Chapter 1

COMBINED CONTROL UNIT, TYPE C.C.U.16 SERIES

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LIST OF ILLUSTRATIONS

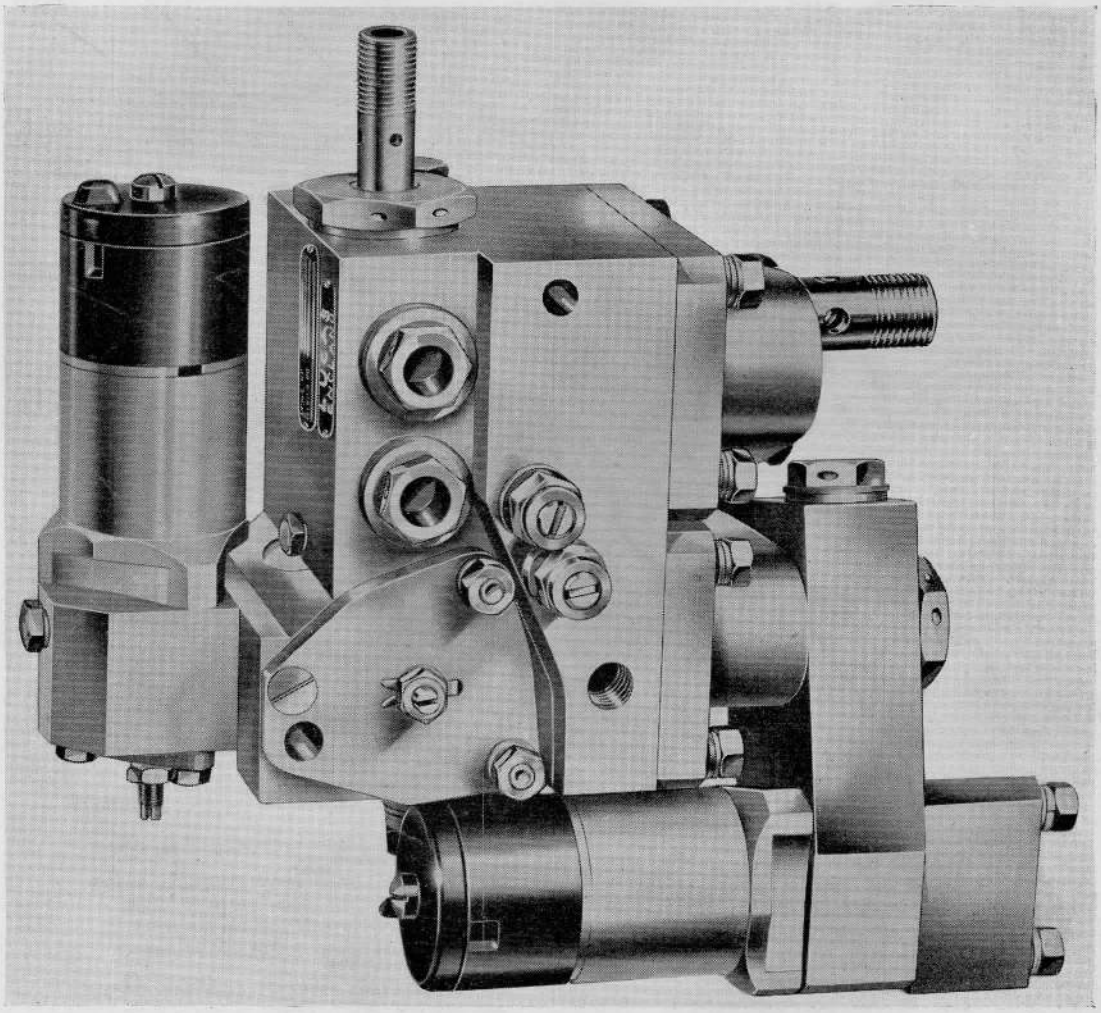


Fig. 1. View on face of control unit

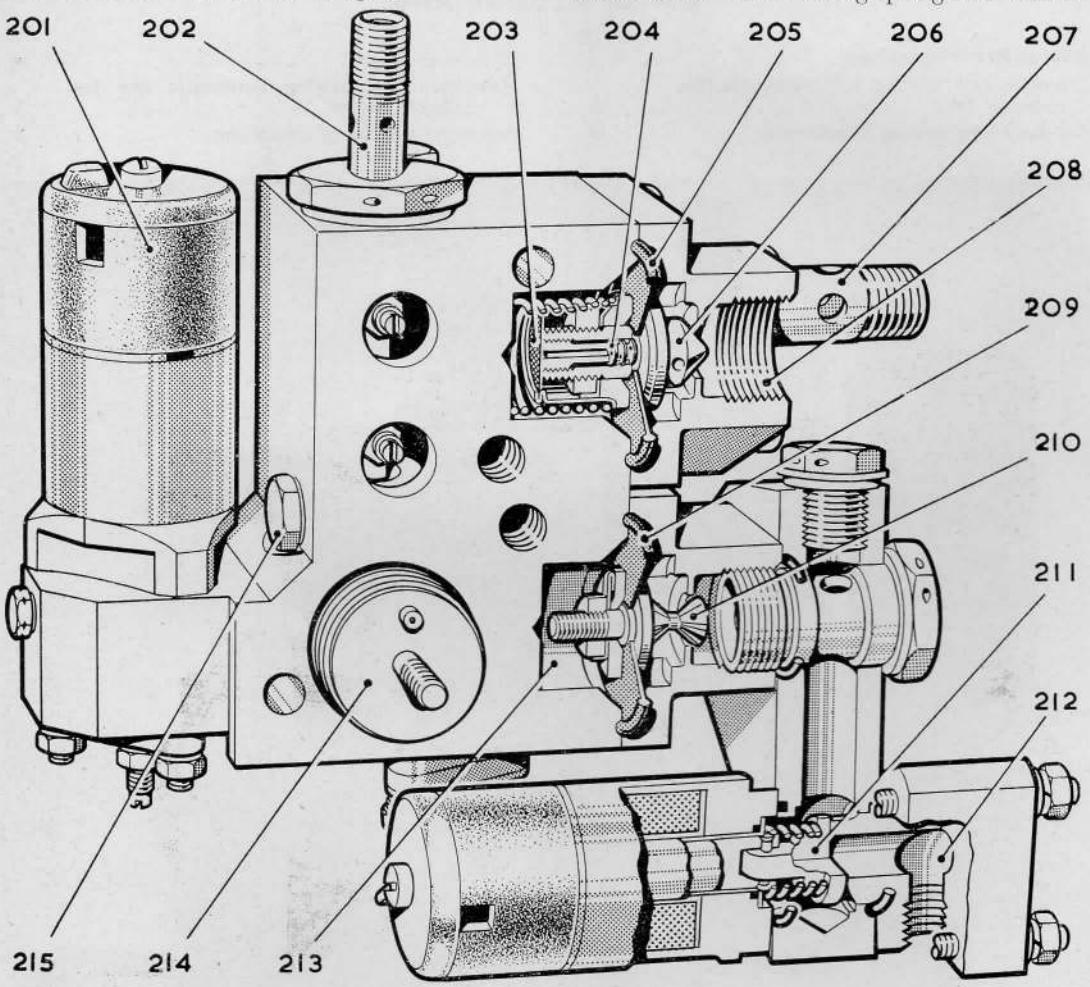
General

1. The combined control unit is designed to contain within one casing a throttle valve, high pressure shut-off cock, a spill valve for the control of pump output, a barometric pressure control and a flow control valve servo operated by a mechanical governor for maximum speed limitation. In the following description the annotation numbers are given in three figures; the first of these indicates the illustration number and the two remaining figures the item number to which reference is being made, so that 616 for example indicates item 16 of fig. 6.

Pump delivery spill valve

2. The spill valve controls the quantity of fuel delivered to the throttle valve by spilling unwanted fuel and returning it to pump inlet.

3. Pump delivery fuel entering the control unit inlet connection passes directly to the spill valve chamber (616), pressure-raising valve (620) and torch igniter feed (603). The spill valve is attached to a diaphragm (205) which divides the chamber into two sections, the lower containing the valve (206) and spill orifice whilst the other, above the diaphragm, contains the valve loading spring and strainer



201 TORCH IGNITER SOLENOID VALVE
202 SERVO SPILL TO PUMP INLET
203 SPILL VALVE SERVO FUEL STRAINER
204 SPILL VALVE SERVO MAKE-UP ORIFICE
205 SPILL VALVE CONTROL DIAPHRAGM
206 PUMP DELIVERY SPILL VALVE
207 PUMP DELIVERY CONNECTION
208 SPILL VALVE RETURN TO PUMP INLET
209 MAXIMUM SPEED FLOW-CONTROL VALVE DIAPHRAGM
210 MAXIMUM SPEED FLOW-CONTROL VALVE
211 SOLENOID-OPERATED SHUT-OFF COCK
212 OUTLET CONNECTION TO BURNERS
213 MAXIMUM SPEED FLOW VALVE SERVO CHAMBER
214 BAROMETRIC PRESSURE CONTROL CAPSULE
215 ROCKE LEVE HINGE PLUG

Fig. 2. Cut-away view showing spill valve and flow control valve

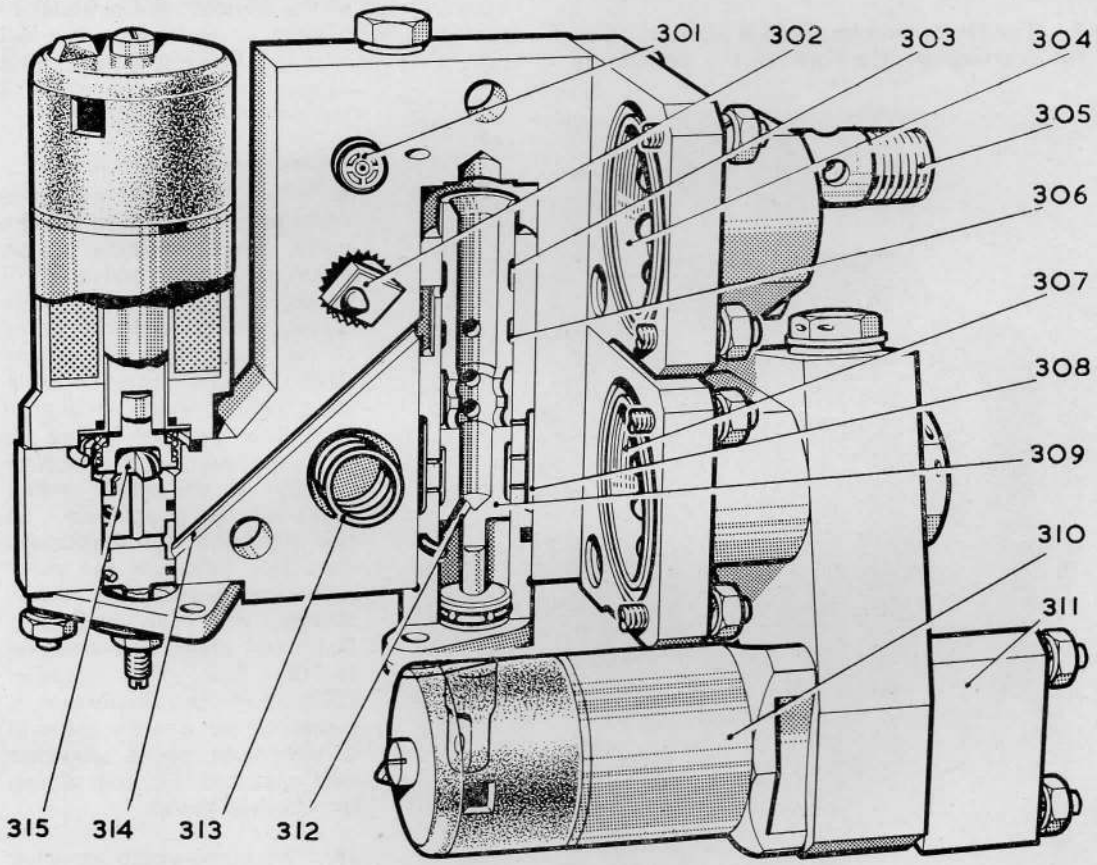
(203) and forms the servo fuel pressure chamber. This servo fuel pressure is supplied through a restricting orifice (204) in the valve bore and provides a pressure balance across the diaphragm so that normally the valve rests on its seat and closes the spill aperture. The valve will not lift off its seat unless a pressure differential is produced across the diaphragm (205) by the opening of a servo control valve (501) in the fuel pressure control unit described in para. 12.

Pressure-raising valve

4. Pump delivery fuel is led to a pressure-raising valve (620), the function of which is to seal the flow to the throttle valve until the pump delivery pressure has risen sufficiently to provide the spill valve control pressure and an adequate torch igniter pressure. The valve consists of a simple conical-ended plunger working in the bore of the inlet connection banjo pillar (207); drillings in the conical portion above the seat communicating with the plunger bore, together with flats on the side of the plunger, permit fuel to pass to the throttle valve when the plunger lifts off its seat under the influence of fuel pressure. A loading spring in the plunger bore holds the valve on its seat until the required pressure is attained.

Throttle valve

5. The throttle valve is of the proportional flow type consisting of a metering plunger



301 SPILL VALVE SERVO CONTROL VALVE ORIFICE
302 FUEL PRESSURE CONTROL PISTON
303 TORCH IGNITER FEED PASSAGE
304 PUMP DELIVERY SPILL VALVE CHAMBER
305 PUMP DELIVERY CONNECTION
306 IDLING FLOW PASSAGE
307 MAXIMUM SPEED FLOW-CONTROL VALVE CHAMBER
308 PROPORTIONAL FLOW DRILLINGS
309 THROTTLE VALVE PLUNGER
310 SHUT-OFF COCK SOLENOID
311 FUEL DELIVERY CONNECTION TO BURNERS
312 THROTTLE VALVE PRESSURE-BALANCE DRILLING
313 CAPSULE TRIMMING SPRING
314 TORCH IGNITER FEED
315 TORCH IGNITER SOLENOID VALVE

Fig. 3. Cut-away view showing throttle valve

(309) working linearly to uncover progressively a series of holes drilled in the sleeve (308). Fuel from the pressure-raising valve enters the bore of the plunger (604) and is transferred to the sleeve passages by radial drillings (605) in the plunger wall. These drillings, of which there are three rows, are connected on the outside of the plunger by two annuli; one midway along the plunger connects one set of crossholes and the other (615), adjacent to the metering edge connects two adjacent series of holes.

6. From the single set of holes, the annulus (306) and (606) transfers fuel to a drilling communicating with an idling flow restricting orifice (608), the orifice outlet leading to the main outlet to the burners and providing the flow required for engine starting and idling speed.

7. The larger annulus (615) is blanked off in the starting position but as the plunger is moved linearly the metering edge (609) of the plunger progressively uncovers a series of staggered radial drillings (611) in the plunger sleeve; these drillings provide the main flow orifices. At the same time the annulus connecting the idling flow drillings (606) moves into the undrilled portion of the sleeve and cuts off the idling flow. A machined slot (603) on the outside diameter of the plunger, at the inlet end, connects two drillings in the sleeve when the throttle is in the idling position and this cross-connection permits fuel at pump delivery pressure to pass to the torch igniter solenoid valve (607).

8. A drilling in the end of the plunger bore (614) permits fuel to pass to the end of the throttle valve sleeve and provide a pressure balance to reduce hydraulic loads. The extreme end of the plunger is machined to provide a shaft which projects through a fuel seal in the casing and is fitted with a clevis attachment for connection to an electric actuator.

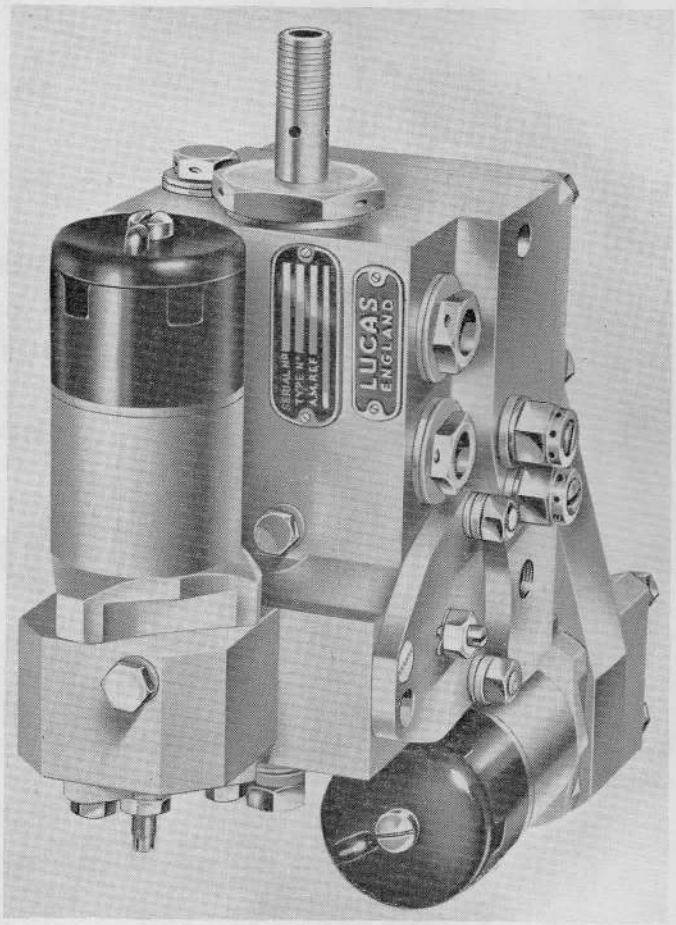


Fig. 4. View on end of unit

Governor servo flow-control valve

9. Fuel from the throttle valve passes to the flow-control valve which consists of an inverted conical valve (210) arranged downstream of its seating orifice and connected to the centre of a diaphragm (209). Under normal conditions the diaphragm is balanced by burner pressure acting on its underside and pressure through a restricting orifice (610) on its upper side. In this condition, the diaphragm does not influence the valve and consequently the valve, moving with the fuel flow, trails and offers no restriction to the flow. The chamber (213) above the diaphragm is connected to a servo valve in a maximum speed governor unit attached to, and driven by, the fuel pump.

10. When the pump governor operates, the servo valve spills fuel from above the flow control valve diaphragm; the resulting reduction in servo pressure will unbalance the diaphragm which will then lift under the influence of the differential pressure and raise

the valve (612) into the orifice to restrict the flow to the burners and so limit the engine speed.

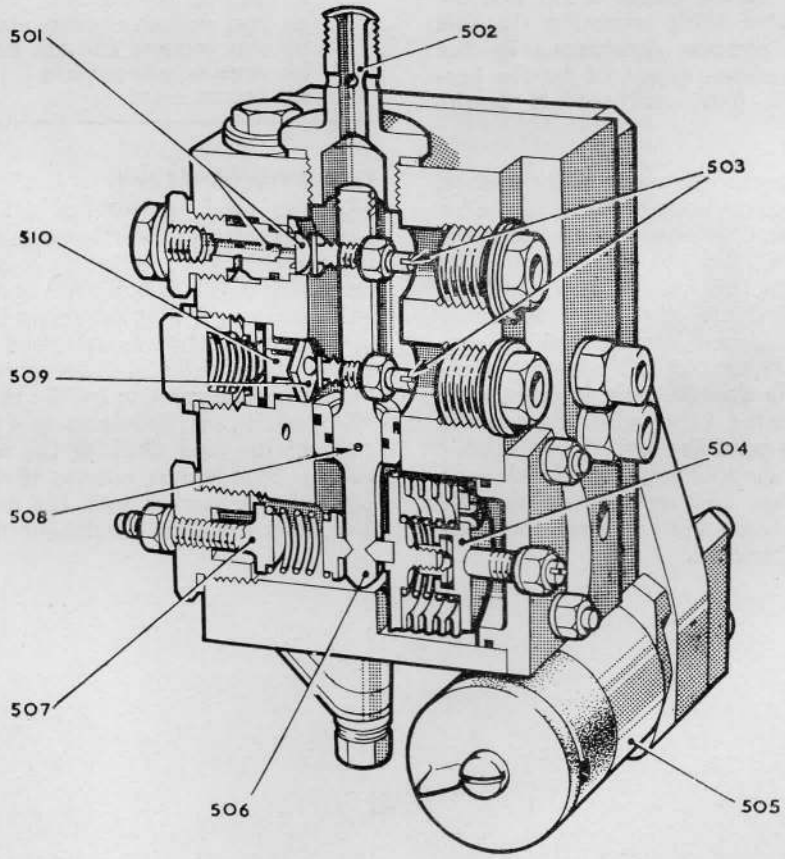
Shut-off cock

11. Fuel leaving the flow control valve passes through a shut-off cock before leaving the control unit and passing to the burner manifolds. The shut-off cock is a solenoid-operated plate valve (211) pinned to the end of the solenoid armature and sealing on an annular seating through which the outlet flow passes. In arranging the valve to close in the direction of flow (613) use is made of the fuel pressure to load the valve hydraulically and ensure positive closure when the solenoid is de-energised.

Fuel pressure control

12. The main spill valve (para. 2) is controlled by a rocker-lever-operated servo valve (501), the balance of the rocker lever (506) being sensitive to changes in fuel pressure at entry to the throttle valve and to changes in barometric pressure.

13. Fuel at throttle valve inlet pressure is led to the underside of a control piston (619) which operates to deflect the rocker lever (621) and open or close a servo valve (617) in the end of the lever. This valve controls the pressure in the pump delivery spill valve (616) servo chamber and so controls the spill to pump inlet and therefore fuel delivery. The rocker lever is balanced by a barometric



501 SERVO VALVE CONTROLLING PUMP DELIVERY SPILL VALVE
502 RETURN TO PUMP INLET
503 ADJUSTING SCREWS
504 BAROMETRIC CAPSULE ASSEMBLY
505 SOLENOID OPERATED SHUT-OFF COCK
506 ROCKER LEVER
507 CAPSULE TRIMMING SPRING ADJUSTMENT
508 ROCKER LEVER HINGE
509 FUEL PRESSURE CONTROL RATIO ADJUSTMENT
510 FUEL PRESSURE CONTROL PISTON

Fig. 5. Cut-away view showing barometric and fuel pressure control

capsule (601) so that fuel delivery is trimmed constantly to suit the barometric conditions.

14. The barometric trim factor is being superimposed constantly on the fuel pressure factor by relating the fuel line pressure "p" to the total pressure P1 by the equation:—

$$p = AP1 + B$$

where A is a constant equal to the ratio of the capsule to control piston diaphragm area and B is the residual spring loading of the system.

15. The correct functioning of the system is, therefore, dependent upon the relationship of p and P1 and at moderate altitudes a sufficiently good compromise can be obtained to ensure a satisfactory degree of control.

16. In operation the system is in equilibrium with the half-ball (617), in the rocker lever, slightly off its seating on the orifice and the pump spill valve (616) trimming the fuel delivery to a pressure determined by the ambient air pressure, as sensed by the barometric capsule (601) and applied to the rocker lever.

17. Should the throttle valve inlet pressure, sensed by the control piston (619), fall below the value required to balance the system, the servo orifice (617) closes, the pressures on either side of the spill valve diaphragm (205) become balanced and the valve moves to decrease the spill and increase fuel delivery and pressure in the control system. Conversely, a rise in throttle valve inlet pressure above the required value will influence the rocker lever to open the servo valve further and unbalance the spill valve which will open the spill passage and so decrease throttle valve inlet pressure until normal operating conditions are restored.

KEY TO FIG. 6

601	BAROMETRIC CAPSULE
602	CAPSULE TRIMMING SPRING
603	TORCH IGNITER FEED ACROSS THROTTLE VALVE
604	THROTTLE VALVE PLUNGER
605	THROTTLE PLUNGER OUTLET DRILLINGS
606	IDLING FLOW PASSAGE
607	TORCH IGNITER SOLENOID VALVE
608	IDLING FLOW RESTRICTING ORIFICE
609	THROTTLE PLUNGER METERING EDGE
610	OVERSPEED GOVERNOR SERVO PRESSURE MAKE-UP ORIFICE
611	THROTTLE VALVE PROPORTIONAL-FLOW METERING DRILLINGS
612	OVERSPEED-GOVERNOR-CONTROLLED FLOW VALVE
613	SOLENOID-OPERATED HIGH PRESSURE SHUT-OFF COCK
614	THROTTLE PLUNGER PRESSURE-BALANCE DRILLING
615	THROTTLE PLUNGER METERING FLOW ANNULUS
616	FUEL PUMP DELIVERY SPILL VALVE
617	SPILL VALVE SERVO CONTROL VALVE
618	FUEL PRESSURE CONTROL DIAPHRAGM
619	FUEL PRESSURE CONTROL PISTON
620	PRESSURE-RAISING VALVE
621	ROCKER LEVER

Torch igniter solenoid valve

18. The torch igniter fuel (314) which is passed across the throttle valve in the starting position (603) is led to a cut-off valve consisting of a half-ball (315) and orifice, the half-ball being held in the end of the armature in a solenoid, which is energised to open the valve. This valve is relieved of fuel loads during normal running by the throttle valve (604), which, as it moves to open the throttle, cuts off the feed (603) to the torch igniter valve. This feature ensures that the engine can only be started with the correct idling flow, thus obviating the danger of wet starts.

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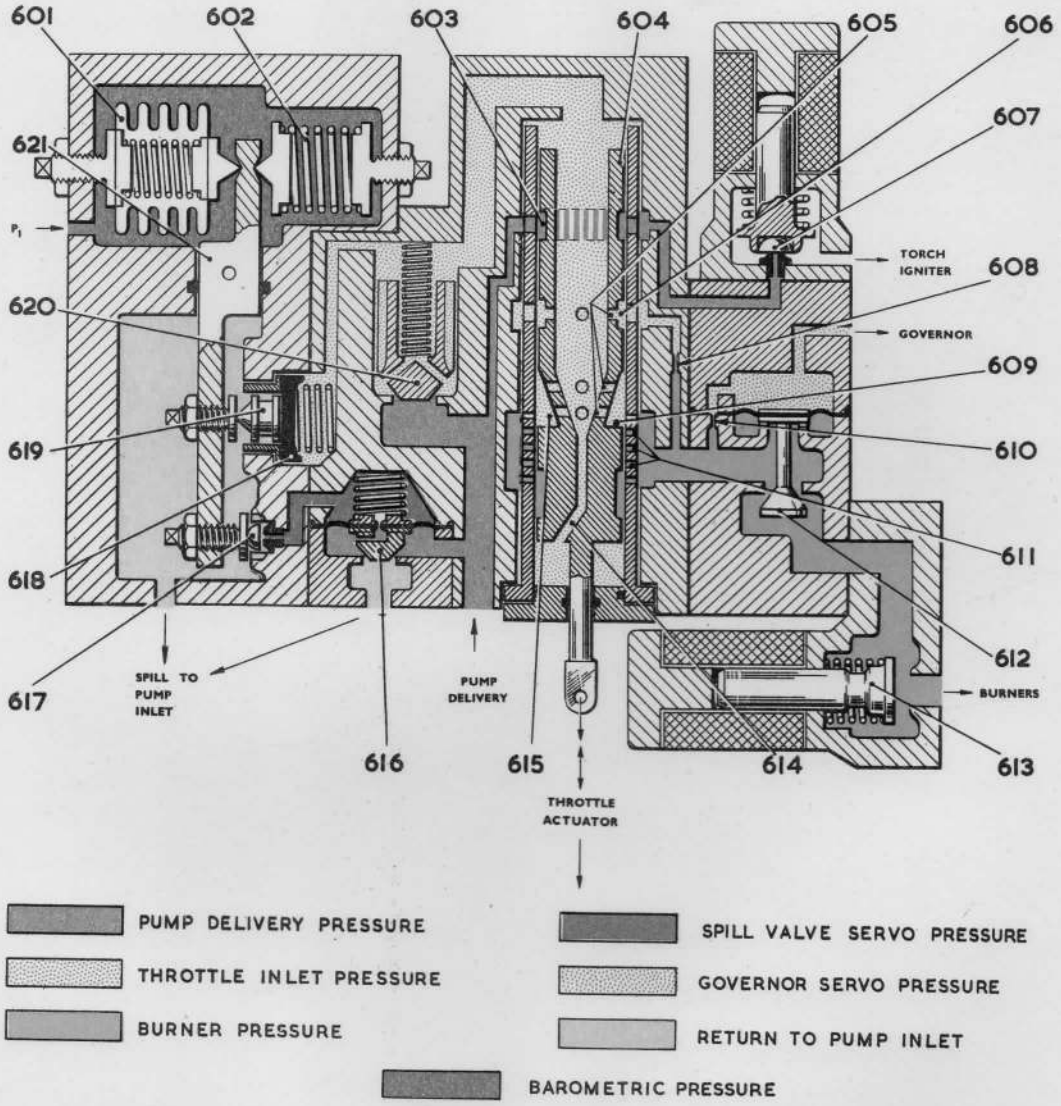

Fig. 6. Schematic diagram of control unit

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