Chapter Four

THE IGNITION SYSTEM

Contents

Illustrations

In order to ignite the fuel issuing from the burners, when starting the engine certain auxiliary equipment is necessary. This chapter is confined to the equipment actually effecting the ignition of the fuel in the combustion chambers, and which is actually mounted on the engine. For information regarding aircraft equipment such as switches and wiring, reference should be made to the relevant aircraft handbook. More detailed information, and instructions for servicing and overhauling the units mentioned in this chapter are contained in chapters 47 and 48 which deal with these units individually.

There are a number of established methods of effecting the initial ignition of the fuel: H.T. igniter plugs as employed on the Goblin, torch igniters, and high energy ignition. High energy ignition is employed on the Ghost 48 Mk. 1, and high energy torch igniters on the Ghost 48 Mk.2.

THE HIGH ENERGY IGNITION EQUIPMENT consists of two surface-discharge type igniter plugs situated in No.3 and No.10 combustion chambers, which are supplied from two high energy condenser units, mounted either side of the air-intake on the diffuser casing, through individual ignition cable assemblies. The condenser units are supplied with low tension current (16 to 29 volts D.C.) from the aircraft battery via a Venner time switch when starting normally on the ground, or when relighting in flight or when checking the ignition equipment on the ground. The low tension side of the system is entirely an airframe item, and, therefore, reference must be made to the relevant aircraft handbook for a detailed description of the wiring and switching.

THE SURFACE-DISCHARGE IGNITER PLUGS consist of an insulated centre electrode and an earth. Unlike the H.T. igniter plugs, or conventional sparking plugs, there is no air gap as such and the space between the electrodes is filled by a semi-conductive insulator. The centre electrode is connected to its individual high energy condenser unit, and the earthed electrode is connected to the screen which surrounds the ignition cable assembly.

THE HIGH ENERGY CONDENSER UNITS contain a coil and trembler mechanism, capacitors, a high-voltage selenium type rectifier, sealed-discharge spark-gap and a choke. The electrical discharges produced by these units are delivered at a much slower repetition rate than those produced by a conventional booster coil, but each discharge is of considerably higher energy. The duration of each discharge is of the order of 50 micro-seconds, and the peak discharge current in the region of 1500 amps. The stored energy per discharge is approximately 12 joules with a frequency of about 60 discharges per minute.

EACH IGNITION CABLE consists of a standard 37-strand annealed copper wire conductor enclosed in a Uniplug dielectric and screened by an outer flexible conduit. Standard elbow,

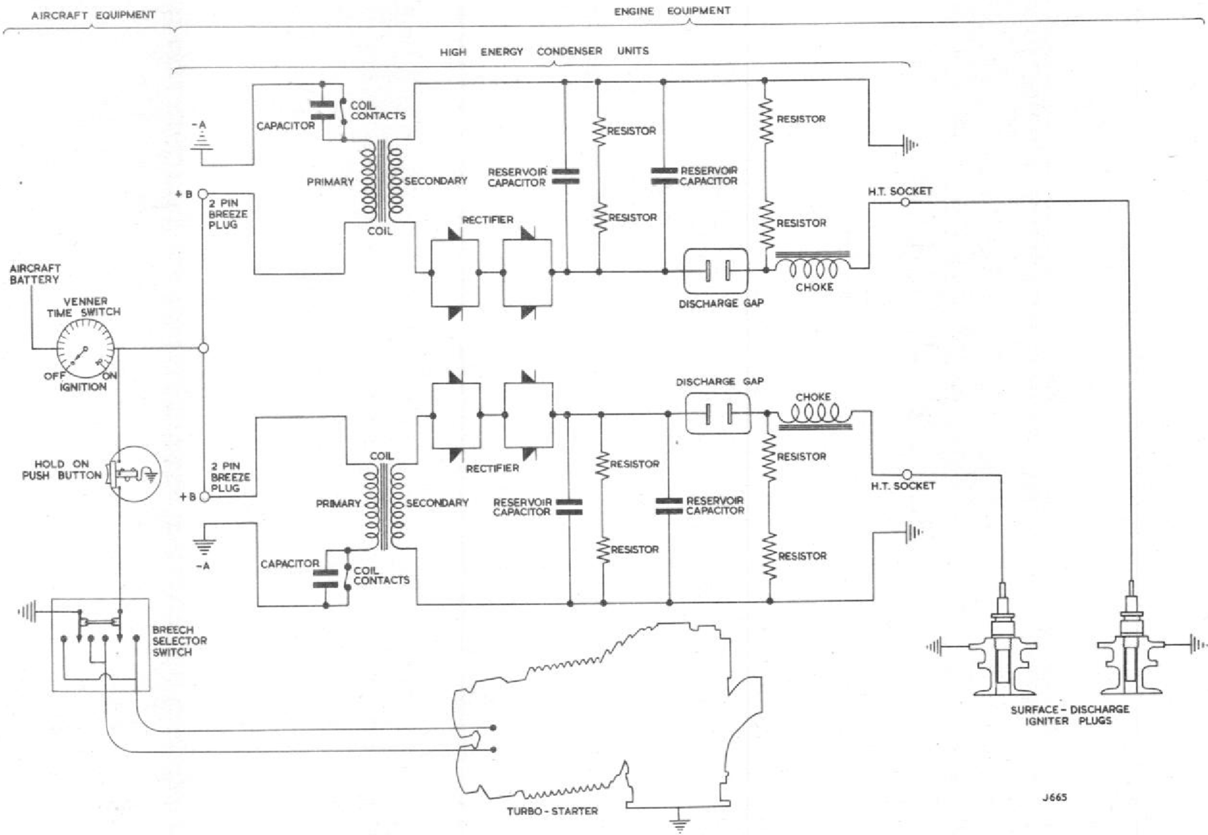


Fig. 1. Diagram of ignition equipment, Ghost 48 Mk. 1 ; the aircraft wiring and equipment shown in this illustration is typical only of the Venom, for precise details of individual installations, reference should be made to the appropriate aircraft handbook ; this illustration is pre-Venom-mod. 201.

sleeve, and contact button assemblies are fitted at each end.

When an engine, fitted with high energy ignition, is being started, 24 volt D.C. (maximum input current 2.5 amps measured on a moving coil instrument) is supplied to the coil and trembler mechanism in each condenser unit. The induction coil repeatedly charges a reservoir capacitor through the selenium rectifier until the capacitor voltage increases to a value at which the sealed discharge gap will "break down". The capacitor then discharges through the sealed gap, an inductance, and the surface-discharge igniter plug, which are all connected in series. The capacitor is then recharged and the process repeated at a frequency of not less than one discharge per second; the stored energy in each discharge being about 12 joules. The discharge across the semi-conductive insulator of the surface-discharge igniter plugs, ignites the fuel issuing from the burners in No. 3 and No. 10 combustion chambers, and the flame spreads to the other eight combustion chambers, through the interconnecting passages.

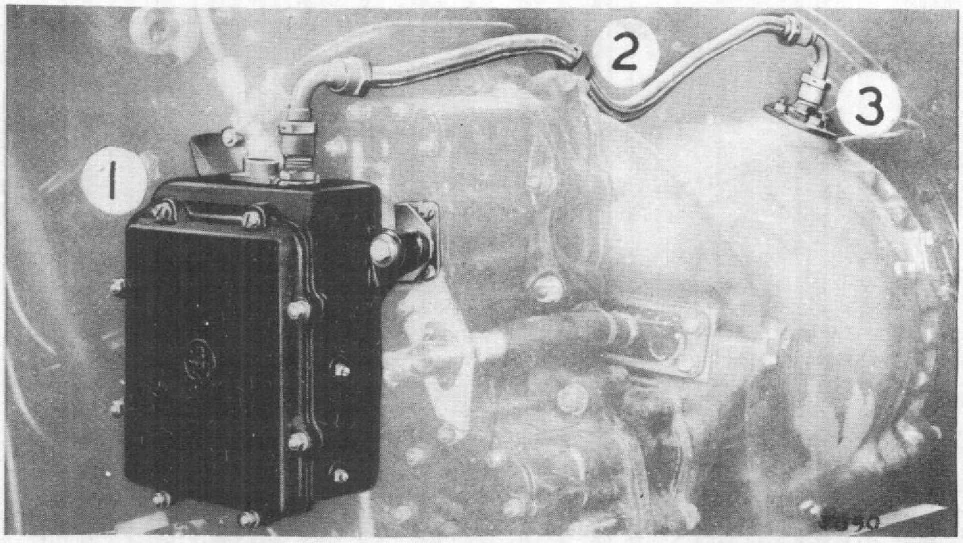


Fig. 2. High energy ignition equipment on Ghost 48 Mk. 1.

1. High energy condenser unit 2. H.T. ignition cable

3. Surface discharge igniter plug

In the case of the Ghost 48 Mk.1 installed in the Venom aircraft, the ignition control takes the form of a Venner time switch in the cockpit. The time switch is marked "ignition, on, off". When the time switch is set to ON, the circuit from the aircraft battery to both high energy condenser units, and to the turbo-starter push button is complete. A normal type of clockwork mechanism in the switch returns the dial pointer to the OFF position during a period of about twenty seconds and thus automatically cuts-off the supply of L.T. current to the condenser units. Thus, as will be understood, this type of control permits approximately twenty seconds operation of the ignition equipment after setting the time switch to the ON position. Since the circuit to the turbo-starter push button passes through this time switch it is impossible to fire a cartridge in the turbo-starter without the ignition being switched ON. Since, however, the condenser units are connected to the circuit on the battery side of the turbo-starter push button, it is possible to operate the ignition system without firing the turbo-starter and thus the time switch can be used both as a switch for re-lighting in flight, and for ground testing.

When Venom mod. 201 is embodied, the turbo-starter push button automatically, by operation of a single control, supplies current to the ignition system, and selects and fires the cartridge. On aircraft where the Venner time switch is retained, it is used only for testing or for relighting in flight. On later aircraft, this time switch is replaced by a push-button mounted on the H.P. cock lever.

GHOST 48 Mk. 2, TORCH IGNITER EQUIPMENT.

On the Ghost 48 Mk. 2, high energy torch igniters are used to ignite the fuel.

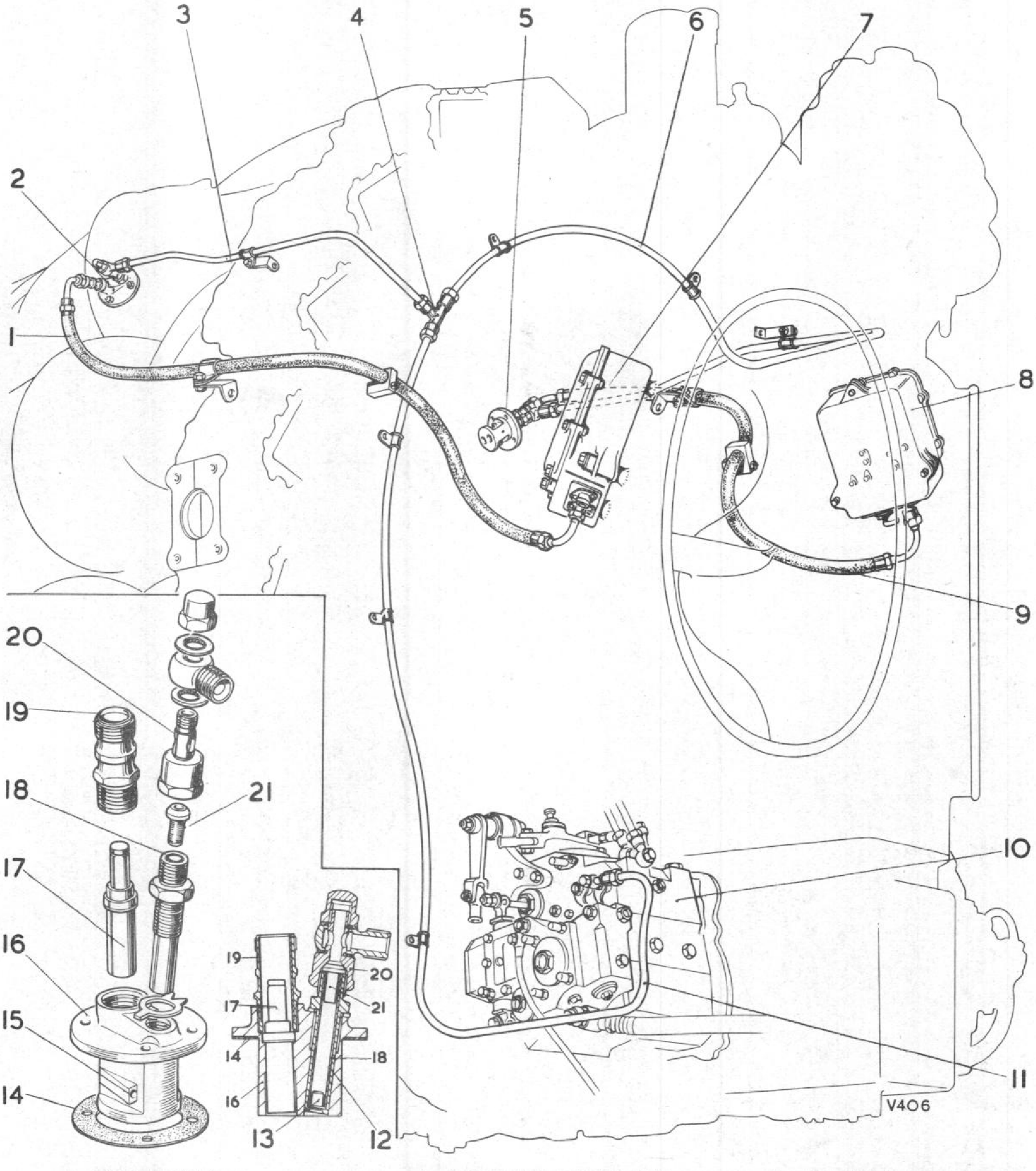
The design of the Dowty spill burner fuel system is such that the circulating pump withdraws all fuel from the burners, burner manifolds and inlet and spill pipes, during the stopping cycle. Therefore, although the system is designed so that the fuel tank booster pump can prime the system as far as possible before the main shaft assembly commences to rotate, a time lapse inevitably occurs before the remainder of the fuel system priming can commence to function. In the design, every effort has been made to reduce this time interval to an absolute minimum, consistent with ensuring that no dribbling occurs from the burners, as this would result in flame from the exhaust upon starting and overheating of the nozzle and turbine blades.

The priming delivery from the burners does not occur until the peak of the turbo starter power curve has been passed and the engine is about to decelerate. Furthermore, the priming delivery has an acute cone angle so that the atomized spray reaches the periphery of the flame tube some distance down stream from the burner; the main flow delivery has a much wider cone angle and, therefore, the atomized spray reaches the periphery of the flame tube nearer the burner.

These considerations call for a very positive method of ignition and this is met by the provision of high energy torch igniters which give a definite burst of flame between the two extremes of spray angle. This gives effective ground starting, and relighting in flight.

The high energy torch igniter equipment, Fig. 3, consists of:-

(1) Two high energy ignition units; either B.T.H. or Rotax.
(2) Two K.L.G. high energy torch igniters.
(3) Two ignition cable assemblies.
(4) A torch igniter valve mounted in the valve group and circulating pump unit.
(5) Fuel pipes.
(6) Clips, brackets, etc., to support the ignition cables and the fuel pipes.



1. IGNITION CABLE
2. TORCH IGNITER IN No. 10 COMBUSTION CHAMBER
3. FUEL PIPE
4. "T" PIECE
5. TORCH IGNITER IN No. 3 COMBUSTION CHAMBER
6. FUEL PIPE
7. HIGH ENERGY IGNITION UNIT
8. HIGH ENERGY IGNITION UNIT
9. IGNITION CABLE
10. VALVE GROUP AND CIRCULATING PUMP UNIT
11. FUEL PIPE
12. ALUMINIUM SLEEVE
13. ATOMISER
14. KLINGERIT JOINT WASHER
15. AIR HOLES IN BODY; MUST FACE UPSTREAM
16. TORCH IGNITER BODY
17. IGNITER PLUG
18. FUEL JET ASSEMBLY
19. SCREEN TUBE
20. BANJO PILLAR NUT
21. FILTER

Fig. 3. Pictorial diagram of Ghost 48 Mk. 2 torch igniter ignition equipment.

The two high energy ignition units which are mounted one on each side of the air-intake casting, are identical with those described on page 1 and in chapter 47.

HIGH ENERGY TORCH IGNITERS. Two torch igniters are fitted one in No. 3 combustion chamber and one in No. 10. Each high energy torch igniter (inset on Fig. 3) consists of a body into which are screwed a high energy igniter plug and a fuel jet assembly. The body is provided with a flange through which it is secured in the combustion chamber by four 2 B.A. studs, plain and spring washers and nuts; a Klingerit joint washer is fitted between the flange and the face on the combustion chamber expansion chamber. Within the combustion chamber, the body enters a sleeve welded to the flame tube so that its inner end communicates with the combustion zone inside the flame tube.

The high energy igniter plug is of the surface discharge type described on page 1 and in chapter 48. A flange on the igniter plug is clamped by a screen tube into a counterbore in the torch igniter body.

The fuel jet assembly consists of a threaded tube which screws into the torch igniter body; a hexagon on this tube enables it to be screwed in to, or out of, the body when necessary. Within the lower end of this tube there is a small atomiser which is retained in the tube by an integral flange at the end of the tube, and by an aluminium sleeve which is pressed into the tube from the upper end. At the upper end of the tube, there is a small wire-wound filter which is secured by a special banjo-pillar nut; this nut also end-loads the aluminium sleeve to ensure leak-free joints. A banjo union, cap nut, and washers complete the fuel jet assembly.

The ignition cables are similar to those described on page 1. To reduce the fire risk which might exist if a potential difference between the metallic covering of the ignition cable and the adjacent engine parts resulted in sparking between the two, a protective rubber sleeve completely encloses the flexible sheath.

TORCH IGNITER VALVE (Fig.4). The torch igniter valve is situated in the valve group and circulating pump unit at the outboard end of the isolating valve. It consists of a piston which butts against a boss on the end of the isolating valve, and operates in a valve sleeve. A compression spring, between the outer end of the sleeve and a flange on the inner end of the piston keeps the piston in contact with the isolating valve. The valve sleeve is ported to permit fuel to reach the valve and to pass through to the torch igniters when it is in the open position.

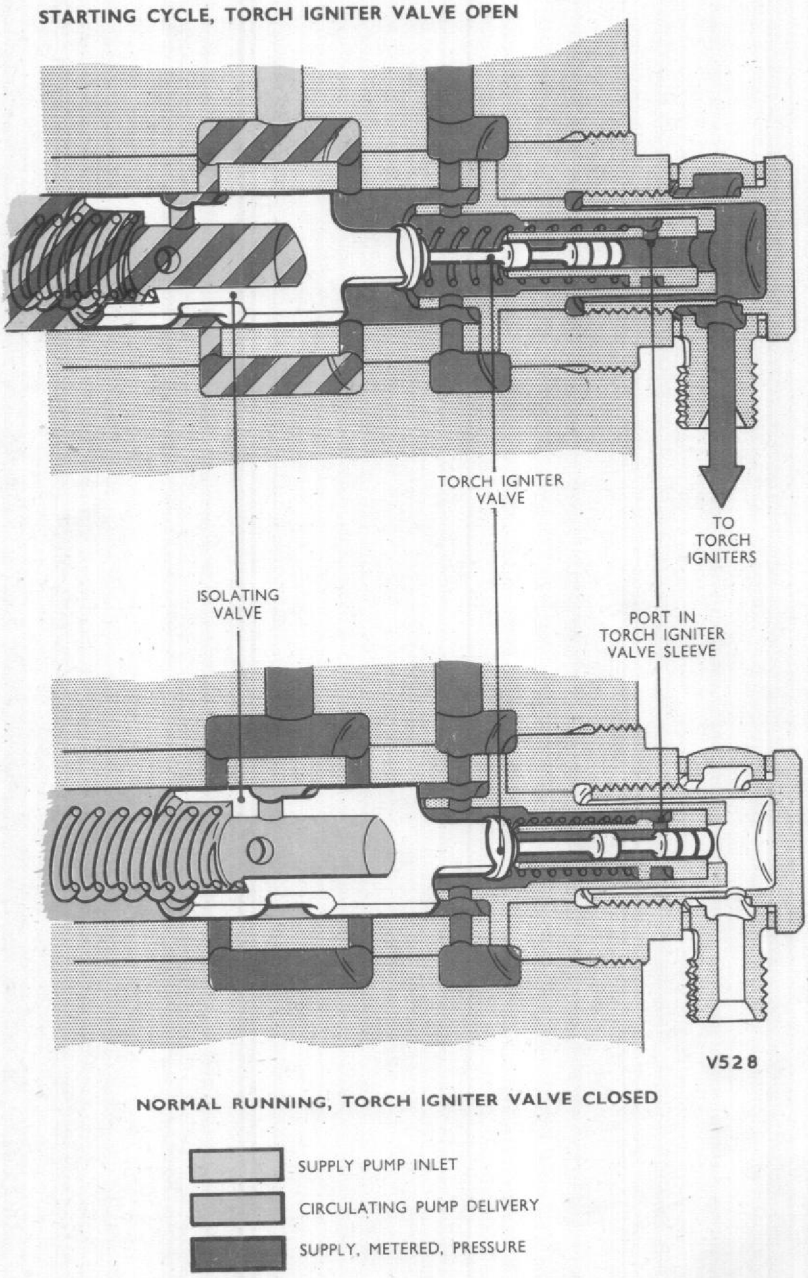


Fig. 4. Diagram showing operation of torch igniter valve.

When the engine is being started, direct current at 16 to 29 volts and approximately 2 to $2\frac{1}{2}$ amp. is supplied from the aircraft electrical system to the two high energy ignition units. These units discharge through the igniter plugs which ignite the fuel issuing from the torch igniter fuel jets. The resultant flame ignites the fuel issuing from the burners in No. 3 and 10 combustion chambers, and the flame then spreads to the remaining eight combustion chambers through the inter-connecting passages. Once started, combustion is continuous and the ignition equipment is no longer necessary. The period during which the electrical equipment is in operation is controlled automatically, and the fuel system automatically cuts off the fuel supply to the torch igniters as soon as normal running conditions are established.

The fuel supply to the torch igniters is controlled thus. When the engine main shaft commences to rotate, the fuel supply pump delivers fuel through the throttle valve and the idling adjuster to the operating side of the isolating valve. The fuel at metered pressure overcomes the spring loading on the isolating valve and moves that valve. Since the torch igniter valve is spring-loaded to follow movement of the isolating valve, this permits the torch igniter valve to uncover the port in its sleeve and thus allow fuel, at metered pressure, to flow through the piping to the two torch igniter fuel jet assemblies. When normal running conditions are attained, since the burner inlet pressure (circulating pump delivery) is higher than the metered pressure the isolating valve closes, under the influence of this pressure difference plus its spring loading. Movement of the isolating valve closes the torch igniter valve and shuts off the supply of fuel to the torch igniter jet assemblies. Thus, except during an actual starting cycle, the torch igniter jets are cut off from the main fuel system. For further information regarding the operation of the fuel system, reference should be made to chapter 3 and to the publications issued by Messrs. Dowty Ltd.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