Part I—Description and Management of Systems

Chapter 7—Electrical System

List of Contents

1 General

(*a*) The electrical system can be divided into three main sections, namely 112-volt for the heavy duty or main consuming equipment, 28-volt for the secondary or low current consuming equipment and single- and three-phase AC at 115 volts with frequencies of 1,600 and 400 cycles per second. Much of the controlling equipment for the 112-volt section is supplied at 28 volts.

(*b*) Power for the 112-volt section is generated by four $22\frac{1}{2}$ Kw engine-driven generators installed one on each engine; 28-volt power is provided by three rotary transformers (housed in the nosewheel bay) which derive their input from the 112-volt section of the system. Single- and three-phase AC supplies for radio, radar and other equipment are provided by five inverters driven from the 112-volt section.

(*c*) The DC control panel 10P is on the port side of the cabin at the AEO'S station and contains all the controls and warning lights for both the 28-volt and 112-volt sections. The AC control panel 11P is at the nav/plotter's station.

(*d*) The power compartment is situated aft of the bomb-bay, and contains the aircraft batteries, one for the 112-volt section and the other for the 28-volt section, their association fuse panels, and their associated control panels.

(*e*) An "essential services" bus-bar which is permanently connected to the 24-volt battery, is on the 24-volt battery control panel in the power compartment. It supplies:

Crash switches
Fire-extinguishers
LP cocks

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Battery isolating control circuits
Relighting and starting circuits
No. 1 28-volt rotary transformer control circuit
1st Pilot's oxygen regulator
Lighting in ECM compartment

In the event of a crash, six inertia switches isolate the generators and the batteries from all aircraft services (including ECM) leaving the " essential services " bus-bar supplied from the 24-volt battery.

2 112-volt section

(a) Generators

Four engine driven 22½ Kw generators supply 112-volts for this section.

(b) Bus-bars

(i) The No. 1 and No. 2 generators operate in parallel and are connected to a common bus-bar known as the No. 1 and No. 2 generator bus-bar.

(ii) The 96-volt battery is connected, via a BATTERY ISOLATING switch, to the battery bus-bar. This bus-bar is normally connected to the No. 1 and No. 2 generator bus-bar by a BATTERY BUS-BAR ISOLATION contactor, which, when energised, allows the No. 1 and No. 2 generators to supply all the loads on both the No. 1 and No. 2 generator and battery bus-bars.

(iii) The No. 3 and 4 generators operate individually and are connected to their own separate bus-bars, the No. 3 and the No. 4 generator bus-bars respectively.

(iv) Provision is made for the No. 1 and No. 2 generator and the battery bus-bars to take over automatically the load of a failed No. 3 or No. 4 generator bus-bar by operation of its appropriate paralleling contactor. Also No. 3 and/or No. 4

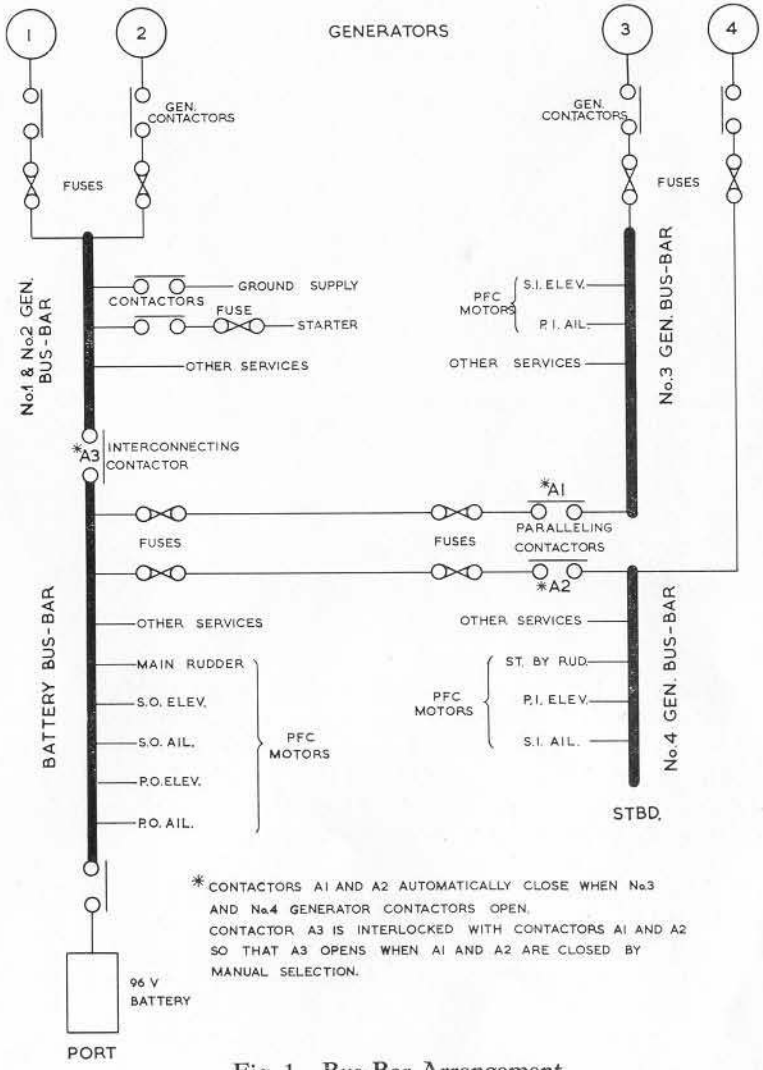

Fig 1 Bus-Bar Arrangement

generator bus-bars may take over the load of the battery bus-bar by manual selection of the appropriate paralleling contactors.

(c) *Voltmeter*

A voltmeter for the 112-volt supplies is on the DC control panel. It continually indicates the voltage of the battery section bus-bar. When any of the four generator VOLTAGE TEST push-buttons are pressed, however, the voltmeter reads the associated generator voltage, but see (e) (ii) below.

(d) *Ammeters*

Nine ammeters in four units are fitted on a panel at the AEO's station. They are as follows: —

(i) Four ammeters, in one unit, one for each generator, to indicate the generator load.

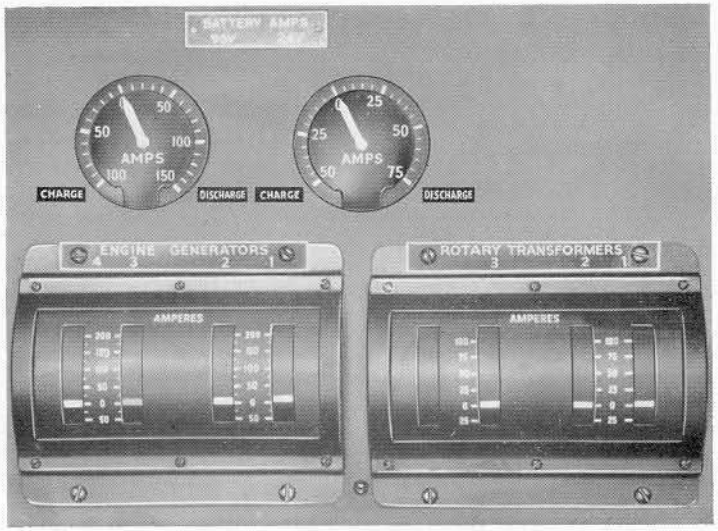

Fig 2 Electrical Load Ammeters

(ii) Three ammeters, in one unit, one for each rotary transformer, to indicate the rotary transformer load.

(iii) One ammeter to indicate the current flow in the 96-volt battery circuit.

(iv) One ammeter to indicate current flow in the 24-volt battery circuit.

During engine starting, the No. 1 and No. 2 generator load ammeters, and the 96-volt and 24-volt battery ammeters are isolated by a relay in order to prevent damage to the instruments.

(e) *Control switches and warning lights*

(i) Each generator has a red failure warning light and a guarded OFF & TRIM—RESET—ON main control switch on the DC control panel. Below the main control switches are four generator ENGAGE push-buttons which are used to connect the generators to their respective bus-bars.

(ii) Four generators VOLTAGE TEST push-buttons, one for each generator, are fitted on the DC control panel. When the No. 3 or No. 4 push-button is depressed, the associated generator voltage is indicated on the 112-volt bus-bar voltmeter. In the case of the No. 1 and No. 2 generators however, the associated generator control switch must be set to OFF & TRIM before pressing the VOLTAGE TEST push-button. The voltage of the generator being tested will then be indicated on the voltmeter. However in the case of the No. 1 and No. 2 generator, this should not normally be done in flight.

(iii) A BATTERY BUS-BAR ISOLATION push switch is on the DC control panel ; this switch, when pressed in, opens the interconnecting contactor to separate the No. 1 and No. 2 generator bus-bar from the battery bus-bar thus isolating the No. 1 and No. 2 generator bus-bar and preventing a fault on that bus-bar affecting the battery bus-bar. An amber warning

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light within the switch comes on when the switch is pressed in. The switch remains in until pulled out, when the amber warning light will go out.

Fig 3 DC Control Panel

(iv) A BATTERY DISCHARGE WARNING red light on the DC control panel comes on when a discharge or charge rate of 150 amps on the 96-volt battery is exceeded. During engine starting from the internal batteries the light will come on and remain on for a few minutes after the generators come on line. A press to test facility for the light is provided.

(v) Two No. 3 and No. 4 CLOSE NORMAL PARALLELING SWITCHES, each with an associated amber warning light are on the DC control panel. These switches are normally set to NORMAL and the amber lights are out when the generators are on line. When manually selected to CLOSE, the paralleling contactor is closed and the load on the battery bus-bar is taken over by the appropriate No. 3 or No. 4 bus-bar. When either or both PARALLELING SWITCHES are selected to CLOSE, the battery bus-bar isolation contactor automatically opens to isolate the No. 1 and No. 2 generator bus-bar. These switches should therefore only be operated when No. 1 and No. 2 generator warning lights indicate failure. The two amber warning lights come on to indicate that the associated paralleling contactors have closed. Each will come on automatically to indicate failure of its associated No. 3 or No. 4 generator bus-bar and automatic operation of the paralleling contactor. Each light will also come on when its associated PARALLELING SWITCH is set to CLOSE, but in this case the BATTERY BUS-BAR ISOLATION amber warning light will not come on although the battery bus-bar isolation contactor will have opened.

(f) Generator control

(i) A generator is brought on line by checking that the generator voltage is between 108-116 volts, moving the main control switch to ON and pressing in the ENGAGE button. The generator failure warning light should then go out. A generator may be switched off line by setting its control switch to OFF & TRIM.

(ii) The generator failure red warning light comes on whenever the main contactor trips, due to failure or overload, causing the generator to go off line. An attempt to bring the generator back on line may be made as in para 12 below.

(iii) A single GEN FAIL red warning light (A/16) on the engine instruments panel comes on in the event of total generator failure.

(*g*) *Transferring generator loads*

(i) Should No. 1 generator fail, the No. 1 and No. 2 generator bus-bar and the battery bus-bar loads will be borne by the No. 2 generator. Similarly if the No. 2 generator fails the loads on these two bus-bars will be borne by the No. 1 generator. Failure of both the No. 1 and No. 2 generators however, will result in the loads on these bus-bars being borne only by the 96-volt battery. In this event, the load on the battery bus-bar may be taken over by the No. 3 and No. 4 generator bus-bars by closing the No. 3 and No. 4 PARALLELING SWITCHES. This action isolates the No. 1 and No. 2 generator bus-bar, as the battery bus-bar isolation contactor is interlocked with the PARALLELING SWITCHES to open automatically when either PARALLELING SWITCH is manually set to CLOSE. Any fault on the No. 1 and No. 2 generator bus-bar is thus isolated, and the loads on that bus-bar will not be supplied.

(ii) Failure of either No. 3 or No. 4 generator causes the associated bus-bar voltage to drop. When the voltage on the failing bus-bar has dropped to approximately 95 volts, the main contactor of that generator will open causing the associated paralleling contactor to close automatically, and the services on this bus-bar are then transferred to the No. 1 and No. 2 generator and battery bus-bars. The automatic changeover is electrically interlocked so that the failing generator is isolated before the change-over occurs. The services on the No. 3 and No. 4 generator bus-bars are thus assured of a continuous supply should either No. 3 or No. 4 generators fail. When either No. 3 or No. 4 generator bus-bars are being supplied by the No. 1 and No. 2 generator and battery bus-bars, the associated amber warning light adjacent to the PARALLELING SWITCHES will be on, plus the failed generator warning light.

(*h*) *Loads on bus-bars*

The distribution of the main electrical loads on the four bus-bars are as follows:

Battery bus-bar	*No. 1 and No. 2 generator bus-bar*	*No. 3 generator bus-bar*	*No. 4 generator bus-bar*
Port outer elevator PFC	No. 1 rotary transformer	No. 2 rotary transformer	No. 3 rotary transformer
Stbd outer elevator PFC	No. 1 inverter	No. 2 inverter	No. 3 inverter
Port outer aileron PFC	Main engine starting	Stbd inner elevator PFC	Port inner elevator PFC
Stbd outer aileron PFC	External supply socket	Port inner aileron PFC	Stbd inner aileron PFC
Main rudder PFC		Nos. 2, 3 and 6 stbd booster-pumps	Stand-by rudder PFC
Normal airbrake		Nos. 3 and 6 stbd auxiliary booster-pumps	Emergency hydraulic power pack
Nos. 4 and 5 inverters		Stand-by air-brake motor	Nos. 1, 4, 5 and 7 stbd booster-pumps
Nos. 1, 2, 3, 4, 5, 6 and 7 port booster-pumps		No. 1 stbd transfer pump	
Nos. 1 and 7 port transfer pumps		H2S	No. 7 stbd transfer pump
		Live busbar indicators	
Nos. 3, 4, 5, 6 and 7 port auxiliary booster-pumps			Nos. 4, 5 and 7 stbd auxiliary booster-pumps
Total failure generator and auto-paralleling warning lights			
Live bus-bar indicators			
Battery heater and and intake inverter intake de-icing			
Windscreen demister heater			

3 28-volt section

(*a*) The three 3 Kw rotary transformers, driven by the 112-volt supply, charge a battery and provide power for operating all services not powered by the high voltage section. The 28-volt section is also used to operate the control relays in all electrical circuits except the generator circuits.

(*b*) No. 1 rotary transformer control circuit is supplied from the essential services bus-bar ; Nos. 2 and 3 are controlled from the main 28-volt section, and consequently only function when the 28-volt main bus-bar is " live ".

(*c*) When a rotary transformer control switch is set to ON, the rotary transformer will start up, providing its respective 112-volt bus-bar is energised (see 2(*h*) overleaf). Failure of any of these bus-bars may cause the affected rotary transformers to be shut down or may require them to be switched to OFF for load shedding purposes (See Part V, Chap 2).

(*d*) Each rotary transformer has a failure warning light and a guarded TRIM—OFF—ON switch on the DC control panel. If a warning light comes on, it normally indicates failure of that particular rotary transformer (but see Part V, Chap 2, Para 13). It may be advisable in these circumstances to switch off some non-essential 28-volt services, in order not to overload the remaining two rotary transformers. An attempt to bring the rotary transformer into use again may be made by moving its control switch to OFF and after one minute to ON. If the rotary transformer starts up again the warning light will go out. If the rotary transformer fails to start, its control switch should be set to OFF.

NOTE: With the switch in the TRIM position the rotary transformer is off line but running. For complete shut-down OFF should be selected.

(*e*) A voltmeter on the DC control panel continually indicates the 28-volt bus-bar voltage.

4 Batteries

(*a*) *96-volt and 24-volt batteries*

(i) These batteries are nominally 96-volt and 24-volt for the 112-volt and 28-volt sections respectively. The 96-volt battery is charged when the No. 1 and No. 2 generator and battery bus-bars are being supplied by the No. 1 and/or No. 2 generators, provided that the bus-bar isolation contactor and battery isolation switch are closed. The 24-volt battery is charged when a rotary transformer is operating. The batteries are located in the power compartment, and the negative poles are normally earthed, using the aircraft metal structure for the negative return.

(ii) Two three-position ON — neutral — OFF BATTERY ISOLATING SWITCHES, spring-loaded from OFF to neutral, on the DC control panel, control the 96-volt and 24-volt batteries.

(iii) A battery blower motor, operating from the 28-volt supply, is used to circulate air in the battery boxes whilst the aircraft is on the ground.

It is controlled by the undercarriage DOWN selector, so that when the undercarriage is selected down a supply is provided to the blower motor. Both the circuit-breaker and relay for this motor are on the central panel on the rear spar at the forward end of the power compartment.

(iv) A thermostatically-controlled heater operating from the 112-volt supply maintains stabilised temperature conditions in the battery boxes whilst the aircraft is airborne. The heater is controlled by the undercarriage UP selector, and the thermostatic switch operates between 10°—15°C and 25°C, i.e. when a battery box temperature of 25°C is reached the supply to the heater is cut off, and when the battery box temperature has fallen to between 10°C and 15°C the supply to the heater is switched on. This cycle is maintained throughout flight. When the undercarriage is selected DOWN the supply to the heater is cut off.

(*b*) *Use of internal batteries for emergency starting*

The 96-volt and 24-volt batteries may be used, in an emergency, to start one engine when no external power supply is available. (See Part III, Chapter 1, paragraph 4 for emergency starting procedure).

(*c*) *Emergency batteries*

Two 24-volt batteries, connected in parallel and fitted on the pilots' floor underneath the port console, provide an emergency source of supply for the 1st pilot's turn-and-slip indicator and for the three emergency lamps in the cockpit.

5 External supply plugs

(*a*) There are two external supply plugs in a small compartment on the port side of the power compartment, one for the 112-volt section and one for the 28-volt section.

(*b*) When the 112-volt external supply is plugged in, all 112-volt services may be operated. In addition the 96-volt aircraft battery will be charged from the external supply provided the 112-volt isolating switch is set to ON. If the rotary transformers are switched ON, the 28-volt services may be operated and if the 28-volt isolating switch is set to ON, the 24-volt aircraft battery will also be charged.

(*c*) When the 28-volt external supply is plugged in all the 28-volt services may be operated, and the 24-volt battery will be charged if the 28-volt isolating switch is set to ON. The rotary transformers should be switched to OFF.

(*d*) When Mod. 1793 is embodied, an aircraft earthing point, for use during ground servicing and refuelling, is provided at the forward end of the nosewheel bay, starboard side.

6 AC supplies

(*a*) *General*

(i) AC for the instruments, auto-pilot, radar, Green Satin and certain radio equipment is provided by five inverters which are controlled from a switch panel at the nav./plotter's station.

(ii) Inverters No. 1 and 3 carry the radar and radio loads, and additionally No. 3 inverter carries the flight instruments load. No. 4 inverter carries the auto-pilot load and No. 5 the Green Satin load.

(iii) In an emergency, the load from the No. 1, 3 and 4 inverters can be transferred to the No. 2 inverter, which is normally standing by without load. The No. 5 inverter however, has no stand-by.

(iv) If failure of the No. 3 inverter occurs, the flight instruments load is automatically transferred to the No. 2 inverter. The remaining loads on the No. 3 inverter must, however, be manually transferred to the No. 2 inverter.

(*b*) *Inverters No. 1, 2, 4 and 5*

(i) These inverters are controlled by ON—OFF switches on the AC controls panel and supply three-phase 400 CPS at 115-volts; the No. 1 and No. 2 also supply single-phase 1,600 CPS at 115-volts to supply the following services: —

Inverter	*Fuse No.*	*Service* 400 CPS	*Fuse No.*	*Service* 1,600 CPS
No. 1 (Type 350)	538, 541, 606, 607	NBS / Windscreen demister	537	NBS
	608, 609	No. 1 Inverter neon indicators		
	717	No. 1 and No. 4 Engine JPT gauges		
	718	No. 1 and No. 4 Engine JPT limiter system		
	719	No. 1 and No. 4 Engine JPT limiter system		
	720	No. 1 and No. 4 Engine JPT gauges		
	721, 722	Starboard pitch damper		
No. 2 (Type 350)		EMERGENCY STAND-BY FOR No. 1, 3 and 4 INVERTERS		EMERGENCY STAND-BY FOR Nos. 1 & 3 INVERTERS
No. 4 (Type 153)*	259, 260, 261, 262	No. 4 Inverter neon indicators / Auto-pilot Mk. 10 and torque switch		
No. 5 (Type 153)*	273, 274, 275, 276	Green Satin / No. 5 Inverter neon indicators		

* Type 153A introduced in lieu when Mod 675 is embodied

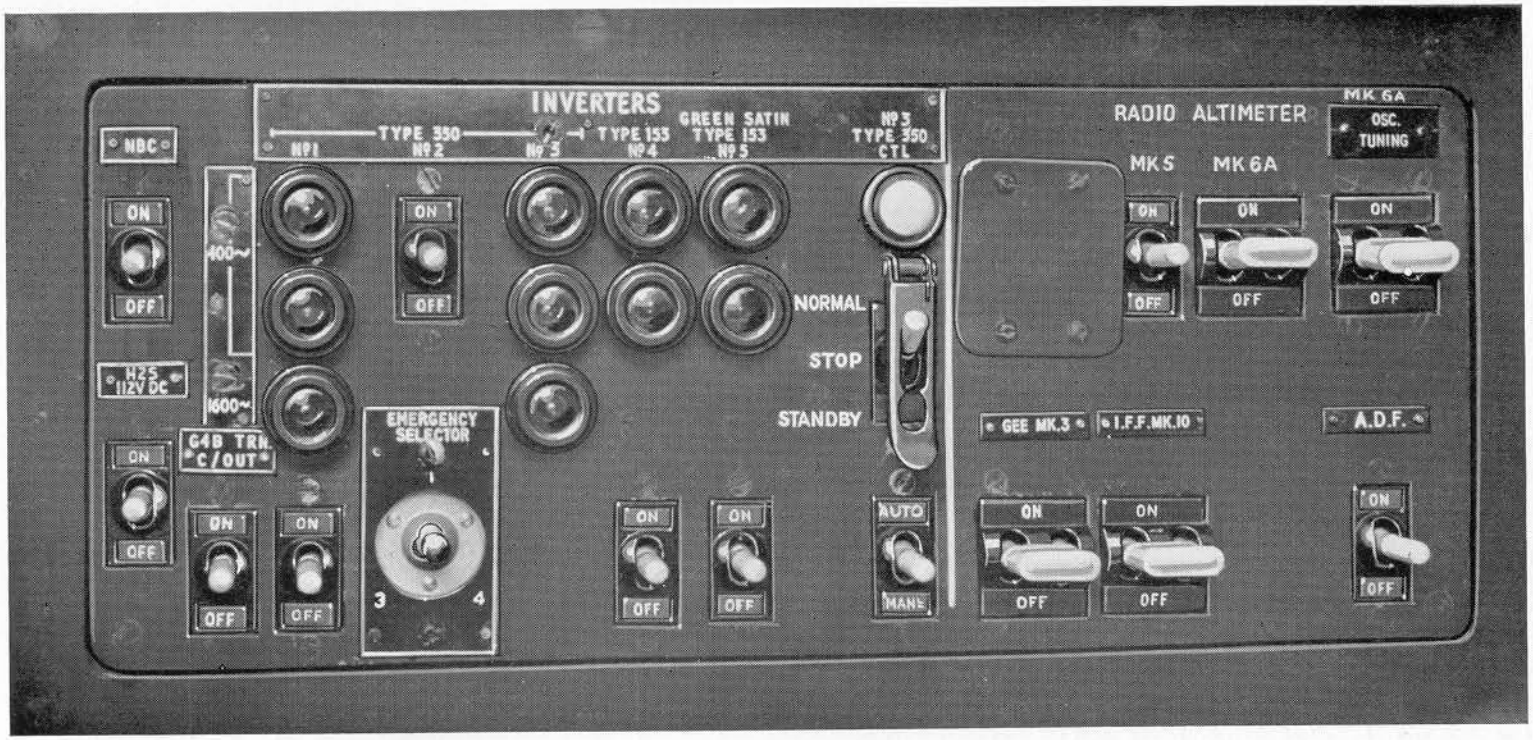

Fig. 4 AC Control Panel

(ii) Inverter No. 1 has three neon indicators, two for the 400 CPS supply and one for the 1,600 CPS supply. Inverters Nos. 4 and 5 each have two neon indicators for the 400 CPS supply. The No. 2 inverter has no neon indicator of its own.

(iii) To transfer a load from either No. 1 or 4 inverter to the No. 2 inverter, move the EMERGENCY SELECTOR switch on the AC controls panel to either No. 1 or No. 4 as required, and ensure that the appropriate neon indicators of the off-loaded inverter have come on.

(c) No. 3 inverter (Type 350)

(i) The No. 3 inverter has three neon indicators, one for each 400 CPS supply and one for the 1,600 CPS supply. This inverter supplies the following services: —

Fuse No.	Service 400 CPS	Fuse No.	Service 1,600 CPS
229, 230	Bomb release	268	Gee Mk. 3
		269	High range radar altimeter
231, 232	—	270	—
233	Bomb bay heating	271	IFF Mk. 10
234	Bomb release	272	No. 3 Inverter neon indicator
235, 236	Fuel sequence timer—Port		
237, 238	Fuel sequence timer—Starboard		
239, 240, 241, 242	Anti-icing system		
243, 244	UV lighting		
245, 246	Time of fall indicator		
247, 248	Yaw damper		
249, 250	No. 3 Inverter neon indicators		
251, 252	Fluorescent lighting		
253, 254	Mk. 4 B Compass		
255, 256	Horizon gyro—Port		
257, 258	Zero-reader		
265	Radio compass		
266	Cabin temperature control		
267	Fuel flowmeters		
199	Input to instruments transformer		
200	Output from instruments transformer		
201	Oil pressure gauge		
202	Fuel flowmeters		
203	Oil pressure gauge		
204	Oil pressure gauge		
611	Oil pressure gauge		
681, 682	Port pitch damper		
683, 684	—		
685	Auto-Mach trimmer	723	Auto-Mach trimmer
686, 687	Explosion protection		
713	No. 2 and No. 3 Engine JPT limiter system		
714	No. 2 and No. 3 Engine JPT limiter system		
715	No. 2 and No. 3 Engine JPT gauges		
716	No. 2 and No. 3 Engine JPT gauges		
610, 734, 735	Flight instruments		

(ii) The switches controlling the starting of No. 3 inverter are on the AC control panel, they are a NORMAL—STOP—STANDBY switch and an AUTO-MANUAL switch (spring-loaded to AUTO). With No. 4 112 volt bus-bar energised and the NORMAL—STOP—STANDBY switch set to NORMAL, this inverter starts automatically when the engine start button is pressed. The inverter may also be started by momentarily holding the AUTO-MANUAL switch to MANUAL. To stop the inverter the NORMAL—STOP—STANDBY switch is set to STOP.

(iii) If the No. 3 inverter fails, a torque switch operates automatically to transfer the flight instruments load to the No. 2 inverter. Only the essential flight instruments load is transferred in this way and the remaining load must be transferred to the No. 2 inverter by use of the EMERGENCY SELECTOR.

Failure of the No. 3 inverter is shown by a magnetic indicator on the AC controls panel turning white and its three neon indicators going out. Should No. 3 inverter subsequently become serviceable and the torque switch fail to transfer the flight instruments back to the inverter, the No. 3 inverter control switch may be placed to STANDBY thus by-passing the torque switch. Remaining loads of No. 3 inverter must be transferred back by returning the EMERGENCY SELECTOR to its neutral position.

NOTE 1: Although the essential flight instruments load will be transferred and supplied automatically, the neon-indicators for No. 3 inverter will only come on again after the remaining loads have been transferred to the No. 2 inverter by use of the emergency selector switch.

NOTE 2: With the No. 3 inverter control switch selected to STANDBY there is no automatic transfer of the flight instruments to No. 2 inverter if a subsequent failure of No. 3 inverter occurs. In this case, the No. 3 inverter control switch has to be set to STOP.

(iv) When Mod. 622 is embodied, the voltage and frequency of the 400 CPS output from the No. 2 and No. 3 inverters is measured by a voltmeter and a frequency meter adjacent to panel 10P. A MAIN—STANDBY switch adjacent to the instruments enables readings to be selected from No. 3 or No. 2 inverters, respectively.

7 Fuses and circuit-breakers

(a) 112-volt power distribution fuses

Fuses for the 112-volt section are contained on panels on the sides of the power compartment (two panels) and the forward bulkhead of the bomb-bay (two panels).

(b) 28-volt fuses

Most of the 28-volt circuit fuses are located on the following six panels:

(i) Two on the cabin walls, one behind each pilot.
(ii) One at the crew station.
(iii) Two in the nosewheel bay.
(iv) One in the power compartment.

(c) 28-volt circuit-breakers

The 28-volt circuit-breakers are on the following six panels:

(i) Two on the cabin walls, one behind each pilot.
(ii) One on the nav/plotter's panel.
(iii) Two in the nosewheel bay.
(iv) One in the power compartment.

(d) 28-volt "essential services" fuses

Fuses for the essential services are located on the following four panels:

(i) Two on the cabin walls, one behind each pilot.
(ii) One in the nosewheel bay.
(iii) One in the power compartment.

8 Starting the engines

(*a*) A 112-volt ground starter rig should normally be used for starting the engines. If a 28-volt external supply is also used, the rotary transformers should be left at OFF. If no 28-volt external supply is used, the Nos. 1 and 2 rotary transformers should be switched ON and the No. 3 rotary transformer left at OFF. The 28-volt external supply is not normally used for engine starting.

(*b*) No. 1 inverter and No. 2 inverter (emergency change-over switch set to 3 to supply No. 3 inverter loads) must be ON during engine starting to ensure AC supply to the engine instruments. Only those services from No. 1 and No. 3 inverter loads required for engine starting are to be switched on until the generators are brought on line.

9 After starting the engines

(*a*) After starting the engines, check that each generator voltage is between 109 and 115 volts, have the ground supply plug removed and then check the 96-volt battery under the following loads:

No. 1 and No. 2 rotary transformers.
No. 1, No. 2 and No. 3 inverters.
One fuel pump per group.

Check that the battery voltage is holding 92 volts minimum.

(*b*) Bring the generators on line by switching ON each generator and pressing the ENGAGE buttons. Check that the generator warning lights go out. Switch ON No. 3 rotary transformer and Nos. 4 and 5 inverters.

(*c*) Set No. 3 generator switch to OFF & TRIM. Check that the No. 3 PARALLELING SWITCH amber light and the No. 3 generator red light comes on and that the load is transferred to the battery section bus-bars. Check that the No. 2 rotary transformer warning light is out to prove the interlink fuses. Select No. 3 generator switch ON, and press the ENGAGE pushbutton. Check that the No. 3 PARALLELING SWITCH amber light and the No. 3 generator red light go out and that the ammeter is loaded.

(*d*) Repeat checks at (*c*) above for the No. 4 generator and the associated paralleling contactor, except that the No. 3 rotary transformer warning light is checked.

(*e*) (i) Set the No. 4 PARALLELING SWITCH to CLOSE. Check that its amber light comes on and that No. 4 ammeter reading increases. Set to NORMAL and check that the amber light goes out and the ammeter load returns to normal.

(ii) Set the No. 3 PARALLELING SWITCH to CLOSE. Check that its amber light comes on and that the No. 3 ammeter reading increases.

(iii) Set the No. 4 PARALLELING SWITCH to CLOSE. Check that its amber light comes on and that both No. 3 and 4 generators are sharing the load equally (within 40 amps). Reset both PARALLELING SWITCHES to NORMAL and check that the amber lights go out and that the readings on the Nos. 3 and 4 ammeters return to their former level.

(*f*) Press the battery bus-bar isolation push-switch in. Check that the amber warning light in the switch comes on and the voltmeter reads battery volts. Pull switch out and note that the warning light goes out and voltage rises to 109-115 volts.

(*g*) Press in the bulb of the BATTERY DISCHARGE red warning light to test the functioning of the filament.

(*h*) Ensure that all rotary transformers are switched ON and check that their warning lights are out.

10 Emergency start

If no 112-volt external supply is available the emergency start procedure (See Part III, Chapter 1, Para 4) must be used.

11 Battery control

(*a*) *96-volt battery control*

(i) The 96-volt battery is connected to the battery bus-bar by selecting the 112-volt isolating switch to ON. Once the battery is connected to its bus-bar, it remains connected until manually selected OFF by the isolating switch.

(ii) If the No. 1 and No. 2 generators fail, the battery will bear all the loads on both the No. 1 and No. 2 generator and battery bus-bars provided that the battery bus-bar isolation contactor is closed. The battery bus-bar loads may however, be transferred to the No. 3 and No. 4 generator bus-bars by means of the PARALLELING SWITCHES. Failure of No. 3 and/or No. 4 generator bus-bars will not affect the loads on the battery; the No. 1 and No. 2 generators will automatically take over the failed No. 3/No. 4 generator bus-bars loads. Failure of all four generators will cause all 112-volt loads to be borne by the battery. In this event, the powered flying controls would be supplied for a limited period by the 96-volt battery, depending on its capacity and the rate of voltage drop. (See Part V, Chapter 2, Paragraph 14.)

(iii) The 96-volt battery can be disconnected from its bus-bar at any time by holding the 112-volt isolating switch momentarily to OFF; it is also automatically disconnected by the operation of the inertia switches in the event of a crash.

(*b*) *24-volt battery control*

(i) The 24-volt battery is permanently connected to the "essential services" bus-bar and can be connected to the main 28-volt bus-bar by selecting the 28-volt isolating switch to ON.

(ii) The 24-volt battery (and also the essential services bus-bar) is disconnected from the main bus-bar by holding the 28-volt isolating switch momentarily to OFF. It is also disconnected automatically by the operation of the inertia switches in the event of a crash.

(*c*) After landing ensure that all electrical services have been switched off before selecting and holding the 28-volt isolating switch momentarily to OFF.

NOTE: When switching OFF a battery isolating switch, care must be taken on releasing the spring-loaded switch that it does not return to ON.

12 Generator control

NOTE: To reduce the possibility of damage to the contacts of circuit-breakers and relays, switching generators and rotary transformers on and off in flight, particularly at high altitude, is to be avoided except in emergency. The appropriate generator must be switched to OFF & TRIM before an intentional engine flame-out and as soon as possible after an inadvertent flame-out.

(*a*) *Bringing a generator on line*

See para 9 above.

(*b*) *Generator failure*—No. 1 or No. 2 generator

If a generator warning light comes on, proceed as follows: —

(i) Check the bus-bar voltage for signs of an over or under-volting generator on line, and if this is the case proceed as in sub-paras. (*d*) and (*e*) below.

(ii) If the bus-bar voltage is normal, press the failed generator VOLTAGE TEST button and check the voltage. If the voltage is between 109 and 115 volts, press the ENGAGE button. Check that the bus-bar voltage and load ammeter readings are normal.

(iii) If the generator fails to come back on line, switch the generator to OFF & TRIM and load shed prior to use of air-brake: —

1 No. 1 inverter (transfer loads to No. 2)

2 No. 1 rotary transformer

(iv) *If after the action in* (ii) *above the generator voltage indicates zero, leave the generator ON.* Only attempt reset action if further generator failures occur, after reducing engine RPM to 40% or below.

(*c*) *Generator failure*—No. 3 or No. 4 generator

(i) Check that loads of failed generators have been automatically taken over by the port bus-bars.

(ii) Check voltage of failed generator by use of the appropriate VOLTAGE TEST pushbutton.

(iii) If the generator voltage is between 109 and 115 volts, press the appropriate ENGAGE button; check that the paralleling amber light goes out and that the associated load ammeter indicates that the generator has taken over its load.

(iv) If the generator fails to come back on line, proceed as in (*b*)(iii) above.

(v) *If after the action in* (ii) *above, the generator voltage indicates zero,* proceed as in (*b*)(iv) above.

(*d*) *Overvolting*

(i) *No. 1 or No. 2 generator*

Overvolting on either No.1 or No. 2 generator will cause its parallelled generator to trip, i.e., if No. 1 generator is over-volting, the No. 2 generator failure red warning light will come on. At the same time the red failure warning lights on the No. 2 and No. 3 rotary transformers may come on. Check the 112-volt bus-bar voltage. If above 120 volts, switch the apparently

serviceable generator to OFF & TRIM. Bring the tripped generator back on line as in (*b*)(iii) above. Check that the No. 2 and No. 3 rotary transformer warning lights are out.

(ii) *No. 3 generator*

Overvolting on the No. 3 generator may be indicated by the red warning lights on Nos. 1 and 3 rotary transformers coming on. Check the voltage on No. 3 generator, and if above 120 volts set its switch to OFF & TRIM. Check that the Nos. 1 and 3 rotary transformer warning lights go out.

(iii) *No. 4 generator*

Overvolting on the No. 4 generator may be indicated by the red warning lights on Nos. 1 and 2 rotary transformers coming on. Check the voltage on No. 4 generator, and if above 120 volts, set its switch to OFF & TRIM. Check that the Nos. 1 and 2 rotary transformer warning lights go out.

(*e*) *Undervolting of No. 1 or No. 2 generator*

Undervolting of No. 1 or No. 2 generator may be indicated by:

Bus-bar volts 100 or less ;

No warning lights ;

Either No. 1 or No. 2 load ammeters indicating zero, the other approximately twice the normal load.

This will probably be caused by an open circuit in the generator control and equalising circuit resulting in the output voltage of the other generator being depressed to a low figure.

Identify the failed generator from the zero reading load ammeter and set the generator switch to OFF & TRIM. The bus-bar voltage should return to normal. Proceed as in para 12(*b*).

(*f*) The minimum engine speed at which a generator is effective on full load is 32%.

(*g*) No. 1 and No. 2 generators should not be switched off in flight for voltage checking unless a failure is suspected.

13 Rotary transformer control

If a rotary transformer light comes on indicating that a rotary transformer has cut out, an attempt should be made to bring the rotary transformer into use again by moving its control switch to OFF for one minute and then putting it ON again. If the rotary transformer starts up again the warning light will go out. If it does not go out the transformer must be switched OFF. If two rotary transformer warning lights come on together the probable cause is overvolting of a generator. Action must then be taken as in 12(*d*) above. If, however, the generators are found to be functioning correctly the fault may be due to overvolting of the remaining rotary transformer. In this case, switch it OFF.

14 Control of the AC system

(*a*) With the 112-volt bus-bars energised, the No. 3 inverter is switched on automatically when the engine starter button is pressed. As soon as the engines are running, the external supply disconnected and the generators put on line, check the operation of the torque switch, the emergency selector and the No. 2 inverter as follows:

(i) With the No. 2 inverter switched on, place the No. 3 inverter NORMAL—STOP—STANDBY switch to STOP and check that the inverter failure magnetic indicator on the AC control panel goes white.

(ii) Check that the flight instruments continue to operate from the No. 2 inverter and, if Mod. 622 is embodied, after selecting STAND-BY on the switch adjacent to the voltage and frequency meters, that the correct voltage and frequency is indicated on the respective meters.

(iii) Restart the No. 3 inverter by selecting the No. 3 inverter NORMAL—STOP—STANDBY switch to NORMAL and the AUTO—MANL. switch to MANL., and check that the No. 3 inverter magnetic indicator goes black. Check that the flight instruments continue to operate from the No. 3 inverter and, if

Mod. 622 is embodied, after selecting MAIN on the switch adjacent to the voltage and frequency meters, that the correct voltage and frequency is indicated on the respective meters.

(iv) With No. 1 inverter switched ON, select No. 1 on the EMERGENCY SELECTOR. Then switch OFF the No. 1 inverter and check that the No. 2 inverter has taken over the load from the No. 1 inverter and the No. 1 inverter neon indicators continue to glow. Restart the No. 1 inverter.

(*b*) The No. 1, 2 and 3 inverters must always be on in flight.

(*c*) Before starting the inverters, ensure that all 1,600 CPS loads are switched off; the 400 CPS loads may be switched on. When voltage and frequency control has been established, i.e. about 10 seconds after starting the inverters, the 1,600 CPS loads may be switched on.

(*d*) If a failure of the output from No. 3 inverter occurs and the flight instruments load is not taken over by No. 2 inverter due to torque switch failure, select the No. 3 inverter control switch to STOP. The essential flight instruments will then be connected to No. 2 inverter. The remaining loads on the No. 3 inverter must then be transferred to the No. 2 inverter by use of the EMERGENCY selector.

15 Load shedding

Complete failure of one or more generators or rotary transformers may necessitate electrical load-shedding (see Part V, Chap 2, para 13). The approximate consumption of the electrical services is given in the tables below and reference should be made to them in deciding which services should be switched off.

Estimated Loads on 112-Volt Bus-bars

	Service	*Loads in amps under various flight conditions*						
		Taxy	*Take-off*	*Climb*	*Cruise*	*Target Area*	*Cruise*	*Landing*
1	Flying control motors (10 off)	100	100	100	100	100	100	100
2	Fuel pumps (main) (14 off)	31·5	31·5	31·5	31·5	31·5	31·5	31·5
3	Fuel pumps (aux) (10 off)	15	15	15	15	15	15	15
4	De-mister heater	9	9	9	9	9	9	9
5	Battery heater	—	4	4	4	4	4	—
6	H2S Amplidyne	—	—	9	9	9	9	—
7	Input to 1050 Rotary Transformers	63	68	72	82	82	82	77
8	Input to 350 Inverters	23	30	72	74	74	72	30
9	Input to 153 Inverters	5	23	23	23	23	23	23
10	Battery charging	19·5	15	10	5	5	5	5
	Totals	266	295·5	345·5	352·5	352·5	350·5	290·5

NOTES

1. The airbrakes can impose an intermittent load of 120 amps for 6 secs. This would normally occur in descent and landing approach.
2. The flying controls can impose an additional intermittent load of 18 amps during normal manœuvres occurring mostly during take-off, target area, and landing.
3. The additional emergency peak load on the flying controls (duration 1 sec) will be approximately 450 amps. (This assumes all surfaces moving simultaneously at max. rate.)

Estimated loads on 28-volt bus-bars (supplied by 3 × 3 kW rotary transformers)

	Service	Load in watts under various flight conditions						
		Taxy	*Take-off*	*Climb*	*Cruise*	*Target area*	*Cruise*	*Landing*
1	NBS	—	—	330	330	330	330	—
2	Red garter	—	—	7	7	7	7	—
3	Radio altimeter, Mk 5	140	140	140	—	—	—	140
4	Radio altimeter, Mk 6A	—	—	25	25	25	25	—
5	IFF and SIF	—	300	300	300	300	300	300
6	Blue study	50	50	50	50	50	50	—
7	Gee, Mk 3	—	20	20	—	—	—	20
8	Calculator, type 7	—	—	—	50	50	—	—
9	VHF	360	360	360	360	360	360	360
10	HF	400	400	400	400	400	400	400
11	ILS	—	—	—	—	—	—	245
12	I/C	40	40	40	40	40	40	40
13	Window launchers	—	—	—	1,032	1,032	1,032	—
14	Radio compass	—	130	130	130	130	130	130
	Totals: Radio and radar	990	1,440	1,802	2,724	2,724	2,674	1,635
15	AMU	112	112	112	112	112	112	—
16	Fuel contents	786	786	786	786	786	786	786
17	Pressure heads	260	260	260	260	260	260	260
18	Auto pilot	—	—	50	50	50	50	—
19	G4B compass	10	10	10	10	10	10	10
20	Other instruments	60	60	60	60	60	60	60
21								
	Totals: Instruments	1,228	1,228	1,278	1,278	1,278	1,278	1,116
22	Heating and pressurisation	280	280	280	280	280	280	280
23	De-icing	—	168	168	—	—	—	168
24	Bomb-bay heating	56	56	56	56	56	—	—
25	Bomb gear	—	—	—	200	200	—	—
26	Lighting	120	120	60	60	60	60	900
27	Ration heaters	—	—	—	—	—	400	—
28	Other services	600	600	600	600	600	600	600
	Totals: General services	1,056	1,224	1,164	1,196	1,196	1,340	1,948
	Grand totals on 28-volt bus-bars							
	Radio and radar	990	1,440	1,802	2,724	2,724	2,674	1,635
	Instruments	1,228	1,228	1,278	1,278	1,278	1,278	1,116
	General services	1,056	1,224	1,164	1,196	1,196	1,340	1,948
		3,274	3,892	4,244	5,198	5,198	5,292	4,699
	Estimated 112-volt DC Input to three type 1050 Rotary Transformers	6,840	7,600	8,000	9,200	9,200	9,300	8,600

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Estimated load on Type 350 and 153 inverters

Inverters, 1, 2 and 3 are Type 350 Output : 2 Kw single-phase 1,600 cps
1 Kw three-phase 400 cps

Inverters, 4 and 5 are Type 153 Output : 750 W each

	Service	*Load in watts under various flight conditions* 115-*v* 3-*Phase* 400 *cps*						
		Taxy	*Take-off*	*Climb*	*Cruise*	*Target area*	*Cruise*	*Landing*
1	Sequence timers (0·6 PF)	48	48	48	48	48	48	48
2	Lighting (0·8 PF Leading)	32	32	80	80	50	80	32
3	De-mister motors (0·7 PF)	63	63	63	63	63	63	63
4	Heating and pressurisation (0·6 PF)	15	15	15	15	15	15	15
5	De-icing (0·6 PF)	—	45	45	—	—	—	45
6	Bomb-bay heating (0·6 PF)	15	15	15	15	15	—	—
7	Yaw dampers (0·6 PF)	—	—	10	10	10	10	—
8	Auto-pilot (0·8 PF)	—	—	320	320	320	320	—
9	Bomb fuzing (0·9 PF)	—	—	—	450	450	—	—
10	NBS (0·9 PF) (on No. 1 Inverter)	—	—	864	864	864	864	—
11	Red garter (0·9 PF)	—	—	235	235	235	235	—
12	Calculator, type 7 (0·9 PF)	—	—	—	18	18	—	—
13	Oil pressure	12	12	12	12	12	12	12
	Totals	185	230	1,707	2,130	2,130	1,647	215
14	Blue study (0·9 PF) (153 INV)	—	590	590	590	590	590	590
15	Green satin (0·8 PF) (153 INV) Total	—	720	720	720	720	720	720
		Load in watts (115-*volt Single-phase* 1,600 *cps*)						
16	NBS 0·95 PF) (on No. 1 Inverter)	—	—	1,520	1,520	1,520	1,520	—
17	Red garter (0·95 PF)	—	—	475	475	475	475	—
18	Gee, Mk 3 (0·9 PF)	—	190	190	—	—	—	190
19	Radio altimeter, Mk 6 (0·95 PF)	—	—	365	365	365	365	—
20	IFF and SIF (0·95 PF)	—	285	285	285	285	285	285
	Totals	—	475	2,835	2,645	2,645	2,645	475
	112-volt DC Input to three 350 Inverters (one normally off-load)	2,610	3,250	7,970	8,260	8,260	7,670	3,240
	112-volt DC Input to two 153 Inverters (50 per cent Eff)	—	2,620	2,620	2,620	2,620	2,620	2,620