Chapter 24

GENERATOR, TYPE 170 (E.E. TYPE AE2060, MK. 2)

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LEADING PARTICULARS

Generator, Type 170	**Ref. No. 5UA/**
Voltage	200*V*, *3-phase a.c.*
Speed	8,000 *rev/min*
Frequency	400 *c/s*
Output	30*kVA at* 0·75 *p.f. lagging*
Current	86·6*A*
Pilot exciter frequency	1600 *c/s*
Main exciter frequency	800 *c/s*
Direction of rotation (locking on drive end)	*Clockwise*
Cooling	*Blast air*
Lubrication	*Pressure fed oil from C.S.D. (Oil OX-38)*
Altitude range	*Sea level to* 43,000 *ft.*
Temperature range	−40°*C to* 150°*C*
Approx. weight	83 *lb.*

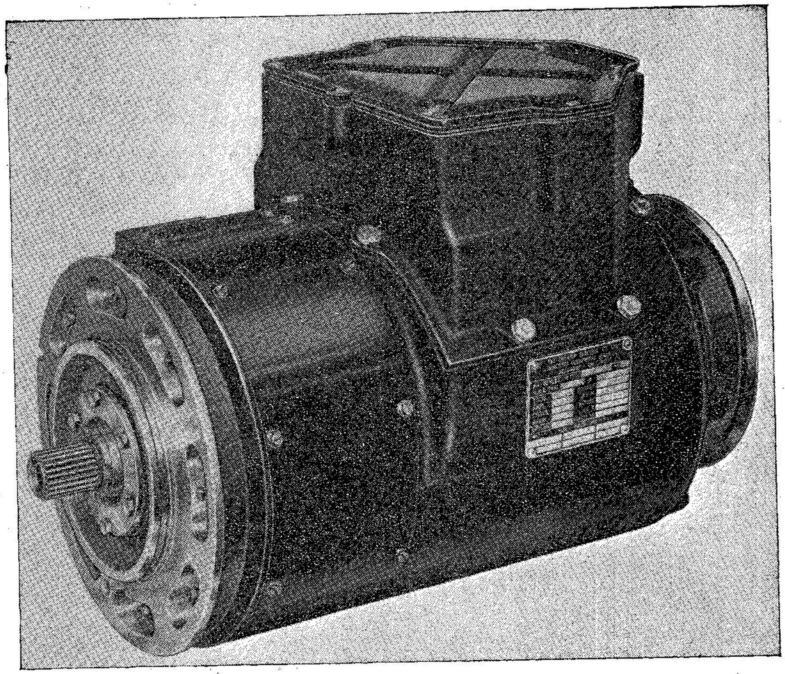

Fig. 1. Generator, Type 170

Introduction

1. The generator, Type 170 is a blast cooled, brushless machine designed to provide a 200V, 3-phase, 400 c/s supply when driven by a constant speed drive unit (c.s.d.) at 8000 rev/min.

DESCRIPTION

2. The generator is a 6 (salient) pole machine having main and pilot exciters mounted on the same shaft as the generator rotor. It consists of two main assemblies: frame and stator assembly, and rotor assembly.

Frame and stator assembly

3. The frame is cast from aluminium alloy and houses three sets of stator assemblies: the main star connected stator winding, the main exciter stator assembly and the pilot exciter stator stator assembly. These are all shrunk into the frame and pinned.

4. The leads from the three stator assemblies and those from a thermo switch attached to the main exciter assembly are brought out to a moulded terminal block mounted externally on the frame. The terminal block also houses three current transformers (E.E. Type AE5734) secured to the three terminal studs. These studs are shorted together by a link connection to form the neutral (star) point of the stator winding. The current transformers form part of a Merz Price protection system provided in the aircraft control circuit. The terminal block is completely enclosed by a cast aluminium terminal box and a sheet aluminium cover.

Rotor assembly

5. The rotor shaft is hollow and in three parts: drive end shaft, tail end shaft and drive quill shaft. The drive end shaft is machined from high tensile steel and one end is provided with a flange for securing to the tail end shaft. The tail end shaft is forged from magnetic iron and is secured by six bolts to the drive end shaft. The drive quill shaft is machined from high tensile steel and has a set of serrations cut at either end. One end fits inside the other two shafts and engages with an internally serrated bush secured inside the tail end shaft; it is secured thereto by a triangular shaped retainer and a single bolt. The other end of the quill shaft protrudes at the free end of the drive end shaft to take up the drive from the c.s.d.

6. The shaft supports three assemblies: the generator field, the main exciter and the pilot exciter. The generator field consists of six coils fitted to six limbs forged integrally with the tail-end shaft; each coil is retained by a steel pole tip. The main exciter is supported by a carrier assembly and is a double layer mush winding with double star connection. Six silicon diodes screwed into the tail end shaft, half wave rectify the main exciter output which is then applied directly to the generator field. The pilot exciter is a 24-pole, permanent magnet, claw type and is keyed to the drive end shaft.

7. The rotor is supported at either end in ball bearings.

Endplates

8. There are two cast aluminium endplates bolted to the frame, each fitted with a flanged phosphor bronze bush for housing the ball bearings.

9. The tail-end endplate is fitted with a fabricated sheet aluminium alloy air inlet cover which has a flange for connecting the external air supply.

10. The drive-end endplate has an integral manacle flange for fixing the generator to the c.s.d.

Arrangement of oil seals

11. The generator has an oil seal fitted at either end. Each is enclosed by an aluminium alloy housing secured to the drive-end and tail-end endplates respectively. The seals are of the "Sealol" type having a carbon ring fixed to one side face. The outer face of the carbon ring is the contact surface forming the oil seal and is in constant contact with an outer mating ring. The two mating faces have a high degree of flatness, each being lapped to within 3 helium light bands of optical flatness.

12. The outer mating ring fits freely over an inner mating ring on the rotor shaft and, so that both rings rotate together, two tabs are provided on the inner ring which engage with two slots on the outer ring.

13. The inner mating ring fits against a shoulder on the shaft; next to it seats the bearing, and the two are secured to the shaft by a locknut and cup washer.

14. Ring seals are fitted to prevent oil leakage between the mating rings, and between the inner mating ring and shaft, and between seal housing and endplate. A ring seal is also fitted between the seal housings and "Sealol" seals because, although the casing of the latter is a tight fit in the housing when cold, the two are of dissimilar metals and therefore at running temperatures their different rates of expansion may cause an oil leakage path between the two items.

15. The mating rings and seal arrangement at the drive end is slightly different from that at the tail end in that the inner mating ring is longer, and the "Sealol" seal fits on the outside diameter of the inner ring instead of on an increased shaft diameter as at the tail end (see fig. 3).

16. An outer bearing cap is fitted to the tail-endplate to completely enclose the bearing and shaft end. A ring seal is fitted between the joint to prevent oil leakage.

Bearing lubrication

17. The bearings are oil lubricated by force feed from the c.s.d. at a pressure of 10 lb/in^2.

18. The generator drive-end endplate flange is provided with an oil inlet hole which mates with a transfer ferrule located in the end face of the frame; a $\frac{3}{16}$ in. outside diameter pipe connected to the ferrule runs through the full length of the frame wall and is connected to another ferrule in the tail-end face of the frame. A hole in the tail-end endplate flange mates with the ferrule, and leads into an oil-way running through one of the endplate ribs; this oil-way leads to a small jet screwed into the bearing bush.

19. Oil from the c.s.d. feeds into the generator endplate and passes along the tube in the frame and through the oil-way in the tail-end endplate. From the jet it spurts directly on to the corner of the outer mating ring nearest the carbon ring of the "Sealol" seal. Owing to the friction between the carbon ring and the outer mating ring considerable heat is generated and there-

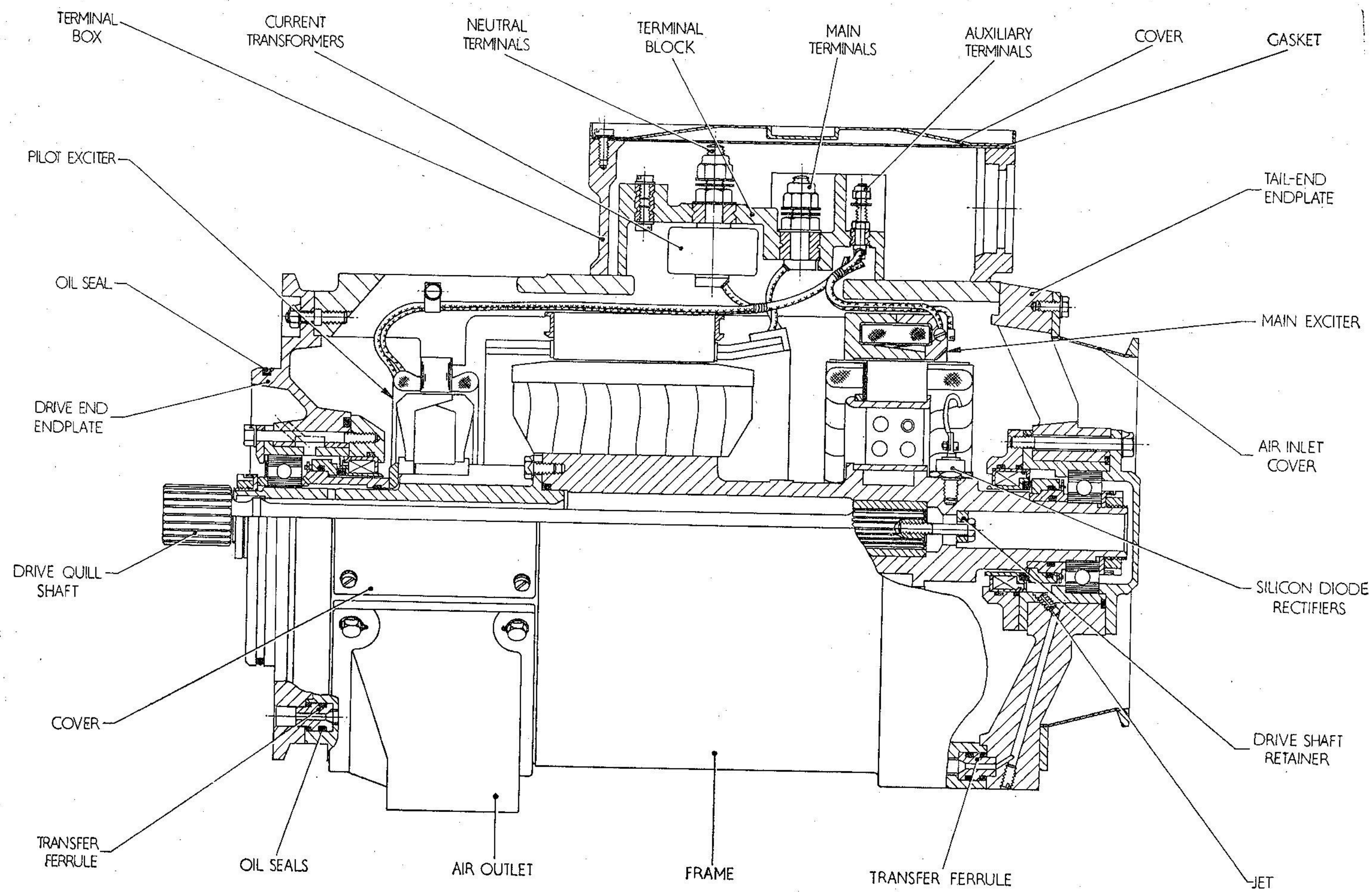

Fig. 2. Section of generator

fore injection of oil here serves to cool the two components.

20. The bearing housing floods with oil and lubricates the tail-end bearing. Two grooves cut in the bearing bush bore provide by-pass pressure relief paths so that a free flow of oil is maintained through the bearing-housing.

21. Oil collects in the outer bearing cap and then flows down the hollow rotor shaft. The triangular shaped drive shaft retainer allows the oil to filter through to the serrated bush; the latter has two flats machined on its outside diameter which provide paths for the oil to pass between the bush and the tail end shaft bore.

22. The oil flows freely along the full length of the rotor shaft to the drive end, where it is prevented from escaping by a shoulder on the drive shaft.

23. Three holes drilled radially in the drive end shaft provide an alternative path leading into a circumferential channel between the drive-end shaft and the inner mating ring. This channel fills with oil which is then forced out of the ring through sixteen radial holes drilled at an angle, and spurts directly on to the drive end bearing. Oil flows through the bearing, out of the retaining plate and back into the c.s.d.

24. Oil also flows round the drive-end outer mating ring and "Sealol" carbon ring, and then escapes through three holes in the bearing bush into a channel in the bore of the drive-end endplate. Three further holes drilled at an angle through the endplate into the channel, allow a further outlet for the oil into the c.s.d. To prevent leakage from the manacle flange joint between generator and c.s.d. a ring seal is fitted on the endplate spigot.

Cooling

25. Cooling of the generator is by blast air fed in axially through the air inlet cover at the tail end. Cool air flows through the endplate and over the stator windings. Warm air collecting at the drive end flows out radially through an air outlet secured to the frame.

OPERATION

26. When the generator is run up to speed the pilot exciter permanent magnet rotor induces 54 volts, 1600 c/s on its stator windings. This output is connected via the control and protection unit (E.E. Type AE7017), to the main exciter stator field. The permanent magnet main exciter stator induces 800 c/s in its rotor windings and the output is half wave rectified by the six shaft mounted silicon diode rectifiers. The rectified output is fed to the generator rotor windings which induce 200 volts, 400 c/s in the stator windings. The output is connected to the loads via control gear and thus the generator provides a supply which is independent of other external electrical supplies.

27. The three current transformers housed in the terminal box sense current in the generator neutral for a Merz Price protection circuit.

INSTALLATION

28. This generator must not be run unless properly connected to its associated constant speed drive, or to a generator test bench which is supplied with proper oil lubrication through the appropriate flange or adapter plate.

29. Make sure when mating the two items to line up the oil transfer ports. Make sure also to fit the ring oil seal (supplied as a separate item) to the generator drive-end endplate spigot.

SERVICING

30. Little servicing can be carried out whilst the machine is installed in the aircraft other than a visual check for mechanical damage and security of nuts and bolts.

31. Remove the terminal box cover and examine for loose connections; ensure that all terminals are free from dirt and corrosion. When refitting the cover ensure that the gasket is serviceable.

32. In addition to the above servicing the following replacements may be effected, if necessary. Note, however, that except for those involving the terminal block, the operations cannot be carried out without first removing the generator from the installation. Note also that the generator must not be dismantled any further than described unless replacement oil seals are available. After removing the generator from the aircraft it is recommended that a vacuum pump be applied to the oil inlet in the drive-end endplate to remove surplus oil.

Renewing terminal block

33. To remove the terminal block it is necessary first to remove the terminal box. Straighten out the tabs on the tabwashers, remove the fixing screws and lift off the terminal box. Note that jointing compound is used between box and frame and therefore light tapping may be necessary to break the seal. Disconnect all the external connections, and unscrew and remove the four cheese head screws securing the terminal block to the frame. Carefully lift off the block noting that the internal connections prevent complete removal.

34. Straighten out the tabs on the tabwashers fitted to the main and neutral terminals and, gripping the squared end of each stud with a suitable spanner, remove the nuts. Remove the nuts securing the auxiliary terminals together with all other nuts and washers, and the neutral link.

35. The terminal block complete with current transformers may now be lifted clear of the terminals by pulling the studs through the holes. Unscrew the six terminal screws and remove the current transformers.

36. Fit the current transformers to the new terminal block and replace the terminal studs in their respective holes. Make sure that each stud is in the same relative position as before.

37. Fit the neutral link; fit new tabwashers to main and neutral terminals ($\frac{1}{2}$ in. U.N.F. and $\frac{5}{16}$ in. U.N.F. respectively) and fit new lockwashers to the auxiliary terminals. Screw on the stud locking nuts, but before tightening down, make sure that the current transformers locate properly on the neutral stud slots, and the square stud heads face as shown in fig. 2. After tightening down bend the tabs on the tabwashers over the nuts.

38. Fit the terminal block to the frame and secure with the four screws and washers.

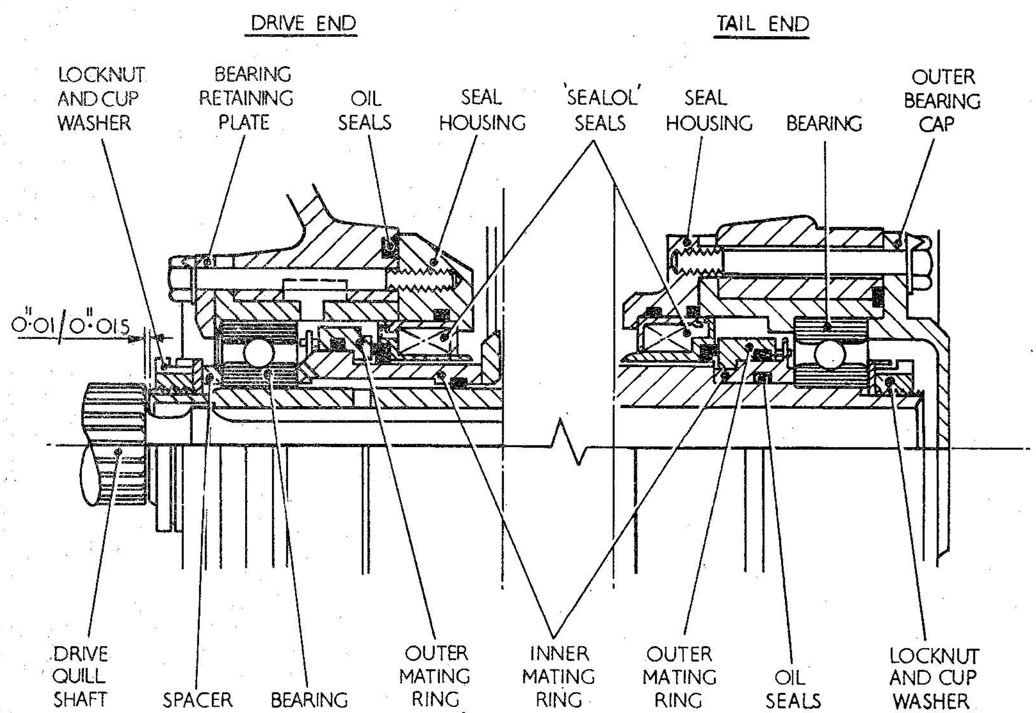

Fig. 3. Details of bearings and oil seals

39. To refit the terminal box first remove all traces of jointing compound from mating faces of box and frame; thoroughly clean these faces using white spirit. Apply a thin uniform film of Hermetite 1250 (DTD900/4134) to both surfaces and leave for 15 minutes; fit the terminal box to the frame and lightly clamp for half an hour, using the four fixing screws. Finally, fit new tabwashers and tighten down the screws; bend the tabs over the screw heads.

40. Reconnect the external leads and tighten securely. Fit the gasket and terminal box cover.

Renewing drive quill shaft

41. At the tail end of the machine straighten out the tabs on the tabwashers on five bolts securing the outer bearing cap. Unscrew and withdraw the bolts and remove the outer bearing cap. Note that sealing compound is used on the joint between endplate and cap.

42. Insert a 2 B.A. box spanner down the tail end shaft to unscrew and remove the drive shaft fixing bolt and retainer. When unscrewing, the bolt will be found stiff to turn owing to the bolt being located in a "Helilock" insert screwed into the end of the drive shaft. The drive shaft may now be completely withdrawn from the drive end.

43. The drive shaft serrations should be examined for damage or wear. In order to alleviate wear the serrations are silver plated and therefore it is unlikely that any wear will be found. However, occasionally the silver plate may become pitted, and in this case the remaining plate should be removed and the serrations replated. Plating should be done in accordance with DTD 919 and thickness of plate should not exceed 0·0002 in.

44. Shafts having damaged serrations may be refitted to the machine provided that the damage is limited to one serration on each set and that the damage does not extend more than a quarter of the length of the serration. Alternatively, if all the serrations are damaged the shaft may be refitted provided that the damage does not extend further than $\frac{1}{8}$ in. from the free end.

45. If any of the aforementioned limits are exceeded a new drive shaft must be fitted.

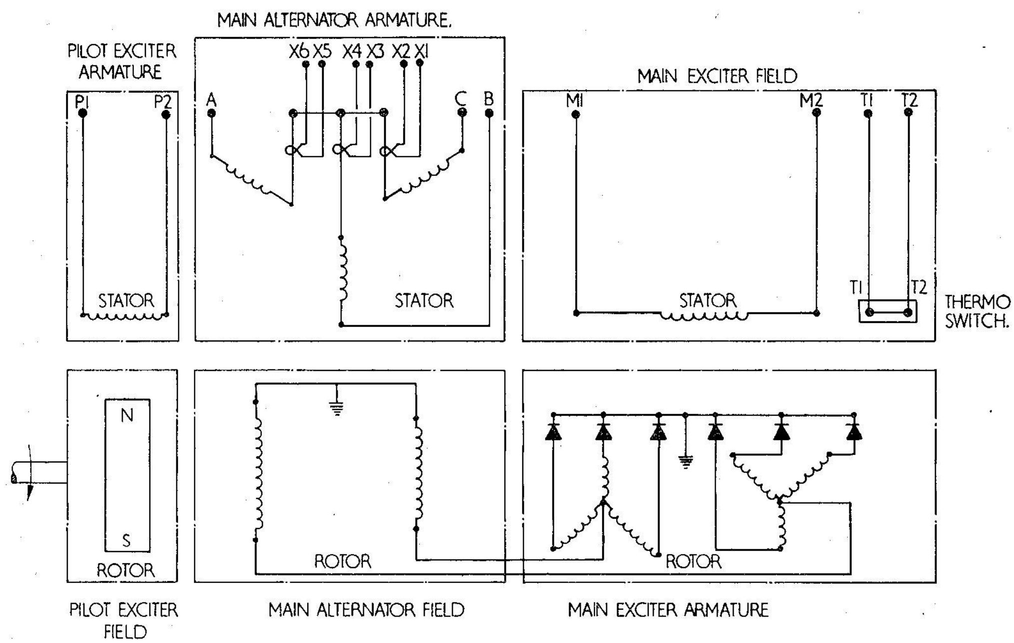

Fig. 4. Wiring diagram

46. Insert the drive shaft into rotor shaft at the drive end (smallest set of splines first) and engage its splines with those in the tail end shaft. Put the retainer on the fixing bolt, insert them into the tail end shaft and screw the bolt into the drive shaft. Again, the bolt will be found stiff to turn. Screw up the bolt so that at the drive end there is 0·01-0·015 in. clearance (to allow this much drive shaft end-float) between the back face of drive shaft splines and the end face of the drive end shaft.

47. When fitting the outer bearing cap ensure first that all traces of old jointing compound are removed from the mating faces of cap and endplate, and clean with lead free gasoline.

48. Apply a thin uniform film of Hermetite 1250 to both surfaces and leave for 15 minutes. Then fit the cap in its original position on the endplate and, with some new tabwashers, insert the five fixing bolts and lightly clamp the cap for half an hour. Afterwards, tighten the bolts to a maximum torque of 35 lb. in. and bend the tabs over.

Testing

49. Details of the tests which should be applied to verify the serviceability of the machine will be found in Appendix A to this Chapter.

Appendix A

STANDARD SERVICEABILITY TEST

for

GENERATOR, TYPE 170

Introduction

1. The following tests should be applied to the machine before it is put into service, or at any time when its serviceability is suspect.

Test equipment

2. The following test equipment is required:

(1) Tester, generator (Ref. No.)

(2) Short-circuit load testing unit (Ref. No. 5G/3055).

(3) Bridge-megger tester, Type B (Ref. No. 5G/1708).

(4) Insulation resistance tester, Type A (Ref. No. 5G/1621).

General

3. The generator must not be run unless properly connected to its associated constant speed drive, or to a generator test bench which is supplied with proper oil lubrication through the appropriate flange or adapter plate. Oil OX-38 must be used and should be applied to the generator flange face inlet at a temperature of approximately 40 degrees C and a pressure of 10 lb/in^2.

Caution . . .

During the following tests, it is essential, before current is allowed to flow in the main stator windings, that the current transformer secondary terminals are connected to an ammeter, or are short-circuited.

Winding resistance test

4. Measure the resistance of the following windings, the values obtained should be within ± 10 per cent of those given at 20 degrees C:—

Main generator stator, terminals
A1-A2—0·054 ohm
B1-B2—0·054 ohm
C1-C2—0·054 ohm

Main exciter field, terminals
M1-M2—2·560 ohms

Pilot exciter stator, terminals
P1-P2—0·40 ohm

Current transformer test

5. Measure the resistance of the secondary windings between terminals X1 and X2, X3 and X4, X5 and X6. The values obtained should be 5 ± 2 ohms at 20 degrees C.

Lubrication system check

6. Run the machine at 8000 rev/min and check that the oil flow rate is not less than 3 pints per hour. During this check and subsequent checks examine for oil leakage inside and outside the machine. No leakage is permitted.

Open circuit characteristic

7. Run the generator at 8000 rev/min and separately excite the main exciter field (terminals M1 and M2) with a 7·5A rated d.c. supply, to give saturation voltage across the main generator terminals (A.B.C.). Reduce the output voltage to residual by gradual reduction of the main exciter field current to zero.

8. Note the generator open circuit voltage and the main exciter field current. Check at 200 volts that the main exciter field current does not exceed 0·6A.

Phase sequence and voltage balance

9. With the generator running in a clockwise direction when viewed from the drive end, check that the phase sequence is A—B—C. Check that the average line voltage is 200 volts r.m.s. $\pm$ 1%, subject to a maximum difference between line voltages of 2 volts.

Short circuit characteristic

10. Short circuit terminals A.B.C.; run the generator at 8000 rev/min, and separately excite the main exciter field. Reduce the generator short circuit current from 100A to zero by gradual reduction of the main exciter field current. Check at a short circuit current of 86·5A that the main exciter field current does not exceed 1·5A.

Pilot exciter characteristic

11. Run the generator at 8000 rev/min and measure the pilot exciter terminal voltage across P1 and P2 and the load current (frequenty is 1600 c/s) for various values of resistance loading from open circuit to short circuit. Check that the open circuit voltage is 54 $\pm$ 4 volts.

Insulation resistance

12. After the machine is completely assembled, check the insulation resistance at 500 volts d.c. of the following:—

Main generator stator between phases (A—B, B—C, C—A)
Main generator, each phase to earth
Main generator, each phase to pilot exciter
Main generator, each phase to main exciter
Main exciter field to earth
Pilot exciter stator to earth
Between pilot exciter and main exciter

The values obtained should be greater than 2 megohms.

13. Check that after 5 seconds electrification at 500 volts d.c. between current transformer and stator terminals X1 and A, X3 and B, X5 and C, the insulation resistance is not less than 5 megohms.

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