

Chapter 1

BRUSH-WEAR AND COMMUTATION IN ROTARY MACHINES

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Introduction

1. The efficiency of direct current rotating machines is directly related to good commutation which is in turn dependent on the condition of brushgear, bearings and commutators. The wide speed range, high armature loading and operating temperatures of modern generators, many of which are designed for high altitude operation with its associated rapid rate of brush wear, combine to make commutating conditions extremely difficult. It is essential therefore that servicing personnel are aware of the problems involved and of the necessity of ensuring that all components are examined carefully to ensure that their condition is satisfactory for a further period of service.

Brushgear

2. Brushes should be able to move freely in their holders without there being any tendency to stick but there should not be excessive clearance between a brush and its holder. Brush spring pressures should be set within the prescribed pressure limits since variations in brush contact resistance lead to wide differences in the currents carried by brushes operating in parallel.

3. Serviceable brushes should be subjected to the minimum amount of handling and should be labelled to facilitate replacement in their original positions whenever it is necessary to remove them from their holders. The minimum length beyond which brushes should not be allowed to remain in use is quoted in the leading particulars of the A.P.4343, Vol. 1 chapters concerned and is also indicated by a horizontal line surmounted by a triangle of aluminium foil on brushes of recent manufacture. New brushes should be fitted at the periods prescribed in the Servicing Schedule and whenever examination reveals that the minimum length may be reached before the next periodic servicing.

4. Details of the procedure for the bedding of brushes are contained in Chapter 2 but reference should also be made to the relevant A.P.4343, Vol. 1 chapter for details of operations which are peculiar to individual types of machines.

Brush-wear

5. In aircraft generators and motors the sliprings and commutators acquire a film of cuprous oxide formed at sea level by the

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oxygen and moisture content of the atmosphere which provides a lubricant for the rubbing contact of the brushes. As the operating altitude is increased the vapour pressure of the atmosphere is reduced until a point is reached when the film wears at a greater rate than that at which it can be produced. The removal of the film leaves two mutually abrasive surfaces in rubbing contact and excessive wear takes place.

6. The method of providing a lubricant

between the rubbing surfaces so as to reduce the rate of wear consists of combining a suitable adjuvant, i.e., a substance which prevents rapid wear, in the material of the brush. Such adjuvants fall into two groups, (a) those which reduce the critical vapour pressure at which rapid wear begins and (b) those which reduce the rate of rapid wear. Barium fluoride falls within the first group whilst copper powder and resins are included in the second. The following table contains particulars of high altitude brushes currently used in Service aircraft.

TABLE 1
High altitude carbon brush grades

Type	Grade	Treatment
Electro-graphitic	HAM	A drying oil basis makes these brushes suitable for operation up to about 30,000 ft.
Electro-graphitic	KC	Inclusion of organic and inorganic adjuvants make the brushes suitable for operation up to 60,000 ft. Barium fluoride is the inorganic adjuvant.
Electro-graphitic	PEG	Molybdenum disulphide cores are extended from the contact surface into the brush making them suitable for operation up to 75,000 ft.
Special	H.100	Molybdenum disulphide is uniformly dispersed in the natural graphite of the brush material. They are suitable for operation up to 55,000 to 60,000 ft.
Copper-graphite	F1B F2B F2C	{ Polytetrafluorethylene (PTFE) is included in the brush material to provide wear resisting properties up to 60,000 ft.

Film forming brushes

7. The KC grades of brushes are film forming and it is important to note that this film should not be disturbed by attempts to clean the commutators or sliprings of generators. Alternative grades of high altitude brushes which are not film forming should never be mixed with the KC grades nor used on a surface on which a film has been formed. Failure to observe this precaution will result in severe sparking and consequent pitting of the brushes. The film should be removed with a piece of rag damped in lead-free gasoline whenever it is

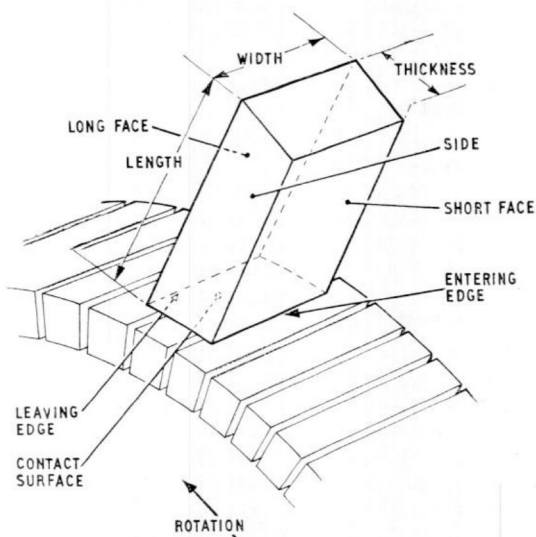
necessary to change from film forming to other grades of brushes.

Cored brushes

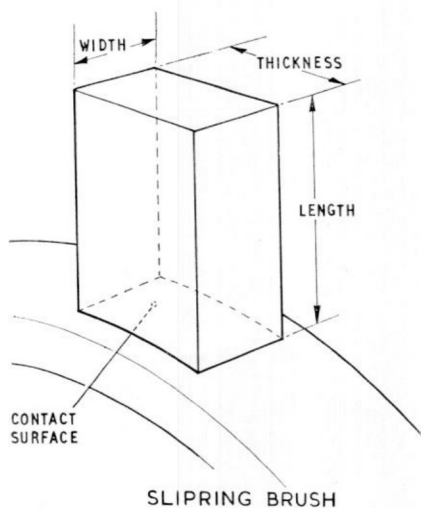
8. The PEG grades of brushes have a higher normal rate of wear than the KC grades but are not subject to catastrophic wear at extreme altitudes. They are not film forming but rely upon the lubrication provided by the molybdenum disulphide cores for their anti-wear properties.

9. Should the brush cores in any machine be found to have disintegrated after a period

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COMMUTATOR BRUSH



SLIPPING BRUSH

Fig. 1. Definitions of carbon brush nomenclature

of operation, the brushes need not be changed provided that $\frac{2}{3}$ of the cores per track are unbroken in 6-pole machines or $\frac{3}{4}$ of the cores are unbroken in 4-pole machines. Individual brushes must however be changed if their cores are disintegrated to a depth greater than $\frac{1}{16}$ in. It is unnecessary to change complete sets of cored brushes if the

stated limits are exceeded; the defective brushes may be changed individually.

Commutation and brush wear

10. The critical conditions under which commutation takes place at high altitudes are aggravated by mechanical and electrical faults which may have little effect at ground level. Internal vibration, shaft whip and commutator eccentricity have an adverse effect on commutation and tend to increase the rate of brush wear, due to sparking, particularly on wide speed range machines with a high current density through the brushes. Increased brush spring pressures associated with high peripheral speeds also tend to increase brush wear.

11. Correct positioning of generator brushes is an essential prerequisite to good commutation. Faulty adjustment or setting of the brushes will cause sparking ranging from bluish white to violent red sparks with occasional streamers dependent upon the degree of maladjustment. The cumulative effects of this sparking are pitting and grooving of the commutator surface and overheating of the brushes.

12. The degree of sparking at a commutator is a good indication of the quality of the commutation but, since sparking which cannot be seen may take place under the brushes, it is not an infallible guide. This is particularly applicable to generators during the bedding of new brushes. The points of contact are carrying current at a relatively high density in the early stages of bedding runs and any interruption of such contacts will cause sparking which may not always appear at brush edges. Until experience is gained with machines on which there is no visible sparking during brush bedding, frequent examinations should be made of the contact surfaces of the brushes and the progressive increase in the machine loading should be related to the bedded area of the brush surface.

13. The adjuvants included in brush materials to resist rapid wear at high altitudes tend to raise the operating temperature of the brushes at low altitudes because of an increased voltage drop at the contact surface. This feature results in such brushes having a higher rate of wear at sea level than would be obtained on brushes produced for other

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than high altitude operations. The grade of brush specified for a particular machine provides a reasonable balance between low and high level operation with the object of obtaining a constant brush performance at all heights. It is important therefore that only brushes approved for use with specified types are fitted to aircraft rotating electrical machines.

14. The rate of brush wear is influenced by various mechanical and electrical factors besides the effect of high altitude operation. These include variations in speed and loads during flight and the effect of disturbing a brush for the purpose of examination during servicing. The aim should be to remove brushes from their holders only when they are to be replaced by new items and to this end the marking of maximum wear positions is being introduced. Due consideration must however be given to the possibility of variations in wear between brushes of the same set when only the accessible items are being examined.

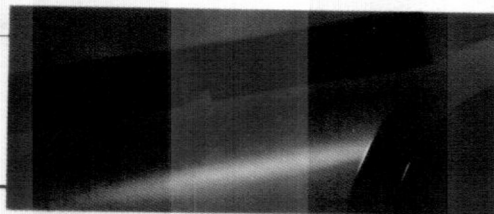
15. The illustration at fig. 2 shows various degrees of sparking categorised from A to D+ together with tangential and circumferential streamers which carry a numerical category. It is intended to publish in the relevant Vol. 1 chapters the normal categories of sparking under full load conditions applicable to the various types of machines in Service use; thus a generator which should have sparkless commutation on full load would be given the category A whilst other types of generator on which a certain amount of sparking was normal under similar conditions would be categorised by the appropriate letter with, where necessary, a + or — symbol. The sparking categories are intended also for use when reporting abnormal sparking conditions, particularly in connection with the compilation of defect reports, which may require the use of the tangential or circumferential streamer categories in addition to the sparking categories. Air Diagram 7555 provides a larger coloured illustration of the same object.

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CATEGORY OF SPARKING



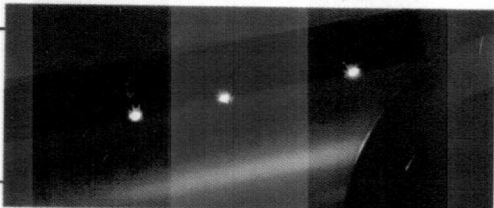
A No sparking



B - Very occasional 'pin-point' sparking at random positions

B

Occasional 'pin-point' sparking at random positions



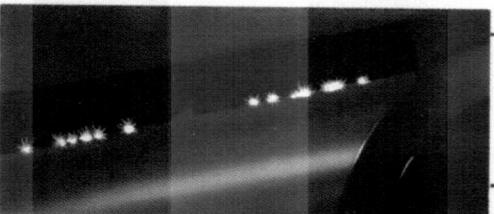
B + Frequent 'pin-point' sparking at random positions

C -

Slight persistent sparking - appearing to persist at the same point along the brush edge

C

Medium persistent sparking - appearing to persist at the same point along the brush edge



C +

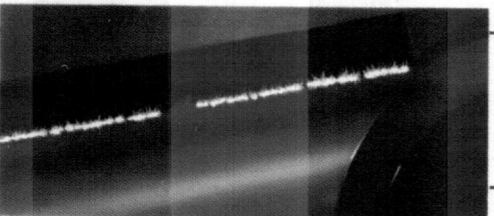
Intense persistent sparking - appearing to persist at the same point along the brush edge

D -

Slight line sparking - sparks distributed uniformly along brush edge to form line

D

Medium line sparking - sparks distributed uniformly along brush edge to form line



D +

Intense line sparking - sparks distributed uniformly along brush edge to form line

GENERAL NOTES

- 1 Sparking may be visible at entering or leaving edges of brushes
- 2 In any category the sparks may be of a bluish-white or yellowish white
- 3 There may be a tendency for the sparks to be

- 4 drawn into arcs by the movement of the commutator
Under category 'D' conditions a roving hot-spot may be visible as a source of intense light superimposed on the line-sparking and moving in either direction between various points

Fig. 2.

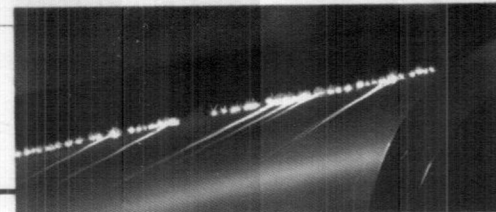
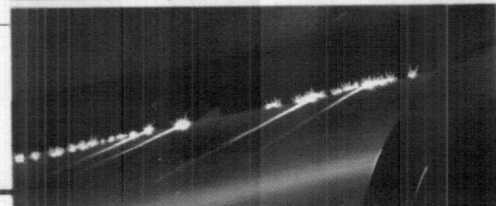
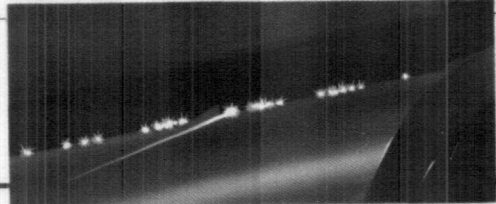
CATEGORY OF STREAMERS

1 Very occasional streamers.
Less than 1 per 3 sec.
per brush

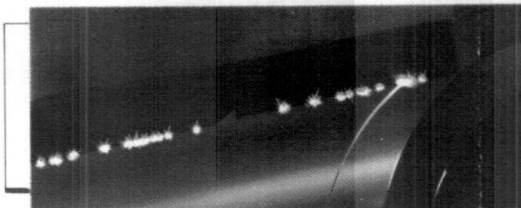
2 Occasional streamers.
Approximately 1 per 2 sec.
per brush

3 Frequent streamers.
More than 1 per sec.
per brush

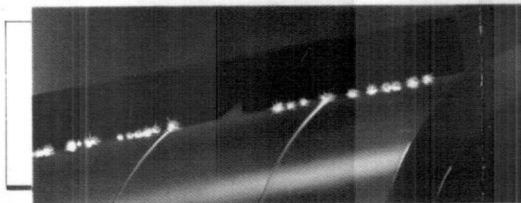
TANGENTIAL



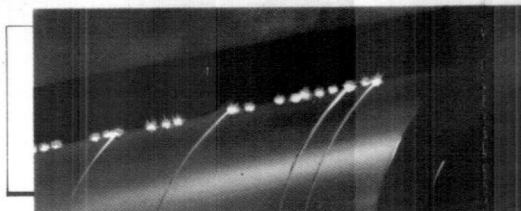
CIRCUMFERENTIAL



1 Very occasional streamers.
Less than 1 per 3 sec.
per brush



2 Occasional streamers.
Approximately 1 per 2 sec.
per brush



3 Frequent streamers.
More than 1 per sec.
per brush

Streamers may be found with any category of sparking

Fig.2.