

CHAPTER 6

ELECTRIC BRUSHING MACHINE—TYPE AI/MY

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General

1. The electric brushing machine (see Fig. 1) is a portable, four-speed flexible-drive machine which is adaptable for wire-brushing, grinding, drilling and polishing operations. The flexible shaft is driven by a  $\frac{1}{2}$ -H.P. electric motor mounted on the underside of a base-plate, the whole being pivoted in a "U" bracket forming part of the stand. The speed of the flexible shaft can be varied progressively by means of two opposed-cone type pulleys, coupled by an endless rubber "V" belt. One of the pulleys is keyed to the motor armature shaft, and the other is coupled to the flexible drive shaft and mounted in a bracket on the motor base-plate. The flexible drive shaft is provided at the motor end with a drive connection and at the other end with an internally threaded union into which the various grinding and drilling attachments can be fitted.

2. The "U" bracket supporting the motor is provided with a boss at its lower end, machined to fit the upper end of the stand, which is fitted in turn to a conical base. A ball thrust-bearing is provided at the upper end of the column to enable the "U" bracket to swivel freely about the axis of the column. The base is mounted on a portable type stand fitted with castors, so that the machine can be readily moved when in operation, or from one working station to another. The castor stand is detachable and the base could if desired be mounted directly on a bench. The motor is controlled by means of an ON-OFF switch mounted on the upper side of the motor base-plate and a suppressor is fitted to the machine to prevent the motor from causing electrical interference to W/T apparatus. The various components of the flexible drive machine are described separately in paragraphs 3 to 7, while information is given on the operation and maintenance of the machine in subsequent paragraphs.

DESCRIPTION OF COMPONENTS

Motor

3. Three types of motor have been fitted to various issues of this type of brushing machine. All three types have a continuous rating of  $\frac{1}{2}$ -H.P. at a speed of 2,800 r.p.m., and a brief description of each type, sufficient for maintenance purposes, is given in the following sub-paragraphs:—

(i) *Short-circuiting, brush-lifting type A.C. motor.*—This type of motor (see fig. 2) comprises an armature with a radial commutator, a cylindrical-type yoke, field coils, and two endshields. Each endshield is secured to the yoke by four screws, and each accommodates an armature ball-bearing retained in position by means of an inner and an outer bearing cap, both caps being held in position by means of four screws, which pass through the outer cap and endshield and are screwed into the inner cap. The inner cap at the commutator end of the motor has an extended sleeve which supports the brush gear. Incorporated in the armature is the short-circuiting, brush-lifting gear which is controlled by the centrifugal force acting on two pivoted weights mounted

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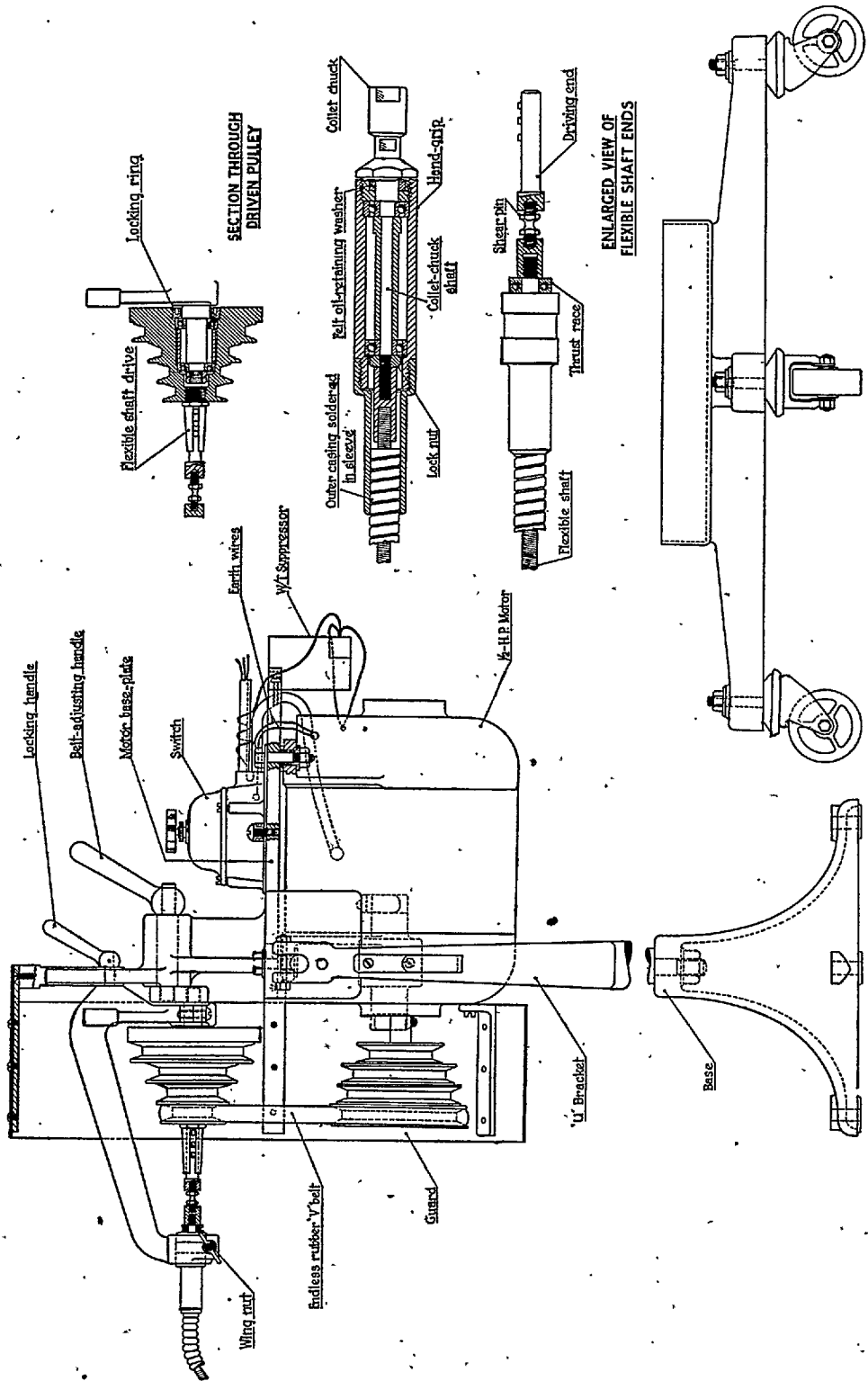


Fig. 1.—Electric brushing machine.

on the armature shaft. The purpose of the gear is to short-circuit the commutator segments and lift the brushes from the commutator face when the motor reaches a speed of approximately 1,200 r.p.m., enabling the motor to start as a repulsion motor and then to run under full load as an induction motor; the commutator segments are short-circuited by a number of copper strips which make contact with the inner ends of the segments under the action of centrifugal force (see fig. 2).

- (ii) *Short-circuiting, brush-riding type A.C. motor.*—This type of motor is a repulsion-starting, induction-running motor similar to that described in sub-para. (i) except

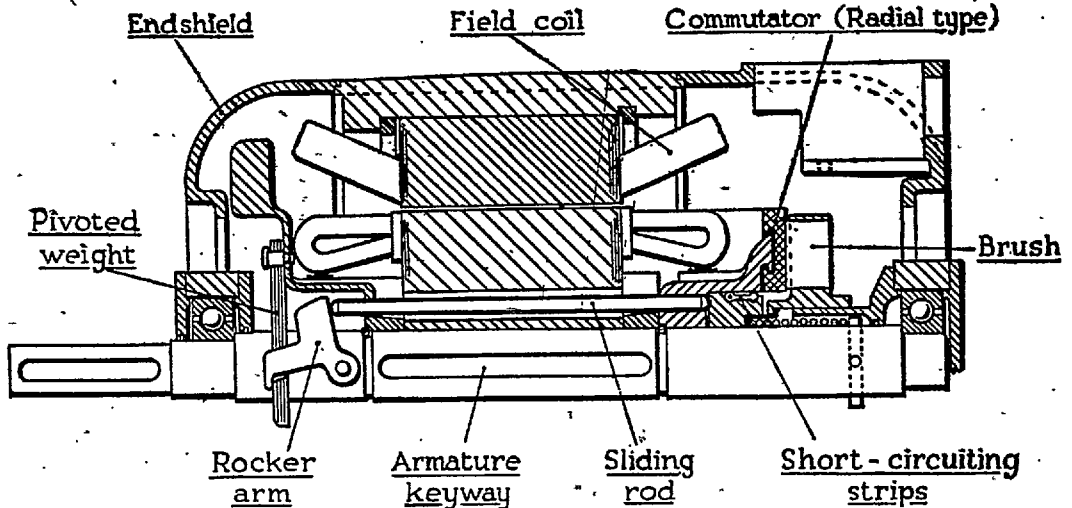


Fig. 2—Short-circuiting, brush-lifting type A.C. motor

that the brushes are not lifted when the commutator segments are short-circuited. The commutator is of the circumferential type and the short-circuiting copper strips are prevented from making contact with the ends of the commutator at motor speeds below 1,200 r.p.m. by means of a ring-type coil spring, but at higher motor speeds the force exerted by the copper strips overcomes the spring pressure and the strips short-circuit the commutator segments, thus allowing the motor to run as a squirrel-cage induction motor, the brushes being permanently shorted by means of a short length of insulated copper wire.

- (iii) *Compound-wound D.C. motor.*—This type of motor comprises an armature provided with a cylindrical-type commutator, a yoke which houses both the series and the shunt-wound field coils, and two endshields which accommodate the ball-bearings supporting the armature. Each ball-bearing is retained in position in the endshield by means of an inner and an outer bearing cap, both caps being retained in position by means of four screws which screw into the inner cap. Provision is made for lubricating the bearings by means of a grease nipple fitted to each outer bearing cap.

#### Suppressor

4. The suppressor is inserted in the motor circuit for the purpose of preventing electrical interference to adjacent W/T apparatus. The suppressor consists of two condensers, each of 0.05 m.f.d. capacity connected in series across the two supply cable connections to the motor, the wire connecting the two condensers being earthed, as shown in fig. 3.

#### Switch

5. The motor control switch is a semi-rotary, single-pole type secured to the motor base-plate, insulation washers being provided where the holding-down screws pass through the switch body. The switch body is earthed by means of the earth wire in the three-core supply cable.

#### Operating-head drive

6. The drive for the operating heads incorporates a belt drive from the motor spindle, a shear

pin and a flexible cable enclosed in a metallic outer casing, each of which is described separately in the following sub-paragraphs:—

- (i) *Belt drive*.—The belt drive consists of two 4-step cast-aluminium pulleys coupled by an endless rubber V-belt, one pulley being keyed to the motor armature shaft, and the other being mounted on ball-bearings supported by a bracket attached to an extension of the motor base-plate, and finally coupled to the flexible shaft driving the operating head. The driven pulley has four speeds of rotation, viz:—1,400, 2,500, 4,000 and 7,500

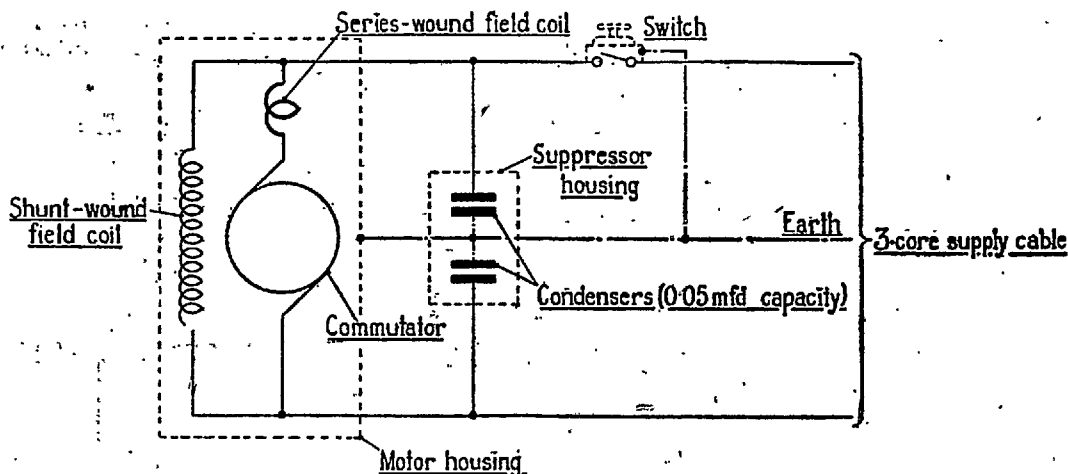


Fig. 3.—Circuit diagram

r.p.m. The tension of the belt can be adjusted by means of the belt-adjusting handle, which should be turned clockwise to increase the tension, and anti-clockwise to decrease the tension or to slacken the belt sufficiently to enable its position on the pulleys to be changed; a locking screw fitted with a handle is provided to lock the handle after it has been adjusted correctly. The outer end of the driven pulley is fitted with a slotted sleeve which accommodates the shear pin adaptor. A sheet-steel guard enclosing the belt and pulleys is supported on brackets secured to the motor base-plate.

- (ii) *Shear pin*.—The shear pin is interposed between the driven end of the flexible shaft and the driven pulley in order to protect the machine and the flexible shaft from damage which would otherwise ensue should undue pressure be applied inadvertently to the operating head. The shear pin consists of a short length of hexagon steel rod provided with screw threads at each end, the centre being reduced to a diameter of  $\frac{5}{16}$  in., which is just sufficient to withstand the maximum permissible torque. One end of the pin is screwed into a sleeve which is soft-soldered to the inner core of the flexible cable, the other end of the pin being screwed into the driving connection which engages with the slotted sleeve carried by the driven pulley.
- (iii) *Flexible drive*.—Various sizes of the flexible shafts are available for use with the machine, the smaller sizes being used in conjunction with small size operating heads for light duties such as wire-brushing, grinding and polishing, whilst the larger size of shafts with large size operating heads are used for grinding, polishing, drilling, etc. All drives consist of an inner flexible cable which transmits the torque enclosed in an outer metallic casing, the inner cable being built up from several layers of high-tensile steel wire wound in alternate layers right and left-hand on a central core. The outer casing of the larger size flexible drive comprises two layers, the inner one being a flat steel strip wound spirally, over which the outer layer of interlocking strip steel covering is wound; in the smaller sizes of flexible shaft the inner layer is omitted from the outer casing. The driving end of the outer casing is secured in an extension of the driven pulley bracket, and a ball-bearing thrust-race is positioned between the end of the outer-casing of the shaft, and the sleeve carrying the shear pin. The other end of the flexible shaft is fitted with a sleeve for the reception of either a ball-bearing hand-grip or grinding and other attachments, the hand-grip being used on small shafts for holding small grinding and polishing heads. The motor end of the inner cable is soldered into the sleeve which carries the shear pin whilst the other end of the cable is soldered into a sleeve for the attachment of the various final drives.

### Equipment

7. A description of the attachments which can be fitted to the larger size flexible drive together with a description of the hand-grip, grinding wheels and milling cutters used with the smaller size drive is given in the following sub-paragraphs:—

- (i) *Hand-grip*.—Two sizes of hand-grip are provided for use with the flexible drive shafts, one for the large type and another for the small, each grip consisting of a sleeve, which screws into the outer casing of the flexible drive shaft and which is provided with a spindle mounted in two ball-bearings. In the smaller sizes, the spindle is integral with the collet chuck, but in the larger size the end is threaded  $\frac{1}{4}$  in. Whit. for the attachment of large grinding wheels, etc. A felt washer is provided in the hand-grip to prevent the escape of grease from the flexible drive shaft. The spindle in each hand-grip is screwed into a sleeve soldered on to the end of the inner cable of the flexible drive. Collets are available to suit operating head spindles of 6 mm. and  $\frac{1}{4}$  in. diameter.
- (ii) *Drilling attachment*.—This attachment is coupled to the larger size flexible drive shaft and consists of a worm, driven direct from the flexible drive shaft, and a worm wheel, housed in a casting provided with a supporting handle. A hand-operated extension screw used for exerting pressure on the drill point during drilling operations, and holes up to  $1\frac{1}{2}$  in. diameter may be drilled with this attachment. The worm is carried in ball-bearings and a thrust-race is fitted on the motor side of the worm to prevent the flexible drive shaft from being subjected to end thrust; the worm wheel shaft is carried in two bearing bushes and a ball-bearing thrust-race takes the drill pressure.
- (iii) *Right-angle drive attachment*.—This attachment is provided to facilitate grinding and polishing operations when using abrasive discs, felt and lambswool bobs, etc., on horizontal surfaces and it comprises a flexible drive shaft coupling, a right-angle bevel gear drive and a collet chuck. The gear shafts are mounted in ball-bearings and felt washers are provided to retain lubricant within the gear case.
- (iv) *Ball-bearing extension handle*.—This attachment is provided for use when large grinding and polishing heads are employed in conjunction with the larger size flexible drive shafts, forming an additional hand-grip for the operating head. The handle consists of a knurled sleeve which houses a spindle and two ball-bearings, the spindle being provided with a screw thread at one end for attachment to a large grinding or polishing head.
- (v) *Grinding wheels and milling cutters, etc.*—Various types of grinding wheels and milling cutters, wire brushes, etc. (see fig. 4) may be used on suitable attachments and these are provided with 6 mm. and  $\frac{1}{4}$  in. diameter shanks to fit the collet chuck of the smaller size hand-grip. Typical grinding wheels and brushes are illustrated in fig. 4, together with the types of spindle which are used with felt, polishing and emery bobs, etc. Milling cutters are available in various types of "cut" to suit the material on which the tool is being used, the coarse type being used on soft metals such as light alloys and the fine types being used on materials such as steel and bronze.
- (vi) *Spindles*.—Spindles are provided with a coarse taper thread at one end for the attachment of mops and bobs and the other end is machined to fit the collet chuck of the small hand-grip. Another type of spindle is provided with an end slot in which a piece of cloth can be held for the purpose of cleaning valve guides, etc.

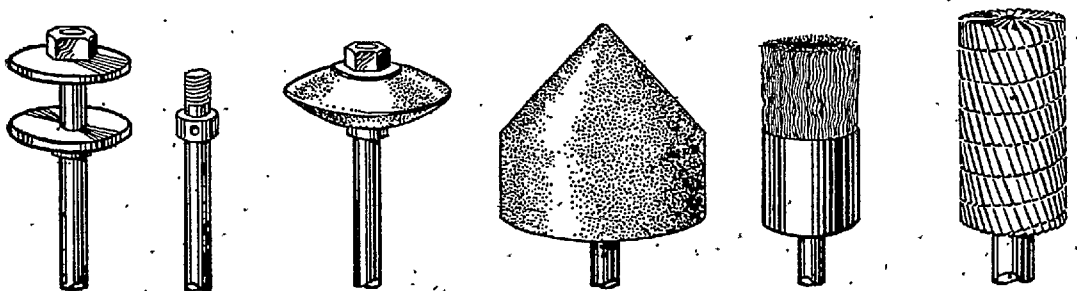


Fig. 4. — Type of spindles and attachments

## OPERATION

### General

8. Before connecting the brushing machine to the electricity supply it should first be ascertained that the voltage, etc., is the same as that indicated on the rating plate attached to the motor or stand. In the case of single phase A.C. supply, the voltage at the motor should not vary more than 5 per cent. above or below that stamped on the motor plate and if lengths of extension cable are used, it should be ascertained that they are of the correct capacity to carry the current without undue voltage drop. A standard three-pin plug is used for earthing the machine and no other earthing is necessary. Whilst in use the machine should be in a position to enable the operator to use the operating head without bending the flexible shaft unduly. When the machine is to be moved, the "U" bracket or the driven pulley support-bracket should be used as convenient handholds, and under no circumstances should the flexible drive or the electric supply cable be used for this purpose. The motor base-plate may be locked in any desired position in the trunnions of the "U" bracket by means of the lock-nuts provided. During the operation of the machine it should be ascertained that the flexible drive does not become overheated, particularly when high speeds are being used, also that no excessive local heating occurs at any point.

### Changing speed of operating head

9. Four speeds of the operating head are provided to enable the different diameters of grinding and milling cutters, etc., to be used at the approximate cutting speed. To change speed the locking screw handle (see fig. 1) should first be released and then the belt-adjusting handle should be turned anti-clockwise to slacken the belt. The belt should then be moved to the appropriate pair of pulleys and the belt-adjusting handle turned in a clockwise direction until the belt is under slight tension; in no circumstances should the belt be over-tightened. The belt should normally be run as slack as is possible without undue belt slip, otherwise the motor bearings and pulleys will be subjected to excessive wear.

### Speed and use of operating head

10. The most suitable speed of the operating head depends on the size and type of head and the material on which it is being used but, generally, the lowest speeds, *i.e.*, 1,400 r.p.m., should be used for milling cutters; medium speeds, *i.e.*, 2,500-4,000 r.p.m., for wire brushes, large polishing mops, sanding heads and grinding wheels from 4 in. to 6 in. diameter; and the high speeds, *i.e.*, 7,500 r.p.m., used only for small polishing mops up to 4 in. diameter and small grinding wheels. When using large sanding heads in conjunction with the right-angle drive attachment one side only of the head should be applied to the work. The use of a cutting lubricant is only necessary when using milling cutters, on materials other than brass and cast iron, suitable lubricants being chalk for steel or copper, and paraffin for light alloys.

## SERVICING

### General

11. The machine is to be kept clean and in a serviceable condition and lubricated periodically; care should be taken to ensure that particles of abrasive or metal cuttings are kept clear of the belt pulleys and the motor casing. Information on the servicing of the machine will be found in the following paragraphs.

## ELECTRICAL EQUIPMENT

### Motor lubrication

12. The motor bearings should be lubricated periodically with grease, high temperature (Stores Ref. 34A/89 or 34A/76) through the grease nipple provided on each outer bearing cap, care being taken to avoid over-filling; the bearings should be kept approximately two-thirds full, and this amount should not be exceeded. The bearing housings are charged with grease during assembly at the manufacturer's and this quantity is sufficient for approximately 12 months under normal working conditions. After a prolonged period of use the motor should be dismantled as described in para. 13 and the bearing housings cleaned out and then subsequently re-charged with grease.

### Dismantling the motor

13. Care should be taken when dismantling the motor to ensure that all electrical connections are clearly marked before they are uncoupled, in order to prevent confusion on subsequent assembly. The supply cables should be disconnected at the junction box on the side of the motor after which the earth leads and the leads to the suppressor should be disconnected. The motor should then be removed from its base-plate by unscrewing the nuts on the four holding-down bolts, meanwhile supporting the motor until all four nuts are removed, to prevent damage being sustained by the

armature shaft and the bearings. To gain access to the interior of the motor for servicing operations, the four set-screws holding the endshield at the pulley end of the motor should be removed, and then the four screws securing the bearing cap at the other end should be unscrewed to allow the ball-bearing at the commutator end of the motor to be withdrawn with the armature shaft. The armature should then be removed with the endshield, care being taken to support the armature until it is clear of the pole pieces, to prevent damage to the armature, field coils and brush gear. The bearing-cap screws of the endshield on the armature shaft may then be removed for the purpose of cleaning and viewing the bearing housing. Worn or defective bearings should be replaced by new ones.

#### **Commutator**

14. The information given in this paragraph on the maintenance of the commutator applies to all types of motor which have been used on the brushing machine, Type AI/MY. The commutator should be cleaned periodically by means of a piece of soft cloth held on a piece of wood, against the surface of the commutator whilst the motor is running. If the commutator has become slightly roughened, it should be smoothed down by means of a piece of fine sand-paper attached to a piece of wood and held against the commutator whilst the motor is running, care being taken to avoid making contact with any live conductors. If the commutator is badly scored or worn unevenly, it should be re-faced in a lathe and then polished, care being taken to remove as little of the metal as possible. After re-facing the commutator, the mica insulation between the commutator bars should be carefully undercut and for this purpose a piece of thin hacksaw blade fixed in a holder will be found satisfactory; the mica insulation should not, however, be undercut in certain instances where the mica is intended to be flush with the commutator surface before re-facing. The edges of the commutator bars should be carefully chamfered after undercutting and the commutator surface highly polished in a lathe, by means of fine-grade glass paper, finally removing all dust from the grooves with a soft brush.

#### **Brushes and brush gear**

15. The brushes on all three types of motor should be inspected periodically to ensure that they are not unduly worn and that they slide freely in the brush-holders. Brushes which are worn down more than  $\frac{3}{16}$  in. should be replaced by new ones of the correct grade. The normal brush pressure should be 3 to 4 lb./sq. in. New brushes should be correctly bedded to the commutator surface by first inserting a strip of fine-grade glass paper between the brush and the commutator, with the prepared side of the paper against the brush; emery paper should not on any account be used, as particles of emery may become imbedded in the brushes or commutator, thus causing sparking and rapid wear. The glass paper should be pulled through in the direction of armature rotation with the brush pressure applied, but the return stroke should be made with the brush lifted from the glass paper, then, lowering the brush, repeat the operation until a good surface contact is obtained between the brush and the commutator. After the brushes have been bedded by the method outlined above, the motor should be run for some time without load, in order that the surface contact will be further improved; before the load is then applied to the motor, a brush should be removed from its holder to determine the condition of the surface which should make as near as possible 100 per cent. contact. In both types of A.C. motor, periodical inspection should be made to ensure that the short-circuiting gear and the brush-lifting gear (where fitted) are free in action, particular care being taken to ensure that the short-circuiting strips are free to move outwards under the action of centrifugal force, otherwise the motor will run continuously as a repulsion motor and inefficient speed regulation and heavy current consumption will result. No carbon dust should be allowed to accumulate on the brush holders, commutator, or the adjacent insulating surfaces; dust may be conveniently removed by means of a jet of compressed air assisted if necessary by a soft bristle brush.

#### **Renewal of ball-bearings**

16. When the motor ball-bearings are to be replaced by new ones the pulley should first be removed from the armature shaft and then the motor should be dismantled as described in para. 13. The defective bearings should then be removed by means of a withdrawal tool. When the new bearings are being fitted they should be pressed on to the shaft in an arbour press, care being taken to ensure that the inner bearing caps are placed on the armature shaft before the ball-bearings are fitted. The motor should then be re-assembled as described in para. 17.

#### **Assembling the motor**

17. The information given in this paragraph on assembling the motor after it has been dismantled for maintenance operations will apply equally to all types of motor fitted on this type of brushing

machine. When assembling the motor all necessary precautions should be taken to prevent the ingress of foreign matter into the interior of the motor casing and ball-bearing housings. The endshield and bearing caps at the commutator end of the armature shaft should first be assembled, the bearing-cap screws being inserted through the outer cap and the central boss on the endshield, and then screwed into the inner cap thereby positioning the endshield on the ball-bearing. The armature should then be inserted in the yoke, care being taken to ensure that the armature or field coils are not damaged during this operation and that the armature has been inserted into the correct side of the yoke, as indicated by the relative positions of the junction box on the yoke and the pulley end of the armature shaft (see fig. 1). A long stud should then be screwed into one of the set-screw holes in the inner bearing-cap at the pulley end of the shaft to enable the inner cap to be held in position whilst the bearing-cap set-screws are being inserted. The endshield at the driving end of the armature shaft should then be fitted and the four set-screws inserted in each endshield and tightened up. Three of the bearing-cap set-screws should then be inserted in the cap at the pulley end of the armature shaft and tightened up after which the stud should be unscrewed and the other set-screw inserted and tightened up. After ensuring that the armature shaft will revolve freely, the pulley should be fitted to the armature shaft and the motor secured to the motor base-plate on the machine. The field coils and armature windings should then be tested for leakage to earth by means of a suitable bridge-megger, or, in instances where a megger is not available, continuity tests should be applied to the field coils, armature windings, etc., by means of a 40-watt lamp in series with the test leads plugged into a 230v. circuit. When tested by means of a megger the insulation resistance between the field coils or armature windings and earth should not be less than 2 megohms.

### **Belt and pulleys**

18. The motor pulley and the driven pulley should be examined from time to time to ensure that the belt is not bearing on the bottom of the pulley grooves or showing other signs of wear such as fraying or cracking; if any of these defects is present a new belt should be fitted. If it is seen that a new belt bears on the bottom of the V-groove, a new pulley or pulleys should be fitted and the belt adjusted as described in para. 9. To fit a new belt, the flexible drive should first be removed by unscrewing the wing nut on the driven pulley support bracket and then the guard should be removed by unscrewing the retaining screws, thereby allowing free access to the pulleys. The driven pulley should now be removed from its shaft, first removing the locking ring, and then the shaft together with the ball-bearings. The new pulley should then be fitted to the shaft and the locking ring tightened securely.

### **Shear pin**

19. To replace a damaged shear pin by a new one, the flexible shaft and casing should first be released from the driven pulley support bracket by unscrewing the wing nut. The halves of the shear pin should then be removed and a new pin fitted, care being taken not to damage the pin or the fittings into which it is secured. The flexible drive should then be replaced and the wing nut tightened.

### **Flexible drive**

20. After approximately 50 hours running time or, if signs of overheating are noticed, the inner cable of the flexible shaft should be removed for cleaning and re-greasing. To remove the inner shaft from the flexible drive, the nut adjacent to the collet chuck on the handpiece should be unscrewed (L.H. thread) and the inner shaft withdrawn until the lock-nut on the collet-chuck shaft is visible; this lock-nut should then be slackened and the collet-chuck shaft unscrewed from the inner flexible shaft sleeve. The inner cable should now be removed from the motor end of the outer casing and the shaft components cleaned thoroughly, the outer casing being cleaned internally by pulling a piece of rag through it. After cleaning, the inner shaft should be coated evenly with grease to a depth of about  $\frac{1}{8}$  inch and the components reassembled, the sequence of operations being the reverse to that described for dismantling.

### **Repairing flexible drive inner cable and outer casing**

21. When the flexible drive is dismantled for cleaning and greasing, the inner flexible cable should be examined for signs of local wear and if this is excessive or the whole length of the cable has worn to such an extent that the outer layer of wire has become loose, the flexible cable should be replaced by a new one. If, however, the wear is localised the defective part should be removed and the ends connected in the manner described in sub. para. (ii). When it has been necessary to shorten the inner flexible shaft the outer casing should also be shortened a similar amount. The

normal procedure to be adopted for repairing the outer casing and the inner cable is described respectively in the following sub-paragraphs:—

- (i) *To repair an outer casing.*—When an outer casing is damaged or broken, the defective part should be removed by cutting a section out of the casing. When repairing the larger size flexible drive it will be necessary to secure the inner spiral lining to the outer casing by means of a screw through the lining and casing. The ends of the screw should be riveted over and then filed flush, after which the casing ends should be thoroughly cleaned and soldered into a sleeve which just fits over the outside of the casing.
- (ii) *To repair an inner flexible cable.*—When an inner shaft sustains any damage or localised wear it may be repaired in a similar manner to that described for the repair of outer casings. The damaged ends of the cable should first be thoroughly cleaned and then de-greased in a degreasing plant, after which the ends should be filed or ground square with the axis and slightly chamfered. The ends should then be soldered into a mild steel sleeve approximately 0.040 in. thick, the inside diameter of which is such that it fits neatly over the ends of inner cable. When the inner cable has been repaired it should be given a light coating of grease prior to replacing it in the outer casing.





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