator and returns to the tank; this ring-main system minimises the chance of vapour-locking.

From the pressurised fuel line are four branches, each connected to one Injector (5) for each of the four cylinders, another branch is connected to the Cold Starting Injector (16) fitted in the throttle—valve housing.

The injectors all have spring-loaded needle-valves which are opened by solenoids; they have constant lift and the fuel is supplied under constant pressure, so that the amount of fuel expelled depends only on the period of time during which the injectors are open.

The four main injectors inject behind the inlet valves (17)(port injection); They are opened by pulses supplied by the Electronic Control Unit. They open in two pairs, i.e. two at a time; Nos 1 and ***3*** inject together, when No.1 is on the inlet stroke **t**he fuel. mixture enters directly at this time piston No.3 is on the exhaust stroke and the fuel mixture waits behind No.3 inlet valve until it opens. Similarly, Nos 2 and 4 inject simultaneously. This is done to simplify the electronic circuits in the ECU., and has no adverse effect on. performance. (Ill.4) The Cold Starting Injector. (16) in the throttle-valve housing is energised by a Relay (Impulse Relay) , while the starter motor is in use, and provided that the engine-coolant temperature is less than 20°C — 30°C, allowing the Thermal Switch to close; above this temperature the cold—start injector does not operate. The Thermal Switch incorporates a device to limit operation of the Cold Starting Injector, to avoid flooding the engine if the Starter motor is used persistently.

OPERATION OF INJECTION SYSTEM (Illustration 3)

The ECU has to sense the needs of the engine, it does this by receiving signals which indicate:— 1) The absolute pressure in the Inlet Manifold (this is the air pressure compared to a vacuum); a Pressure Sensor (6) supplies this information, being connected by a hose to the Inlet Manifold (union housing marked "S") downstream from the throttle-valve; this pressure varies with the throttle opening.

2) The speed of the engine; Triggering Contacts on the shaft of the Ignition Distributor (7) supply this information.

The ECU receives these signals, passes them through its internal circuits, creates and sends pulses to the Injectors (5) which cause them to open for **a** certain time; the quantity of fuel injected depends on the width, (that is the duration) of the pulse supplied to the injector by the E.C.U.

On cars with hydraulic gearchange a Fast Idle Air Channel bypasses the Supplementary Air Control (13); the air volume is adjusted by the Fast Idle Screw, and cut off by the Fast Idle Device (17).

Apart from normal running, different mixture strengths are required at different times and for different conditions. It is also necessary to introduce compensation for variations of battery voltage, otherwise injection times would vary and the mixture would be incorrect.

These various requirements are met by a series of circuits in the ECU which correct the pulse—width in accordance with the signals received, cut off the pulses when the accelerator pedal is released, restart pulses when the engine speed is below 1100 rpm, and so on.

The ECU, by the triggering impulses from the distributor, senses the engine speed and controls the operation of the Fuel Pump accordingly.

When the engine is being started, or is idling, it has only its own internal friction to overcome; but this friction varies with temperature, and the colder the engine, the more fuel and air it will need to run; a Thermal Switch allows the Cold Starting Injector to inject fuel; the Thermal Sensor & the Supplementary Air Control maintain the required balance of fuel and air as the engine warms up.

An Intake Air Temperature Sensor, fitted from April 1971, supplies a signal from which the ECU corrects the fuel supply to correspond to the mass of the intake air.

Sequence of operation from cold—starting (temperature below 68° F):—

— Switch on ignition; General Feed Relay energised, injection system can operate, ECU energised. Fuel pump Relay energises Fuel Pump, operates for 1 second (timed by ECU).
  — Thermal Switch is cold, therefore switch is closed, and Cold Starting Injector can function, (Injection duration limited according to temperature).
  — "Throttle~shut" switch in Throttle Spindle Switch is closed.
  — Thermal Sensor is cold, so it signals ECU to supply a rich mixture,
  — Supplementary Air Control is cold, so air port is open, to balance additional fuel.
  — Full-Load Switch is closed.
  — Operate Starter Motor
— Impulse - Relay for Cold-Starting Injector energised, Cold-starting Injector injects;
  - When engine speed exceeds 100 rpm, ECU switches fuel pump on, sensing engine speed from signals from Triggering Contacts on Distributor.
  — ECU supplies pulses to injectors which inject fuel. Pulses are started by signals from 1 triggering contact, & stopped by responses frog Pressure Sensor.
  — engine starts to run.
  — Full-Load Switch opens.
— Release Starter Motor Control:- Cold starting injection ceases.
— Engine running:- Pressure Sensor senses change of inlet manifold pressure due to Supplementary Air, signals ECU to adjust injection pulse width accordingly.
— Engine warms up:- Thermal Sensor signals ECU to reduce fuel supply, until at 70°C quantity is normal, and
  — Supplementary Air Control reduces supplementary sir until at 70°C quantity is normal, and
  — Pressure Sensor senses change in air manifold pressure and signals ECU to correct its pulses.
— Acceleration:— When throttle valve opens, Pressure Sensor senses rise in inlet ~ pressure and signals ECU to increase supply of fuel, but this signal, due to. delay in air movement in hose and capsules, arrives too late for instant response. The Throttle Spindle Switch sends additional impulses to the Switching circuit and to the pulse—correction circuit in the ECU, which in turn supplies additional pulses to the injectors. The circuits are so arranged that these additional pulses cease when the signals from the Pressure Sensor take effect; the more quickly the throttle is opened, the more rapid the additional pulses (Note:— when the throttle is being closed, a switch in the Throttle Spindle Switch opens and no additional pulses are supplied). If a clogged air-filter reduces airflow the Pressure Sensor senses the lower pressure and signals the ECU to reduce the fuel supply.

- Full Load requirement:- when the throttle valve is more than 2/3 open the difference between atmospheric pressure and inlet manifold pressure causes the Full Load Switch to close, signalling the ECU to supply more fuel. Use of pressure—differential compensates for changes of altitude.

— Fuel cutoff on overrun (engine—braking):-
When the accelerator pedal is released completely and the throttle shuts, the “Throttle—Shut” switch in the Throttle Spindle Switch closes and signals the ECU to cut off the supply of pulses altogether to minimise atmospheric pollution end to avoid wasting fuel; this it does until it learns from the distributor triggering contacts that the engine speed has fallen to 1100 rpm,

, or below, when it starts injection again to ensure that the engine will idle. If, for example on a slope, the car then starts to gain speed again, the ECU will cut off the fuel supply again, but not until the engine speed has reached 1800 rpm; these two different speeds are chosen so as to avoid intermittent power-on and power-off conditions which would occur if the car's speed were such as to make the engine run at slightly above & below 1100 rpm.

GENERAL NOTES.

1) As long as the Injection System is in use, the fuel—pressure is regulated to 28.5 psi by the Fuel. Pressure Regulator.

2) The output from the Fuel Pump is considerably greater than the maximum consumption of the engine, therefore once the Fuel Supply Pressure has reached its level of 28.5 psi, fuel is constantly being returned to the tank. With the engine idling, the operation of the Fuel-Pressure Regulator can be heard distinctly.

3) When the installation of electronic injection is being developed for a given engine, numerous tests are carried out to obtain maximum power and minimum consumption in all various operating conditions which can arise. The circuits of the Electronic Control Units used for development work have adjustable settings, and when optimum results have been achieved these settings are built into the Electronic Control Units for production use. In addition to running conditions, account is taken of the various legal requirements on atmospheric pollution.

4) The results of fitting this system are appreciable:—

   a) With the exact metering of fuel to each cylinder the engine runs more smoothly.

   b) The engine can be driven in all gears from idling speed on; maximum torque is at 2500 rpm, you can drive in a high gear at low speed, although of course, acceleration is limited by the gear ratio in use;

   c) Even from cold the engine pulls smoothly.

   d) Fuel economy:— typical comparisons between a carburetted DS 21 and. a DS 21 Injection, both driven in the same way:-

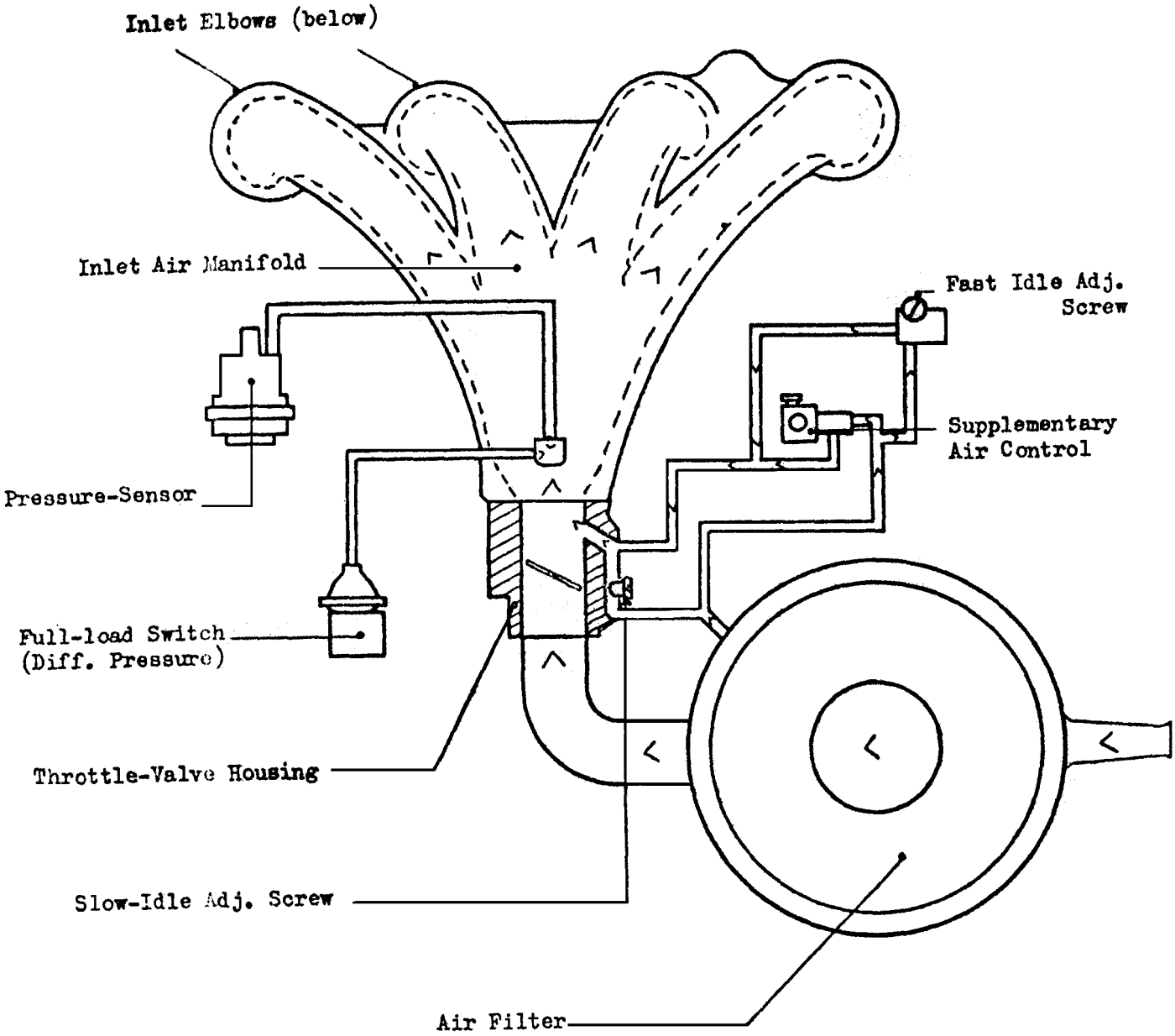
	Standard.	Injection.
- DIN Consumption, average 68.35 mph	25.06 mpg	27.21 mpg
- Touring with 2 people and 1 cwt of luggage:		
– Average 55.9 mph	23.85 mpg	24.47 mpg
- Average 46.6 mph	28.25 mpg	30.37 mpg

   — But of course, if you use the extra power available, you burn more fuel.

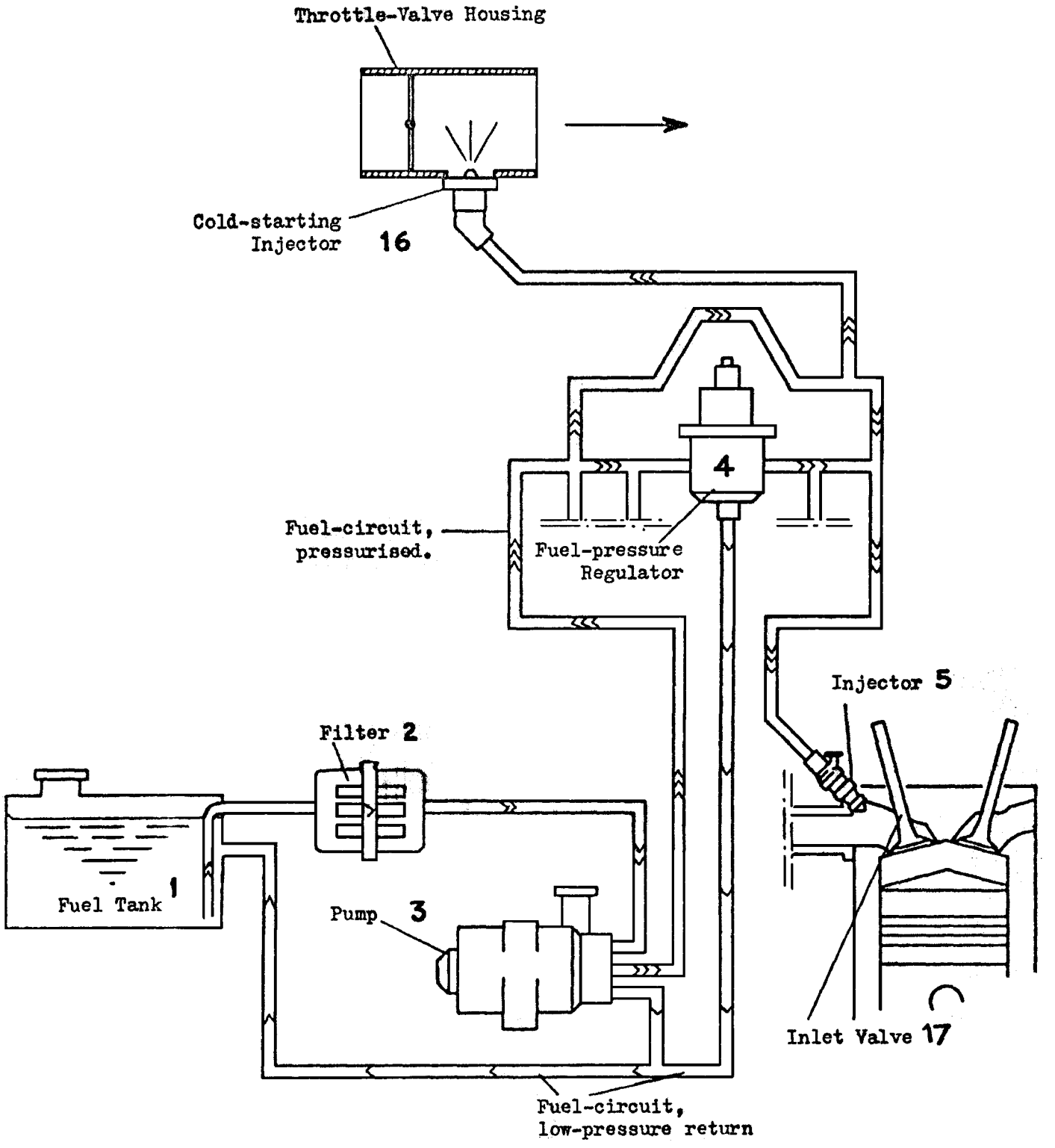
   e) Acceleration:—
      Typical acceleration times are:-

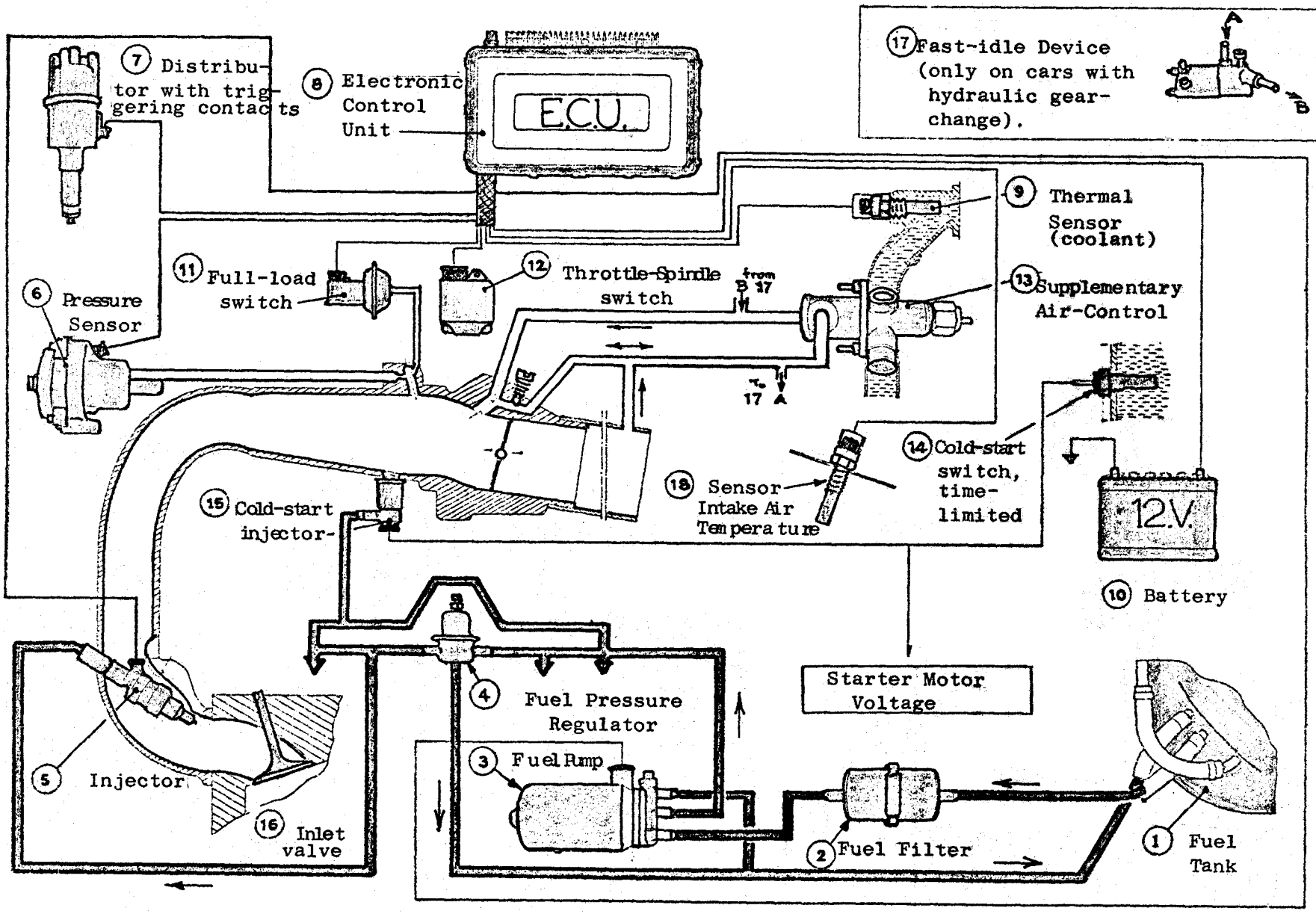
      0-50 mph:— 8.4 secs.
      0—60 mph:— 12.0 secs.

AIR CIRCUIT


Inlet Elbows (below)
Inlet Air Manifold
Fast Idle Adj. Screw
Supplementary Air Control
Pressure-Sensor
Full-load Switch (Diff. Pressure)
Throttle-Valve Housing
Slow-Idle Adj. Screw
Air Filter

FUEL CIRCUIT.





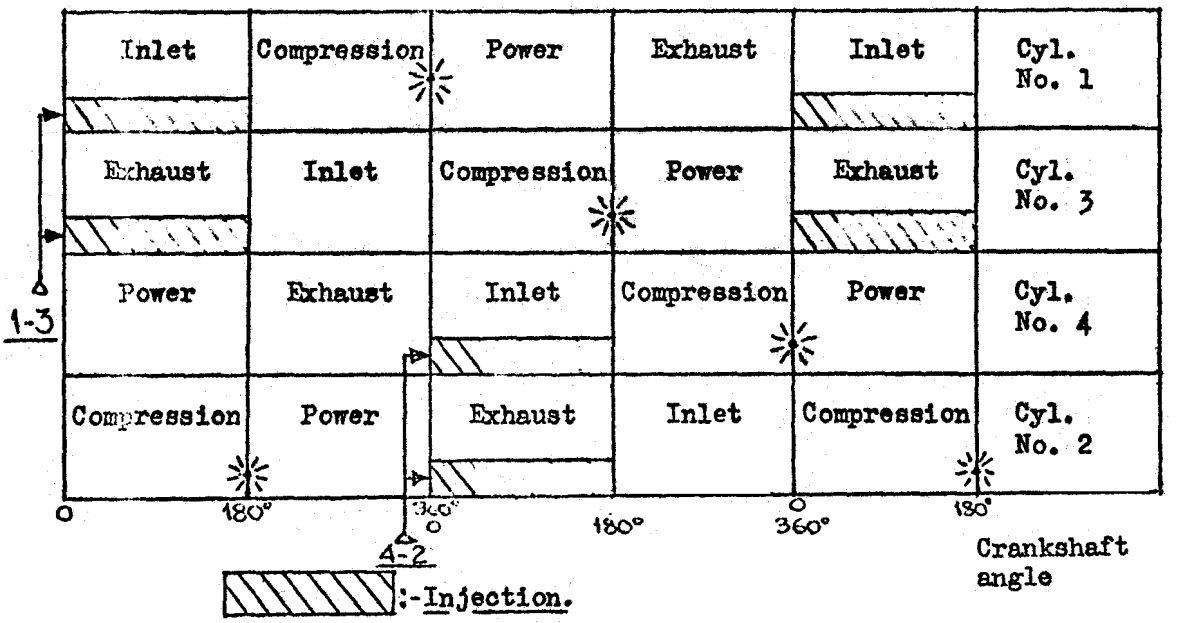
Item 18 introduced 4/71.

ELECTRONIC FUEL - INJECTION.

III.3.

INJECTION & FIRING ORDER

Firing Order: 1 - 3 - 4 - 2



To simplify the Electronic Control Unit circuits, pulses are supplied to two injectors at a time. Injectors I and 3 deliver simultaneously, injectors 4 and 2 deliver simultaneously. When injectors I and 3 deliver, piston no. I is on the inlet stroke, with the Inlet Valve open, piston no. 3 is on the exhaust stroke with the Inlet Valve closed. The mixture passes straight into cylinder no. I, whereas the mixture for no. 3 waits behind the no. 3 Inlet Valve until it opens on the next (inlet) stroke of the piston. Injection for nos. 4 and 2 operates in a similar manner.