Chapter 2

LEAD-ACID BATTERIES

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

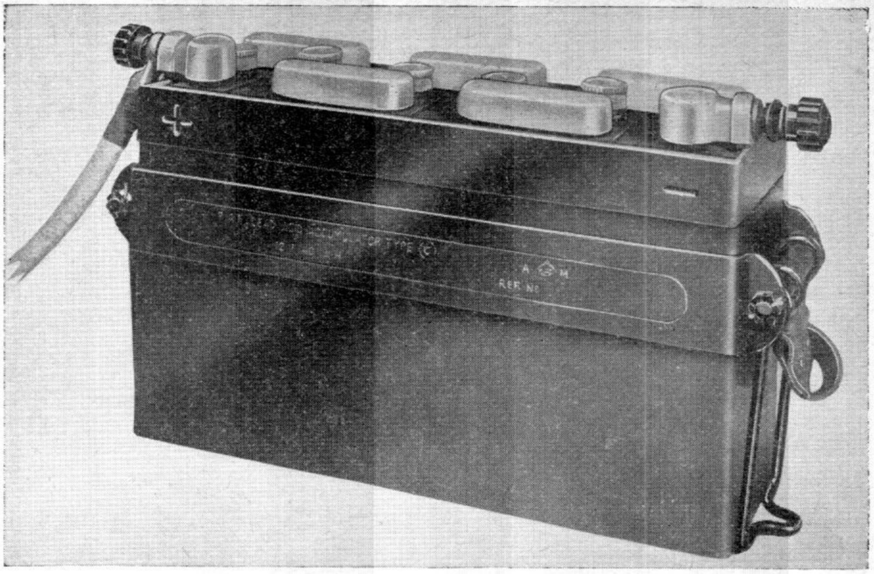

Fig. 1. Aircraft battery, Type C

Introduction

1. The information given in this chapter is relevant to lead-acid batteries used in M.T., marine craft and ground equipment, as well as in aircraft. Information on lead-acid batteries of the Varley type, which have fully-absorbed electrolyte, will be found in Chap. 5 of this Section.

DESCRIPTION

2. A typical lead-acid battery, the Type C, is illustrated in fig. 1. A lead-acid battery consists essentially of a number of linked positive plates (containing lead peroxide) interleaved with a number of linked negative plates (containing spongy lead), as shown in fig. 2, immersed in an electrolyte of dilute sulphuric acid, with separators of microporous rubber or synthetic material between the plates. If a circuit is connected between the positive and negative plates, chemical action takes place in the cell and current flows externally from the peroxide (positive) to the lead (negative) plate, resulting in the formation of lead sulphate on both plates, and a reduction in concentration of the sulphuric acid electrolyte. This action is reversible, and if current is passed through the cell from the positive to the negative plates, the cell is restored to its original condition and may again be used to supply current.

Plates

3. Two types of plates are in use, the Planté and the Fauré. The former consists of a lead blank, shaped to provide a large surface, over which a layer of lead peroxide is formed, whilst the latter consists of a lead grid filled with a paste of lead oxide, which is converted to lead peroxide for a positive plate and to spongy lead for a negative plate. The use of Planté plates is confined to stationary batteries, where long life is the primary consideration and weight is unimportant. For portable batteries Fauré plates are used, because, although the useful life is shorter, they have a much higher capacity to weight ratio. The thickness of the plates varies according to the discharge rate for which the battery is designed, thin plates being used for heavy discharge rates.

Containers

4. The containers used for portable batteries are made of insulating material such as polystyrene which is impervious to the action of dilute sulphuric acid; those used for permanent installation are usually of glass. The plates are supported by ribs formed on the inside of the containers and are raised clear of the bottoms of the cell to prevent ‘ shorting ’ by sediment.

Vent plugs

5. Aircraft batteries are fitted with unspillable vents, designed to allow gas to escape without leakage of electrolyte, irrespective of the position of the battery. To enable the vents to function correctly, the correct level of the electrolyte must not be exceeded. If it is allowed to rise above the centre cone, gas pressure will eject electrolyte through the vent.

Electrolyte

6. Only pure sulphuric acid diluted with distilled water is to be used as an electrolyte. It must be of the correct specific gravity; this is usually 1·270 for batteries used in aircraft. This information may not apply to batteries used for special purposes, and it is important that electrolyte of the correct specific gravity, as given in the makers' instructions, is used.

DEFINITIONS

Voltage

7. The voltage of a cell is the potential difference existing between its terminals either on open or closed circuit. The voltage of a fully charged cell immediately after charge may be as high as 2·3 owing to a film of gas bubbles clinging to the plates, but it will fall to approximately 2·1 volts when the bubbles disperse. The voltage may rise to 2·7 volts when the cell is on charge, and should never be allowed to fall below 1·8 volts on light load. As may be seen from fig. 3, the voltage of a fully charged cell falls quickly at first, then slowly during the greater part of the discharge period, and finally falls away quickly. At high ambient temperatures, the battery has a higher rate of self-discharge.

Discharge rates

8. The time taken to discharge a fully charged cell until it reaches its normal end point (1·8 volts on light load) is called the discharge rate. Battery tests are normally based on the ten-hour rate, when the load current is equal to $\frac{\text{Nominal Capacity}}{10}$ amp.; alternatively they may be based on the 15 min. or one hour rate, depending on the role of the aircraft to which they are fitted.

Capacity

9. The quantity of electricity that can be taken from a fully charged cell at a given discharge rate, before the voltage falls to a defined end point, is termed the capacity of the cell. It is the product of the average current and the time, and is normally stated in ampere-hours. The capacity of a battery decreases with increasing load current, and decrease of temperature; as full information

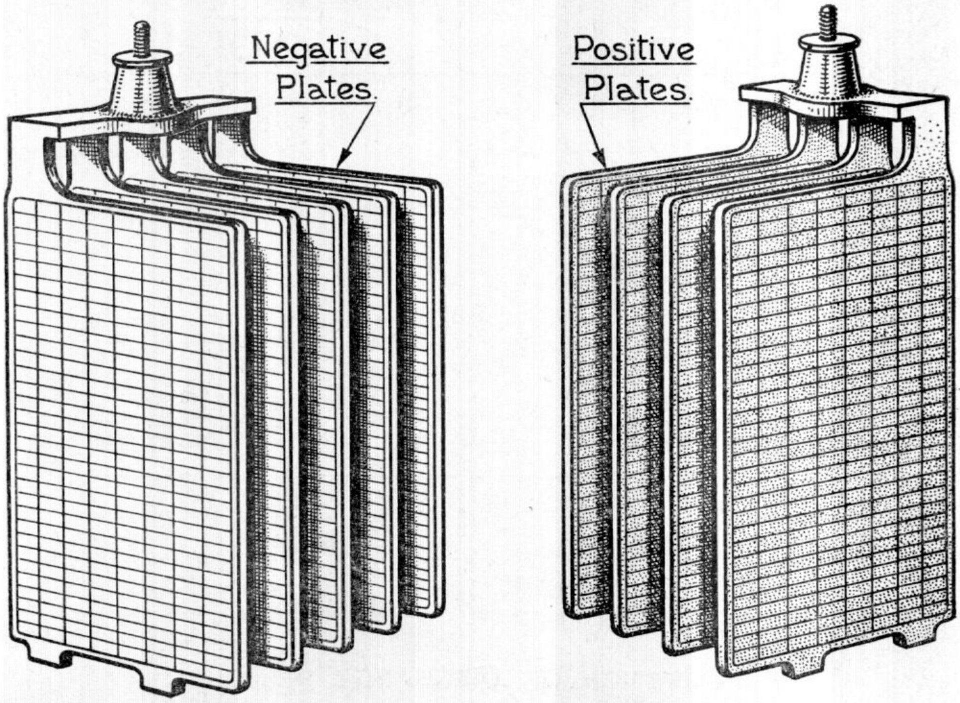

Fig. 2. Elements of lead-acid cell

becomes available, this will be included in the form of curves in the chapter on the particular battery in A.P.4343A, Vol. 1.

10. The one-hour rate has been found to be a more satisfactory medium than the ten-hour rate for assessing the capacity of an aircraft battery, and in future the capacity at the one-hour rate will be introduced in the official nomenclature of the battery and the relevant Specification. ▶

Useful life

11. Batteries deteriorate when in use, and the capacity falls until the capacity/weight ratio becomes uneconomic. The useful life of a battery may be expressed as the number of cycles of charge and discharge (approximately 120) which can be carried out at the normal rate before the capacity is reduced to an uneconomic value. Batteries become uneconomic for Service use when:—

(1) Sufficient paste has dropped from the plates as sediment to reduce the capacity below 75 per cent (aircraft use) or 60 per cent (ground use).

(2) The separators have become perforated and the battery fails to hold its charge.

(3) The plates have become sulphated.

The life of a battery is affected by the treatment it receives in Service, and the above conditions are accelerated by continued overcharging, undercharging, subjection to temperatures in excess of 110 deg. F., or failure to recharge when in a discharged state.

Shelf life

12. The shelf life of a battery is that period for which a new battery may be stored, before filling and initial charge, without deterioration. For all lead-acid batteries fitted with dry separators, the maximum permissible shelf life is ten years.

STATE OF CHARGE OR DISCHARGE

13. The state of charge or discharge of a battery is indicated in four different ways, as referred to in para. 14 to 17.

Terminal voltage

14. The voltage will rise during charge and fall during discharge as shown in fig. 3. During discharge the voltage falls rapidly at first, then remains almost constant during the middle period, and again falls rapidly at the end of the discharge period, so

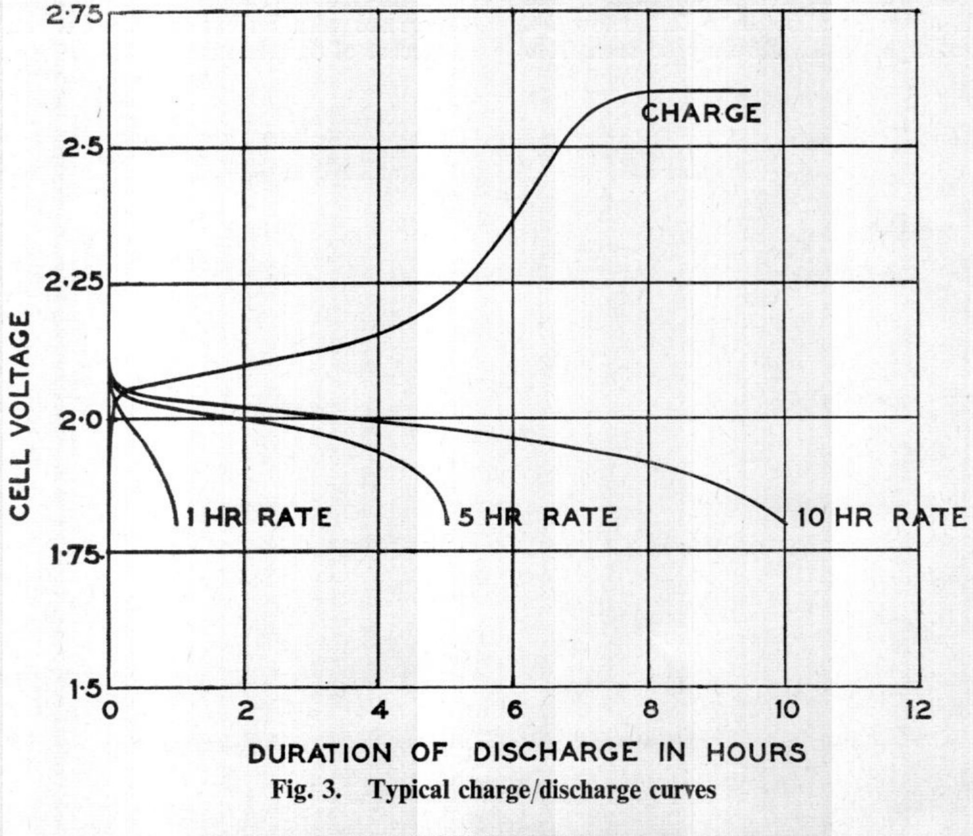

Fig. 3. Typical charge/discharge curves

giving a definite indication of a state of full charge or complete discharge. The maximum voltage of a cell on charge may vary with variations in the specific gravity of the electrolyte, but under normal conditions should reach, and maintain, a stable maximum voltage for approximately one hour before it can be taken as one of the indications of complete charge.

Specific gravity

15. The specific gravity of the electrolyte is lowest when the cell is fully discharged and rises to a maximum during charge. As one of the indications of full charge, this maximum must be maintained for a period of at least one hour whilst the battery is on charge.

Gassing

16. When a cell is fully charged, both positive and negative plates should gas freely.

Colours of plates

17. The colours of the plates in a battery are:—

(1) Fully discharged (i.e., voltage on light load 1·8 volts per cell):—

Positive ... Light brown
Negative ... Dull slate

(2) Fully charged (i.e., voltage on charge a stable maximum):—

Positive ... Chocolate brown
Negative ... Clear grey

In practice, the plates can be seen only in cells with transparent cases, and as shades of colour are not easily determined this indication is informative only. When a cell is fully charged, all the above indications are present. At least two of the first three indications should be observed for a cell to be considered fully charged (*para.* 34); one indication alone is not sufficient.

PREPARATION FOR SERVICE USE

18. The majority of lead-acid batteries require initial filling with electrolyte, followed by an initial charge of up to 24 hours or more, depending on the type of battery, before being ready for service use. For certain special applications, however, dry-charged batteries may be available. These batteries have been charged during manufacture, and are normally made ready for use in approximately two hours, by filling with electrolyte and allowing to stand, no charging being necessary. Such batteries are readily identifiable by being marked DRY CHARGED on the case.

◀ **Note . . .**

After prolonged storage, it may be found that some of the charge has been lost. ▶

Electrolyte

19. In batteries with dry separators, the S.G. of the initial filling electrolyte is usually some 20 points below that of the electrolyte when fully charged, to allow for acid already present in the plates due to the forming charges. The electrolyte used in most types of lead-acid batteries consists of pure sulphuric acid diluted with distilled water to a specific gravity of 1·270. In cases of doubt, the directions given by the makers on the instruction label must be followed. Electrolyte may be drawn from stores ready mixed, as follows:—

S.G.		*Winchester quarts*	*10-gall. carboys*
1·250	...	33C/1242	33C/1241
1·270	...	—	—
1·285	...	—	—
1·350	...	33C/824	33C/578
1·840	...	33C/882	—

Breaking down electrolyte

◀ **20.** When electrolyte of the required S.G. is not obtainable ready mixed from stores, it must be prepared by diluting acid of a higher S.G. with distilled water (Ref. No. 33C/202). ▶ For this purpose a glass, glazed earthenware, or lead-lined mixing vessel must be used, protective clothing consisting of goggles, rubber gloves and apron must be worn, and a first aid outfit as outlined in para. 52 must be at hand. It is important to remember that if *water* is added to concentrated *acid*, the heat of reaction is sufficient to convert some of the water into steam. THIS IS HIGHLY DANGEROUS BOTH TO EQUIPMENT AND PERSONNEL. When mixing electrolyte, the usual proportion is approximately three parts of water to one part of concentrated acid. The acid must be added to the water very slowly, the mixture being stirred continuously with a clean glass rod or wooden stick. After mixing, allow to cool and, if necessary, re-adjust the specific gravity by the addition of acid or water. If it is required to dilute ready-mixed electrolyte, add distilled water only.

Temperature correction

21. Specific gravity is measured by means of a hydrometer (Ref. No. 5J/1579). This consists essentially of a graduated float usually placed inside a glass tube into which the electrolyte may be drawn by a rubber bulb. The specific gravity is indicated directly by the position of the surface of the liquid with respect to the scale fixed to the float. The reading is correct when the temperature of the liquid is 60 deg. F (15 deg. C). If the temperature is not 60 deg. F. when the specific gravity is measured, a temperature correction must be made by adding 0·001 to the reading for each 2·5 deg. above, or subtracting 0·001 for each 2·5 deg. below 60 deg. F.

Initial filling

22. Before filling, the battery should be examined for mechanical damage, the vents tested to see that there is no blockage, and all metal parts very lightly smeared with protective PX–7. It should then be filled with electrolyte of the correct S.G. The correct level is usually indicated by a line on the side of the container, or by a statement given on the instruction label, but should no indication of the level be given it may usually be taken as $\frac{1}{4}$ inch above the separators. The height of the electrolyte may be measured by inserting a glass tube into the container until the end of the tube rests on the top of the plates. The upper end of the tube is then closed by placing a finger over it and, when the tube is withdrawn, the length which remains filled with liquid will indicate the height of the electrolyte above the plates. A similar check can be made with a topping-up syringe nozzle tube notched through at the correct distance from the end. After filling the battery, it must be allowed to stand for six hours and the level of the electrolyte restored by the addition of acid of the same specific gravity. It is important that the electrolyte is maintained at the correct level; under filling is harmful, and over filling will cause electrolyte to be ejected through the vents.

Initial charge

23. The capacity and useful life of a battery depend on the treatment it receives, and it is important that batteries are properly treated both before and after they are put into service. Full instructions for preparation and first charge are usually issued with each battery; these must be followed in detail. Where the instructions given in the following paragraphs differ from those given by the makers, the latter must be followed.

24. With the vent plugs in position, but with the threads disengaged, connect the battery to a suitable charging circuit, switch on, and charge for the time and at the rate stated on the instruction label. For details on the charging of individual batteries see A.P.4343A, Vol. 1, Sect. 11. Whenever possible the initial charge should be continuous, but if this is not possible, the charge may be split up into daily periods of approximately 8 hours. Charging must be continued until the voltage and specific gravity cease to rise, as shown by three readings taken at intervals of 30 minutes. When the cells gas freely the charging current should be halved, and when charging is completed the current must be switched off, the battery removed and allowed to stand for 12 hours.

25. Tilt the container slightly to each side to free the trapped gases, then check and adjust the level of the electrolyte. Wipe the outside of the battery dry, re-screw the vents and smear all exposed metal parts with a small quantity of protective PX–7.

GENERAL CHARGING PROCEDURE

Cleanliness

26. Before being put on charge all batteries must be examined; the containers and vent plugs for leakage, and the terminals for corrosion. The outside of the container must be washed with clean water and dried, particular attention being paid to the top. The terminals must be thoroughly cleaned of old grease and corrosion by washing with diluted ammonia solution followed by water, great care being taken to prevent any ammonia solution entering the cells. When all the corrosion has been removed, the terminals and other exposed metal parts should be lightly smeared with protective PX–7.

Topping up

27. The correct level of the electrolyte must be maintained in order to obtain the full rated capacity from a battery. This level may fall whilst the battery is in service due to evaporation or spilling of the electrolyte. To restore the original level when caused by evaporation, *distilled water only* should be used for " topping up ". (In tropical climates this may be required daily). When the level falls, due to electrolyte having been spilt or absorbed by the plates, it should be restored by adding electrolyte of the *same specific gravity* as that already in the battery. When topping up after the battery has been on charge, wait until gassing has ceased and trapped gases have been dispersed by tilting the battery from side to side, otherwise a false level will be obtained.

Routine charging

28. Batteries to be charged at the same charging rate should be connected in series, the number which may be so connected depending on the voltage available in the charging circuit. In determining this number, a voltage of 2·8 must be allowed for each cell, e.g., two 12-volt or twelve 2-volt batteries would require a charging voltage of 34. Each group of batteries must have a separate charging circuit and two or more groups must never be connected in parallel in the same circuit. Each charging circuit must have its own ammeter, variable resistance, and other control apparatus connected in series with it. A charging board may have several such circuits connected to it, each terminating in a pair of terminals, but only one series of batteries must be connected to each circuit.

29. To prevent reverse charging, check the polarity of the supply leads with a centre-zero voltmeter or by one of the following methods:—

(1) Dip the ends of two wires connected to the terminals into a vessel containing tap water. Bubbles will be given off most rapidly from the wire connected to the negative terminal.

(2) Press the ends of the two wires against a piece of damp blue-print paper. The negative wire will leave a white spot.

30. In order to minimize the potential difference between adjacent points, batteries should, where space permits, be placed in a single line with the supply leads connected at opposite ends. Where this is not possible, they should be arranged in a double row connected in zig-zag fashion. A space of at least ½ in. must be allowed between adjacent batteries.

31. All supply leads and connecting cables must be well insulated, of ample cross-sectional area and kept as short as possible. Free ends of wire or cable should never be connected to battery terminations. Use should be made of cable end lugs, connectors or clips which are in a clean and serviceable state. Before connecting the supply leads and switching on, fit all connecting cables between the batteries and check each joint for tightness as it is made. Loose connections cause sparking with consequent risk of explosion.

32. All vent plugs must be completely unscrewed and lifted, but left in the vent holes, before charging is commenced, and must remain in this position during the whole period of charge. When ready to charge, place the rheostat in the position of maximum resistance (i.e., minimum current), close the switches, and adjust the current to the appropriate value by means of the rheostat. The correct charging current is usually specified by the makers for each battery and this should be rigidly adhered to except where it is necessary to modify it for the reason given in para. 35. When the cells commence gassing, the voltage and specific gravity must be periodically measured. If the charging is interrupted, and the batteries left unattended after switching off, both positive and negative supply leads must be disconnected from the terminals. If the voltage of the bank of cells exceeds 35 volts the bank should be disconnected near the centre.

33. The time taken for a complete re-charge will vary with different types of batteries, but for the normal aircraft battery it is approximately 12 hours. It is essential to ensure that each cell is fully charged, but not overcharged. Prolonged overcharging will cause shedding of the active material from the positive plates, and excessive rates of charge cause buckling, thus rendering the battery unserviceable. Persistent under-charging causes hard sulphation, the plates will lose porosity, and the capacity of the battery will be impaired. Charging should, when practicable, be continuous and should be carried out until a fully charged condition is indicated. If some batteries reach the fully charged condition before the others, switch off the charging circuit and disconnect those that are fully charged. Re-connect the remaining batteries, re-adjust the charging current to a suitable value, and switch on the charging circuit.

34. When a cell is fully charged, the voltage and specific gravity should have reached and remained steady at the maximum for one hour. The free gassing of the plates is a further indication that charging is complete.

35. The temperature of cells on charge must not be allowed to exceed 110 deg. F◀ (43 deg. C). ▶In temperate climates, when normal charging currents are used, it is unlikely that this figure will be exceeded, but in tropical climates special precautions must be taken to prevent overheating. The temperature in the charging room must be kept as low as possible, and, if necessary, charging should be carried out at night. If the temperature tends to exceed 110 deg. F., the charging current should be halved, or even reduced still further, and the duration of the charge increased proportionately.

36. When charging is completed, switch off, disconnect the supply leads from the batteries and then from the charging board terminals. The batteries should be removed, allowed to stand for 12 hours, the vents screwed home and the procedure outlined in para. 25 followed.

TESTS

◀ **37.** On receipt, all batteries should be examined for mechanical damage. No repair should be attempted below the acid line, but a limited repair is possible above the acid line. For bitumastic material the procedure is described in para. 46; for Type J batteries, where polystyrene and polyester are used, instructions are given in Chapter 5. ▶

Leakage test

38. If no apparent damage is visible, the battery should be subjected to a leakage test, using the battery leakage tester (Ref. No. 5J/3323), which is described in A.P.4343S, Vol. 1, Book 3, Sect. 16.

39. Remove the vent stoppers from the battery, and hold the tester firmly in a vertical position over each vent in turn. Apply a pressure of 1 lb. per sq. in. by means of the hand pump; this pressure must not fall off by more than 0·1 lb. in 15 seconds.◀ If a battery fails this test, it should be repaired if practicable; if no repair is possible, it must be rejected. ▶

Insulation test

40. Before a battery is issued from the charging room, it should be tested for insulation resistance between the battery terminals and the metal case, using a 250-volt insulation resistance tester; the minimum permissible reading is 0·5 megohm.

Note . . .

If the battery has no metal case, it should be placed on a metal plate, and the metal clamps be connected to this plate. The test should then be made between the plate and the battery terminals.

Capacity test

41. Once every three months, all batteries in use, whether aircraft, ground or M.T. types, are to be capacity tested.

42. Batteries with a nominal capacity not exceeding 80 amp. hr. are to be fully charged and tested, using the battery capacity test set (Ref. No. 5G/2181), information on which will be found in A.P.4343S, Vol. 1, Book 3, Sect. 16.

43. Batteries with a nominal capacity above 80 amp. hr. are to be tested as follows:—

(1) Fully charge the batteries at the correct rate and allow to stand on open circuit for two days.

(2) Connect in series a battery rheostat, Type 1 (Ref. No. 5G/2582), an ammeter, 0–50 amp. (Ref. No. 5Q/1632), and a tumbler switch, 30 amp. (Ref. No. 5A/2583), the switch being in the open position. For 12-volt batteries, the two resistance tubes should be in series, but for 6-volt batteries the resistance tubes must be in parallel.

(3) Close the switch, adjust the rate of discharge to one-tenth of the rated ampere-hour capacity, or as instructed if the battery is required to be tested at a different rate, and note the time.

(4) Maintain the discharge current at this value by adjusting the resistance, and after half the rated time of discharge has elapsed, take periodic readings of the cell voltages. When the voltage of any cell has fallen to 1·8, the switch must be opened and the time recorded.

Note . . .

Capacity = *Rate of discharge* (*amp.*) × *time of discharge* (hours).

44. It is not economic to keep a battery in service if the capacity is less than that given below:—

(1) If the capacity is found to be 75 per cent or more of the rated capacity, an aircraft type of battery is fit for aircraft use. Ground and M.T. types of batteries are serviceable if the capacity is 60 per cent or more of the rated capacity. Thus a 40 amp. hr.◀ (at the 10-hour rate) ▶ battery must maintain a steady discharge of 4 amp. for 7½ hours to be fit for aircraft use, or for 6 hours to be fit for M.T. or ground use.

(2) An aircraft type of battery which fails to reach the 75 per cent standard

may be used for ground purposes until the capacity falls to 60 per cent.

(3) All batteries whose capacity is below 60 per cent are totally unserviceable.

(4) Batteries passed as serviceable must be recharged immediately.

STORAGE AND TRANSPORT OF FILLED BATTERIES

45. Full instructions for the storage and transport of filled batteries will be found in A.P.830, Vol. 2, Leaflet F2.

Note . . .

Batteries must always be transported by the carrying straps and never by the terminals.

FAULTS

Cracked sealing

46. (1) Method 1.—The bituminous sealing on the top of a battery may be found to be cracked during the leakage test. It may be repaired by the use of sealing compound. Bitulac No. C167 (Ref. No. ◀ 33H/100 ▶). The cracked portion of the sealing should be wiped clean and free from acid and any foreign matter. When this has been done, the sealing compound dissolved in lead-free gasoline or carbon tetrachloride (the former being the more satisfactory), may be applied. The consistency of the solution should be such that it will flow readily. To allow for complete evaporation of the solvent and to ensure a good seal, at least 48 hours must elapse before the battery is re-tested.

(2) Method 2 (R.N. use only).—An alternative method of repair, for R.N. use only, is as follows. The battery must be emptied, thoroughly cleaned with two separate rinses of distilled water, and allowed to drain. After each cell has been blown out with a jet of air for 1–2 minutes, cut back the cracks to be treated until all contaminated material has been removed, place the battery in an oven and maintain at a temperature of 100 deg. F. for 1 hour. All unnecessary naked lights in the vicinity should be extinguished. Immediately the battery has been removed from the oven, sufficient molten Bitulac No. C167 should be poured into the prepared cracks at one pouring to complete the repair. The battery should then be allowed to cool and the repair to set, when the cells should be pressure tested for leaks. The repaired battery should then stand for at least 24 hours before use.

Internal short circuits

47. Internal short circuits are caused by:—

(1) Paste shed from the plates forming conducting paths between plates of opposite polarity.

(2) Splits or perforations occurring in the separators.

(3) Permeation of the separators by lead hydrate.

The two former occur with normal usage but are accelerated by over-charging; the latter occurs when over-discharged batteries are left in that condition or as a result of batteries being left connected to a load and forgotten. The indications of internal short-circuit are no gassing on charge, and little or no voltage between the cell terminals. The sediment can be removed by washing out the cells with weak acid. The cells should then be refilled with electrolyte of the correct S.G. and re-charged. There is little hope of rectifying the other conditions except at a Repair Depot.

Sulphation

48. Sulphation is caused by neglect or improper treatment, usually in the form of persistent under-charging or persistent discharging to too low a voltage. When a battery is discharged, lead sulphate is formed on the plates, and if it is allowed to stand in a discharged condition the sulphate first formed slowly changes to a harder form which is difficult to remove. Failure of the specific gravity to rise in the correct value after charging is an indication of slight sulphation, which, if allowed to continue, will become visible as a white deposit on the plate. When this stage is reached it is very difficult and often impossible to remove it. BATTERIES ARE NEVER TO REMAIN IN A DISCHARGED CONDITION (i.e., below 1·8 volts per cell on light load).

49. The method of treatment for sulphation is as follows:—

(1) Empty out half the electrolyte, shake

thoroughly to remove any loose sludge or sediment, invert, and drain until completely empty.

(2) Fill to the correct level with electrolyte of specific gravity between 1·06 and 1·10.

(3) The battery should then be placed on charge for 100 hours, the charging current being $\frac{\text{Rated Capacity}}{40}$ amp.

(4) At the end of this period, while still on charge, the voltage per cell should have reached a minimum of 2·3. If this figure is not reached, the battery is totally unserviceable.

(5) Using a discharge panel, discharge at a rate equal to the battery capacity (e.g., a 20 amp. hr. battery should be discharged at 20 amp.). This discharge should be continued until the voltage per cell on load has fallen to 1·33.

(6) Re-charge at the rate given in (3) above until all cells are gassing freely, and the voltage per cell on load reaches a steady value of at least 2·3.

(7) Charge at the normal rate for 2 hours, after which the specific gravity of the electrolyte should be measured and adjusted to its correct value, allowing for temperature correction as stated in para. 21. The battery should now stand idle for 24 hours.

(8) At the end of this period, if the voltage of any cell is less than 2·15, repeat the cycle of treatment (6 and 7) twice; if this figure is not then reached, the battery is totally unserviceable.

(9) Batteries whose voltage per cell is not less than 2·15 should be given a measured discharge at the 10 hour rate, taking voltage and specific gravity reading periodically, until any one cell on load falls to 1·8 volts. If the capacity is 85 per cent or more of the rated capacity, the battery should now be re-charged at the normal rate and issued as 'Fit for use in aircraft.' For M.T. and ground types of batteries, 70 per cent capacity can be accepted. Should the capacity be less than 85 per cent of the rated capacity for aircraft types (or 70 per cent for M.T. types), two further cycles of charge and discharge may be given; if then the required efficiency is not reached, the battery is unfit for use in aircraft (or M.T.). A ground type battery whose capacity is less than 70 per cent is to be classified as unserviceable.

Alkali contamination

50. Alkali will ruin lead-acid batteries. It is therefore very necessary to ensure that hydrometers, syringes, distilled water containers, tins of temporary protective, etc., used for lead-acid batteries have not been in contact with alkali.

Salt water precautions

51. With marine craft batteries, great care must be taken to avoid contamination with salt water. Particular care must be exercised to see that all terminals and metal parts are thoroughly greased and kept free from corrosion. Batteries must have their vents screwed firmly in position, except during charge, and all covers must be kept fitted to avoid salt water mixing with the electrolyte in order to avoid the generation of chlorine gas.

SAFETY PRECAUTIONS

Protective clothing

52. When handling batteries or acid, aprons and rubber gloves should be worn; in addition, goggles must be worn at all times when handling or dealing with acid. After use, these articles must be rinsed free of acid and dried thoroughly. To avoid cracking or perishing they should be stored in a cool place, the aprons being hung with as few folds as possible.

Naked lights

53. The gases given off during battery charging are highly inflammable. Naked lights, therefore, are not to be brought into charging rooms, or at any time used to examine a battery.

Spilt acid

54. When acid has been spilt on the floor or benches it should be soaked up with sawdust, which should be removed and buried. The surface should then be washed with water, until all signs of acid are removed.

First aid

55. Instructions on first aid for chemical burns are given in Poster 174.