Part I

Chapter 1—Electrical System

List of Contents

Description

1 General

(*a*) (i) Power for the electrical services is derived from separate port and starboard generating systems via two independent but identical distribution points. Each system consists of two 3-phase 73 KVA alternators, one driven by each engine. Each alternator produces two outputs, one delivering three phase, variable frequency AC at a nominal 208 volts for electrical anti-icing equipment and battery and feel simulator compartment heating; the other at 104 volts which is transformed and rectified to produce power for the DC services, at 112 volts and 28 volts. Constant frequency 3-phase and single-phase alternating current at 115 volts 400 cycles and 115 volts, 1,600 cycles respectively is obtained by rotary inverters operated from the 112-volt DC bus-bars.

(ii) *Engine mounted alternators*

When Mods 2744(B1) or 2979 (B1A) are embodied the mountings and drives of the alternators are changed to engine-mounted direct drives. This greatly minimises the risk of secondary damage occurring to surrounding components if drive failure occurs.

(*b*) *Bus-bars*

(i) Nine bus-bars are provided as follows:

Two three-phase 208 volts variable frequency AC
Two 112 volts, port and starboard, DC (medium voltage)
Two 28 volts, port and starboard, DC (low voltage)
Two 28 volts, port and starboard special feeders.
One ECM bus-bar (Mk. 1A only)

(ii) One 112-volt and one 28-volt DC bus-bar is fed from each of the distribution points. In an emergency each port 112-volt and 28-volt bus-bar can be connected to its starboard counterpart by a paralleling system which, when manually operated, provides a single source of supply for each voltage. The 208-volts bus-bars do not have paralleling facilities.

(*c*) *Batteries*

(i) Ten 24-volt 25 a.h. batteries are fitted in an electrically-heated ventilated compartment on the port side of the aircraft just aft of the nosewheel bay and accessible through a door.

(ii) Two banks of four batteries are each wired in series to form two 96-volt units. One unit connects to the port medium voltage bus-bar and the other to the starboard bus-bar. The remaining two 24-volt batteries are each connected to the appropriate low voltage bus-bar and special feeders.

(*d*) *Inertia switches*

Four inertia switches are fitted two port and two starboard, which automatically shut down the alternators and disconnect the batteries from the bus-bars if the aircraft decelerates at more than 3G.

NOTE: If the inertia switches operate after a crash landing the LV battery switches must be switched OFF before the MV. If the reverse procedure is adopted the LV battery will be reconnected.

2 DC supplies to bus-bars

(*a*) The 112-volt DC bus-bars are fed from the transformer rectifiers through a reverse current relay and a contactor. The 28-volt DC bus-bars are similarly fed through a combined reverse current relay/contactor. A 350-amp fuse is incorporated between each 112-volt bus-bar and the contactor.

(*b*) If a short circuit develops in the output lines from the transformer rectifier units the reverse current relays prevent total power supply failure by disconnecting the short circuited line from the bus-bar.

(*c*) Voltage trimmers are mounted on panel BA.

(*d*) The electrical equipment in the plenum chamber is normally cooled by ram air in flight or by two plenum chamber cooling fans when the aircraft is on the ground with the nose-wheel oleo depressed. (On Mk. 1 aircraft pre-modification 716 the cooling fan switching is controlled by pressure switches within the nostril

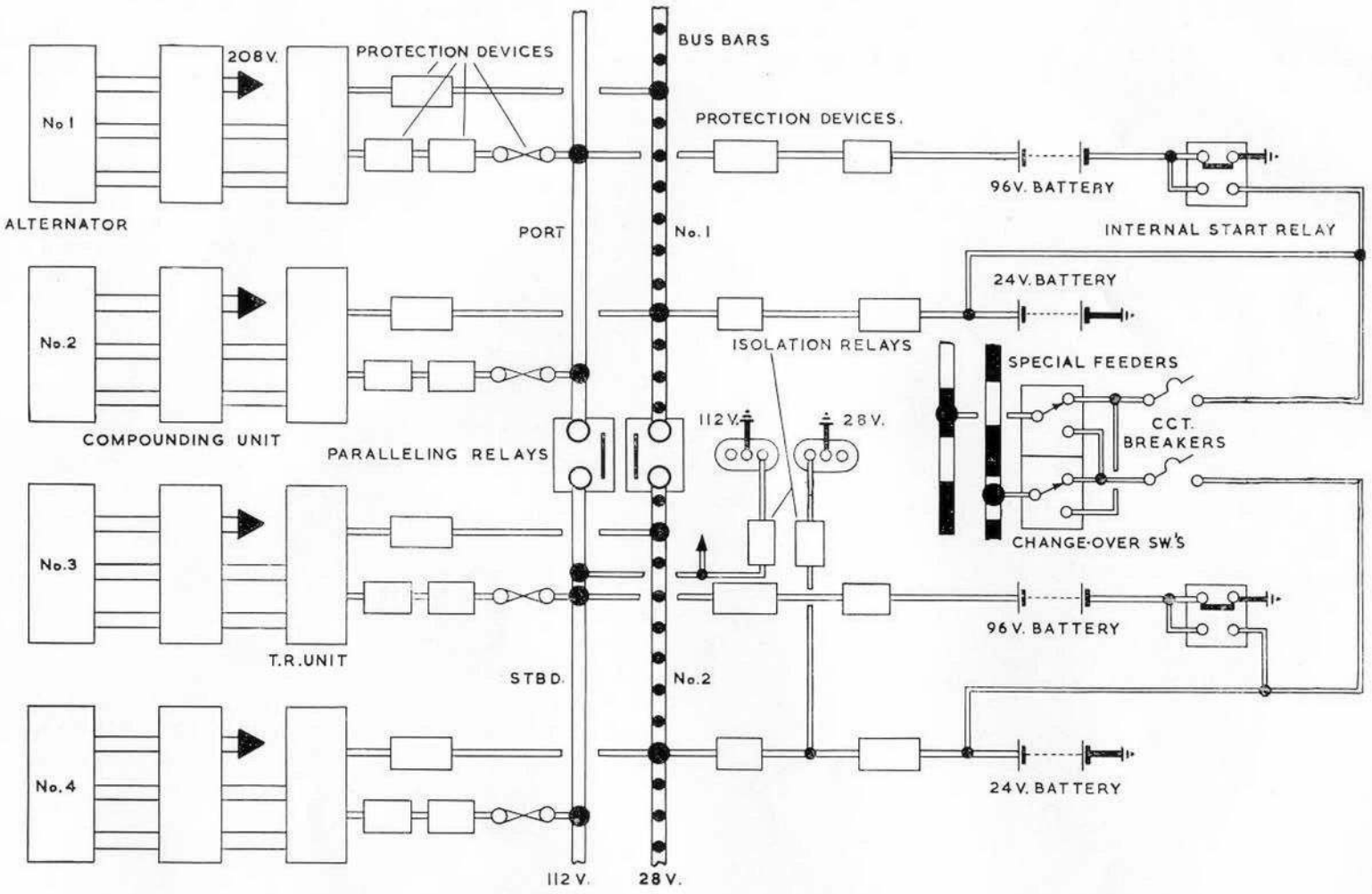

Fig. 1 Alternator system

intake ducting and not by nosewheel micro switch action.) Two red warning lamps, PORT COOLING FAN FAIL and STARBOARD COOLING FAN FAIL will come on if insufficient air pressure is provided for adequate cooling.

(*e*) LV and MV multi-position indicating ammeters are fitted, at panel BA, to indicate the current flow in the generator circuits.

3 Bus-bar paralleling

(*a*) A split bus-bar system divides the aircraft electrical system and ensures that a supply is readily available for the duplicated essential control services should bus-bar or power failure occur.

(*b*) The arrangement of supplies for essential services is as follows:

(i) On each 112-volt bus-bar:

One hydraulic pump feeder

One sub-unit of each powered flying control unit

Half of the booster pumps in each wing and half of the fuselage booster pumps.

(ii) On each 28-volt bus-bar:

One VHF/UHF set

(iii) One special feeder from each 24-volt battery.

(*c*) As the aircraft will continue to operate normally with one half of the electrical system inoperative the need to parallel the bus-bars will only arise in emergency. Careful thought must be taken before deciding to parallel the bus-bars since any fault in one bus-bar will be transferred to the other and could cause complete electrical failure. A combined voltmeter and ammeter is provided for each bus-bar to provide sufficient information for the AEO to decide whether the bus-bar to be transferred is serviceable.

4 DC ground supply

A medium voltage and a low voltage ground supply socket are located adjacent to the battery compartment. When a supply is connected to either voltage socket, the respective bus-bars are paralleled.

5 DC flight instruments supply

The DC supply for the turn and slip indicators and Mk. 4B compass is obtained through circuit breakers 1F4 and 2F4 on panel BB. Normally No. 1F4 only is required but should the supply routed through this circuit breaker fail, an alternative supply is routed through circuit breaker 2F4. Feeder 8P7 on panel BB supplies the No. 1 flight instrument inverter.

6 Low voltage DC special feeders

Two special feeder 28V bus-bars capable of operating independently of the LV battery master switches are installed to ensure a separate 24V supply for essential control circuits and are fed directly from the internal batteries (one battery for each bus-bar). To connect external power to the special feeder bus-bars the LV battery switches must be ON.

7 Low voltage DC distribution

(*a*) From the 28-volt bus-bars power is transferred to the various distribution boards through feeders protected by circuit breakers, on panel BB coded for the distribution board they protect.

(*b*) Inside each fuse and distribution panel is a list of the various fuses contained therein.

8 AC supplies

(*a*) The 208-volt variable frequency AC supply is required for the anti-icing heater mats and battery and feel simulator compartments

heating. When the low power warning light is on, e.g. if engine speed is below 51% the 208-volt supply is not available at the AC bus-bars. The 208-volt AC bus-bars supply the following services:

No. 1 bus-bar

*Port engine air intake heaters
*Port alternator and jet pump air intake heaters
Front fuselage port air intake heaters
*Port aileron power unit air duct heater
Battery compartment heaters

No. 2 bus-bar

*Starboard engine air intake heaters
*Starboard alternators and jet pump air intake heaters
Front fuselage starboard air intake heaters
*Starboard aileron power unit intake heaters
Artificial feel unit compartment heaters
*Rudder power unit air duct heaters

(* Mk. 1A only)

(*b*) When the alternators are in high power, i.e. the low power warning lights are out, the 208-volt AC supply of only two alternators is used, the others being automatically held in reserve in the event of a fault occurring.

(*c*) Normally Nos. 1 and 4 alternators supply the port and starboard AC bus-bars respectively, Nos. 2 and 3 being held in reserve. If two alternators on one side fail, no paralleling facilities are available.

9 AC inverter supplies

(*a*) *Type* 153 *inverters*

Two type 153 inverters are fitted. One inverter supplies the Green Satin system, via two ON/OFF switches on panel CA. The other, which is the primary flight instruments inverter, is controlled by any one alternator switch and the No. 1 flight instrument circuit breaker 1F4 on panel BB. This inverter supplies the following:

Mk. 4B Compass
Artificial horizons
Bomb relay unit
Bomb calculator
Yaw damper (electric)
Tank fire warning
Jet pipe temperature control (Mk. 1A only)
Fuel flowmeters
Bomb spacing unit
JPT gauges
Zero reader.
UHF D/F

If this inverter fails, a standby supply is automatically obtained from the No. 3 type 350 inverter, provided that it is switched on. No standby supply is available for the Green Satin installation. The starboard 112V bus-bar supplies the Green Satin inverter and the port 112V bus-bar supplies the flight instruments inverter.

(*b*) *Type* 350 *inverters*

(i) Three type 350 inverter sets supply the equipment listed below. The available output from each inverter is 1 KVA 115V—3-phase 400 CPS and 2 KVA 115V—single-phase 1,600 CPS.

"A" Group No. 1 set	*"B" Group No. 2 set*	*"C" Group No. 3 set*
NBC		
H2S	IFF Mk. 10	(Standby)
Bomb sight	Auto Mach trimmer	
	GEE Mk. 3 (Mk. 1 and 1A only)	
	Tail warning	
	Cabin and bomb-bay temp. control	
	Anti-icing control	
	Yaw damper (hydraulic)	
	Auto Pilot	
	ADF supply (DF only)	

(ii) Nos. 1 and 2 inverters are fed from the port 112-volt bus-bar and No. 3 from the starboard 112-volt bus-bar. In the supply line to each inverter is a fuse and a circuit breaker.

(*c*) *Tacan inverter*

A separate inverter, fed from No. 1 LV bus-bar, provides the electrical supplies for Tacan. It is controlled by an ON/OFF switch at the nav./plotters position.

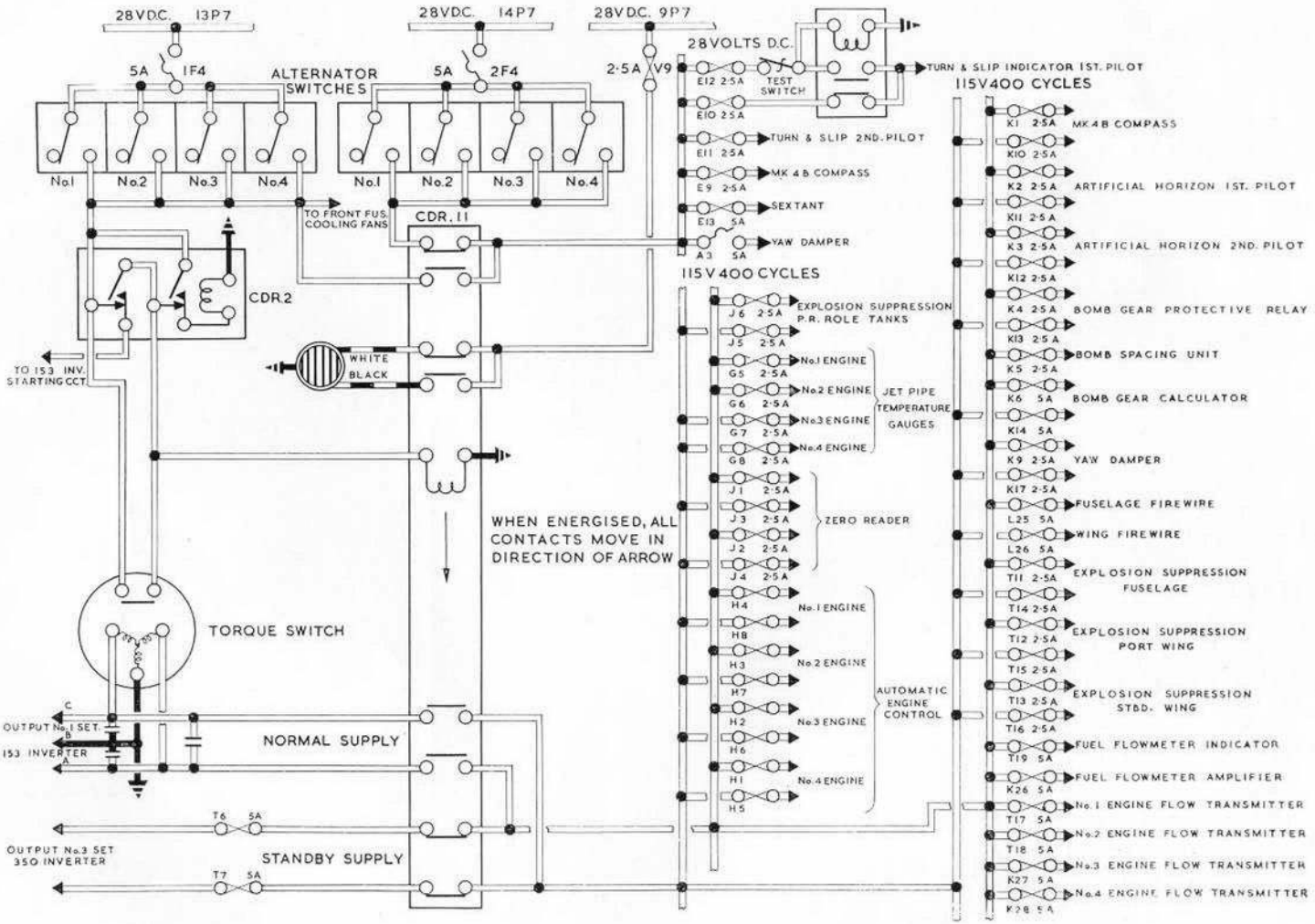

Fig. 2 Inverter supplies

10 ECM AC power supplies (Mk. 1A aircraft only)

AC power for the ECM equipment is supplied by either No. 2 or No. 3 alternator. When either of these is supplying the ECM equipment it cannot be used to supply the normal bus-bars. Thus if No. 1 or No. 4 alternator fails when No. 2 or No. 3 is supplying the ECM equipment, the appropriate bus-bars will be dead except for battery power or unless the bus-bars are paralleled. The Nos. 2 and 3 alternators run at engine speed, but Nos. 1 and 4 alternators run at 1·1:1 engine speed.

11 ECM cooling (Mk. 1A aircraft only)

(*a*) The ECM equipment is cooled by a water-glycol mixture which is circulated by two pumps from a separate water-glycol container in the rear compartment, through a freon cooling pack and then to the canisters. A constant circulation then obtains.

(*b*) The system is controlled by an ON/OFF switch on panel BC. The switch controls the electrical supplies to the water-glycol pumps, the rotor compressor and amplifier of the freon cooling pack. Post-Mod. 3031 the glycol pumps and rotor compressor are controlled by separate switches.

(*c*) An adjacent magnetic indicator shows HIGH (above 26°C) or LOW (below 1°C) if unsatisfactory water-glycol temperatures exist and striped under all other conditions (between 1°C and 26°C).

(*d*) Post-Mod. 3031, a red warning light beside the control switches comes on when a high pressure condition is detected in the compressor. The compressor must then be switched off for two minutes before switching on again.

(*e*) Supply to the ECM bus-bar is from the 208V AC output of the alternator.

Controls and Indicators

12 Battery controls

(*a*) Battery circuit breakers and supply indicators for each MV and LV battery supply are on panel BB together with battery master switches for control of each battery.

(*b*) The LV batteries may be reset after a disconnection from a bus-bar by means of a two-way, spring-loaded to OFF, battery reset switch on panel BD. This switch should only be used in extreme emergency when all LV supplies to that bus-bar have been lost. The MV batteries have no resetting facility.

13 Alternator controls and indicators

(*a*) Four ON/START/OFF switches, one for each alternator are mounted on the AEO's side panel BB. The switch positions function as follows:

OFF . The alternator is inoperative

START . The alternator is still inoperative, but the start circuit of the TRU is energised. This eliminates damage to the voltage regulator during initial voltage surge when the alternator is switched on

NOTE: The switch must not be left in the START position for more than 15 seconds or damage will be caused to a resistance in the TRU.

ON . . The power supplies are automatically connected to the bus-bars. The 208-volt AC supply will also be connected to the appropriate bus-bar provided that engine speed is above approximately 50%.

(*b*) Four low power warning lights, one for each alternator are mounted on the AEO's panel BB. If the control switches are set to ON, the appropriate amber light comes on whenever its alternator is in the low power condition, i.e. when engine speed is below approximately 50%.

(*c*) Four press-to-test red warning lights adjacent to the amber warning lights come on when alternator failure has occurred.

(*d*) A feeder circuit breaker supply for each alternator control switch is also fitted on panel BB.

14 Bus-bar paralleling control

The two low voltage bus-bars may be interconnected by operating an ON/OFF paralleling switch on panel BB: a similar switch is also on panel BB to parallel the two medium voltage bus-bars. Mod. 2154 introduces a magnetic indicator for each bus-bar paralleling switch which show black when the bus-bars are split and white when they are paralleled.

15 LV special feeders controls and indicators

(*a*) Two switches NORMAL/OFF/1P8 and NORMAL/OFF/2P8 control the routing to the two special feeders. Two magnetic indicators one above each switch show black when current is being fed to the special feeders. The first switch when set to NORMAL, supplies the 2P8 special feeder and the second similarly supplies the 1P8 special feeder. Should the electric supply to either special feeder fail, shown by its magnetic indicator going white, the switch below the indicator can, in emergency, be set to 1P8 or 2P8 respectively. This enables both special feeders to be supplied from the same battery.

(*b*) When the switches are at NORMAL a supply is routed through the appropriate circuit breakers on panel AJ to the following circuits:

Engine fire extinguishers
LP cocks
HP cocks
Fuel proportioners

and through fuses on distribution board BA to the following circuits:

Plenum chamber cooling fans warning
Tank fire extinguishers and warning lights
Battery warning
Bus-bar paralleling
Alternator warning

16 AC bus-bars controls and indicators

(*a*) At the top of panel BB are four CONTROL circuit breakers, together with four magnetic indicators which show pictorially which alternators are supplying AC POWER to the AC BUS-BARS. The supply indicators show a vertical line when energised.

(*b*) The indicators are energised when their respective alternators are either " working " or " running and available if required ".

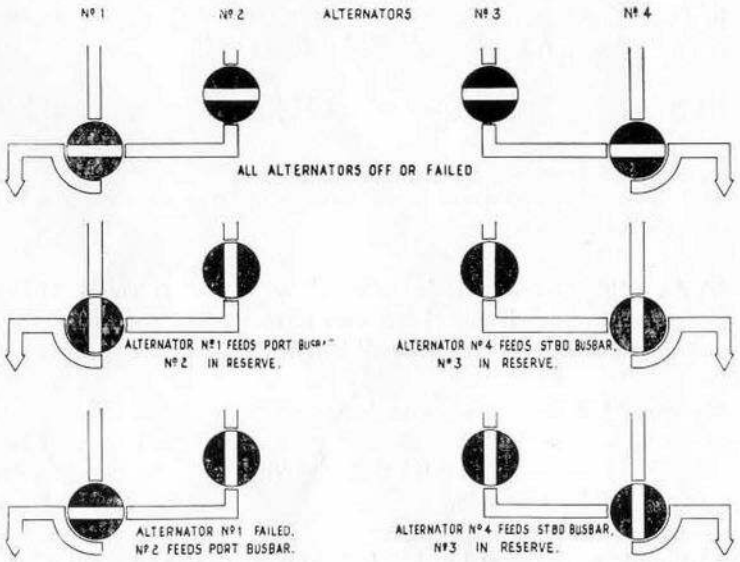

Fig. 3 Alternator indicators

17 AC type 350 inverters controls and indicators

The inverter circuit breakers are remotely controlled by three ON/OFF switches on panel CA. Six neon indicators, adjacent to the switches, glow when the inverters are operating correctly at 400 c/s and 1,600 c/s.

18 ECM controls and indicators (Mk. 1A aircraft only)

(*a*) The ECM switch panel CAL is at the left of panel BF. At the top right hand corner of the panel is a five-position No. 2 ALTR/RUN/START/OFF/START/RUN/No. 3 ALTR switch. This switch is inoperative whenever the No. 2 and No. 3 alternator switches are away from the OFF position. To supply the ECM equipment, No. 2 or No. 3 alternator must first be switched OFF and the appropriate engine RPM set to 93 ± 4½%. The alternator should then be selected to START on the five-position switch for a few seconds and then to RUN. Adjacent to the five-position switch is a frequency meter, which should read 400 ± 20 cps and a volt meter which should read 200 volts while supplies are being made. Two voltage trimmer controls are provided on panel BF.

(*b*) Whenever ECM is selected engine RPM must be kept constant within the range of 93 ± 4½% in order that the correct frequency of 400 ± 20 cps can be maintained. If the frequency is not maintained the supply of the ECM bus-bars is lost and the equipment must be reset. If the supply is lost the alternator supply does not automatically revert to the normal bus-bars.

(*c*) Whenever ECM equipment is in use all the normal alternator " switched off " indications are given at the AEO's station.

(*d*) At the right of panel AZ, at the pilot's station are two ECM frequency indicators which show as follows:

Striped	No power at indicator, generator switch not at OFF
Black	ECM selected and available at bus-bars, within correct frequency range
White	ECM supplies not available at the bus-bars

19 Ration heaters

(*a*) A ration heater is fitted at each pilot and crew station (except the downward observation station).

(*b*) Two circuit breakers are fitted, one on panel AF (AD-Mk. 1) controlling the two pilots' ration heaters and one on panel BB controlling the three crew ration heaters.

(*c*) When using the ration heaters it is imperative that a hole is made in each food tin before it is placed in a heater and that no tin is heated continuously for a period of more than two hours.

20 Internal lighting

(*a*) Miniature pillar lighting is installed throughout the pilots' cockpit, illuminating all panels with the exception of fuse and circuit breaker panels AJ, AH and AV.

(*b*) The following switches control the lights as follows:

Location	*Controls lights on panels*
Aft of panel AC	AC, AE
Left-hand side of panel AB	AB
Aft of panel AT	AT
Aft of panel AT	A
Right of panel AZ	AW, AZ
Left of panel AL	AL
Bottom of panel AB	AB
Outboard of quadrant on panel AF	AD, AF

21 External lighting

(*a*) *External lights control*

The EXTL. LIGHTS MASTER CIRCUIT BREAKER is on panel AC and controls the navigation lights, and, via the port and starboard light circuit breakers, the filaments of the landing lamps. The navigation lights ON/OFF switch is on panel AC. (The navigation lights have no flashing facility.) The beacon switch is independent of the external lights master circuit breaker.

(*b*) *Anti-collision beacon*

The anti-collision beacon is controlled by a three position switch on panel AC. The switch positions are FLASHING/OFF/STEADY.

(*c*) *Landing and taxying lights*

(i) Two master circuit breakers one for the PORT and STBD. lights are on panel AC. Adjacent is a three-position IN/TAXY/LAND switch. Setting the switch to TAXY or LAND selects the appropriate position. When set to IN the lights are retracted and switched off.

(ii) A further two circuit breakers are on panel AJ.

Normal Management of the System

22 Before starting engines

(*a*) *Electrical checks*

(i) On entering the aircraft check that all alternator switches are OFF and their circuit breakers tripped. When the external power supply is on, switch on the Special Feeders checking that the magnetic indicators are black. Make all LV circuit breakers on the lower part of panel BB with the exception of the following:

Window dispensers Nos. 1, 2, 3 and 4
Ration heaters
Flight Instrument No. 1

The external supply voltages will be indicated on the bus-bar voltmeter and the paralleling indicators (Mod. 2154) show white.

(ii) Ensure that the MV battery switches are off and the indicators white then switch on the LV battery switches and check that the indicators show black. Make all four AC circuit breakers at the top of the panel, the indicators should be horizontal. The No. 1 LV volt meter/ammeter should read a charge rate of 0-10 amps thus indicating a normal battery condition, but No. 2 will show a discharge reading of 50-60 amps. This is not a fault in the electrical system but is due to the ammeter being so placed in the external power circuit as to read all current being supplied to the aircraft LV bus-bar.

(iii) Make the crash switch circuit breaker and check that the warning lights are out.

(iv) Re-check that the No. 1 Alternator circuit breaker is tripped and switch the alternator to START then ON; this connects a 28v DC supply via No. 2 Flight Instrument circuit breaker to the Mk. 4B compass, the 1st and 2nd pilot's Turn and Slip indicators and the sextant.

NOTE: An alternator must never be switched ON with its circuit breaker made if the engine is stationary, or severe damage will result.

(v) Trip circuit breaker 1P25 and watch for a flicker on the total contents gauge at the Navigator Plotter's station (this indicates that the alternative electrical supply has taken over), then remake it.

(vi) Switch ON No. 3 type 350 inverter to supply the Mk. 4B compass and engine instruments.

(vii) Make all circuit breakers on panels AJ and AV.

(*b*) *Functional checks*

On commencing the functional checks prior to the use of hydraulic pumps make the No. 1 Flight Instrument circuit breaker and check that the cooling fan warning lights are out. The Plenum Chamber pressure gauge should now read a minimum of 0·07 PSI and the Flight Instrument Inverter indicator on panel CA show black. When the hydraulic pumps are no longer required for functional checks, trip the No. 1 Flight Instrument circuit breaker and check that the cooling fan warning lights are illuminated.

(*c*) *Normal starting procedure*

Immediately prior to starting the engines switch OFF No. 1 alternator switch and make the No. 1 Flight Instrument circuit breaker.

(*d*) *Internal start procedure*

When the aircraft batteries are used to start the engines the alternator switches must be OFF and the No. 1 Flight Instrument circuit breaker made. Switch ON the LV batteries and parallel the LV bus-bars, then switch ON the MV batteries. It is not necessary to parallel the MV bus-bars as this is done automatically on selecting INTERNAL on the Start Master Switch.

23 After starting engines on external power

(*a*) *Battery control*

When all engines are running at idling speed switch ON the MV batteries and ensure that the charge rate is normal (0-10 amps after one minute). The maximum permissible charge rate is 20 amps for 30 minutes.

(*b*) *Alternator control*

When the MV batteries are on, make all the alternator field circuit breakers and switch on the first alternator as follows: Select the START position, pause for a period of five seconds then switch to ON. The alternator Power Failure Warning light (red) should now go out and the Low Power (amber) light illuminate. Simultaneously the cooling fan warning lights should be extinguished and the Flight Instrument Inverter indicator show black. Repeat the above switching procedure for the remaining three alternators and check that their individual ammeters show LV and MV output when external power is removed.

(*c*) *Bus-bar de-paralleling check*

When the alternator output is stabilised remove external power and check that the paralleling indicators show black. A further check may be made by loading each bus-bar and observing the effect on the alternator ammeters.

24 After starting engines on internal power

(*a*) *Alternator control*

When the first engine is running at idling speed, switch on its alternator as described in 23(*b*). As the engine is run up to 75% check that the alternator Low Power (amber) warning light goes out at 51% power and its AC magnetic indicator becomes vertical. As each engine is started repeat the switching procedure.

(*b*) *Bus-bar de-paralleling*

With all engines started and the Start Master Switch at FLIGHT, place the LV paralleling switch OFF and check that the LV and MV paralleling indicators are black.

(*c*) *Battery control*

After an internal start the battery charge rate will be higher than usual but should soon settle down to a figure of 10 amps or less.

25 Pre take-off electrical checks

When all engines are at full power prior to take-off ensure that all electrical power circuits are functioning normally, as follows:

(i) Alternator Failure Warning Lights out.

(ii) Alternator Low Power Warning Lights out.

(iii) Alternator Cool Close Lights out.

(iv) AC Power Supply indicators vertical.

(v) MV and LV voltages and current within limits.

26 Control in flight

(*a*) *Alternators*

(i) Switching of alternators in flight should be restricted to a minimum and not between engine speeds of 40 to 70% RPM.

(ii) In normal flight with all the alternator Low Power Warning lights out, all AC magnetic indicators should be vertical, with Nos. 1 and 4 alternators supplying the AC bus-bars.

N.B.—If the AC output of two alternators on one side fails, no cross-feeding facilities are available and all the 208v AC supplies will be lost on the affected side.

(*b*) *Batteries and bus-bars*

Check periodically that the MV and LV battery indicators are black and bus-bar voltages normal (112v, 28v). If the battery is switched off in flight and switched on again before landing a charge rate of up to 80 amps for 30 seconds may occur until the TRU settles down.

(*c*) *Special feeders*

During flight periodic checks should be made to ensure that the Special Feeder indicators are black, as if either indicator changes to white the special feeder together with its associated battery is lost.

(*d*) DC *bus-bar paralleling*

Before paralleling the bus-bars in the event of a fault care should be taken to ensure that:

(i) No earth fault is present on the dead bus-bar (as indicated by the volt/ammeter).

(ii) All loads are switched off the dead bus-bar.

WARNING : *If a wrong decision is made it is possible to transfer a fault to the live bus-bar thus losing all electrical supplies.*

27 Inverter control

(*a*) The Flight Instrument Inverter indicator on panel CA will normally show black in flight. In the event of its failing, No. 3 Type 350 Inverter will automatically take over its loads; for this reason No. 3 350 Inverter should always be switched ON in flight.

(*b*) When switching Type 350 Inverters on and off the loads must always be switched off first. This also applies when use is made of the transpose facility.

28 Limitations on electrical power

Loading of each alternator must be limited to a sustained MV load of 200 amps and an LV load of 100 amps. Normal in-flight loads with four alternators in use will be approximately 50 amps MV and 25 amps LV per alternator.

Malfunctioning of the System

29 Loss of an LV battery

(*a*) If during flight an LV magnetic indicator changes to white, that battery is then disconnected from the bus-bar. Put the appropriate battery switch to OFF, allow time for the thermal trip to reset (approximately 30 secs.) then switch the battery ON again. If the magnetic indicator changes to black then white switch OFF and leave off.

(*b*) If an LV battery becomes disconnected and cannot be reset, care must be taken not to throttle back both engines on that side in such a manner that both alternators change into low power at the same time. Failure to take this precaution may result in failure of both associated alternators and loss of resetting facilities. This situation is caused by the frequency sensing units in the transforming rectifier units moving to the low power condition simultaneous with the throttle movement, thus momentarily breaking the TRU LV supply to the bus-bar. As no LV battery supply is available on the bus-bar the subsequent loss of alternator field current will cause both alternators to fail. Non-synchronous movement of the throttles will prevent this by ensuring that one TRU is supplying field current to both alternators whilst the frequency sensing unit of the other is moving to the low power position.

(*c*) If the disconnection of the battery is accompanied by the loss of alternators, load shedding must be carried out and action taken to reset the LV battery as in (a) above. If this action is unsuccessful the LV bus-bar reverse current reset switch at the edge of the AEO's table may be used. This switch should not normally be used

in flight to recover a failed battery but, in the event of failure of battery and alternator supplies, range considerations or subsequent faults may justify its use.

30 Loss of an MV battery

(*a*) Should an MV battery indicator show white indicating disconnection from the bus-bar, switch OFF then ON. If the indicator shows black no further action is necessary.

(*b*) If after switching OFF then ON the indicator goes black then white no further action is possible.

(*c*) Should the indicator remain white after reset action the battery is connected but the indicator is unserviceable and the fuse should be checked.

31 Loss of a special feeder

(*a*) If either magnetic indicator changes to white indicating a failure it is inadvisable to use the alternative supply except in the case of an engine fire on the failed side. The special feeder switch should in this event be put over to the alternative position whilst the fire button is being pressed.

(*b*) All other actions as for loss of an LV battery.

32 Single alternator failure

(*a*) The loss of an alternator will be indicated by the illumination of the Power Failure Warning Light (PFWL) on panel BB and nil readings on the appropriate ammeter. If the field circuit-breaker has tripped, switch OFF, reset the circuit-breaker and switch ON via the START position. If the alternator Power Failure Warning Light comes on again switch OFF and leave OFF.

(*b*) If an alternator PFWL comes on whilst engine RPM is less than 51% and the low power light is on, it is possible that the alternator has tripped off line due to a temporary overload condition. Switch the alternator OFF, shed the appropriate MV loads and switch the alternator ON again after a minimum period of 30 seconds. If the alternator then operates satisfactorily the MV bus-bar loads may be reconnected, but if the PFWL comes on again switch OFF and leave OFF.

(*c*) If both the low power light and the PFWL come on whilst engine RPM is above 51% it is an indication of a sheared drive shaft, in this case switch the alternator OFF and leave OFF. Consideration should be given to flaming out the engine.

33 Double alternator failure

(*a*) Should two alternators fail on one bus-bar both Power Failure Warning Lights will illuminate. Switch OFF the MV battery switch thus removing all heavy loads from it immediately, and reduce LV loads by selective switching. The MV loads can then be individually switched OFF by use of the appropriate switches. Restore the MV battery to its bus-bar by switching ON and check its ammeter for any discharge. Reset the alternators as in para. 32 above and switch ON MV services again. If neither alternator can be reset the MV and LV voltmeter/ammeters must be checked before any decision to parallel the bus-bars is made.

NOTE: *No attempt is to be made to recover an alternator if the bus-bars have been paralleled.*

(*b*) In the event of the loss of two alternators accompanied by the disconnection of an LV battery and loss of special feeder, the MV battery latched contactors will interlock due to the lack of supplies to open them. The MV bus-bars may in this instance be paralleled at the captain's discretion.

(*c*) In all instances where two alternators fail on one side or are switched off, load shedding should be carried out as listed in the Double Alternator Failure Drill. However, the LV battery should not be switched off immediately such an emergency occurs as it is important to retain various indicators and control circuits, the most

important of these being, Engine Fire Warning, PFCU indicators, Hydraulic control and indicators and Abandon Aircraft lights. If it is not possible to reset the alternators and a decision is made not to parallel the bus-bars the LV battery will become discharged if left on. Therefore after the immediate emergency is over it is advisable to switch it off and trip the LV feeder circuit breakers on the failed side. If the battery voltage is kept above 19 volts it can be used for important control and indicator circuits as although some indicators will work at very low voltage, control circuits become useless below 17 volts. In the event of the loss of two alternators on one side being accompanied by the disconnection of the LV battery, the MV latched loads cannot be switched off the bus-bar. Therefore consideration must be given to paralleling the MV bus-bars or switching off the MV battery.

34 Four alternator failure

The chance of four alternator failure due to an electrical fault is considered remote in a split bus-bar system, but in the event of its happening the following procedure must be carried out:

(i) Shed loads as in sub-paras. (v) to (xix)

(ii) Trip all alternator field circuit breakers and remake individually

(iii) If unable to regain alternators trip circuit breakers and, if safe to do so, parallel the bus-bars

(iv) Airbrakes as required

(v) Switch OFF both hydraulic pumps

(vi) Switch OFF half Power Flying Control Units

(vii) Select all proportioners to BYPASS

(viii) Leave three fuel pumps ON, all others OFF

(ix) NORMAL yaw damper STANDBY—standby yaw damper as required

(x) Switch OFF all inverters except the (153) Flight Instrument Inverter

(xi) Trip NBC and H2S circuit breakers

(xii) Switch OFF scanner stabilisation

(xiii) Switch OFF the VHF/UHF set not in use

(xiv) Minimum use of the HF then trip the circuit-breaker

(xv) Switch all lighting to minimum requirements

(xvi) Switch OFF all heater and anti-icing switches except pitot head heaters

(xvii) Trip ILS and ADF circuit breakers

(xviii) Trip ration heater circuit breaker

(xix) Switch OFF conference inter-comm. and UHF (Mk. 1A and Tanker aircraft only)

(xx) IFF to EMERGENCY if required. (No. 2 350 Inverter must be ON for same)

NOTE 1: The MV bus-bar voltage must be monitored continuously, as the power flying controls will be inoperative at below 75v and the aircraft must be abandoned when this figure is reached.

NOTE 2: If the alternator failure is due to a four-engined flame-out the alternator field circuit breakers should not be tripped until the Transformer Rectifier Unit LV outputs fall to 5 amps as the alternators will continue to give an output under windmilling conditions. In this event the air-brakes should not be extended.

35 LV or MV bus-bar overvolting

If an overvolting condition of more than 35v on an LV bus-bar or 125v on an MV bus-bar occurs check the ammeters to find the generating system carrying the heaviest load. Switch OFF the alternator with the highest output and if the voltage returns to normal no further action is necessary. If the overvolting persists switch this alternator back ON again and switch OFF the second alternator. If the voltage is now normal no further action is necessary but if the overvolting condition persists switch OFF both alternators, shed the appropriate loads and consider paralleling action if safe to do so.

36 High or low voltage on LV or MV bus-bars

Should an LV or MV bus-bar voltage increase to 30-35v or 115-120v respectively or should voltage fall to 24-26v or 105v respectively, switch OFF either alternator and trim the remaining alternator to 28v. Switch both alternators ON again and then switch OFF the alternator which has been trimmed. Trim the second alternator to 28v and switch both alternators ON again. If unable to trim any one alternator, switch OFF and leave off, but if unable to trim both alternators switch both ON, leave on and monitor the voltmeter/ammeter for excessive charge or discharge.

37 Failure of cooling fans whilst taxying

(*a*) The failure of one cooling fan whilst taxying will be indicated by the illumination of the red warning light on panel BB. Load shedding must be carried out on the appropriate bus-bars, the MV and LV bus-bars paralleled to distribute the Transformer Rectifier Unit loads evenly, and the aircraft taxied back to dispersal.

(*b*) Two cooling fan warning lights illuminating on panel BB will indicate the failure of both fans. Check the No. 1 Flight Instrument circuit breaker on panel BB and its associated magnetic indicator on panel CA. If the indicator is white and the circuit breaker tripped, reset the latter and if the cooling fan warning lights go out and plenum chamber pressure as indicated on panel BC is above 0·07 PSI, no further action is necessary. If the cooling fans remain unserviceable the engines should be closed down as quickly as possible and all services switched OFF. Fuse E20 in panel CD over the Navigator/Radar station can now be checked, also the appropriate HRC fuses in the plenum chamber.

38 Loss of plenum chamber pressure in flight

Any loss of plenum chamber pressure in flight will be indicated by a negative reading on the gauge on panel BC, and is usually indicative of the loss of a hatch, i.e. dinghy hatch, plenum chamber hatch. All Transformer Rectifier Unit loads should be reduced to a minimum consistent with safety and the bus-bars paralleled if safe to do so. It is considered that where flight conditions necessitate, a further 90 minutes flying time is permissible without undue overheating but where possible the aircraft should be landed and closed down.

39 Failure of a type 350 inverter

The failure of a type 350 inverter will be indicated by one or both neon indicators on panel CA failing to glow. Before attempting to reset the inverter its loads must be switched OFF, then the inverter switch held in the trip position for one second. Switch the inverter ON and if the neon indicators are normal, reload. In the event of failure to re-establish the inverter a transpose facility exists to enable its group of services to be transferred to another inverter. This facility is controlled by the POWER EMERGENCY TRANSPOSE SWITCH on panel CA at the Navigator's station. Before operating the switch both the unserviceable inverter and the inverter to which the group is to be transferred must be unloaded and switched OFF to prevent arcing of the relay contacts. After transposition the serviceable inverter must be switched ON again and the loads re-introduced. The table below summarises the operations involved in effecting transposition.

U/S Inverter	*Group*		*Switch OFF Inverters*	*Select*	*Switch ON Inverter*
	Reqd.	*Not Reqd.*			
1	A	B	1 and 2	A/B	2
1	A	C	1 and 3	A/C	3
2	B	A	2 and 1	A/B	1
2	B	C	2 and 3	B/C	3

40 Failure of a type 153 Inverter

Loss of type 153 inverter supplies will be indicated as follows:

(*a*) No. 1 Flight Instruments Inverter—the magnetic indicator on panel CA will indicate white but the services supplied will be automatically taken over by No. 3 350 inverter. The reset action is to trip and remake the No. 1 Flight Instrument circuit breaker.

(*b*) The Green Satin Inverter — the only indication of loss of Green Satin inverter supplies will be the failure of the Green Satin equipment. The reset procedure is to switch OFF the Green Satin equipment and the inverter, then switch ON in the reverse order. If the inverter remains on no further action is necessary but if it fails again no alternative supply is available.

41 Load shedding

The following tables list all the MV loads and the main LV loads which may be shed

MV loads

Switch off appropriate MV Battery to ensure complete load shedding.

Port MV *Bus-bar*	*Starboard* MV *Bus-bar*
Nos. 1 and 2—350 Inverters	No. 3—350 Inverter
Flight Instrument Inverter	Green Satin Inverter
No. 1 Hydraulic Pump	No. 2 Hydraulic Pump
Odd PFCU's	Even PFCU's
Red Fuel Pumps	Green Fuel Pumps
H2S Amplidyne	H2S Scanner
Ration Heaters	Ration Heaters
TR Cooling Fan	TR Cooling Fan

Attention is drawn to the small H2S load on both bus-bars which will preclude the use of H2S when either bus-bar has completely shed its loads.

Main LV *Loads*

No. 1 LV *Bus-bar*	*No.* 2 LV *Bus-bar*
Landing lamps	UHF
HF	Panel lights
No. 1 VHF/UHF	No. 2 VHF/UHF
Starboard pitot head heater	Port pitot head heater
Panel lights	Cabin lights
NBC	Trim control
H2S	Main Alternator control
IFF Mk. 10	Cabin Temperature Control
Radio Altimeter	ADF
Navigation lights	Engine anti-icing
Main Alternator Control	Tail anti-icing
Trim control	Port wing anti-icing
PFCU control	Starboard wing anti-icing
Cabin ventilation	Bomb-bay heating
Tail anti-icing	Wing air exit shutters
Engine anti-icing	Controlled AC supplies and
Starboard wing anti-icing	flight instruments standby DC
Port wing anti-icing	Flying controls
Wing air exit shutters	Bombing controls and indicators
Trip circuit breaker 1P25	
Tacan	

NOTE: In the event of double engine or double alternator failure where it is decided not to parallel, the LV battery will be switched off to conserve it after the immediate emergency is over. The hydraulic, fuel, PFCU and inverter control circuits will be affected as detailed under these sections.


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