PART 1 : SECTION 6

CHAPTER 1

ELECTRICAL SYSTEMS

General

1. The electrical services in aircraft are normally supplied by one or more engine-driven D.C. generators, which also keep the aircraft batteries fully charged. Batteries are provided to damp out fluctuations in voltage and provide a small reserve of power for operation of the essential services in the event of generator failure. Alternating current (A.C.) required for the operation of aircraft services such as radar and some flight instruments is supplied on some aircraft by engine-driven alternator(s) ; on other types it is provided by means of inverters which convert current from the aircraft's D.C. supply to A.C. at the required voltage and frequency.

Generator Control

2. The generator, which normally has a rated output of 1,500, 3,000, 6,000 or 9,000 watts at 28 volts D.C., according to the type of aircraft, has an automatic cut-out fitted to disconnect the generator from the electrical system when the engine r.p.m. fall below a predetermined value. This prevents the aircraft battery discharging through the generator windings when the output voltage, which drops as the r.p.m. fall off, falls below that of the battery. On piston engines the cut-out r.p.m. is usually between 1,200 and 1,500 ; on jet engines the cut-out r.p.m. varies according to the type of engine and is given in Pilots' Notes for the type.

3. On jet-engined heavy bomber aircraft the supply voltage is 112 volts D.C. The generators are either engine-driven at 112 volts D.C. with $22\frac{1}{2}$ kW output or engine-driven alternators at 200 volts A.C. with part of the output rectified and transformed to 112 volts D.C. and 28 volts D.C. (30 kW and 3 kW respectively). In the latter case raw A.C. direct from the engine-driven alternators is used for any heating services. Where A.C. is required for radio and the like it is provided from inverters which are closely controlled with respect to voltage and frequency.

4. The generator voltage is controlled by an automatic voltage regulator so that, irrespective of the changes of electrical load or generator speed, a constant voltage is maintained.

5. A generator-failure warning light or indicator is usually fitted in the circuit from each generator and indicates when the generator is not charging for any reason, such as low engine r.p.m. or complete failure of the generator.

6. A fuse or circuit-breaker is usually fitted in each generator field circuit to protect the generator field-windings. Some installations have a double-pole generator switch which can be used to switch off the generator, enabling the field circuit-breaker to be reset if overload conditions have caused it to open the generator main line.

Batteries Control

7. **Ground/Flight Switch.** On many aircraft a master electrical switch, usually called a ground/flight switch, is fitted in most cases in the cockpit and in a few types externally. With this switch in the "ground" position the aircraft batteries are disconnected, and ground testing of the electrical services may then be carried out with an external battery plugged into a socket normally fitted on the side of the fuselage. With the switch in the "flight" position the aircraft batteries are connected to all the electrical services.

8. Some later aircraft have no ground/flight switch, but a three-pin external battery plug is fitted. The third pin of this plug automatically operates the aircraft battery circuit relay when the socket is attached to the plug, ensuring that the aircraft battery is disconnected when an external power supply is connected. When this type of plug is fitted, an adaptor is necessary if the external power supply is designed for the older type of installation.

9. **The Battery-Isolating Switch.** On many aircraft, whether fitted with a ground/flight switch or not, a battery-isolating switch is fitted. With this switch the pilot can isolate the aircraft battery from the main electrical services in an emergency, thus reducing fire risk ; but it does not affect the essential emergency services, *e.g.* fire extinguishers, dinghy jettison, and canopy jettison.

10. When the aircraft battery is isolated in this way all the aircraft services can still be operated by the generator when this is running above the cut-in speed. After shut-down, the battery isolating switch can be used, instead of the ground/flight switch, to switch off the electrical services.

Circuit Protection

11. The electrical distribution system is usually divided into a number of main circuits, such as engine starter, fuel booster pump, pressure head heater, lighting, etc., and most of the circuits are protected by push-to-reset circuit-breakers or by fuses to prevent damage which might be caused by overloading, misuse, or other faults.

Operating Notes on the Use of Electrical Systems

12. All the crew should be familiar with the following details of their aircraft :—

(*a*) Those services which are operated electrically, and those whose selectors are operated electrically, although the services themselves are operated hydraulically or pneumatically.

(*b*) The aircraft services that are classified as "essential" if an emergency occurs such as electrical failure, and the time for which they will operate before exhausting a fully-charged battery.

(*c*) The location of all circuit-breakers and fuses, which circuits they protect, and the method of resetting the circuit-breakers and replacing the fuses.

13. When an electric engine-starter is fitted which can be run from the aircraft battery, ensure that the battery is well charged. On multi-engine aircraft, an engine driving a generator should be started first, warmed up, and run up to generator cut-in speed so that this generator can augment the battery while starting the other engines.

14. Ensure that the generators are charging at all times. Engine r.p.m. should not be reduced to a point where the generator-failure indicator comes on ; and when one generator only is fitted, practice feathering or relighting should be confined as far as possible to the engine not driving the generator.

15. Should a generator-failure warning light come on at r.p.m. above the cut-in speed, an attempt may be made to correct the fault by changing the fuse or resetting the circuit-breaker. If this fails to correct the fault, or if the fuse blows a second time, or the circuit-breaker springs out again, no further attempt should be made. All non-essential electrical services should then be switched off to reduce the load on the batteries.

16. If one or more electrical services fail, the appropriate main or subsidiary fuse should, if possible, be checked and replaced ; circuit-breakers should be reset manually after a short pause to allow them to cool. No attempt should be made to hold them in—most types cannot be held in against a serious fault. After resetting, if the fault is not serious, the circuit may remain live at least long enough to enable an essential service, such as a landing lamp, to be operated ; circuit-breakers may be reset several times if the service affected is essential. If, however, there is evidence of smoke or fire, or if a fuse blows, or a circuit-breaker comes out immediately on being replaced or reset, indicating that the fault is serious, the fuse should not be replaced or the circuit-breaker reset unless the fault can first be located and rectified.

17. On larger aircraft, voltmeters and ammeters are usually fitted in the charging circuit to enable the generator output to be checked. On some aircraft the voltmeter replaces the generator-failure warning light. If on a long flight an ammeter shows a discharge, indicating that the electrical load is in excess of the generator output, any non-essential services should be switched off to prevent the battery being discharged.

18. If a generator-failure warning light comes on in aircraft fitted with only one generator, not only should all non-essential electrical services be switched off at once and left switched off, but the operation of essential services such as radio and radar equipment should also be restricted to conserve batteries for the occasions when the safety of the aircraft depends on them.

19. A considerable load is imposed on batteries by the electrical equipment. Whenever practicable, and unless otherwise recommended in Pilots' Notes for the type, the engine should therefore be run above generator cut-in speed while the aircraft is stationary during delays either before take-off or after landing.