Chapter 2

ROTARY INVERTERS

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

1. This chapter provides descriptive and servicing information which, in general, is common to all rotary inverters. Information on particular machines will be found in A.P.4343B, Vol. 1, Book 3.

2. The function of a rotary inverter is to convert a d.c. supply at a certain voltage to a.c., generally at a higher voltage. The main application in aircraft is to provide the correct a.c. supplies for various instrument and radar services.

DESCRIPTION

3. There are two main groups of rotary inverter. In one type (*fig.* 1), a d.c. motor is coupled to an a.c. generator, mounted on a common shaft. In the other type (*fig.* 2), the input and output windings are both carried on a common rotor; three-phase output is taken off from the rotor by slip-rings, and single-phase from a common stator assembly.

4. The voltage output of the rotary inverter is normally maintained approximately constant by the associated control panel, which incorporates a carbon pile voltage regulator and a rectifier. This control panel may be an integral part of the machine, as with the inverter shown in fig. 1, or it may be a separate unit suitable for remote mounting as with the inverter in fig. 2.

Commutator

5. Commutators are of composite construction, consisting of copper segments separated from each other and the armature shaft by mica or micanite sections. After assembly

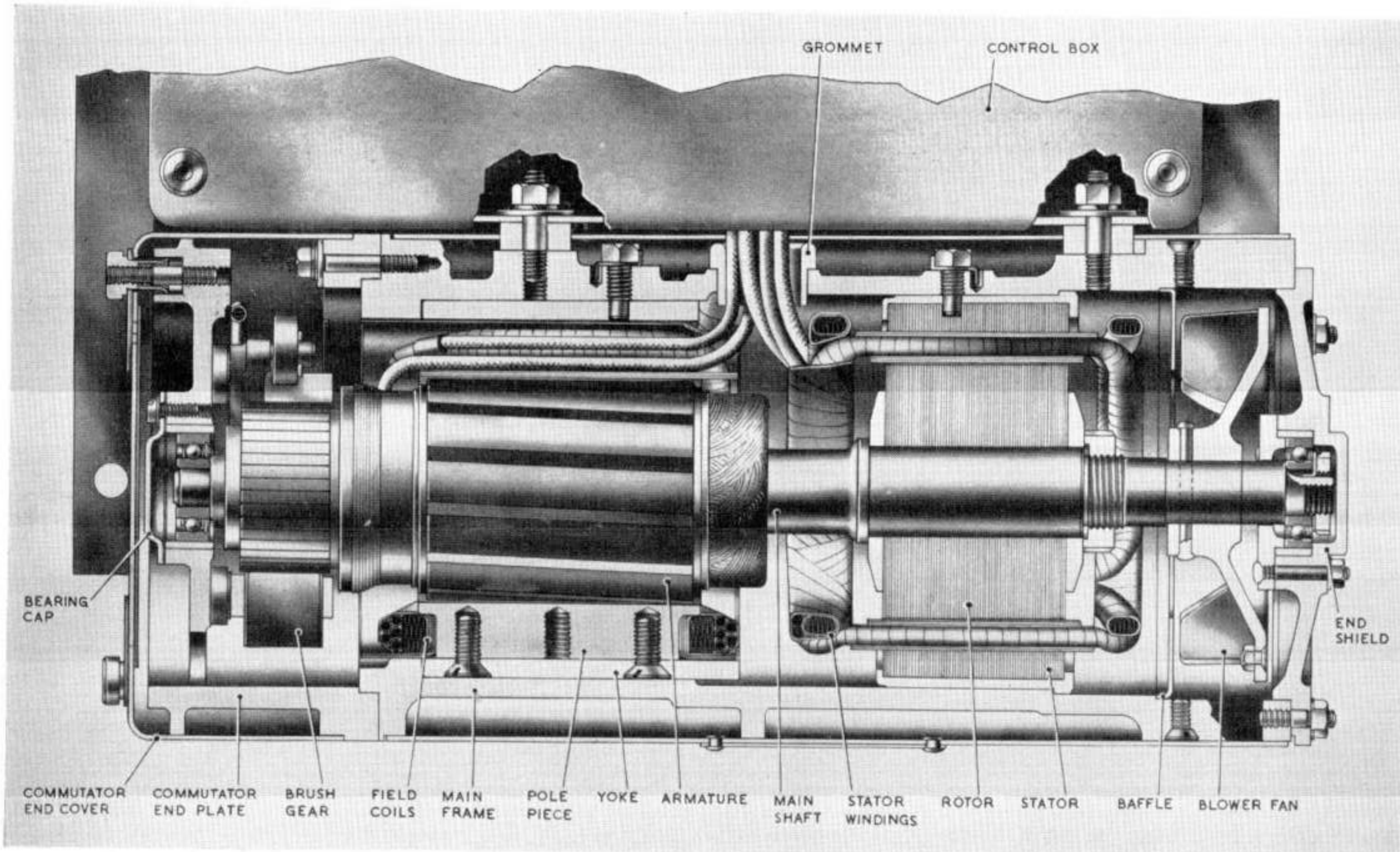

Fig. 1. Rotary inverter with two armature stacks

on the armature shaft and after winding and impregnation, the commutators are turned to the required limits and then run in on light load. At this stage the film begins to form over the brush track which is essential for good commutation. This film ultimately becomes a chocolate brown, glossy track.

Brush gear

6. The d.c. brush gear is normally secured to the commutator end frame, access to the brushes being gained after removal of the end cover. Brush pressure is maintained by coil type springs, and is not adjustable.

7. At the output end, the conductors may be brought out to slip-rings, access to the assembly being gained by removal of the cover band. Brush pressure is maintained by coil springs; the outer ends of the spring bear on small copper strips held in position by, and forming electrical connection to, the brush terminal.

Armature

8. The armature is of orthodox laminated construction, with skewed slots to reduce commutator ripple. In some types of inverter the input and output windings are carried in common slots in the rotor, being held in position by slot wedges and finally bound with steel wires. The ends of the conductors are soldered to the appropriate segments of the commutator risers and are secured by binding cord.

9. The armature shaft runs in bearings mounted in the end plates, and fitted with bearing caps to prevent the ingress of dirt. Cooling of the machine is normally effected by a fan mounted on the armature shaft, circulation of air being assisted by perforations in the covers. If the machine is required to operate at high altitudes, blast cooling may also be employed.

SERVICING

Brush gear

10. Remove the appropriate cover bands and end covers, and check the brushes for correct spring tension. The brushes should be free to move in their boxes, and all traces of carbon dust must be blown out.

11. Check the brushes for wear. Brushes should be renewed before they are excessively worn, only brushes of the correct size and grade being used. When new brushes are fitted, they should be bedded down by wrapping a strip of grade 00 glass paper round the commutator, abrasive side uppermost. The brush is then placed in the brush box, full spring pressure applied, and the armature rocked backwards and forwards a few times to form the brush-face to the commutator radius. The glass paper should then be removed, and the machine run on 50 per cent of full load until the brush is bedded down over its full arc and over at least 80 per cent of its contact area.

Commutator and slip rings

12. Carbon dust should be thoroughly removed from the commutator and slip-rings using an air blast, but no further cleaning nor use of abrasives is permissible. If it is badly scored or burnt, the machine must be returned to a Repair Depot for servicing.

Bearings

13. Bearings are lubricated with grease at the manufacturers, and should not be touched or inspected except when the machine is dismantled at a Repair Depot.

General condition

14. Examine all leads to ensure that they are secure and in good condition. If, for any reason, they have been disconnected, a check should be made to ensure that they have been replaced correctly, and with three-phase machines that the phase sequence is correct. Check the field connections and brush pigtails.

15. Any indications of oil in the inverter should be investigated and the point of ingress located. Oil inside the inverter will impair its performance, and will also carry carbon dust into the windings and lower the insulation resistance.

16. Check the security of terminal posts, screws, and locking nuts.

Location of faults

17. The following table indicates possible faults which may be met with when servicing rotary inverters, and the appropriate remedy. If any servicing other than that described in this chapter is required, the machine must be sent to a Repair Depot which is equipped with the necessary equipment. Instructions for this procedure will be issued in the appropriate chapter of Volume 6 of this publication.

TABLE 1

Fault-finding chart

Defect	Possible cause	Remedy
1. Sparking at the commutator	(1) Brush sticking in holder	(1) Clean with cloth moistened with lead-free gasoline.
	(2) Brush not bedded	(2) Bed according to para. 11.
	(3) Brush edge broken	(3) Bed according to para. 11.
	(4) Worn brushes	(4) Renew and bed according to para. 11.
	(5) Dirt on brushes or commutator	(5) Clean according to para. 12.
	(6) Incorrect brush position	(6) Return to Repair Depot for adjustment.
	(7) Projecting mica	(7) Return to Repair Depot for undercutting and/or skimming.
	(8) Worn commutator	(8) Return to Repair Depot for skimming.
	(9) Formation of flat on commutator	(9) Return to Repair Depot for skimming.
	(10) Commutator out of truth	(10) Return to Repair Depot for skimming.
	(11) Armature current excessive	(11) Return to Repair Depot for testing.
2. High speed	(1) High resistance or break in field circuit	(1) Return to Repair Depot for testing.
3. Overheating	(1) Low insulation resistance	(1) Return to Repair Depot for testing.
	(2) Short-circuit in one or more field or armature coils	(2) Return to Repair Depot for testing.
4. Failure to start	(1) No supply	(1) Check terminal voltage of line and between brushes.
	(2) Brushes not in contact with commutator	(2) Treat as for sticking brushes. Examine brush pressure.
	(3) Short-circuit in field coils	(3) Return to Repair Depot for testing.
	(4) Open-circuit in field or armature	(4) Return to Repair Depot for testing.
5. Low output voltage	(1) Dirty slip-rings	(1) Clean according to para. 12.
	(2) High resistance face on the brushes	(2) Proceed as for bedding brushes (*para.* 11).
6. Excessive mechanical vibration	(1) Broken fan	(1) Renew fan. If vibration persists, return the machine to Repair Depot.

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Appendix 1

ROTAX, TYPE S3100 SERIES

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

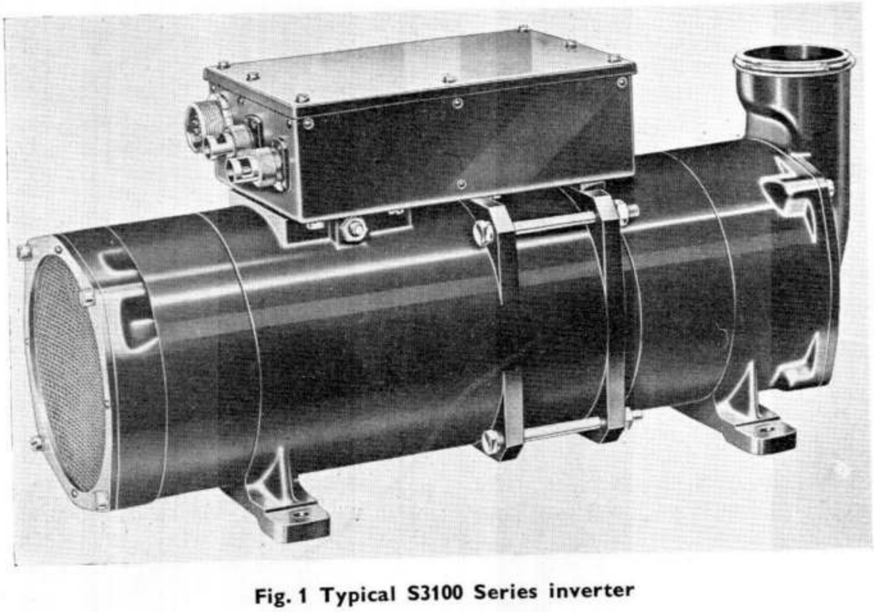

Fig. 1 Typical S3100 Series inverter

Introduction

1. The S3100 Series of inverters has been designed to provide, in conjunction with a control panel or panels, certain aircraft instruments and equipment with an a.c. supply at controlled voltage and frequency. A typical inverter of the series is illustrated in fig. 1. Basically, all the inverters are similar in general appearance and construction, and differ only in the value of the input voltage, type of d.c. field system, associated control panel and cooling arrangement, the latter being the limiting factor in operational altitude. Details of individual inverters will be found in A.P.4343B, Vol. 1, Sect. 16 and 17.

DESCRIPTION

2. Electrically, the inverters consist of a d.c. compound-wound motor driving a 3-phase alternator, the mechanical coupling being achieved by mounting the armature and rotor on a common shaft. Each inverter comprises four main sections, namely, the d.c. housing, yoke, poleshoes and field coils assembly, a.c. housing and suppressor unit.

D.C. housing

3. Contained within the d.c. housing is the d.c. brushgear, roller bearing and fan assembly. The brushgear assembly is secured by four screws passing through slots in the housing. These slots allow for positioning of the brushgear relative to the Geometrical Neutral Position. A clamp plate secures the outer race of the roller bearing, through the centre bore of which the armature and rotor shaft extends to support the fan assembly.

4. Secured to the end of the housing is the air inlet spout or end screen, dependent upon whether a blast or free air inlet is required. Access to the brushgear, for inspection purposes, is provided by a removable window strap assembly.

Yoke, poleshoes and field coil assembly

5. The yoke, poleshoes and field coil assembly is positioned and clamped between the a.c. and d.c. housings by four bolts passing through flanges in the respective housings. Accurate alignment between the sections is ensured by the provision of spigoted faces on the yoke.

A.C. housing

6. Situated in the a.c. housing are the stator assembly, ball bearing, a.c. brushgear, and fan assembly. The stator is secured in the correct position relative to the rotor by a clamp bolt through two holes in the upper part of the housing and locating in a groove machined in the stator frame. The a.c. brushgear is mounted directly to the housing adjacent to the bearing housing and is suitably spigoted to ensure correct alignment and also to clamp the outer race of the bearing. The armature and rotor shaft is extended to carry the two slip-rings and the fan assembly. A screen is secured directly to the end of the housing in order to provide a free air outlet. Access to the a.c. brushgear is facilitated by a second removable strap assembly.

Suppressor unit

7. The suppressor unit is mounted directly to the top of the inverter and is secured in position by four screws. This unit contains the components which comprise the suppression circuit, together with terminal blocks for the internal a.c. and d.c. connections and also for the d.c. input connections. Cables for the latter enter the suppressor box via cable glands. The a.c. output from the inverter is taken via a 3-pole miniature plug (Stores Ref. 10H/19082), and interconnection between the inverter and control panel effected via a 12-pole miniature plug (Stores Ref. 10H/19101). The appropriate mating sockets for the 3-pole and 12-pole plugs (Stores Ref. 10H/19070 and 10H/19087 respectively) are included in the associated aircraft equipment. All components within the suppressor box are screened electrically and protected mechanically by a cover secured to the top of the box by seven screws.

Mounting

8. Mounting of the inverter in the aircraft is achieved by four mounting feet which are cast integrally with the a.c. and d.c. housings, each foot having a hole 0·312 in. in diameter for the mounting belt.

OPERATION

9. The principle of operation is that of a 4-pole motor, driving a 6-pole, 3-phase alternator. Direct current is applied to both the motor section (causing the armature/rotor shaft to rotate in a clockwise direction, viewed from the commutator end) and to the rotor via the slip-rings. The current supplied to the rotor windings causes a magnetic flux around the six laminated poles of the rotor, which, as it rotates, induces an e.m.f. in each of the stator windings in turn, phase sequence relative to the 3-pole plug being A–B–C.

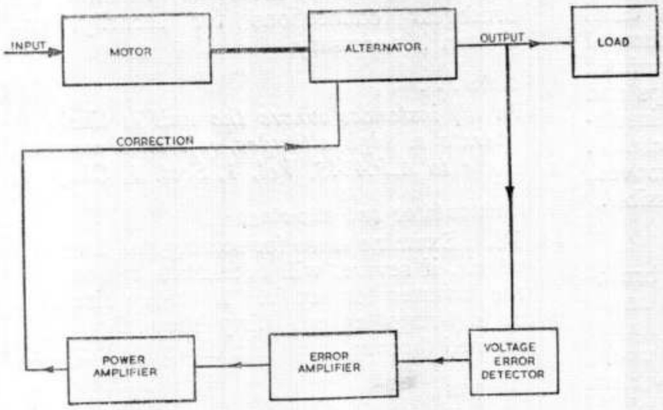

Fig. 2 Voltage correction channel

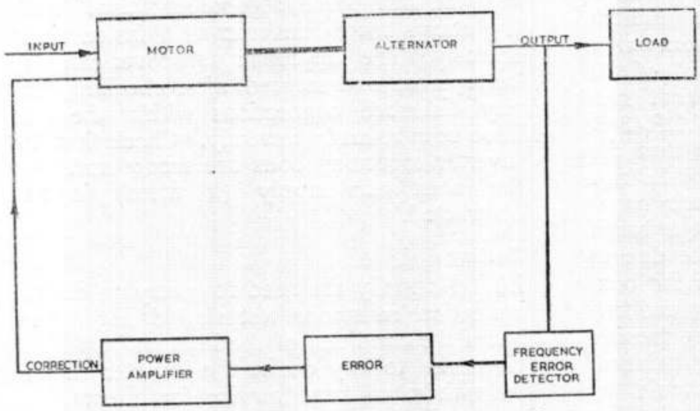

Fig. 3 Frequency correction channel

10. As previously mentioned (*para.* 1), the inverters are normally used in conjunction with a control panel, e.g., Type 15 and Type 19 control panels (*A.P.*4343*B*, *Vol.* 1, *Sect.* 7 *and* 8), which maintain the a.c. output voltage and frequency at 115V ±2 per cent and 400 ±2 per cent cycles per second, respectively, under varying conditions of load and temperature. As the performance of the inverter and its associated panel is closely related, a brief description of a typical installation is given in the following paragraphs.

11. Fig. 2 and 3 are schematic layouts of the voltage and frequency control channels respectively of a typical installation, comprising an inverter and control panel. Referring to these blocks, the output voltage and frequency variations are first determined by the voltage "error" and frequency "error" detectors, causing out-of-balance effects in the respective tuned circuits. When a load is applied to the output, both the voltage and frequency tend to fall. The out-of-balance conditions are suitably amplified magnetically through various stages, and corrective currents are passed to (a) the control winding of the d.c. field, resulting in a speed increase to restore the frequency, and (b) to the rotor via the slip-rings, causing a stronger flux which results in a restoration of the voltage. The out-of-balance effect in the error detectors is also produced when the load of the output is reduced, but in this instance the corrective currents to the motor and slip-rings are such that they tend to cause, respectively, a speed and voltage decrease, which result in corresponding correction of the output voltage and frequency.

INSTALLATION

12. Information on the installation of the inverters will be found in the relevant Aircraft Handbook.

13. The inverters can be mounted in any position to suit the requirements of the particular aircraft installation and then secured by suitable bolts through the four $\frac{5}{16}$ in. diameter holes in the mounting feet.

14. If an air inlet is fitted to the inverter, suitable arrangements must be made for a blast air supply. Where an inverter is fan-cooled only, provision for an adequate circulation of free air through and around the unit should be made. The blast air requirements for these units are given below:—

Air temperature	*Cooling air requirements*
−30 deg. C.	0·95 lb./min.
−10 deg. C.	1·15 lb./min.
+10 deg. C.	1·55 lb./min.
+30 deg. C.	2·10 lb./min.
+50 deg. C.	2·90 lb./min.

15. For interconnection between the inverter and its associated control panel(s), screened cables fitted with plugs and sockets are used. All cable runs, including the input d.c. cable, should be kept as short as possible so that weight and volt drop are reduced to a minimum.

SERVICING

16. Normal servicing of the inverter will not necessitate its removal from its usual position in the aircraft. The minimum of dismantling is required, and this is confined purely to removal of the window straps and the cover of the suppressor unit and insulation of the inverter from its associated control panel or panels. With these covers removed, all items to be examined are easily accessible.

Brushgear

17. Examine both the a.c. and d.c. brushgear, paying particular attention to the brush lengths. The minimum permissible length for the a.c. and d.c. brushes is given under details appertaining to individual inverters and will be found in A.P.4343B, Vol. 1, Sect. 16 and 17. Ensure that the remaining lengths are sufficiently greater than the minimum to give satisfactory operation until the next servicing period. If brush renewal is required, it will necessitate removal of the unit from the aircraft in order that new brushes can be properly bedded (*A.P.*4343, *Vol.* 1, *Sect.* 8, *Chap.* 2). Check that the brushgear is free from carbon deposits and that the brushes slide freely in their boxes without any tendency to stick. If a brush appears to be binding, this may be due to an accumulation of carbon dust in the box, which should be cleaned off with lead-free white spirit or gasoline. The spring tension should be measured with a spring balance, and the tension of each spring should be measured when the trigger is level with the top of the brush box. Correct brush spring measurements will be found in A.P.4343B, Vol. 1, Sect. 16 and 17, under chapters dealing with individual inverters. Examine the brushgear connections for security, and tighten if necessary.

Note . . .

In all instances where the unit is likely to operate at high altitudes, reference must be made to A.P.4343, Vol. 1, Sect. 1, Chap. 1.

Commutator and slip-rings

18. Examine these for scoring and burning, which, if severe, will necessitate removal of the inverter for repair. If the commutator or slip-rings appear dirty they should be cleaned thoroughly as laid down in Chap. 2.

General

19. Examine the window straps, ensuring that they are not damaged in any way and that the linings are in good condition. Refit the straps to the inverter and fasten them securely. The suppressor unit cover can also be replaced and secured, after checking that any disturbed connections within the box have been re-made correctly. Check that the inverter mounting bolts are secure and that the blast air supply (if fitted) is not obstructed.

Testing

20. Normally the need for carrying out an insulation resistance test should not occur, but if the condition of the internal insulation gives rise to any doubt the inverter should be withdrawn from service for a complete overhaul. Under no circumstances must an insulation resistance tester of greater than 250 volts be used when testing capacitors.

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