WS No. 19 Mark III

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ELECTRICAL AND MECHANICAL ENGINEERING REGULATIONS
(By Command of the Army Council)

POWER
J 330

LEAD ACID BATTERY MAINTENANCE AND REPAIR

FIELD AND BASE REPAIRS

Errata

NOTES: 1. THIS IS NOT A NEW INSTRUCTION
2. This page, Page 0 will be filed immediately in front of Page 1, Issue 2, dated 26 Jul 47

1. Amend as follows:-

Para 32:-

Delete heading: 'Separators other than Porvic separators'

Insert heading: 'Wood separators'

Para 33:-

Delete heading: 'Porvic micro-porous plastic separators'

Insert heading: 'Porous plastic and rubber separators'

Lines 5, 10, 13:-

Delete: 'Porvic'

Insert: 'Plastic'

Para 33:-

Add new sub-para (c)

'Porous rubber separators which are in good condition may be refitted'

Para 40:-

Delete: 'existing para'

Insert: 'After assembly of a re-conditioned battery (unless fitted with an approved dry synthetic separator) fill to the correct level with electrolyte of specific gravity 1.350 at 60°F. If fitted with one of the approved synthetic separators, electrolyte of specific gravity 1.250 may be used; electrolyte of specific gravity 1.350 is totally unsuitable for batteries fitted with dry synthetic separators. When preparing the electrolyte, always add acid to water and never add water to acid.'

57/Maint/3665

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Errata

Note: This page 01 will be filed immediately in front of Page 1, Issue 2, dated 26 Jul 47.

2. Amend as follows:-

Page 10, Schedule of equipment and tools required for battery repair workshop:-

(a) Against: 'Voltmeter, d.c., 3V secondary cell Mk 1'
Delete: 'XA 9650'

(b) Delete: 'Instrument, testing, universal, 40-range, Qty 1, Z2 ZB/4622'
Insert: 'Avometer, 50-range, No 1, Mk 2 equipment'

(c) Delete: 'Testers cell, heavy discarge, Qty 2, W3/WX 0921'
Insert: 'Voltmeters 0-3 - 0-3V, heavy discharge, cell testing'

Encl 3 to 57/Maint/5900(ME4)

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LEAD-ACID BATTERY MAINTENANCE AND REPAIR

SECOND TO FOURTH ECHELON WORK

Note: This issue, Pages 1 to 11, supersedes Pages 1 to 12 of Issue 1. The whole regulation has been revised.

GENERAL

1. This regulation should be read in conjunction with Power J 305 and J 318.

2. Second to fourth line battery maintenance and repair can be sub-divided under the following headings :—

(*a*) Maintenance, testing, minor repair and charging by second line workshops, R.E.M.E.

(*b*) Maintenance, testing, major repair and charging by third and fourth line workshops, R.E.M.E.

In second line

3. Batteries received in second line for repair or charging, on vehicles or individually, will be dealt with as follows :—

(*a*) Procedure as indicated in Power J 318, paras. 15 and 16, should be carried out.

(*b*) Battery electrolyte should be changed only if impurities are suspected.

(*c*) Equalizing charge should be given as indicated in Power J 318, para. 75, unless local conditions dictate normal charging.

(*d*) The specific gravity of the electrolyte should be adjusted, if necessary, after an equalizing charge has been given.

(*e*) Defective battery cell lids should be changed as necessary.

(*f*) Necessary repair of wooden battery crates (not cell containers) should be undertaken.

In third and fourth line

4. Batteries received in third and fourth line for repair and charging, on vehicles or individually, will be dealt with as follows :—

(*a*) Procedure as in Power J 318, paras. 15 and 16, and para. 3 of this regulation should be carried out.

(*b*) Major repairs should be carried out by the use of such spares as are available and by cannibalization, provided that the local situation is such that demands for new batteries cannot be fully met, and that quantities of unserviceable batteries are available for repair or cannibalization.

TESTING OF BATTERIES BY WORKSHOPS

5. Batteries removed from vehicles as defective should be carefully inspected and tested before sentencing as scrap. Due to lack of testing in the past, large numbers of serviceable batteries, and also new batteries, have found their way to produce.

6. When a battery is received into workshops as defective, other than extensive mechanical damage, top up with distilled water to the required level and recharge. Then apply tests as detailed in Power J 318, paras. 17 to 21. Batteries found to be obviously defective should be sentenced "For repair" or "Beyond local repair" as conditions dictate.

REHABILITATION OF BATTERIES

General

7. The term "rehabilitation" is applied to the process of giving special charging treatment to batteries and thus recovering those which are low in capacity and which do not respond satisfactorily to ordinary charging due to the plates having become sluggish as a result of undercharging in service.

Batteries capable of rehabilitation

8. In actual practice instances where special charging treatment is worth while will be found to be very limited. It is only really worth while in the case of batteries which have been opened up, examined, and the components passed as satisfactory or replaced where necessary, and which, after recharging, show no serious irregularities on the high-rate discharge tests, but which nevertheless fail to give satisfactory service or to comply with the test requirements laid down.

9. Special charging treatment may, of course, be given to batteries which have not actually been opened up for examination, but which fail to give the required performance, even though the high-rate discharge tests do not reveal any obviously defective cells. In these circumstances, however, it will be found that a large proportion do not respond to the special treatment, so that time and labour will be wasted.

Method of rehabilitation

10. The procedure for rehabilitation is as follows :—

(*a*) Empty the existing electrolyte from the battery.

(*b*) Refill with temporary electrolyte of 1.050 specific gravity, which may be made by diluting acid of normal gravity from stock with distilled water.

(*c*) Charge at half the normal rate and take specific gravity readings on each cell every five hours. If the specific gravity rises above 1.100, pour off the electrolyte and fill up again with acid of 1.050 specific gravity. Continue charging until three successive five-hourly readings show no rise, i.e., until the specific gravity in each cell has remained steady for ten hours. The duration of charge required may be anything between 30 and 100 hours.

(*d*) Pour off the temporary electrolyte and refill the cells with acid of about 1.350 specific gravity, charge again for about one hour and then adjust the specific gravity to within the limits of 1.290 to 1.300.

If a hydrometer is not available for reading specific gravities below 1.100, then the restoring charge will have to be given in 1.100 specific gravity acid instead of 1.050, and the cells should be refilled if their specific gravity rises during charge to above 1.150. This will, however, reduce the efficiency of the treatment to a certain extent.

11. If, after this treatment, the battery still does not give good service, or if it fails to comply with the specified tests, removal of the plates will be necessary.

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Batteries not capable of rehabilitation

12. It is useless to give such treatment to batteries in which :—

(*a*) The separators are badly worn, punctured, or impregnated with lead hydrate, so that one or more cells is/are internally short-circuited.

(*b*) The positive plates have shed much active material, or show weakness and disintegration of the grids. The latter point is particularly important since the special charging treatment will itself have some weakening action on the grids.

(*c*) The negative plates are very hard and sulphated, or show swelling or shedding of the active material.

(*d*) The cells lose charge rapidly on standing, i.e., the electrolyte drops in specific gravity more than, say, 0.200 per week.

BATTERY REPAIR

General

13. The main function of the battery repair workshop is to dismantle, inspect and salvage serviceable battery components, and use these components to rebuild serviceable batteries.

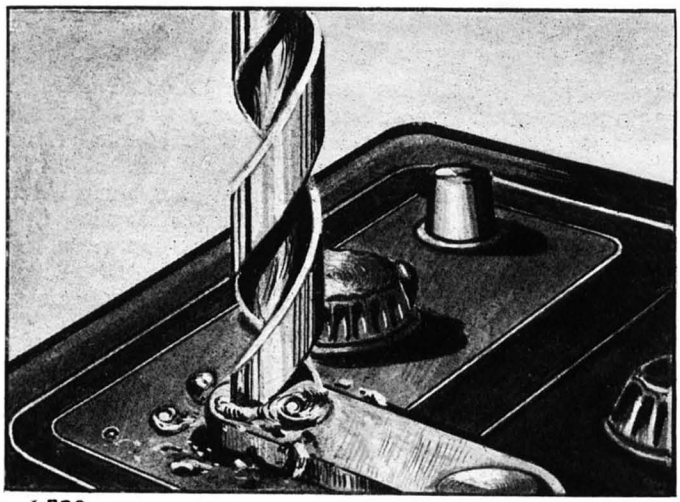
14. On receipt, all batteries will be examined externally, the type number, condition, age, and consignor being recorded.

Cleaning

15. Thoroughly clean the outside of the battery by brushing, taking care that none of the dirt gets inside the cells.

Draining

16. Remove the vent plugs and drain off the electrolyte into a used electrolyte draining tank. This electrolyte will *not* be used again in batteries except for the testing of battery containers for leaks. For this purpose used electrolyte should be filtered through a glass wool filter.



P J-330 2-1

Fig. 1—Removal of interconnector by drilling

Removal of connectors

17. All connectors will be removed by drilling (see Fig. 1).

Note: For batteries of the insert-lid type, a hollow post cutter (see Fig. 2) of the same diameter as the terminal post will be found a more suitable tool than an ordinary drill. This type of cutter has the advantage of leaving two reduced diameter lead posts on each group which may be used to obtain a grip with pincers or pliers to remove the plate assemblies. In the design of cutter shown it will be noticed that the cutting edges are arranged so as to leave a flange on the lead insert after drilling. This flange will facilitate the reburning of the group and ensure a good acid seal.

Removal of plates

18. After removal of all connectors, the battery should be placed in a steam heater for about 10 minutes to soften the compound so as to permit the plates to be withdrawn (see Fig. 3).

19. Set up the battery under a plate withdrawal clamp, as shown in Fig. 4, and with an even pull remove the plates.

Note: As already stated, if a hollow post cutter is used for drilling out the connectors, the terminal posts may be utilized for withdrawing the plates, and this method is less likely to damage the lids than would be the case if the old method of withdrawing the plate group by means of a hook inserted through the filling hole is adopted.

Rest the set of plates on the battery container to allow any remaining electrolyte to drain off and then scrape off the sealing compound. *The used sealing compound will be scrapped.* Unscrew the sealing nuts from the terminal pillars and remove the lids.

Inspection of containers

20. Types of containers to be dealt with are:—

(*a*) Composition monobloc

(*b*) Ebonite monobloc

(*c*) Single-cell wrapped ebonite boxes, as used in wood tray batteries.

All readily detectable defective containers, i.e., leaking, broken, or badly damaged, should be scrapped. Apparently serviceable containers should be thoroughly washed with water-pressure jets, cleaned and dried off. Careful visual examination of the containers may then be made, and any showing visual, internal or external cracks, or flaws, will be rejected and scrapped.

Resistance testing of containers

21. All containers which have passed the above visual inspection should then be subjected to an electrical resistance test as follows :—

(*a*) The top edges of the container under test should be wiped over with a cloth, moistened with dilute ammonia to neutralize any trace of acid. The edges should then be thoroughly dried off, using a dry rag.

(*b*) Fill the container with dilute sulphuric acid (specific gravity, 1.200 to 1.250 at 60° F.) to within about $\frac{1}{8}$ in. of the top edge. Place the container in an outer vessel also filled with dilute sulphuric acid of the same specific gravity so that the levels inside and outside the container are approximately the same. Let the container stand thus for one hour, or, if the container is really dry, at least eight hours in order to ensure that the liquid has percolated any

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doubtful places. If the container has recently been in service, it is usually safe to assume that percolation has already taken place.

(*c*) The electrical resistance of the container may then be measured by inserting a pair of electrodes, one into the liquid inside, and one into the liquid outside the container. If a low voltage is used for the test, e.g., as from an accumulator or dry battery, it is desirable to use electrodes of tinned copper. If a high testing voltage is used, e.g., from the mains, the use of tinned copper electrodes is not important.

(*d*) When measuring the resistance an ordinary megger is not suitable and should never be used. For low-voltage testing, a suitable method is to apply the Wheatstone bridge principle: Instrument, Cat. No. WB 0230, Coils, resistance, 10,000Ω, Mk. 4,

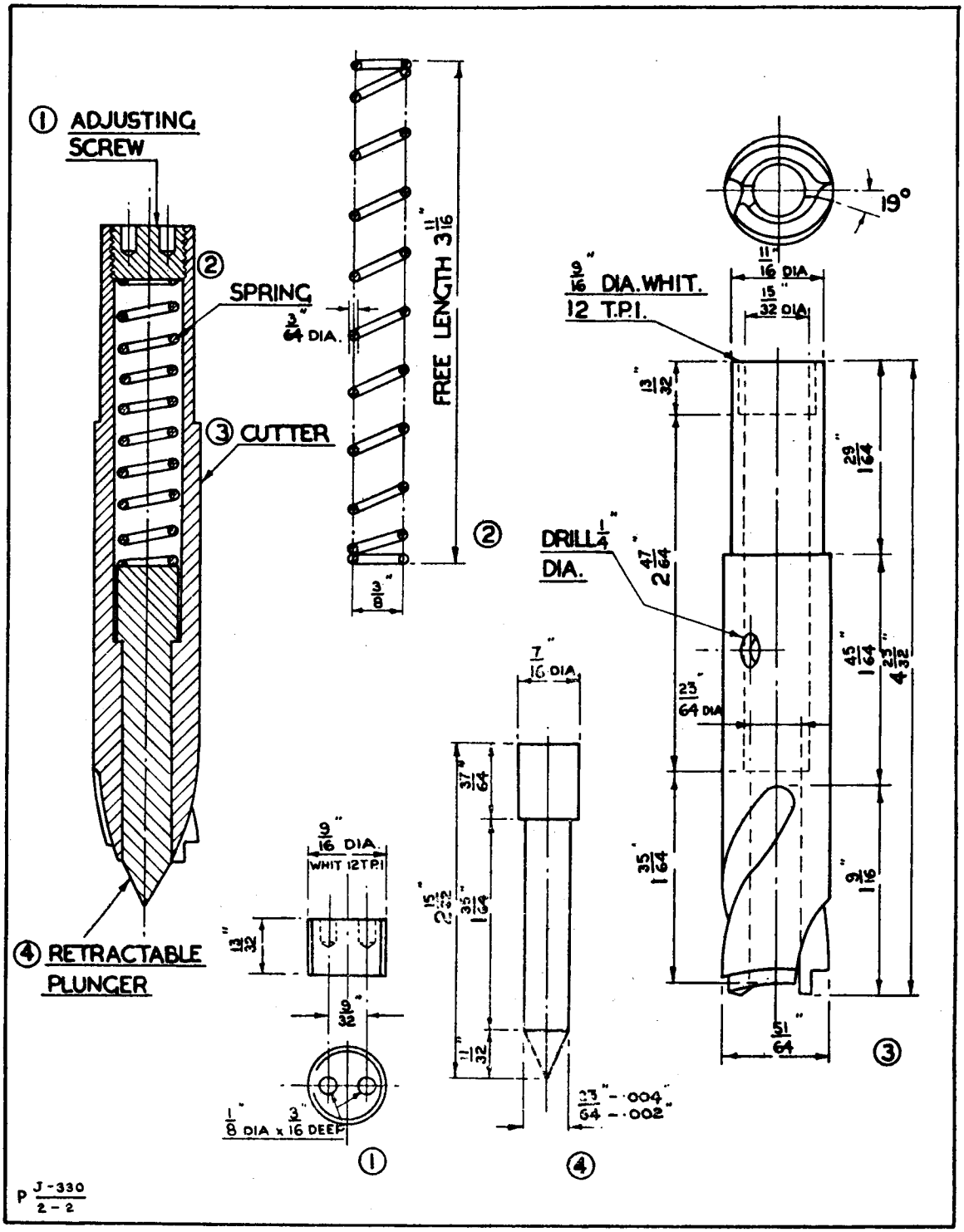

Fig. 2—Details of hollow post cutter

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with Galvanometer, No. 24A, is quite suitable. An alternative method is to connect the two electrodes to a 6-volt accumulator with a 0 to 100 milliammeter in series.

(*c*) In the case of monobloc containers, the resistance must be measured between each adjacent pair of compartments to check the partition, and also between each compartment and the outside to check the outer wall.

All containers with electrical resistance between adjacent compartments or between compartments and the outer wall less than 200 ohms will be rejected.

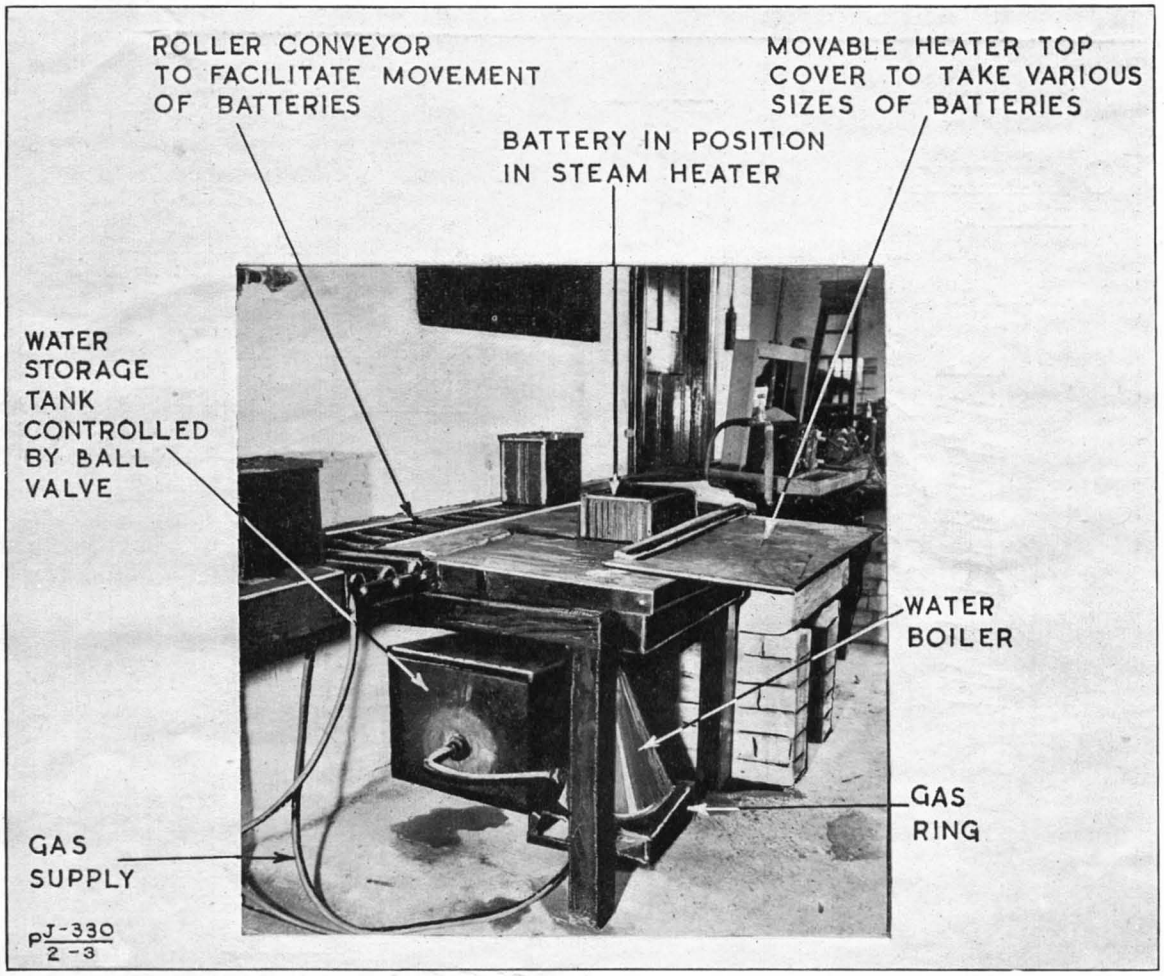

Fig. 3—Heating the cell-sealing compound by steam heat

Cleaning of plates

22. Plate groups which are obviously perfectly sound, not heavily sulphated, and which have been removed from a fairly new battery rendered defective due to container breakage, should not be opened up but passed for reassembly in a new container.

23. Plate groups which are obviously old and in bad condition, i.e., are heavily sulphated, or show excessive shedding of active material, or bad bulging of plates, will be scrapped without further examination.

24. Plate groups which are not new but appear reasonably sound should be dealt with as follows :—

(*a*) Carefully remove a few separators from the cell group and then, holding the positive and negative terminals, one in each hand, work the negative and positive groups backwards and forwards, great care being taken not to injure the posts or break the plates.

(*b*) Separate each cell group in this manner and put all positive and negative sets of plates from the particular battery into an open box provided for the purpose.

(*c*) The negative sets of plates should then be cleaned by holding under a strong stream of water, washing them thoroughly and removing all foreign matter from their surfaces. Negative plates should not be left exposed to the atmosphere for more than a few minutes. Always store them totally immersed in water.

(*d*) The positive plates should be cleaned of all foreign material by rinsing in clean water. They should be moved up and down in still water and not placed under a running stream.

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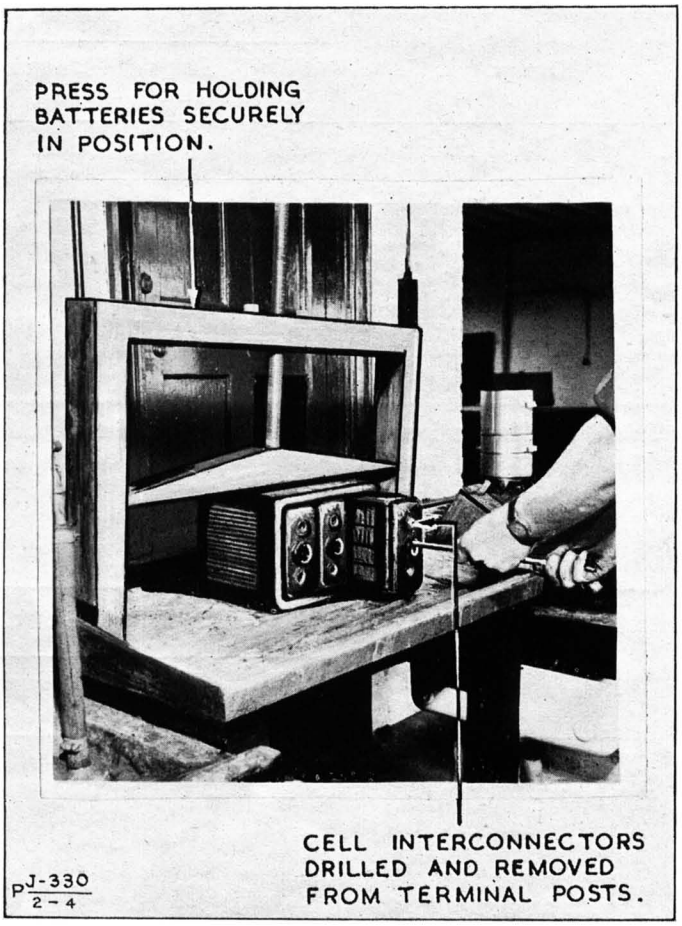

Fig. 4—Removal of cell groups after heating of the sealing compound

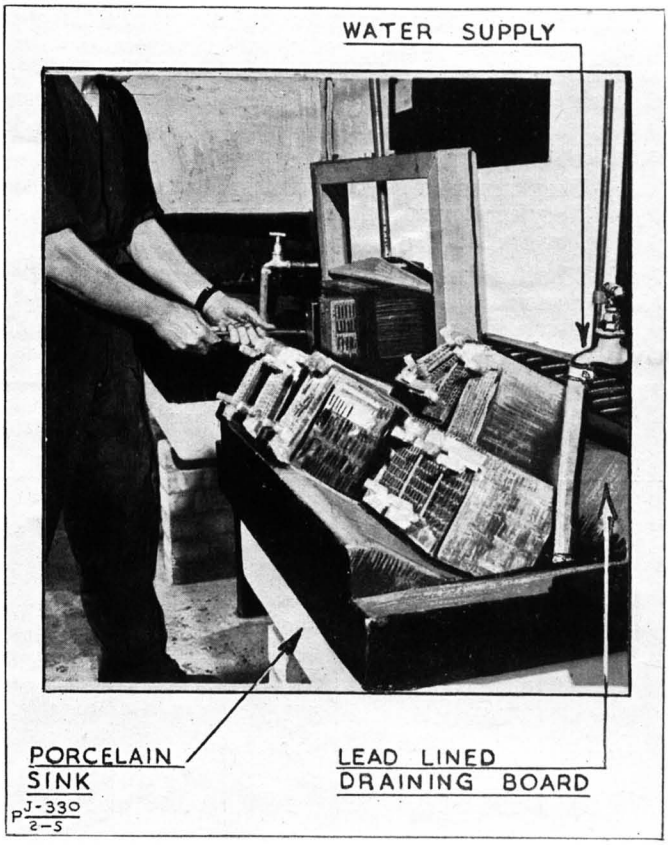

Fig. 5—Draining and cleaning of cell groups after removal from container

Inspection of plates

25. Negative plates in good condition and suitable for further use should have shed little or no active material. The active material should be dark grey in colour and not blistered or granulated.

26. Badly bulged negative plates cause lack of capacity, because the active material is loose and not making good contact with the grids. If the active material is not badly granulated (having a grained appearance), the plates may be pressed out and used again.

27. Badly sulphated negative plates will have very hard active material which will feel as hard as stone when scratched with a knife. Such plates should be scrapped.

28. Positive plates which are suitable for further use will have shed little or no active material. The active material should be a dark chocolate colour, fairly hard and with little or no signs of sulphating. The grids should not be brittle and the active material should adhere to, and firmly touch them.

29. Positive plates which are only slightly buckled may be used again, provided that they are otherwise satisfactory. They cannot be pressed in a similar manner as negative plates. If slightly buckled, they may be straightened carefully with pliers, but, in general, all buckled positive plates will be scrapped.

30. Rotten and disintegrated positive plates should be scrapped; such plates will be found to fall to pieces at the slightest pressure. Disintegration is an indication of over-charging or impurities, provided that the battery is not more than two years old, when disintegration would be a normal process.

31. If it is found that one or more positive or negative plates is/are broken from the connecting straps, or the joint between plates and strap is poorly made, reburning of the plate straps may be carried out, provided that the plates are in good condition otherwise.

~~Separators other than Porvic separators~~ Wood Separators

32. When, in order to inspect plates fully, the separators have been removed, new separators will normally be fitted. New separators in stock should be kept immersed in water to which a trace of acid has been added. A separator should be scrapped when suffering from one or more of the following defects :—

(*a*) Pores clogged with foreign matter.

(*b*) When a buckled plate or bulged active material breaks through.

(*c*) When cut by the edges of buckled plates, etc.

(*d*) When lead sulphate is deposited on it.

(*e*) When rotted, burned and charred, or if, when held to the light, holes are visible.

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~~Porvic micro-porous plastic separators~~ Amps plastic and rubber separators

33. These separators are used in some Signals type batteries, and it is anticipated that their use will be extended. They are supplied dry and, therefore, require different handling from wet wood separators. The following points which relate to ~~Porvic~~ Plastic separators should be carefully noted :—

(*a*) They must be kept absolutely dry when in store. If by accident they become wet and dry out again, they should be discarded.

(*b*) When a battery fitted with ~~Porvic~~ Plastic separators is dismantled for repair, the separators should be discarded and new ones fitted, even though the old ~~Porvic~~ plastic separators appear to be perfectly sound.

Type	*Firm*	*Height in.*	*Width in.*	*Thickness in.*
WD. 1	Oldham	$5\frac{15}{32}$	$5\frac{13}{16}$	0·060
	C.E.S. Co.	$5\frac{11}{16}$	$5\frac{7}{8}$	0·058
	J. Lucas Ltd.	$5\frac{5}{8}$	$5\frac{7}{8}$	0·075
WD. 2	Oldham	$5\frac{15}{32}$	$5\frac{13}{16}$	0·060
	C.E.S. Co.	$5\frac{3}{4}$	$5\frac{7}{8}$	0·066
	J. Lucas Ltd.	$5\frac{5}{8}$	$5\frac{7}{8}$	0·075
WD. 3	Oldham	$5\frac{15}{32}$	$5\frac{13}{16}$	0·060
	C.E.S. Co.	$5\frac{7}{16}$	$5\frac{7}{8}$	0·054
	J. Lucas Ltd.	$5\frac{3}{8}$	$5\frac{7}{8}$	0·080
WD. 4	Oldham	$5\frac{7}{16}$	$5\frac{13}{16}$	0·052
	C.E.S. Co.	$5\frac{11}{16}$	$5\frac{7}{8}$	0.058
	J. Lucas Ltd.	$5\frac{5}{8}$	$5\frac{7}{8}$	0·075
WD. 5	Oldham	$5\frac{15}{32}$	$5\frac{13}{16}$	0·060
	C.E.S. Co.	$5\frac{3}{4}$	$5\frac{7}{8}$	0·066
	J. Lucas Ltd.	$5\frac{3}{8}$	$5\frac{7}{8}$	0·080
WD. 6	Oldham	$5\frac{15}{32}$	$5\frac{13}{16}$	0·060
	C.E.S. Co.	—	—	—
	J. Lucas Ltd.	$5\frac{3}{8}$	$5\frac{7}{8}$	0·080
WD. 7	Oldham	$9\frac{1}{4}$	$5\frac{13}{16}$	0·066
	C.E.S. Co.	$9\frac{1}{4}$	$5\frac{25}{32}$	0·059
	J. Lucas Ltd.	$9\frac{1}{4}$	$5\frac{7}{8}$	0·080
WD. 8	Oldham	$5\frac{3}{4}$	$5\frac{13}{16}$	0·083
	C.E.S. Co.	—	—	—
	J. Lucas Ltd.	$5\frac{5}{8}$	$5\frac{7}{8}$	0·080
WD. 9	Oldham	$5\frac{3}{4}$	$5\frac{13}{16}$	0·083
	C.E.S. Co.	$6\frac{5}{8}$	$5\frac{23}{32}$	0·077
	J. Lucas Ltd.	$6\frac{5}{16}$	$5\frac{13}{16}$	0·075
WD. 10	Oldham	$9\frac{1}{4}$	$5\frac{13}{16}$	0·066
	C.E.S. Co.	$9\frac{1}{4}$	$5\frac{25}{32}$	0·059
	J. Lucas Ltd.	$9\frac{1}{4}$	$5\frac{7}{8}$	0·080
WD. 11	Oldham	$5\frac{3}{4}$	$5\frac{13}{16}$	0·066
	C.E.S. Co.	—	—	—
	J. Lucas Ltd.	$5\frac{5}{8}$	$5\frac{7}{8}$	0·080

Table 1—Comparisons in dimensions of separators, manufactured by Oldham, C.E.S. Co. and J. Lucas Ltd., used in W.D. range of batteries

Battery type	*Separator dimensions*		
	Width in.	*Length in.*	*Thickness in.*
24V, 170 Ah., Mk. 1/1	$5\frac{7}{8}$	$8\frac{1}{2}$	0·064
6V, 170 Ah.	$5\frac{7}{8}$	$8\frac{1}{2}$	0·116
6V, 100/125 Ah., Mk. 4	$5\frac{7}{8}$	$5\frac{3}{16}$	0·087
6V, 85 Ah., Mk. 2/1	$5\frac{9}{16}$	$4\frac{11}{16}$	0·060
6V, 85 Ah.	$5\frac{9}{16}$	$4\frac{11}{16}$	0·060
6V, 85 Ah., Mk. 3	$5\frac{9}{16}$	$4\frac{11}{16}$	0·060
24V, 85 Ah., Mk. 2	$5\frac{9}{16}$	$4\frac{11}{16}$	0·060
6V, 40 Ah., Mk. 1/1	4	$4\frac{3}{8}$	0·068
12V, 75 Ah.	$4\frac{7}{32}$	$5\frac{9}{32}$	0·067

Table 2—Dimensions of separators used in Signals type batteries, manufactured by The Chloride Electrical Storage Co. Ltd.

Battery type	*Separator dimensions*		
	Width in.	*Length in.*	*Thickness in.*
2V, 14 Ah.	$2\frac{1}{32}$	$3\frac{3}{32}$	0·05
2V, 16 Ah.	$3\frac{11}{16}$	$3\frac{1}{8}$	0·03
2V, 75 Ah.	$5\frac{9}{16}$	$3\frac{1}{2}$	0·094
6V, 40 Ah., Mk. 1/1	4	$4\frac{5}{16}$	0·07
6V, 40/50 Ah.	$6\frac{1}{2}$	$4\frac{15}{16}$	0·09
6V, 85 Ah., All Marks	$5\frac{9}{16}$	$4\frac{21}{32}$	0·061
6V, 100/125 Ah., Mk. 2	$5\frac{5}{8}$	$5\frac{1}{8}$	0·098
6V, 170 Ah.	$5\frac{13}{16}$	$8\frac{9}{32}$	0·118
12V, 22 Ah., Mk. 1	4	$4\frac{5}{16}$	0·07
12V, 75 Ah.	$4\frac{1}{4}$	$5\frac{1}{4}$	0·065
24V, 85 Ah., Mk. 2	$5\frac{9}{16}$	$4\frac{21}{32}$	0·061
24V, 170 Ah., Mk. 1/1	$5\frac{7}{8}$	$8\frac{7}{16}$	0·061

Table 3—Dimensions of separators used in Signals type batteries, manufactured by Pritchell and Gold, and E.P.S. Co. Ltd.

REASSEMBLY OF BATTERIES

34. Groups of serviceable negative and positive plates from the same type of battery can now be assembled (with new separators as and when necessary) into cell units. The correct method of inserting a separator is shown in Fig. 6.

Cell units into containers

35. Using a serviceable container of the correct type, assemble the cell units into it. Care should be taken to assemble the cells in correct sequence, i.e., positive to negative connections. If a cell group fits loosely in the container, it must be tightened. This may be achieved by placing one or more separators on one or both sides of the groups. If the elements are left loose, the heavy vibration experienced in service will crack the sealing compound.

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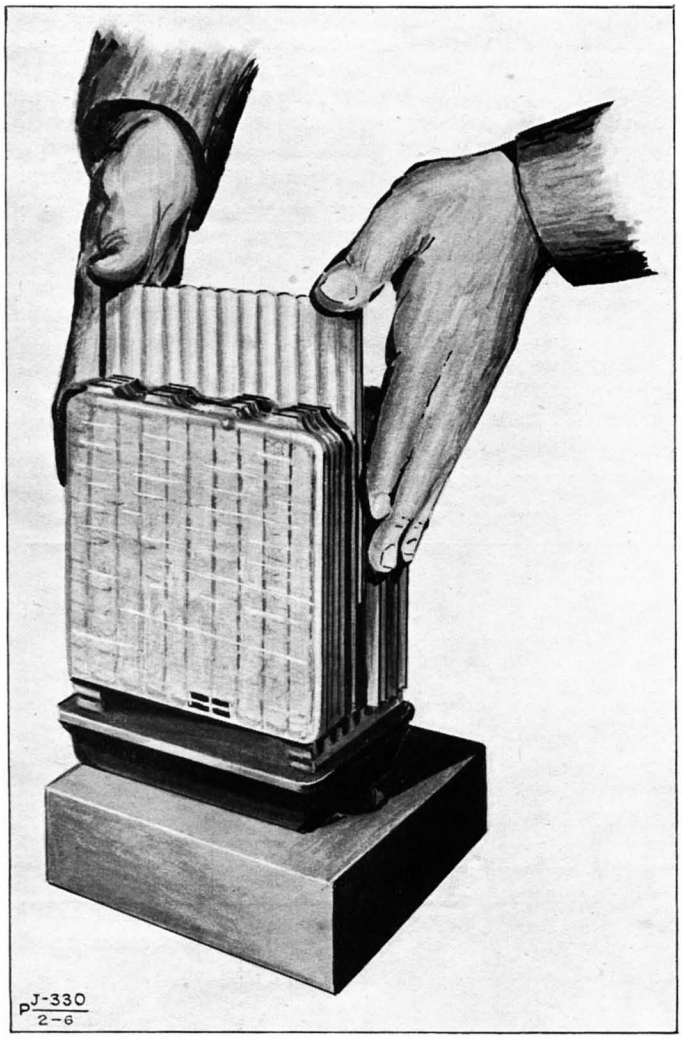

Fig. 6—Correct method of inserting a separator

Sealing (see Fig. 7)

36. After assembly of cell groups into the container, replace the cell lids and seal them in position with sealing compound. The sealing compound to be used is Bitulac, M 1458. This should be heated uniformly in a large supply pot to between 220° and 250°C. There are two stages for sealing: firstly, the compound should be run around the cell lid to make an effective seal between the cell lid and container, and secondly, after allowing to cool, the second portion of compound at a temperature between 250° and 270°C. should be run on to complete the operation, and finally "flushed" with the aid of a "white" flame.

Note: An improved type of pourer which can be made up locally is shown in Fig. 8.

Burning on cell connectors

37. Assemble the cell connectors and burn them in position to the tops of the cell posts or pillars, using an oxygen-coal gas flame and sticks of hard lead to make up any shortage of metal. Before adding the metal, the lid insert and post should be joined together. It may be necessary to build up terminal posts to the correct height.

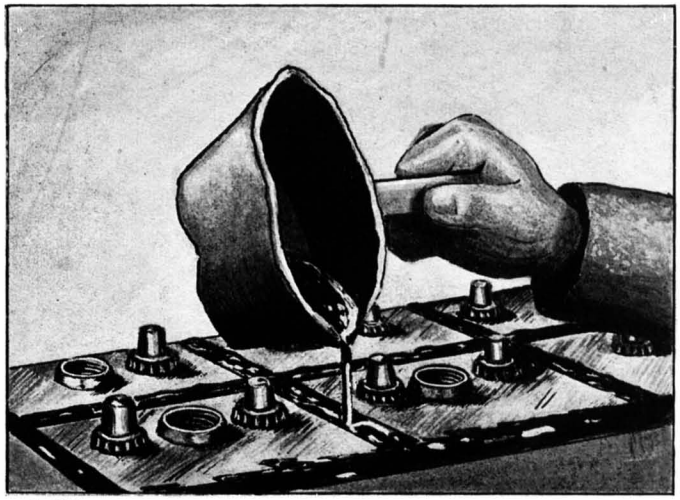

Fig. 7—Applying sealing compound

Marking of batteries

38. New connectors will be stamped with the battery type, "Reconditioned battery," and dated. All reconditioned batteries will be painted with a 1 in. red band around the outside of the case.

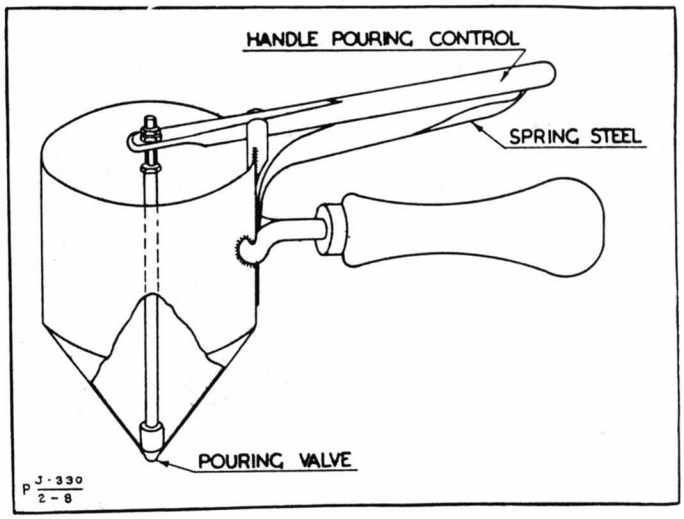

Fig. 8—An improved type of sealing compound pourer

Repair of case

39. If the battery container is carried in a wooden case, the case should be repaired, as necessary, and repainted

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Fig. 9—Lead-burning an inter-cell connector

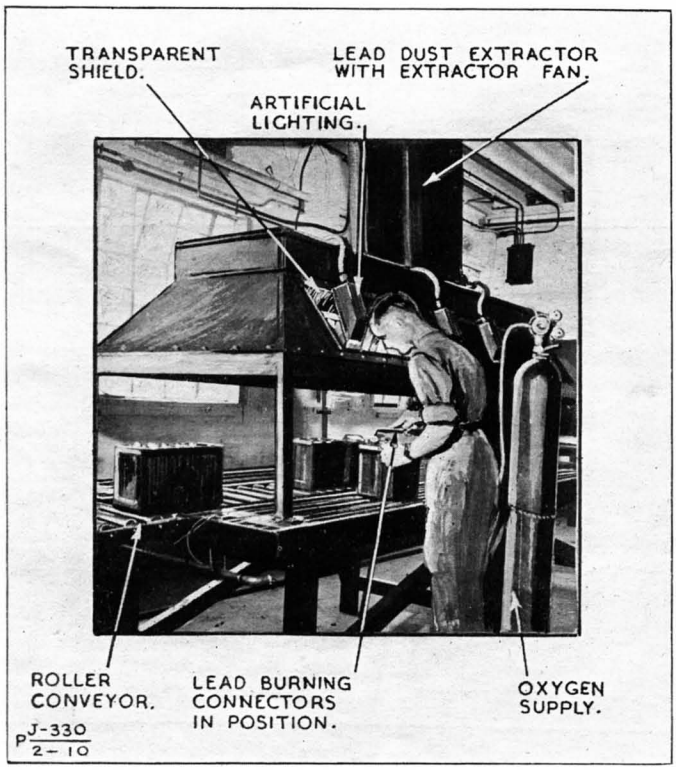

Fig. 10—Lead-burning bench

with acid-resisting paint. To neutralize acid on old cases, soak them in a solution of bicarbonate of soda, 1 lb. of bicarbonate of soda to 1 gallon of water.

Filling with electrolyte

See Page 10

40. After assembly of reconditioned batteries (unless fitted with Porvic micro-porous plastic separators) fill to the correct level with electrolyte at specific gravity of 1.350 at 60°F. If fitted with Porvic separators, electrolyte of specific gravity 1.250 should be used; electrolyte of specific gravity 1.350 is totally unsuitable for batteries fitted with Porvic separators. When preparing the dilute acid, always add acid to water. Never add water to acid.

Initial charging

41. The batteries will then be given a prolonged charge at initial (new) charging rate for 40 to 80 hours. The charging rates are as set out in Table 4. After charging, the specific gravity should be adjusted as required to 1.290 at 60°F. for each cell.

Type	*Capacity*	*Charging rate*
WD. 1	6V, 63 Ah.	4A
WD. 2	6V, 75 Ah.	5A
WD. 3	6V, 110 Ah.	8A
WD. 4	12V, 63 Ah.	4A
WD. 5	12V, 72 Ah.	5A
WD. 6	6V, 100 Ah.	7A
WD. 7	6V, 150 Ah.	10A
WD. 8	6V, 150 Ah.	10A
WD. 9	6V, 150 Ah.	10A
WD. 10	6V, 180 Ah.	12A
WD. 11	6V, 180 Ah.	12A
Motor cycle batteries		0·8A

Table 4—Initial charging rates for reconditioned lead-acid batteries

TESTING RECONDITIONED BATTERIES

Heavy discharge test

42. All reconditioned batteries, excluding Signals and motor cycle, after charging, will be subjected to a heavy discharge test for 15 seconds. Using a standard discharge tester, the voltage of each cell indicated after 15 seconds should not be below 1.50V, the voltage remaining fairly constant during the tests. If one cell is more than 0.20V lower than the others, or if its voltage falls off rapidly, that cell is still defective, is insufficiently charged, or the top connectors are not burned on properly. Cell connectors which heat up during the test require reburning. Any battery not passing the above test will be rejected. See Table 7 for typical examples of temperature, state of charge and discharge rate.

Prolonged heavy discharge test

43. Five per cent of all reconditioned batteries will be subjected to a prolonged discharge test for 20 minutes at the rates specified in Tables 5 and 6. Motor cycle batteries should be discharged for five hours at 1.5A, at the end of which the cell voltage should not be less than 1.75V per cell.

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Battery type	Discharge rate		
	60°F.	70°F.	80°F.
WD. 1	65A	70A	75A
WD. 2	85A	90A	95A
WD. 3	120A	130A	140A
WD. 4	65A	70A	75A
WD. 5	80A	85A	90A
WD. 6	105A	115A	125A
WD. 7	165A	175A	190A
WD. 8	165A	175A	190A
WD. 9	165A	175A	190A
WD. 10	200A	210A	225A
WD. 11	200A	210A	225A

Table 5—Prolonged heavy discharge rates

Battery type	Discharge rate		
	60°F.	70°F.	80°F.
6V, 40 Ah., All Marks	40A	43A	45A
6V, 85 Ah., All Marks	85A	90A	95A
6V, 100/125 Ah., All Marks	100A	110A	120A
6V, 170 Ah., All Marks	170A	180A	190A
12V, 22 Ah., All Marks	22A	23A	24A
12V, 75 Ah., All Marks	75A	80A	85A
24V, 85 Ah., All Marks	85A	90A	95A
24V, 170 Ah., All Marks	170A	180A	190A

Table 6—Prolonged heavy discharge rates for Signal type batteries

44. Connect a suitable resistance in series with the fully charged battery under test through an ammeter and adjust the resistance to the rate corresponding with the battery type. Continue the discharge for 20 minutes, keeping the current constant for that period. Voltage readings of each cell should be taken at the commencement of test and after 5, 10, 15 and 20 minutes. At the end of 20 minutes the voltage of each cell must not be less than 1.6V, that is, provided the initial temperature of the electrolyte is between 60° and 80°F. The temperature of the electrolyte after test should not exceed 105°F.

45. The results of a number of the above tests will determine the efficiency of inspection and repair.

Note: In the absence of specific information on a particular battery, an indication of the efficiency of repair can be obtained by discharging the battery through a suitable resistance in five hours and/or in one hour. The battery should give approximately 85 per cent of its rated capacity when discharged in five hours and 58 per cent of its rated capacity when discharged in one hour.

SAFETY FIRST FOR THE BATTERY REPAIRMAN

46. (*a*) Do not work on an empty stomach. In this condition you are liable to absorb lead easily.
(*b*) Keep your fingers out of your mouth when at work.
(*c*) Keep your finger nails short and clean.
(*d*) Do not chew tobacco, the lead oxides are carried to your mouth. Chewing tobacco does not prevent you from swallowing lead.
(*e*) When you leave the shop at night, and before eating, wash your face, hands and arms with soap, and clean your nose, mouth and finger nails.
(*f*) Do not eat in the repair shop.
(*g*) Drink your milk allowance. It assists in the prevention of lead poisoning.
(*h*) Use Epsom salts when constipated; this is very important.

Battery type	Nominal capacity	Discharge rate	Fully charged, S.G. 1·290 at 60°F.		Half-discharged, S.G. 1·210 at 60°F.	
			Temp.	Volts	Temp.	Volts
LWD2 or CWD2	75 Ah.	160A	80°F.	1·82	80°F.	1·74
		,,	40°F.	1·75	40°F.	1·68
		,,	0°F.	1·65	0°F.	1·48
		300A	80°F.	1·65	80°F.	1·53
		,,	40°F.	1·45	40°F.	1·41
		,,	0°F.	1·32	0°F.	1·10
LWD9 or CWD9	150 Ah.	160A	80°F.	1·92	80°F.	1·91
		,,	40°F.	1·90	40°F.	1·87
		,,	0°F.	1·82	0°F.	1·78
		300A	80°F.	1·84	80°F.	1·68
		,,	40°F.	1·74	40°F.	1·76
		,,	0°F.	1·68	0°F.	1·63

Table 7—Cell volts after ten seconds heavy discharge at varying temperatures—examples

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(*i*) Bathe frequently to assist in the prevention of lead poisoning.

(*j*) Leave your working clothes in the shop.

(*k*) It is better not to wear a moustache ; keep your hair covered with a cap.

(*l*) Before sweeping the shop, dampen the floor to keep down the dust.

(*m*) In handling lead, wear gloves as much as possible, and wash and dry the gloves every day that you wear them.

(*n*) Wear goggles to keep lead and acid out of your eyes.

(*o*) Wear rubber shoes or boots. Leather shoes should be painted with a hot mixture of equal parts of paraffin and beeswax.

(*p*) Wear woollen clothes if possible. Cotton clothing should be dipped in a strong solution of baking soda and dried. Wear a flannel apron covered with sacking.

(*q*) Keep a bottle of strong ammonia handy. If you should spill acid on your clothes apply some of the ammonia immediately to neutralize the acid, which will otherwise burn a hole in your clothes.

(*r*) Keep a stone, earthenware, or porcelain jar filled with a solution of washing soda or baking soda (bicarbonate of soda). Rinse your hands in this solution occasionally to prevent the acid from irritating them.

(*s*) If you should splash acid in your eye, wash it out immediately with warm water, and drop olive oil in the eye. If you have no olive oil at hand, do not wait until it is available, but use any lubricating oil, or Vaseline.

SCHEDULE OF EQUIPMENT AND TOOLS REQUIRED FOR BATTERY REPAIR WORKSHOP

Item	*No. off*	*Cat. No.*	*Section*
Plant, battery charging, C.P., motor-driven, 7½/15V, 200/400A, 400/440 A.C. Complete with switchboard, cut-out, ammeters, main switch, cables, charging bus-bars, charging leads with spring clip connectors, and bus-bar ammeters	1	WX/0425	W3
Plant, battery-charging, 3-circuit, metal rectifier, 230/250 A.C. Provided with a separate rectifier for each circuit and supplied with moving-coil ammeters. All circuits may be parallel. Capacity : No. 1 circuit, 30 cells up to 1·5A No. 2 circuit, 30 cells up to 3A No. 3 circuit, 18 cells up to 6A	2	WX/0429	W3
Voltmeter, D.C., 3-volt secondary cell, Mk. 1 Avometer. 5v range, NO1 MK 2 equipment	2	[illegible]	Z1
~~Instrument, testing, universal, 40 range~~ Tester cell, heavy discharge, cell testing.	[illegible]	[illegible]	[illegible]
~~Testers, cell, heavy discharge~~	[illegible]	[illegible]	[illegible]
Hydrometers, acid testing	3	29018	LV6/MT4
Boxes, tin, 10 in. × 2½ in. square	3	41345	LV6/MT4
Gloves, rubber, 4½ in. × 11 in., A, Mk. 1, prs. Aprons, rubber, acid-proof	3 6	WB. 0686 WB. 1847	W2 W2
Funnels, filling, glass, 4 oz. Syphon, acid, No. 1516 Funnels, battery cell, Mk. 2 Measure, glass, 10 oz.	2 1 2 1	ZB. 0047 ZB. 0137 ZB. 3534 KD. 3663	Z2 Z2 Z2 K
Blowpipes, lead-burning (oxy-coal gas type) Machine, drilling, bench, ⅜ in., 230/250 A.C.	4 1	WX/0027 WX/1070	W3 W3
Chest, tool, filled, electric cable Screwdrivers, London, 18 in. Hammers, hide-faced	1 3 3	FA. 0786 FA. 16789 (Old Pt. No. FA. 4612) FA. 14157 (Old Pt. No. FA. 2163)	F F F

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Schedule of equipment and tools required for battery repair workshop—(*continued*)

Item	*No. off*	*Cat. No.*	*Section*
Saws, hack, hand, frames	2	FA. 16653 (Old Pt. No. F. 4444)	F
Scissors, 8 in.	1	FA. 16701 (Old Pt. No. FA. 4526)	F
Brushes, scrub, hand	3	KB. 0883	KE
Brushes, flat, paint, G.S.	3	FA. 10628 (Old Pt. No. FA. 0541)	F
Knives, putty and stopping	3	FA. 14961 (Old Pt. No. FA. 2452)	F
Measures, oil, ½ gal.	3	KE. 3667	KE
Irons, soldering, electric, heavy, straight bit, 3 lb, 350 watt, 200/220 volts	3	FA. 14836 (Old Pt. No. FA. 1367)	F
Trucks, storehouse, No. 8	3	KH. 8954	KH
Conveyors, gravity, runway, 14 in. × 2¼ in. roller	Approx. 150 to 200 ft.	—	E3
Voltmeter, 0-3 volts, 8 in. scale	1		
Ammeter, 0-300 amperes, 8 in. scale	1		
Ammeter, shunt, 0-500 amperes	1		
Carbon piles, variable resistance (continuous rating, 400 amperes)	2		

Equipment to be locally manufactured

4—Tanks, 10 ft. × 3 ft. for storing charged negative groups.

1—Assembly bench, 10 ft. × 3 ft.

3—Steamers, 2 ft. 2 in. × 1 ft. 4 in. × 6½ in. deep (1 gas point).

1—Group extractor.

2—Sinks, lead-covered, with water taps and high-pressure pipe for swilling containers.

1—Water tank, 150 gal., for neutralizing acid.

5—Charging benches, 15 ft. × 2 ft. × 6 ft., fitted with bus-bars and asphalt-covered.

1—Lead-burning bench, complete with :—
Hood, trunking and 24 in. extractor fan.
6 Gas points.
8 Electric 60W lamps
4 Oxygen cylinders complete with gauges.
2 Gas rings.

2—Precision Ralston water stills, Index No. TE. 2220.

4—Gas points.

4—Water points.

57/Maint./1490(M.E.8(c))

END