SECTION
Z
CARE AND MAINTENANCE

CARE AND MAINTENANCE

GENERAL INFORMATION.

This section summarises the various precautions that must be taken to keep a W/T set in efficient working order.

The rating in charge of any installation should always remember that it is his duty to keep his set in instant readiness for use, unless permission has been obtained from the Signal Officer to have the set out of action. W/T apparatus deteriorates very rapidly if neglected, and should be subjected to periodical overhauls. A thorough overhaul and cleaning of the external parts of instruments should be carried out at least every week.

In all maintenance work the use of unsuitable tools should be avoided. With the correct tools the work can be done more quickly and the apparatus will not be damaged. Small screwdrivers should be used on small screws and large screwdrivers on screws with large slots in their heads. Spanners of the correct size should be used on bolts and nuts. Pliers and quick-grips should not be used for this purpose.

If it is necessary to dismantle a machine or other piece of W/T apparatus, care must be taken to ascertain how it was assembled. An armature usually can only be removed from one end of a machine, and if attempts are made to remove it from the other end, the wiring will be damaged. Nuts, screws etc., must not be forced when dismantling until the construction has been definitely ascertained. When reassembling apparatus cleanliness is essential.

The painting of W/T apparatus should be avoided if possible. Machines are given a good enamelled finish before they leave the works of the manufacturer, and if painted later this high grade finish will be spoilt. There is also a possibility of the holes in the expanded metal covers being filled up, or paint adhering to the commutators, the result being overheating or breakdown of the machine.

Transmitting panels and other W/T apparatus are also given a very good finish and should not be painted over later as the good appearance will be spoilt and there is great danger of paint adhering to contact surfaces which will probably result in a breakdown. (An instance occurred of the wooden panels of a transmitting set being painted with lead paint which resulted in the set failing to oscillate.).

It is essential for efficient operation that all W/T apparatus should be kept absolutely clean, and in particular all insulators, including deck insulators. Pencil marks should not be made on insulating material as such marks form high resistance paths which may cause breakdowns.

Ebonite panels exude sulphur when subjected to changes of temperature or to a damp atmosphere. This corrodes the metal parts fixed in or to the panel. All panels should be cleaned frequently with a damp methylated spirit cloth before the sulphur adheres to the metal parts and produces a form of crystal on the ebonite. Paxolin panels should be cleaned by rubbing with a soft dry cloth.

The contact surfaces of switches should never be rubbed with any abrasive material e.g., emery cloth. First all dust must be removed from between the studs etc., with a small brush, then a very light smear of vaseline oil should be applied and the switch operated several times. This will bed in the contacts and the surplus oil should then be removed. Care should be taken not to allow oil to reach the surface of the panel.

In variable condensers the spaces between the vanes should be blown out with bellows occasionally to remove any dust. When the contact to the moving vanes is of the rubbing type, the surface should occasionally be cleaned with a dry cloth and lightly oiled. Careful watch must be kept for the development of end play in the moving plate system.

Aerial coils should be blown out with bellows frequently so that no dust collects between the turns or on the surface of the coils. The moving spindles of condensers, contacts of barrel switches, moving arms of resistances etc., should be given a thin coating of fine oil occasionally, but the oil must be used sparingly or high resistance contacts will result and dust will be attracted. A soft haired brush should be used for clearing dust from instruments. Places inaccessible to the brush should be blown through with bellows.

It is often necessary to open out the split legs of receiving valves in order to secure good contact with the holders. Care must be taken during this operation not to sever the connecting wire which passes through each valve leg. With metal spring holders valves should only be removed when necessary as frequent removal soon fractures the metal spring system.

When removing or inserting plug-in coils they should be held by their base in order to avoid straining the connections to the winding. The split legs will also require periodical opening out to secure good contact with the socket.

Fixed condenser (Mansbridge Type) should be tested for insulation periodically and replaced if the insulation falls below 100 megohms. When soldering connecting wires to the spills care should be taken not to heat up these spills as the heat will pass to the insulating component and probably ruin the condenser.

Telephones should not be roughly handled or the permanent magnets will be affected and probably the windings broken. In hot climates after being worn they should be placed in an air draught to disperse the accumulated moisture which would otherwise penetrate them and cause rust on the diaphragm.

TRANSFORMERS, CONDENSERS AND CABLES.

OIL-IMMERSED TRANSFORMERS.

Each oil-immersed transformer is supplied by the manufacturer completely assembled in its tank, but without oil. Joints between the cover and the tank, cover and insulators etc., are made with special washers, such as "Langite", which make the transformer oiltight. Before the transformer is despatched from the maker's works the oil-filling hole and air-escape hole are fitted with plugs which prevent water and dampness getting into the transformer. These plugs should not be unscrewed until the transformer is ready to be filled with oil. Pattern 109 Oil is used in the transformer and the airtight oil tins should not be opened until the oil is required for use. Transformers are filled with oil so that all windings are completely covered; the exact height of the oil required is generally given on a label attached to the transformer. After the correct amount of oil has been put into the transformer the oil-filling plug and air-escape plug are tightened up. To ensure satisfactory operation it is important that the insulators be kept clean.

If a transformer has been operated on full load, or on overload for a considerable time, the oil thickens and sludge settles on the windings, in the ventilating ducts and on the bottom of the transformer. Excessive sludge causes the transformer to become overheated and may result in a breakdown. Consequently, when a transformer is used on full load for long periods it is desirable to pump out a sample of the oil from the bottom of the tank of the transformer periodically. If there is sludge in this sample all the oil should be pumped out of the transformer and a fresh supply should be substituted.

AIR-COOLED TRANSFORMERS.

Care must be taken to keep dirt, dust and water from the terminals and from the windings.

INSULATORS.

If it should become necessary to renew the porcelain insulators on a transformer, care must be taken to insert the cushioning washer between the insulator and the steel cover of the transformer. Cushioning washers fitted by the manufacturers are usually of "langite" or "woodite", but any oil-treated leather may be used for this purpose. Screws which hold the insulators in position must be tightened up carefully, otherwise the insulators may be cracked.

OIL-FILLED CONDENSERS.

The same care should be exercised with oil-filled condensers as with oil-filled transformers. It is essential to keep moisture from the inside of the condensers and consequently only dry Pattern 109 Oil from an airtight tin is to be used for filling the condensers, and the filling holes are not to be opened until the oil is ready for insertion.

LEAD-COVERED CABLES.

These are used for connecting the various machines, transformers, inductances, condensers, etc.; in the W/T Sets. It is essential that these cables be examined periodically, particularly in the tropics, to make sure that they are in an efficient state.

Instances have occurred of W/T sets breaking down in the tropics owing to the lead-covering of the cables crumbling away and the rubber insulation becoming defective. This defect frequently occurs where oil leaks from transformers or condensers and soaks into the lead-covered cable. Consequently, care should be taken to prevent oil from coming into contact with cable, the parts of panels near oil-insulated transformers or condensers being wiped periodically.

PAPER-INSULATED CABLE.

Pattern 9749 paper-insulated cable is used for connecting aerials to the outside of the silent compartment if the distance is not less than 30-feet. This cable consists of a core of stranded copper-wire insulated with dry paper wrappings spaced apart with string, and enclosed in a lead casing which is covered with cab-tyre sheathing. Great care is taken during transport and whilst fitting the cable in position to prevent the paper-insulation of the cable absorbing any moisture. For this reason the ends of the cable are left sealed while it is being run, and the paper insulation is not exposed to the air until immediately before the joints are made in the terminal boxes. For satisfactory operation the insulation-resistance of the paper-insulated cable should not be less than 200-megohms. If it is suspected that the insulation resistance is low, or if it does not read "Infinity" on the ship's insulation test set, the cable must be dried out. This requires the use of a special dry air pumping plant which is available at the principal dockyards, where it can be brought on board and operated by S. E. E. Department. If at any time the cable be cut or disconnected the ends should be sealed immediately, the seals to consist of a lead cap soldered with a wiped joint to the lead casing of the cable.

Pattern 1107 compound is used for filling the junction boxes for Pattern 9749 cable. In the event of this cable having to be replaced it is very important that only Pattern 1107 compound be used for filling the boxes, as other types of compound allow the cable to absorb moisture.

It is most important that the lead casing of the Pattern 9749 cable be efficiently earthed at each end, the earthing being effected by special lead-washers inside the cable-glands fitted to the cable-boxes. The method of fitting the paper-insulated cable, together with drawings showing details of the cable-boxes, etc., is given in A.F.O. 3224/30, and E.F.O. 186/30 (1), (2), (3), and (4).

CARE AND MAINTENANCE

CELLS AND BATTERIES.

GENERAL

Secondary cells are used for heating the filaments of receiving valves, for supplying the high potential to the anodes of receiving valves, for emergency sets and auxiliary lighting, and for working the buzzer-communication system. Primary cells are also used on occasions for supplying high potentials to the anodes of receiving valves and for grid bias purposes. Details of cells used with W/T apparatus are given in Sub-Section NA.

The efficient working of W/T receiving apparatus depends so vitally upon the healthy state of the batteries that the greatest possible care must be taken to carry out the instructions for their maintenance, some of the specially important points being as follows:-

(a) Cells must not be handled roughly or knocked, and particular care must be taken when handling cells which have been in use for a long time as the plates become weaker with age and the active material in the plates may be soft and loose.

(b) Everything used in connection with batteries must be kept clean.

(c) Cells must be charged and discharged correctly.

(d) Cells must not be left in a discharged condition as in such circumstances the plates become sulphated.

(e) Defective cells must receive attention immediately.

(f) The level of the acid must be kept well above the tops of the plates. distilled water must be added to make up for the evaporation, when necessary.

(g) The plates of a cell deteriorate if moisture gets to them before the cell is filled with acid. Consequently at the completion of assembly during manufacture, the top of the container in most cells (particularly in larger cells) is sealed. It is most important that the seals should not be broken until all is in readiness for the acid to be put into the cell.

In the "Admiralty Handbook of W/T (1938) Vol. I. ~~(1931) paragraph 112~~, a simple explanation is given of the construction and theory of secondary cells and the precautions to be adopted to ensure that the cells will work correctly.

A very useful and more detailed book is entitled "Secondary Battery Handbook, 1925". This book is B.R.170, and various sections in it are referred to in the following notes.

CLEANLINESS.

Great care must be taken to keep batteries, battery-room, cupboards, shelves, etc., clean. All implements, containers, hydrometers, measuring glasses, and everything used in connection with batteries must be free from impurities. Hydrometers and measures not in use should be washed and kept in the boxes supplied for them. Dirty hydrometers carry dirt into the cells.

It is essential that the dilute sulphuric acid be free from impurities and consequently great care must be taken that all vessels used for storing, mixing, and transferring acid and distilled water from one vessel to another, or from a vessel to the cells, should only be composed of clean lead, glass, porcelain, or inert moulded material provided for the purpose. Metal vessels or funnels are not to be used in any circumstances.

Cells must be wiped regularly as there is always a certain amount of creeping of the acid in addition to the ordinary spraying and this may lead to a short-circuit between terminals and leaks between cells. Terminals should be kept clean and coated with a small quantity of clean vaseline.

ELECTROLYTE.

The specific gravity of the acid to be used in any cells is given on the maker's label attached to the cell. If acid of the correct specific gravity cannot be obtained from store it will be necessary to dilute more concentrated acid with distilled water. Table No. 3 on Page 72 of the Secondary Battery Handbook, referred to above, shows the volume of water to be used to reduce one gallon of acid of any specific gravity to the lower specific gravity required in the cells.

Sulphuric Acid must be added to distilled water when it is necessary to dilute the acid. IT IS EXTREMELY DANGEROUS TO ADD WATER TO ACID AS EXCESSIVE HEAT IS GENERATED WHEN THE WATER COMES INTO CONTACT WITH THE ACID.

The maker's label gives the specific gravity when the acid is at a temperature of 70° F. As the temperature goes up the specific gravity of the acid goes down and vice versa. The correction constant is 0.004 for each 10°F. To obtain the equivalent specific gravity at 70°F. add the correction to observed reading when the acid temperature is above 70°F. and subtract it when below 70°F.

After the electrolyte has been mixed it must be allowed to cool before it is put into the cells.

FIRST CHARGE.

The cells must be filled with acid of the correct specific gravity until the plates are well covered: some cells have a mark on one of the sides showing the exact height to which the acid is to be filled. The plates and separators absorb some of the acid during the first charge and the correct level of the acid must be maintained.

The first charge of all cells must be carried out in accordance with Manufacturer's instructions given on the label attached to each cell. The treatment of cells of different makes varies considerably, some cells having to be put on first charge immediately after being filled with acid, while other cells require the acid to soak into the plates and separators for several hours before the first charge is commenced.

CELLS AND BATTERIES.

NORMAL CHARGE AND DISCHARGE.

One of the principal points in the successful maintenance of secondary cells is that they shall receive the correct amount of charge. If possible, cells should be charged at not greater than the normal charging rate laid down on the maker's instruction label, but this charging rate may be increased to the maximum allowed by the maker if time is limited. The maximum rate must not be exceeded, otherwise the cells will be damaged owing to excessive gassing and excessive temperature.

If cells are repeatedly over-charged the active material of the positive plates is disintegrated and thrown off, and forms a deposit of perioxide-sludge in the bottom of the cells. If cells are under-charged repeatedly, sulphation of the active material occurs, the specific gravity of the electrolyte is reduced, and there is a permanent loss of capacity.

The cells will be kept in very good condition if they are alternately charged and discharged to the limits of specific gravity given on the maker's instruction label. It may be inconvenient to discharge the cells fully as a general procedure on board ship, but if possible they should be discharged fully at least once a month. On the next re-charge the specific gravity and voltage should be maintained for ½-hour after they have both reached their maximum steady values, and during this time both plates of the cells should be gassing freely.

If a battery is charged once every day it should be given not more than 15-minutes free gassing at every charge. If it is charged oftener than this the cells must only be brought to the gassing point once every 24-hours; the other charges should be stopped when the voltage of each cells has reached 2.4 volts whilst on charge.

The state of charge of a cell is indicated by the voltage, the specific gravity of the acid, and the colour of the plates. The following are the signs that a cell is fully charged.

(a) The voltage has reached a steady maximum value of approximately 2.6 volts whilst on charge.
(b) The specific gravity of the acid is that given on the maker's label.
(c) Both plates are gassing freely.
(d) The positive plate is chocolate colour, the negative slate-grey.

None of these signs is an adequate guide in itself. Heavy gassing, for instance, is also a sign of a sulphated cell, and may, through this defect, commence as soon as the charge is started.

If the voltage and specific gravity of some cells in a battery do not rise regularly with the other cells, arrangements must be made to give these low cells additional charge until they are normal.

Cells must not be discharged below 1.8 volts whilst on discharge.

Useful information regarding the charging and discharging of cells is given in Chapter 3 of the Secondary Battery Handbook.

BATTERY BOOK.

A book should be kept in which the specific gravity and voltage of each cell at the completion of charge and the completion of discharge should be taken weekly. When these readings are taken it is essential that the charging current or discharge current be flowing as the voltage readings are not accurate when cells are on open-circuit.

BATTERIES IN TROPICAL CLIMATES.

The only way to make batteries work satisfactorily in tropical climates is to give them constant attention -- far more than is necessary in more temperate climates.

The principal causes of trouble are the rapid evaporation of the electrolyte, and excessive gassing and spraying during charge. Consequently it is necessary to be constantly filling up the electrolyte with distilled water to prevent the plates becoming uncovered.

Where practicable the temperature of the cells should not be allowed to rise above 110°F, consequently when the temperature of the air is already above 90°F, the charging rate may have to be reduced or it may even be necessary to stop the charge until the cells cool down. In extreme tropical climates (such as are experienced in the Red Sea) it is necessary to use discretion in this matter.

EXPLOSIONS AND POISONOUS GASES.

Cases of spontaneous explosion during the charging of secondary cells have been reported. It must be remembered that when a cell is gassing, hydrogen is given off and this makes an explosive mixture with the oxygen in the air. Consequently a bad connection in the charging circuit, an internal short-circuit, or any other fault which may cause a spark, may result in an explosion. If the electrolyte leaks rapidly due to a broken container, a spark may occur as the liquid leaves the bottom of the plates and ignite the mixture. Great care must be taken to avoid any sparking, and naked lights should never be allowed near cells, particularly when they are on charge.

In certain circumstances very poisonous gases have been produced during the charging of batteries, and it is consequently very important that the ventilation of the cells should be continued during charge and for some time after the charging is completed.

CELLS AND BATTERIES.

REFERENCES IN SECONDARY BATTERY HANDBOOK.

The following parts of the Secondary Battery Handbook should be referred to when required:-

(1) General remarks on care and maintenance. — Pages 40 and 77.

(2) Effects of mal-treatment of secondary cells. — Chapter 6, Page 42.
This chapter explains the results of:-
(a) Over-charging.
(b) Under-charging.
(c) Charging at too high rates.
(d) Charging at too low rates.
(e) Leaving cells uncharged.
(f) Incorrect electrolyte.
(g) Salt water in cells.
(h) Internal short-circuits.
(i) Failure to top-up cells.
(j) Reversed cells.
(k) Temperature. etc.,

(3) Summary of defects of secondary cells and the various methods of attending to these defects. — Chapter 7, Page 51.
This chapter deals with:-
(a) Sulphation of plates.
(b) Abnormal growth, bending, buckling and breaking of plates.
(c) Cells which do not become charged as quickly as the others.
(d) Sludge.
(e) Cells gassing on "Open-circuit".

(4) Cleaning out cells. — Page 36.

(5) Changing the electrolyte. — Page 37.

(6) Putting a battery out of commission. — Pages 37 - 40.
Various manufacturers give different instructions for putting their cells out of commission, and the methods recommended by the Chloride, Hart and D.P Co's are given in this part of the Handbook.

(7) Recommissioning a battery. — Page 40.

(8) Repairs and maintenance of secondary batteries. — Page 80.

(9) Capacity and efficiency of a battery. — Page 10.

CHEMICAL TESTS FOR PURITY OF THE ACID.

What is known as "Brimstone" acid should be used. This has, at 60° F., a density of 1.840.

Should there be any reason, such as the consistent degeneration of all batteries, to suspect that the acid contains any impurities, the following simple tests may be applied. All the reagents can be obtained from the Sick Bay.

The most harmful and frequent impurities are chlorine, nitric acid, acetic acid, iron and copper.

Proceed as follows: Make a solution of one part of the suspected acid in 100 parts of distilled water. Call this solution "Solution A". Take a small quantity of Solution A (about one-eighth of the total quantity) and add sufficient liquid ammonia to neutralise the acid. This should be done slowly and carefully. The state of the mixture can be ascertained by the use of purple litmus paper, which if dipped into the mixture will turn red if still acid, blue if already too alkaline, and remain unchanged if the solution is neutral.

Call this neutral solution "Solution B".

Proceed with solution A.

(1) To a small quantity of A add a few drops of silver nitrate solution. A WHITE precipitate indicates CHLORINE.

(2) Make a weak solution of ferrous sulphate in water and pour it into a test tube. Very carefully add a little of A, so that this liquid lies on the top of the other. A BROWN RING at the junction of the two liquids discloses the presence of NITRIC ACID.

(3) Add to a small quantity of solution A a few drops of a solution of ammonium carbonate. A pale BLUISH-WHITE precipitate indicates COPPER.

Take solution B.

(4) Add to portion of B a few drops of a solution of ferric chloride. Should ACETIC ACID be present, a RED precipitate will be thrown down which, on the addition of hydrochloric acid, will be decolourised.

(5) Take some more of B and boil with a solution of hydrogen peroxide. A BROWN precipitate on the addition of a small quantity of potassium hydrate (caustic potash) solution will show the presence of IRON.

In the event of impurities being found, fresh acid should be demanded.

CELLS AND BATTERIES.

CELLS, INERT, PATTERN 4976.

These cells are of the Leclanche type (see Admiralty Handbook of W/T ~~(1931) paragraph 111~~ (1938) Vol. I. and contain the necessary chemicals in a dry state. In this state they should keep in condition, until required, for any length of time provided they are kept perfectly dry. While in store in temperate climates they remain in good condition, but in the tropics the combined heat and moisture have a most deleterious effect on them, and special care should be taken that the cells are stored in as dry a position as possible.

Typical instructions for rendering the cell active. Remove the cork and the vent plug. Gently tap the cell to clear the filling holes. Fill to the brim with clean drinking water slowly and once only. Do not fill up again or shake out surplus water. The water and the syringe must be absolutely free from traces of sulphuric acid. Keep the cell in an upright position for eight hours with both vent and filling holes open. Wipe off surplus moisture and replace cork and vent plug. If, during use, creeping of electrolyte is noticed, remove and discard the vent plug.

It is proposed in future to provide a filler (somewhat similar to a fountain-pen filler) to enable a measured quantity of water to be inserted without difficulty. The actual instructions issued by the makers should be followed carefully. These will be found on the instruction label which is attached to each cell.

Great care must be taken to dry the tops of the cells. The chemical is liable to creep and a white substance is then seen on the top, round the terminals; this being hydroscopic absorbs moisture from the air and forms a paste which corrodes the terminals and the negative wire connector. Special care must be taken to keep the tops of the cells dry if they are tightly packed in battery boxes, as corrosive matter may spread over the tops of adjacent cells and cause short-circuits besides corroding the terminals.

MACHINES.

ROTATING MACHINERY GENERAL.

The following remarks apply to motors, motor-alternators, motor-generators and rotary converters.

There are two principles which must be observed in the care of electrical machinery to obtain maximum efficiency with the minimum of trouble; the first is that absolute cleanliness of all parts, particularly the commutator, slip-rings, and brushgear, is essential. The second is that any defect, however, trifling, should be investigated at once and remedied without delay.

Machines must be kept as free from damp as possible and no water allowed to drip or splash on them.

Machines must be blown out occasionally with a pair of bellows to remove the dirt and dust which collects on all the internal parts, particular care being taken to ensure that all parts of the brush gear, commutator and slip-rings are clean.

Machines must not be overloaded and the ventilation holes must not be restricted in any way, otherwise the machines may become too hot, which will damage the insulation and may melt the solder on the commutator connections.

Duplicate machines should normally be run alternately so that each gets the same amount of work. Every machine for which the W/T staff is responsible should be run weekly. If electrical power is not available the armatures should be turned by hand. It is a good plan to draw up a "weekly inspection routine for machines" to ensure that they all receive attention. It is on record that machines, which had not been run for a considerable time, failed to start when power was switched-on, owing to defects which could have been avoided if inspection had occurred.

When an armature has to be removed from the carcase of a machine, various internal wires have to be disconnected; labels should be tied to each side of the disconnections as this saves time on reconnecting and ensures that all wires are correctly replaced. At least two men should be employed in removing an armature from its carcase. The armature must be moved gradually and the weight taken at both ends to ensure that the various parts are not damaged. Unless great care is exercised, the armature and field windings may be cut, the commutator segments may be knocked out of position, or part of the insulation of the machine may be damaged.

After an armature has been removed from a machine and it is necessary to lift it by power, precautions must be taken to prevent damaging the ball-bearings, commutator, slip-rings, or the windings. The ball-bearings should be covered with clean cloth, free from fluff, to prevent dirt getting into the bearings; sacking and wooden chocks should be used to prevent the wire strops from damaging any part of the armature, commutator, etc., during lifting operations or during transit.

MACHINES.

When replacing an armature in its carcase remember that the brush gear (if any) at the far end of the machine has to be lifted and it should be ascertained that all leads -- such as those interconnecting field coils and brushes -- are clear.

BRUSHES AND COMMUTATORS

The carbon brushes to be used on the commutators and slip-rings of machines have been selected very carefully and the windings of the machines have been designed to work with a particular grade and size of brush. Pattern numbers of the brushes to be used are given on the label plates fixed to the lids of the terminal boxes on all later types of machines, and it is most important that the correct brushes be obtained when replacements are necessary. The pattern numbers of the brushes to be used in any machine will be found in section H.

Commutators when operating correctly become a rich brown colour and when in this condition work satisfactorily without attention.

If sparking occurs at the brushes the commutator becomes black. The commutator should preferably be cleaned with clean rag whilst the armature is rotated, but fine glass paper may be used instead of the rag if the rag will not remove the dirt. It is, however, highly desirable that the rich brown colour shall not be removed provided the commutator is true. Carborundum, or similar heavily abrasive cleaners should not be used. The reason for the sparking must be ascertained, and the fault rectified.

At first it is advisable to see if sparking is being caused by something which can be rectified easily, the more complicated causes being tested later. Sparking may occur owing to the following reasons:-

(1) Brushes not free in brush-holders. It should be ascertained whether all the brushes on the commutator are free in their holders, particularly those at the back of the machines which may not be seen very easily. The brushes should be pulled out of the holders, dirt and dust should be removed both from the brushes and the holders, and on re-inserting the brushes care should be taken that they move up and down the brush-holders readily.

(2) Grit and dirt on the brushes. The underside of brushes must be examined carefully to see that there are no particles of grit or dust embedded in the brushes. This particular examination should always be carried out if the spark always appears at one point of the brush. Brushes must be kept clean from the dust and dirt which collect on their edges.

(3) Brush pressure incorrect. The brush pressure of all brushes should be from 2 lbs to 2½ lbs per sq inch except for the C.M.3 and C.M.6 qualities for which it should be from 3 to 3½ lbs per sq inch. (The brush pressure can be measured by a small spring balance.) C.M.3 and C.M.6 brushes are used on the commutators of some machines generating low voltages. Sparking will occur if there is not sufficient pressure on the brushes to enable them always to remain in contact with the segments of the commutator. It is very important that all the brushes on the commutator shall have the same pressure otherwise the brushes do not share the current equally and therefore some may be over-loaded. The brush-springs must be quite free, not fouled by the flexible connections or connection-screws, and must press on the middle of the top of each brush.

(4) Brushes not properly bedded down. To prevent sparking the whole of the underside of brushes must have exactly the same curvature as the commutator. It will be readily understood that if only part of the brush is the same curvature as the commutator, this part will have to carry more current than it was designed to do, with consequent overheating and other troubles. Again, if only part of the brush is in contact with the commutator, it is not in the correct relative position to the other brushes on the commutator and this may cause circulating currents.

On examination, it will be seen whether brushes require rebedding owing to their edges having broken away or for some other reason.

Bedding can best be done by putting the brushes in the holders, and the brush springs on the top of the brushes, placing a piece of fine glass-paper between the brushes and the commutator, and turning the armature and glass-paper in the direction of rotation of the machine. (The correct direction of rotation is given by the arrow fixed to the carcase of the machine at the motor end). It is essential that the armature and the glass-paper be moved in one direction only, as if moved backwards and forwards the underside of the brushes would not be exactly the curvature of the commutator, as there is bound to be some slackness between the brushes and their holders.

If new brushes have to be bedded and a comparatively large amount of brush has to be removed, carborundum cloth may be put between the brushes and the commutator, and drawn across the brushes. The finish of the bedding of the brushes must always be with fine glass-paper so that a fine smooth surface is finally obtained.

After bedding is completed remove the brushes from their holders and thoroughly clean all parts, particular care being taken that there are no pieces of grit on the bottom surfaces of the brushes. After replacing the cleaned brushes, it is desirable to run the machine on no-load for a short time as generally the whole surface of the brushes will not be in contact with the commutator immediately after bedding down.

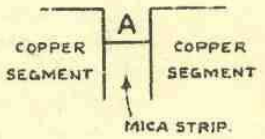
MACHINES.

(5) Connections not efficient. The electrical connections between the brushes and the brush-holders should be examined and also the connections between the sets of brush holders and other parts of the machine. All loose connections must be tightened up.

The brush gear must be rigid and bolts and nuts must be screwed up as necessary.

(6) Commutator mica projecting. Sparking is caused by the mica projecting above the copper segments of the commutator.

C.M.3., C.M.6., E.G.11. and H.M.8 brushes wear the copper segments, but are not capable of wearing down the mica at the same rate: to prevent the mica from projecting above the surface of the copper segments when these brushes are used, it is the usual practice to undercut all the mica in the commutator to a depth equal to the width of the mica as shown in the adjoining sketch. Makers arrange for all the mica to be removed from the space marked "A" during the manufacture of the machines and great care should be taken when undercutting has to be carried out again that all the mica is removed from "A". A short piece of hacksaw blade stiffened by a piece of metal and provided with a handle at the end, is suitable for undercutting the mica.



(7) Dirt and dust on the mica. Small pieces of carbon and copper may become wedged between the copper segments of the commutator on the top of the mica, especially when the mica is undercut, and sparking results. It is essential that the mica be kept free from dirt and dust, by scraping if necessary.

(8) Machine overloaded. Sparking may occur at the commutator if the machine is overloaded. A machine may be delivering its normal full-load output and may still be overloaded owing to defective insulation either in the machine or in external apparatus: if this is suspected the insulation resistance of the apparatus should be measured.

(9) Brushes not in alignment. In most W/T machines there are pairs of brushes which bear on the same segments of the commutator at the same time. The two brushes are required in parallel on some occasions as one brush is not sufficient to carry the armature current, but in other machines the second brush is put in parallel to maintain the circuit in the event of the first brush sticking in its holder or becoming defective for any other reason. If one of the pair of brushes is slightly in advance of the other on the commutator, sparking will occur. To remove this sparking the brush holder should be loosened and the two brushes put in alignment.

(10) High and low commutator bars. One or more of the copper segments of the commutator sometimes rise above, or sink below, the level of the remaining copper segments owing to the commutator being knocked, or owing to excessive speed, etc. These defective segments can readily be perceived on examining the commutator, and it will usually be found essential for the commutator to be turned.

(11) Commutator and slip-rings not concentric. Very occasionally the commutators and slip-rings become eccentric and sparking results. If the armature of the machine is turned slowly and the up-and-down movement of the brushes in their holders is noticed, it will readily be seen if the commutator and slip rings are concentric. If they are very eccentric special examination should be made and the fault should be removed, by turning or grinding if necessary.

(12) Excessive vibration. Many W/T armatures rotate at speeds of the order of 3,000 r.p.m. At this rate of rotation it is most important that armatures should be well balanced, otherwise vibration is excessive and sparking at the commutator and other troubles result. Manufacturers of machines have been impressed with the necessity for good balancing, and during the last few years armatures have been balanced in special balancing machines while rotating at high speed.

It is possible for the balance of a machine to become worse during its life and if this occurs the armature should be removed and rebalanced. Rebalancing can, however, only be undertaken in properly equipped workshops.

(13) Defective armature coils. If a commutator is examined and it is noticed that the mica between two of the copper segments is burnt, it generally shows that the coil between these segments is open-circuited or that the soldered joints are bad.

If one part of the armature becomes hotter than the remainder, or if the armature begins to smoke, it probably means that one of the armature coils has become short-circuited.

In both the above cases the commutator should be examined for open circuits or short circuits; - the solder may not be making efficient connection between the copper segments and the armature coils, or solder, dirt, or dust may be short circuiting two of the copper segments.

(14) Brushes in wrong position. To obtain correct commutation it is very important that the carbon brushes should be in a definite position on the commutator in relation to the poles of the machine. During the testing of machines at the maker's works the correct position of the brush-rocker ring, and therefore the correct position of the brushes, is indicated by a pointer attached to the ring which is opposite to a cut on a small plate let into the end bracket. Some machines made years ago had the positions indicated by painted lines. If the brush rocker has to be moved it is essential that it be put back to its correct position before the machine is operated.

CARE AND MAINTENANCE

MACHINES.

In some machines, after the commutator has been turned, it may be necessary to move the brush rocker ring slightly to obtain sparkless commutation.

Sparking will occur if brushes are not evenly spaced round the commutator, and it is possible for this spacing to become incorrect if care is not taken when bolts are tightened up. If this defect is suspected the distances between the brushes on the commutator should be carefully measured.

(15) Staggering of brushes. Many W/T machines have a commutator with brushes spaced 90° apart as shown in Figure a, brushes B_1 and B_3 being positive, and B_2 and B_4 negative.

To increase the life of the commutator and also to prevent ridges from developing, owing to unequal wear, the brushes are "staggered" so that they press on the maximum length of the commutator. It is most important that the brushes be staggered so that every part of the commutator shall be swept by the same number of positive and negative brushes as shown in Figure b.

Figure c. shows the incorrect way of staggering brushes, the positive brushes sweeping one part of the commutator and the negative brushes sweeping another part of the commutator; with this arrangement of staggering if current is passed into the commutator at the brushes marked + and if it leaves the commutator at the brushes marked – it will be found that the part of the commutator swept by the + brushes will be blackened and the part swept by the – brushes will be bright copper and probably particles of copper will be found adhering to the – brushes. These results are detrimental to efficient working.

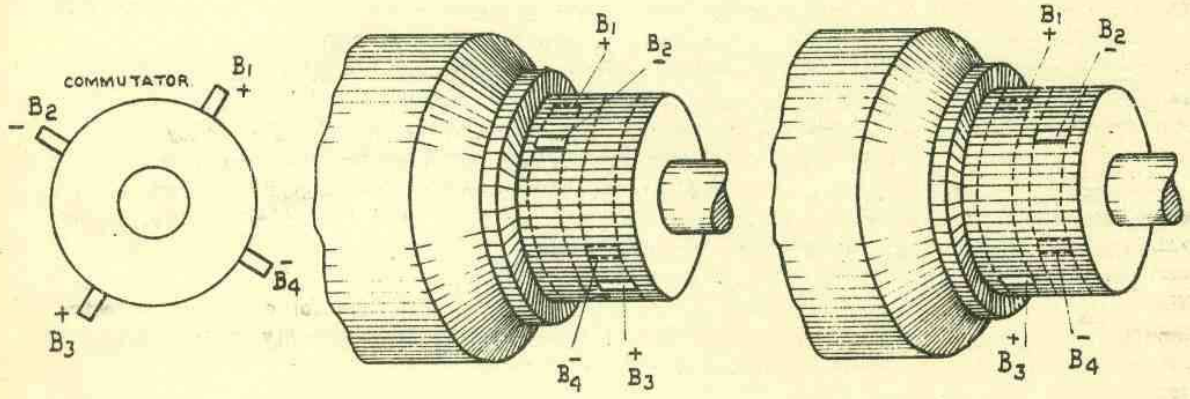


FIG. (a) FIG. (b) FIG. (c)

(16) Incorrect brushes being used. Sparking may occur if incorrect brushes are used; only brushes of the pattern numbers detailed on the label plates fixed to the various machines are to be fitted.

BEARINGS.

Ball-bearings are used in all W/T machines manufactured in recent years. The inner race of each bearing is a "light driving fit" on the shaft which has been ground to receive it. The outer race is a "hand push fit" in the bearing housing. Ball-bearings have been specially developed for use in electrical machines, and in the event of new bearings being required in W/T machines, reference should be made to the nameplate fixed on the defective machine, as the nameplate of all modern machines gives the Admiralty pattern number of the ball bearings which are used in the machine. The pattern numbers of the ball-bearings used in W/T machines will also be found in section M.

The greatest care must be taken at all times (whilst in store, when unpacking, and when assembling) to keep the ball bearings entirely free from dirt, dust, grit, or water.

Ball bearings should be lubricated by giving the lubricator-cap about one turn each month. Bearings only require greasing sparingly, and for most machines it will be satisfactory if the grease lubricator at each end of the machine is refilled with grease once a year only.

The makers of the ball bearings used in W/T machines and also the makers of lubricating greases have been consulted and, as a result, it has been decided that the following greases are the best to use in W/T machines:–

(a) In temperate and sub-tropical climates.
Admiralty Pattern 553 Grease, Lubricating, Tube of, for High Speed W/T Machines.

(b) In tropical climates or for machines installed in very hot situations.
Admiralty Pattern 554 Grease, Lubricating, High Melting-Point, Tin of, for High Speed W/T Machines.

The ball bearings of machines newly made by manufacturers are filled with Pattern 553 Grease and this is satisfactory until the machine requires regreasing in a tropical climate, when Pattern 554 Grease should be used.

If a ball bearing runs hot, or if a rattle or click be heard in the bearing, it is generally necessary for the bearing to be renewed.

MACHINES.

If it is necessary to replace a defective ball-bearing, great care must be taken not to damage the shaft or the ball-bearing during the operation.

As stated above, the inner race of the ball-bearing is a driving fit on the shaft, and if a hammer is used carelessly in endeavouring to remove the bearing, the following damage may be caused:-

(a) The shaft may be bent. If this occurs it will be found on re-assembly that the armature rubs on the poles of the machine, and that there is sparking at the commutator, and the machine will be unfit for use.

(b) The centres at the end of the shaft may be damaged. The shaft is centred at each end, these centres being used when the commutator has to be returned, etc. If the centres are damaged it is very difficult to correct them, and it may be necessary to return the machine to store as defective.

(c) The commutator bars may be knocked. "Flats" on the commutator may result and this will cause sparking at the commutator and necessitate re-turning.

The best method of removing a ball bearing from its shaft is by the use of the tool shown in the adjoining figure. It consists of a steel plate (P) with a threaded hole at its centre in which a steel bolt (B) turns, the end of (B) being circular and its centre removed. Three levers (A) are pivoted on the edges of plate (P) at equal distance from each other. (Two only are shown in figure d.).

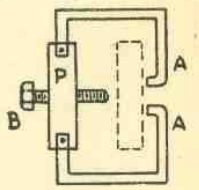


FIG. D.

To remove a ball bearing the ends of (A) are put against the inner race of the ball bearing and bolt (B) is tightened up against the end of the shaft. The centre at the end of (B) is removed to ensure that the centre of the shaft is not damaged during this operation.

If this tool is not available, two tapered steel-wedges can be usefully employed.

A short length of steel tube, internal diameter slightly greater than the shaft, should be used for knocking a new ball bearing on to the shaft. If one end of this tube be put against a ball bearing and the other end be hammered, the ball bearing will be knocked on squarely and there will be no danger of the end of the shaft being damaged.

LUBRICATORS.

Grease cup lubricators are fixed at the two ends of motor-alternator or motor-generator sets and these lubricators are connected to the ball bearings. The type usually fitted is made by Rotherham & Sons and is of nickel-plated brass, size R3 or R4.

FAULTS.

(1) If a machine will not start when the power supply is switched on and if no current flows, a testing instrument or test lamp should be used to ascertain whether the necessary voltage is being applied between the ARM. and COM- terminals in the terminal box of the machine.

If the voltage is not correct between these two points, the fault may be due to:-

(a) a fuse being blown,
(b) defective circuit breaker, switches, etc.,
(c) defective starter,
(d) wiring between ring-mains and machine being disconnected or earthed.

Any defective apparatus external to the machine should have its coils, contacts and mechanical gear tested and any faults should be rectified.

If the voltage is correct between terminals ARM. and COM- the brushes may have stuck in their holders and not be in contact with the commutator, or some other part of the armature circuit may be open-circuited.

(2) If the machine will not start and there is excessive supply current, the fault may be due to a disconnection in the shunt-field or to a short-circuit.

(3) If the machine does not generate the correct voltage the generator field should be tested to confirm that normal current is flowing in the circuit. If this current is correct the armature circuit must be tested.

(4) Various other faults and their remedies are described in the section "BRUSHES AND COMMUTATORS", pages Z3 to Z5.

Faults in machines which necessitate the withdrawal of the armature should receive the attention of F.A's.