GROUP C.1

ENGINE STARTING AND CONTROL (CODE S AND SA)

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DESCRIPTION

Equipment employed

1. The major components employed in the engine starting and control circuits are as listed in Table 1, together with the appropriate Air Publication to which reference should be made for a detailed description and the necessary servicing information.

TABLE 1

Equipment Type and Air Publication reference

Equipment Type	Air Publication
Liquid fuel starter system, Plessey Type LTS.A 150	A.P.103D–0208–16
Starter control unit No.7 CZ/102155 or No.7 CZ/106201	A.P.113D–1400–Series
Starter control unit (static timer) Pt.No. 700–1–12170	A.P.113D–1007–16 A.P.103D–0208–16A
Pump motor circuit breaker, Type B.4	A.P.113D–1329–1
Starter push switch, Type B Engine master switch, Type D.5504 Ignition isolation switch, Type D.5404 Relight switch, Type D.5407	A.P.113D–1100–Series
Main circuit breaker, Type A.6	A.P.113D–0903–1
Main ignition units, Type C.10TS/2 or C.10TS/3	A.P.1374G, Vol.1, Sect.4
Ignition relay, Type S.1	A.P.113D–1309–1
Relight time delay switch, Type FHM/A/68	A.P.113D–1404–16

General

2. The engine is started through the medium of a liquid fuel starter mounted on the forward end of the engine. Its starting cycle is automatically controlled by a starter control time switch unit located on the starter access door.

3. An electrically driven blower and fuel pump supplies the combustion chamber of the starter and is mounted vertically below and forward of the starter. The blower feed air drawn through a filter directly from the atmosphere and the pump supplies isopropyl nitrate from the starter fuel tank fitted above the pump on the port

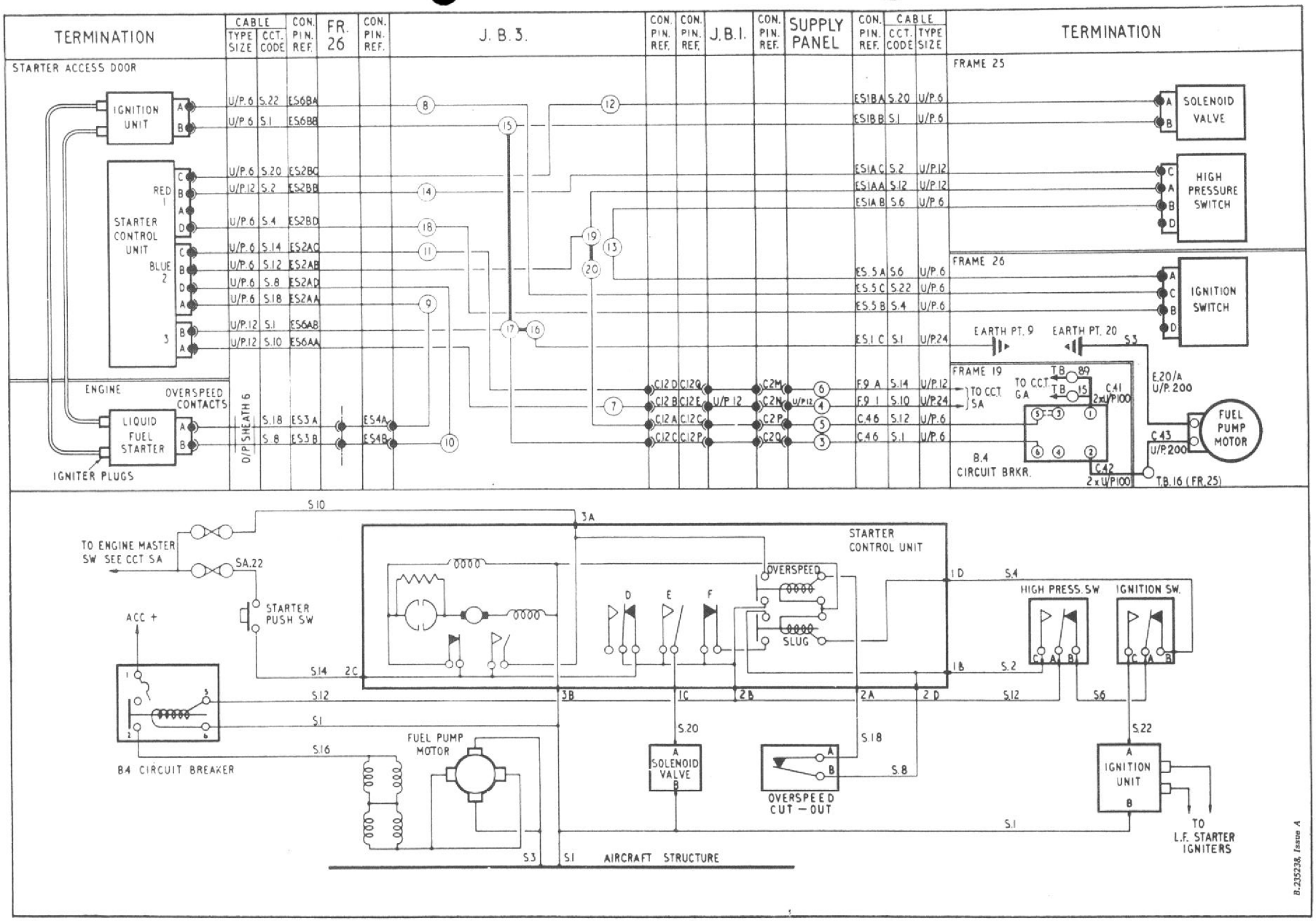

Fig. 1 Engine starting (pre Mod. 639)

side of the fuselage. The flow of starter fuel is controlled by a solenoid valve attached to the aft face of the main spar on the starboard side.

4. The starter ignition unit is mounted, together with the starter control time switch unit on the starter access door. It is energized by a pressure switch, fitted to frame 26, and de-energized by another pressure switch, incorporated in the solenoid valve.

5. The engine main ignition circuits are independently fused. All other engine services are protected by a circuit breaker located on the cabin starboard shelf and also have their own fuses. The supply to the starter circuits is controlled by the engine master switch, mounted on the leg panel, which also controls the supplies to the fuel tank pumps, the fuel pressure indicator and the a.c. supplies circuit. The starting cycle is initiated by pressing the starter push-switch, also mounted on the leg panel.

6. Two high energy ignition units, supplying the igniter plugs in the engine combustion chambers, are mounted one on each side of the fuselage between frames 35 and 36. The supply to these units is controlled by the ignition relay positioned on the supply panel. This relay is energized by the ignition switch situated above the starter push-switch via the normally closed contacts of the relight time delay switch mounted under the cabin port shelf.

Operation

General

7. To understand the function of the engine starting circuit, it is necessary to trace the sequence of operations which occur when the starter push-switch is operated. It should be noted that the starter circuit breaker, the engine master switch and the ignition isolating switch must all be closed before a start may be made. The ignition isolating switch is normally locked on. As the theoretical diagrams show, contacts A to B of both the high pressure and ignition switches and the contacts of the overspeed cut-out, are all made at the commencement of the starting cycle.

Type No.7 CZ/102155 control
(pre Mod.639)

8. This control unit embodies a time delay switch, the cam operated contacts of which, function in the following sequence:-

Contacts B, D and F are closed at the commencement of the cycle.
Contact A closes immediately the motor clutch is energized.
Contact D opens after 1¼ seconds.
Contact E closes after 2¾ seconds.
Contact F opens after 3½-4 seconds.
Contact E opens after 9¼-10¼ seconds.
Contact B opens after 18 seconds when the time switch motor stops, its clutch is de-energized and its contacts are in the start position again.

9. When the starter push-switch is pressed the time switch motor and its clutch is energized via contact B. Contact A then closes to provide the time switch motor supply independently of the starter push switch which may now be released. Simultaneously a supply is fed, via contact D to the coil of the pump circuit breaker coil, so that the pump and blower unit will start to operate. Also, via contact D and the A to B contacts of the high pressure and ignition switches in series, the slug relay coil is energized.

10. The closing of the slug relay contact completes the circuit of the overspeed relay coil, via contacts A, D and F and the overspeed cut-out. The overspeed relay contacts then close to provide:-

(1) A direct supply to the pump and blower unit.

(2) A supply to the slug relay coil via the high pressure and ignition switches A to B contacts.

(3) Its own holding circuit via contact F, the slug relay contacts and the overspeed cut-out.

11. Contact D opens after 1¼ seconds and during this time air from the blower enters the combustion chamber to scavenge any gases from a previous start. Fuel from the pump is meanwhile returned to its tank via the two way solenoid valve. When the air scavenge is complete, approximately 1 second later, contact E closes to energize the solenoid valve thereby transferring the fuel flow through atomizers to the combustion chamber. The pressure created in the fuel line, by flow through the atomizers, operates the ignition pressure switch.

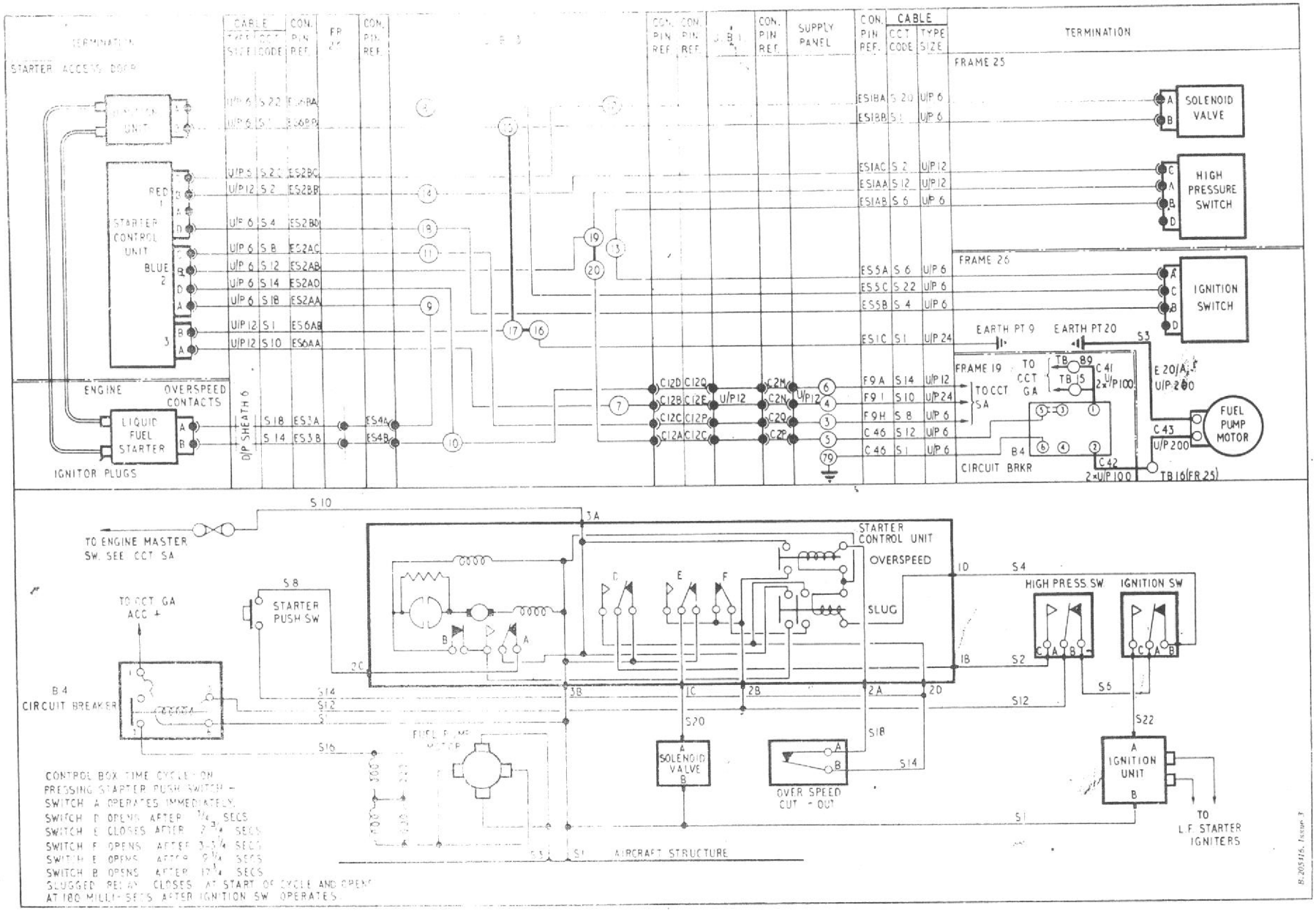

Fig.2 Engine starting (Post Mod.639)

RESTRICTED

12. The ignition pressure switch then opens its contacts A to B, and closes contacts A to C, which pass a supply to the starter ignition unit. This, in turn, causes the plug igniters in the combustion chamber to spark, the mixture to ignite and the starter to turn the engine. Meanwhile the opening of contacts A to B has broken the slug relay coil circuit, but its slugged action causes it to remain closed while the fuel pressure increases, during combustion, and operates the high pressure switch.

13. The high pressure switch then opens its contacts A to B, and closes contacts A to C, thereby opening the starter ignition circuit. Closing contacts A to C now complete a holding circuit for the overspeed relay coil, via its own contacts and the overspeed cut-out, i.e. by-passing contact F and the slug relay contacts. The slug relay drops out and at 3½-4 seconds from the starter push switch being pressed, contact F opens.

14. Further operation of the starter control is common to both types of control unit and the operation is continued at paragraph 21.

Type No.7 CZ/106201 control
(post Mod.639)

15. This control unit embodies a time delay switch, the contacts of which function in the following sequence:-

Contact A operates immediately the motor clutch is energized.

Contact D operates after ¾ seconds.
Contact E operates after 2¾ seconds.
Contact F opens after 3-3¼ seconds.
Contact E operates, returning to normal, after 9¾ seconds.
Contact B opens after 17¾ seconds when the time switch motor stops, its clutch de-energizes and its contacts are in the start position again.

16. Operating the starter push switch energizes the overspeed relay by a supply fed via contacts A, the push switch and the overspeed cut-out. The overspeed relay contacts close to pass a supply direct to the pump circuit breaker coil so that the pump and blower unit start to operate. At the same time a supply, through the overspeed relay contacts, is fed to the slug relay coil via the A to B contacts of the high pressure and ignition switches, in series.

17. The slug relay being energized, its two pairs of contacts close to complete the following circuits:-

(1) Holding circuit of the overspeed relay coil, via the overspeed relay contacts, contact F, the slug relay contact and the overspeed cut-out.

(2) The time delay switch motor, by a direct feed from the circuit fuse via the slug relay contact, the un-operated side of contact A and via contact B. The overspeed relay having operated and a holding circuit provided, the start push switch may now be released. The time delay switch motor starts to run and contact A operates to maintain the motor supply independently of the supply from the slug relay contacts.

18. After ¾ seconds contact D operates to connect to C of the high pressure switch, preparatory to its operation. Meanwhile scavenging action, by the blower, has occurred in the combustion chamber and the fuel pump has by-passed fuel back to the tank.

19. After 2¾ seconds contact E operates to energize the solenoid valve. Fuel is now passed through the atomisers where the resulting fuel pressure causes the ignition switch to operate opening contacts A to B and closing contacts A to C. This energizes the starter ignition unit starting combustion and causing the starter to turn the engine. At the same time the slug relay circuit has been opened at the ignition switch but the relay holds in due to the slug action while fuel pressure builds up, due to combustion and causes the high pressure switch to operate.

20. The high pressure switch operates to open contacts A to B, thereby cutting off the supply to the starter ignition unit, and closes contacts A to C. A holding circuit for the overspeed relay is then provided, via the overspeed relay contacts, A to C of the high pressure switch, contact D of the time switch and the overspeed cut-out. The slug relay drops out and, at 3-3¼ seconds from the start of the time delay cycle, contact F opens.

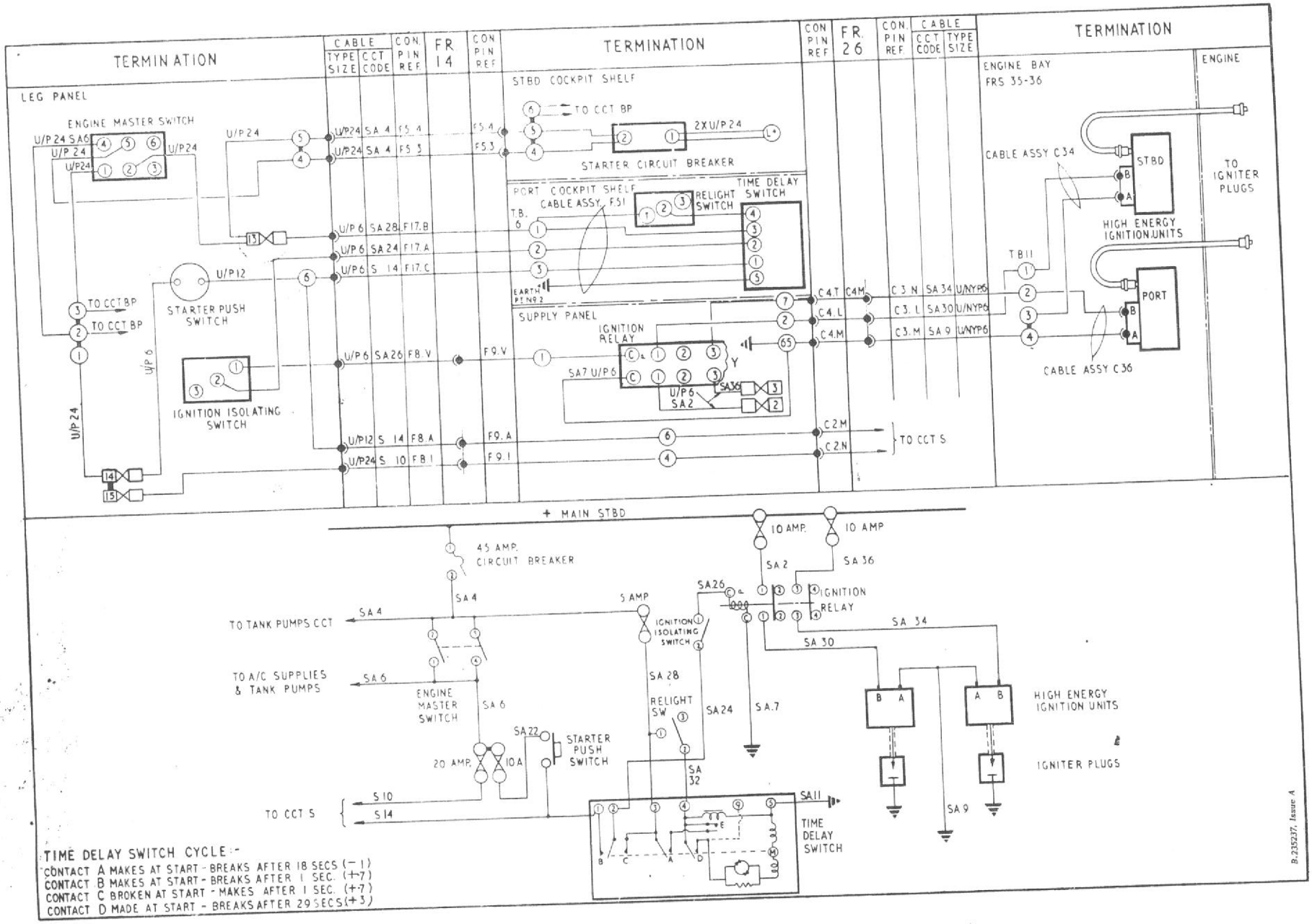

Fig.3 Engine ignition control (Pre-Mod.639.)

RESTRICTED

21. The slug relay contacts open 0.18 seconds after its coil is de-energized and provides a safeguard by shutting down the start operation if ignition does not occur within that time. The opening of contact F provides a further break in the overspeed relay coil circuit, should the slug relay contacts remain closed for any reason.

Starter disengage

22. Assuming combustion takes place satisfactorily, the engine accelerates to idling speed, when a governor in the starter, will cause the overspeed cut-out to operate and open its contacts. This occurs normally 6 seconds after ignition in the starter causing the overspeed relay to de-energize and open its contacts. This, in turn, opens the pump circuit breaker coil circuit and the pump and blower unit stops. The pressure switches then return to the pre-start condition. As the starter slows down it disengages from the engine and the overspeed cut-out contacts close.

23. The time delay switch unit continues to operate until, after 18 seconds from the start of the cycle, its contact B opens to break its supply. Meanwhile, at approximately 9½ seconds from the start of the cycle, contact E operates to open the supply to the solenoid valve and to divert the fuel flow back to the tank.

Engine ignition

24. While being run up to speed by the starter, the engine will be lit by the igniter plugs which are fed by the high energy ignition units. Power to these units is from fuses 2 and 3, on the supply panel, through contacts of the ignition relay. This relay is energized, via contacts B of the Relight Time Delay unit, throughout the starting cycle, first via the start push and later via contact A *(pre Mod.639)* in the starter control unit, or via contact F and the slug relay contact *(post Mod.639).*

False starts

25. The starter control unit operates for 18 seconds and, in the event of a false start, no further attempt to start should be made until this time has elapsed. If the engine reaches idling speed without igniting, the overspeed cut-out will operate to stop the starter as in the case of a successful start.

26. In the event of a start being attempted without fuel in the starter tank neither pressure switch will operate, contact F will open the overspeed relay circuit causing the pump to stop. If a start with fuel is made and the mixture fails to ignite the high pressure switch will not operate to maintain the overspeed relay, which will open when the slug relay falls out, or later by the opening of contact F. Should the starter and engine not attain idling speed before contact E opens, the solenoid valve will be de-energized and stop the starter by diverting its fuel back to the tank.

Relight control

27. This system is used to energize the high energy ignition units when re-lighting the engine in flight. When the re-light switch toggle is pressed the re-light time delay switch is brought into operation by the energizing of its clutch coil which closes contacts D and E. Contacts D complete the circuit of the switch motor which runs and within one second causes contacts A to close. A cam keeps these contacts closed for approximately 18 seconds. Contacts A provide, via contact E, a retaining supply to the clutch and motor independent of the re-light switch which may now be released.

28. Within one second of the start of the time delay switch, its contacts B open to isolate the normal supply and contacts C close to provide a direct, re-light supply *(via fuse 13 on the leg panel)* to the ignition relay. This relay operates to complete the separately fused supplies to the high energy ignition units. Contacts C remain closed while contacts A maintain the motor running, i.e. for approximately 18 seconds, after which the motor stops and contacts B close again to return the starter circuit to normal. In the event of contacts A welding up, the motor would continue to run without resetting to the start position, with the provision of contacts D, this action is inhibited and the motor will only run for a further 11 seconds after the normal closed period of contacts A. When contacts D finally open, the motor will be reset.

Starter control unit (static timer) Pt.No. 700–1–12170 (Mod.1397)

29. The control unit (static timer) is introduced in lieu and by conversion of the Mk.8 control unit Pt.No. 7CZ/106201 (Plessey Mod. S.647) (post Mod.639).

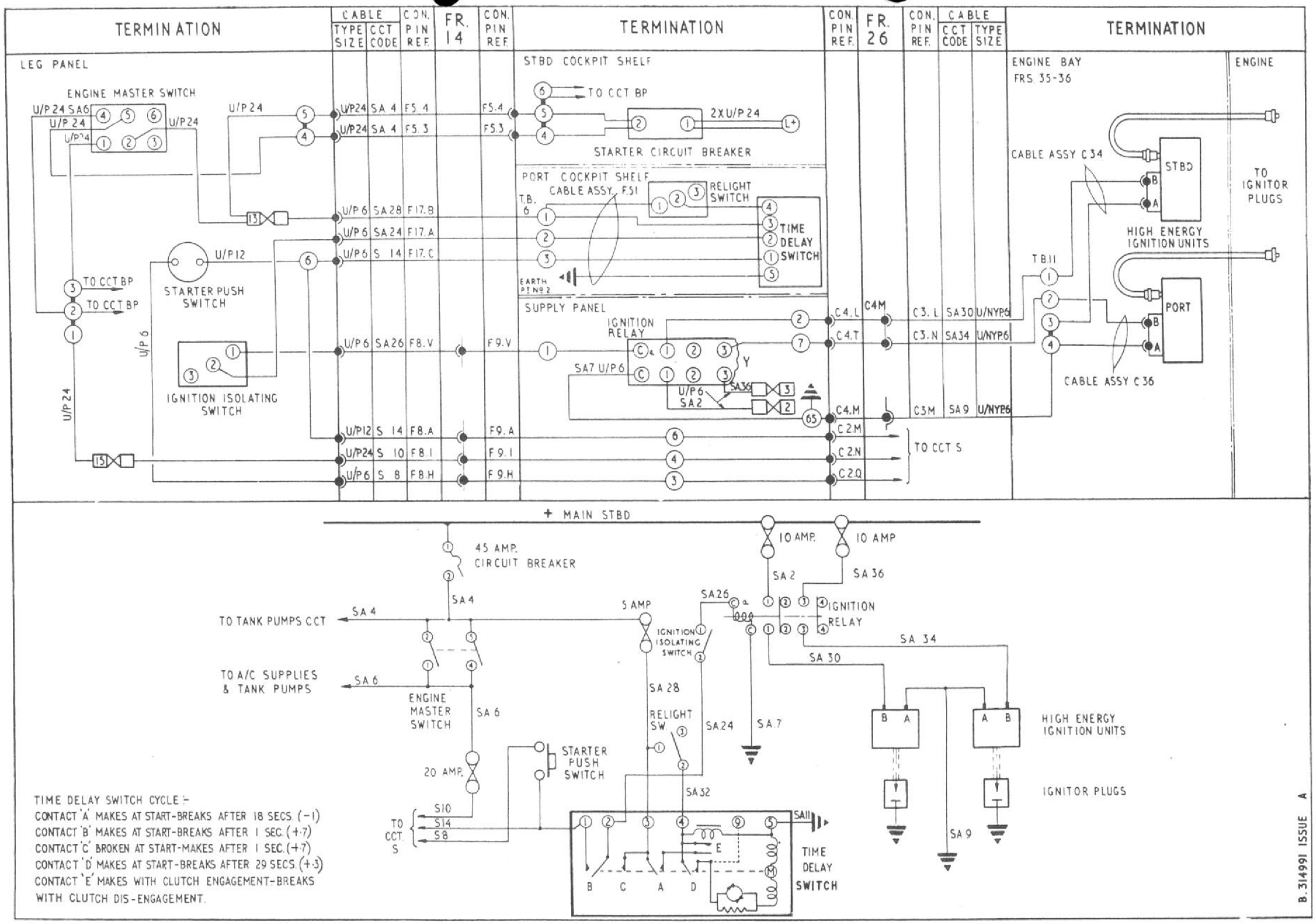

Fig. 4 Engine ignition control (post Mod. 639)

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30. The description and operation of the control unit (static timer) is described in A.P.113D–1007–16 and the operation of the starter control unit within the I.P.N. starting cycle is fully described in A.P.103D–0208–16A.

WARNING . . .

THE FOLLOWING PROCEDURE MUST BE ADOPTED WHEN THE 20A FUSE HAS BLOWN ON AIRCRAFT EMBODYING THE P/N 700–1–12170 (PLESSEY MOD S.647) (HUNTER MOD 1397).

(1) Disconnect the two-pin plug from the ignition unit.

(2) Ensure that the aircraft MASTER switch is set to OFF.

(3) Replace the 20A fuse.

(4) Select the aircraft MASTER switch to ON and if the IPN system operates (without depressing the starter button) select the aircraft MASTER switch to OFF immediately then reject the IPN control unit.

SERVICING

General

31. For general servicing of the electrical system, reference should be made to Group A.1. All the components should be kept clean and the contacts of the switches, relays, etc., inspected for signs of pitting, which if found must be removed in the approved manner. The brushes of the motors should be examined to ensure that they are in good condition. Apart from the standard bench testing and servicing of the components described in the appropriate Air Publications quoted in para.1 of this Group, no further servicing should be necessary.

Testing high energy ignition units

32. The high energy ignition units, Type C.10TS/2 or /3 employed in this circuit are to be checked as follows to ensure that they are suitable for this aircraft. All the tests are to be carried out with suitable H.T. cables and discharge plugs fitted. Care must be taken not to touch the H.T. connections of the units or plugs when the units are operating, and an operated unit must be discharged before handling, or otherwise a lethal shock can be received:-

(1) Connect a 24 $^{-0}_{+1}$ volt d.c. supply to the units input connection, observing the correct polarity and check:-

(a) That the input current measured on a d.c. moving coil instrument does not exceed 2.5 amp.

(b) That the plug discharges at not less than 60 times per minute.

(2) Connect as in operation (1), but with a 21 $^{-0}_{+1}$ volt d.c. supply and check that the time for 10 discharges at the plug does not exceed 12 seconds. This test must not exceed 3 minutes.

(3) Connect as in operation (1), but with a 16^{-0}_{+1} d.c. supply and check that the input current does not exceed 4 amp. Any units which take more than 4 amp. are unsuitable for this aircraft.

Note . . .

The above checks must be made by tapping the batteries and NOT by use of a dropping resistor.

Testing engine starting circuit

33. To test the engine starting circuit, using the I.P.N. turbo-starter test set described in A.P.4343S, Vol.1, Book 1, Sect.3, proceed as follows:-

(1) Ensure that the test set is serviceable by carrying out the serviceability checks detailed in A.P.4343S, Vol.1, Book 1, Sect.3. On completion of these checks ensure that all the switches are set to their normal selections.

(2) Prepare the aircraft for test by disconnecting the aircraft's cables from the following components.

(a) High energy ignition unit, L.T. input connector only.

(b) High frequency ignition unit, L.T. input connector only.

(c) Low pressure switch *(ignition).*

(d) At J.B.3, disconnect cable reference ESI A-B from terminal 13, cable ESI B-A from terminal 12 and cable ES4-A from terminal 9; thus isolating the high pressure switch, solenoid by-pass valve, and the overspeed switch.

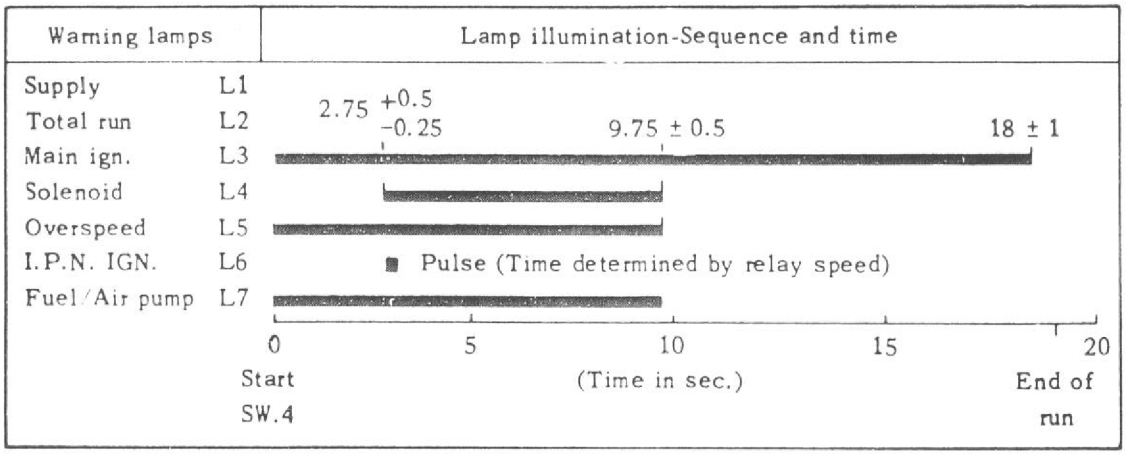
(e) At terminal block 16, disconnect the fuel and air pump motor.

(f) Connect the turbo-starter test set to the aircrafts' terminations using the appropriate test cable.

(g) Connect a 28 volt d.c. power supply to the aircraft's external supply plug and switch ON.

CHART 1

Normal light up - overspeed inoperative



34. Test for normal light up with overspeed inoperative, as follows:-

(1) Set the engine master switch and ignition switch to ON.

(2) Operate the engine starter push-switch. Ensure that the test lamps illuminate in the correct sequence and timing according to Chart 1.

35. Test for normal light up with overspeed operative, as follows:-

(1) Operate the engine starter push-switch. Ensure that the test lamps illuminate in the correct sequence and timing according to Chart 2 when test switch 5 is operated between 4 and 8 seconds from the start.

36. Test for no light up, fail safe, contact F, as follows:-

(1) Set test switch 2 to RELAY.

(2) Operate the engine starter push-switch. Ensure that the lamps illuminate in the correct sequence and timing according to Chart 3.

37. Test for no light up, fail safe, slugged relay, as follows:-

(1) Set test switch 2 to UNIGNITED.

(2) Operate the engine starter push-switch. Ensure that the lamps illuminate in the correct sequence and timing according to Chart 4.

CHART 2

Normal light up - overspeed operative

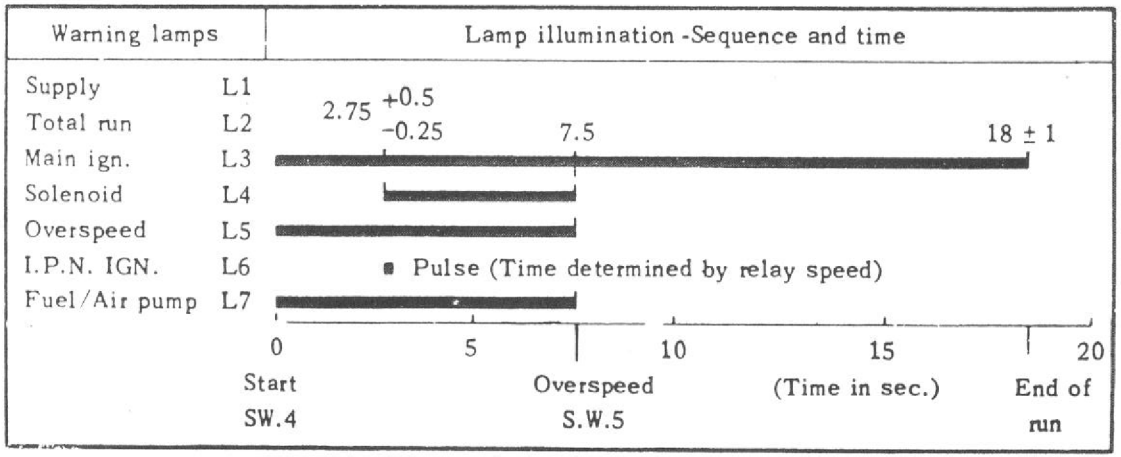


CHART 3

No light up - fail safe, contact F

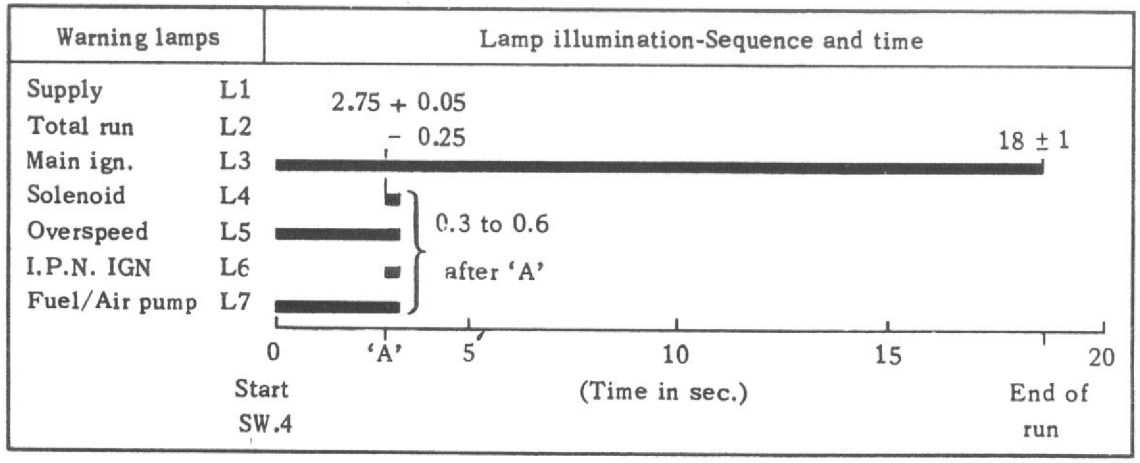
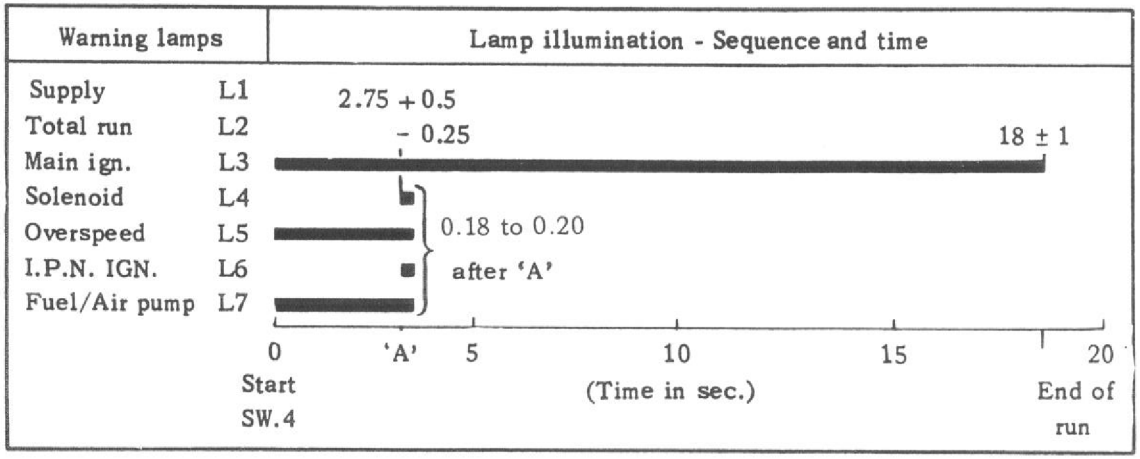


CHART 4

No light up - fail safe, slugged relay



38. If any circuit adjustments have been made or any components changed as a result of these tests, repeat the operations given in para.33 to ensure that the circuit is operating correctly.

Note . . .

Accurate timing checks can be carried out using the Chronotron Electronic Timer (Ref.5G/3733), connected to the appropriate terminals on the test set. Approximate timing checks can be obtained using a stop watch (Ref.6B/9101001).

39. On completion of tests, set the engine master switch and ignition switch to OFF. Switch OFF the external power supply, disconnect servicing trolley and reconnect the aircraft's components disconnected during the tests.

REMOVAL AND ASSEMBLY

General

40. Once access has been obtained, the removal and assembly of the equipment forming the engine starting and control circuits should present no unusual difficulties. The location and access to all the equipment employed is fully described in Group A.3 of this chapter.

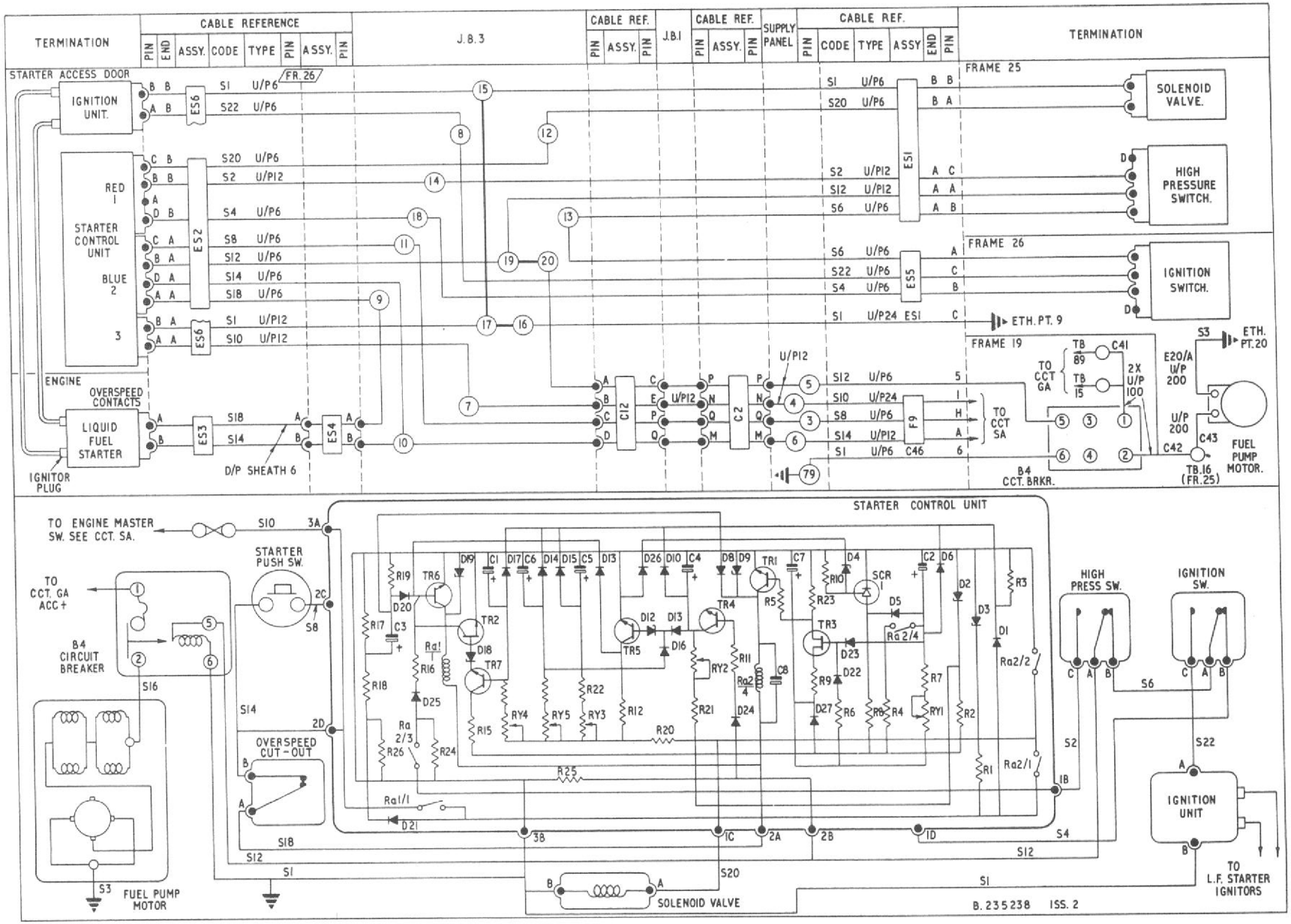


Fig. 5 Engine starting (post Mod. 1397)

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