Chapter 45

ACTUATORS, TEDDINGTON, TYPE FJC/A SERIES (TWO SPEED)

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Introduction

1. These two-speed rotary actuators are designed for the operation of units employed on high-temperature air installations such as hot-air valves for anti-icing purposes, and cabin temperature, where variation in speed of operation is a desired function.

2. Some actuators in this series will rotate in either direction at a fast or a slow speed, as selected, on operation of the control switch. Others are designed to rotate fast in one direction only and slow in the opposite direction. Details of individual types are given in Appendix 1 to this chapter.

DESCRIPTION

3. This type of actuator is driven through an in-line reduction gear train by a reversible, split series field, 28 volt d.c. motor, via an intermediate shaft, round which are grouped the components of a centrifugal switch assembly, which governs the speed.

4. Snap action switches incorporated in the unit, limit the rotary arc of travel and an electro-magnetic brake integral with the motor, and in series with its field, virtually eliminates over-run of the output shaft when the motor is de-energized.

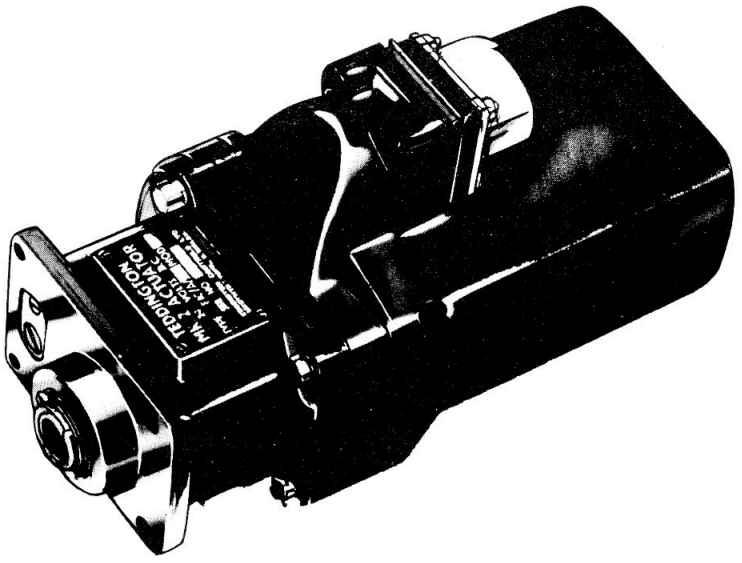

Fig.1. General view of actuator

5. The brake coil is always in circuit with the motor armature and one half of the series field, whenever the control switch is operated.

Electrical connection

6. A plug provides the electrical connection to the motor; the position of the plug relative to the housing is dependent upon the application of the unit when installed in the aircraft.

Plug adapter

7. The plug adapter is a rectangular frame, which has a hollow-shaped pedestal cast integral with it. The plug is fitted over a sealing gasket to this pedestal, and the leads from it pass through the pedestal to emerge from a slot internally machined in the adapter. Bonding is achieved by a split brass sleeve located in a counterbored hole in one pair of the aligned holes in the adapter and gear housing. The plug pins are specially adapted by shortening, to allow the use of rubber "O" rings over them for sealing purposes.

Housings

8. The actuator is completely enclosed in an aluminium alloy housing which is sealed against the ingress of moisture, and designed to withstand a pressure differential of 20 lb/in^2. The housing is built in two sections, the motor and gear housing, between which is interposed an adapter for a plug mounting.

9. The motor casing is rectangular, closed at one end, with a joint face at the open end. The gear housing is rectangular, closed at one end, and drilled to receive four 2 B.A. bolts or studs for installation purposes. Location is achieved by a spigot, machined on the end face. Internally it is machined on three offset diameters. Each section is flanged, and four clearance holes are drilled in the housing flanges and plug adapter. Through these holes pass special B.A. screws which, with nuts and spring washers, clamp together the sections. Rubber sealing rings fitted in recesses at the face of the motor casing and at one face of the plug adapter render the instrument pressure tight to 20 lb. per sq. in.

10. Four captive screws with eccentric heads fitting in recesses to prevent rotation, pass through the gear box top plate from the gear assembly side, and are retained by round nuts which seat in recesses on the outer face of the plate

11. The governor and brush holder housings, containing all other components of the centrifugal switch assembly, fit over these captive screws, and are held in position by the motor and suppressor assembly; these in turn are secured to the threaded ends of the captive screws by four 4 B.A. nuts, plain and spring washers.

Reduction gear train

12. The reduction gear train is carried on two parallel shafts on which the pinion and gear assemblies are disposed alternately.

13. The main shaft is supported between a bush fitted to the internal face of the top plate, and in a machined recess and blind hole in the output shaft. This shaft is carried in a flanged phosphor-bronze bush, which is housed in a mounting spigot at the rear housing closed end, and has an integral spur wheel, which meshes with the stage below pinion. Two "O" rings in annular grooves in the bore of the bush provide a seal between housing and shaft. The bush is secured at its flange to the inside of the gearbox by three csk.hd. screws. An "O" ring is also fitted between the bush and the gear housing.

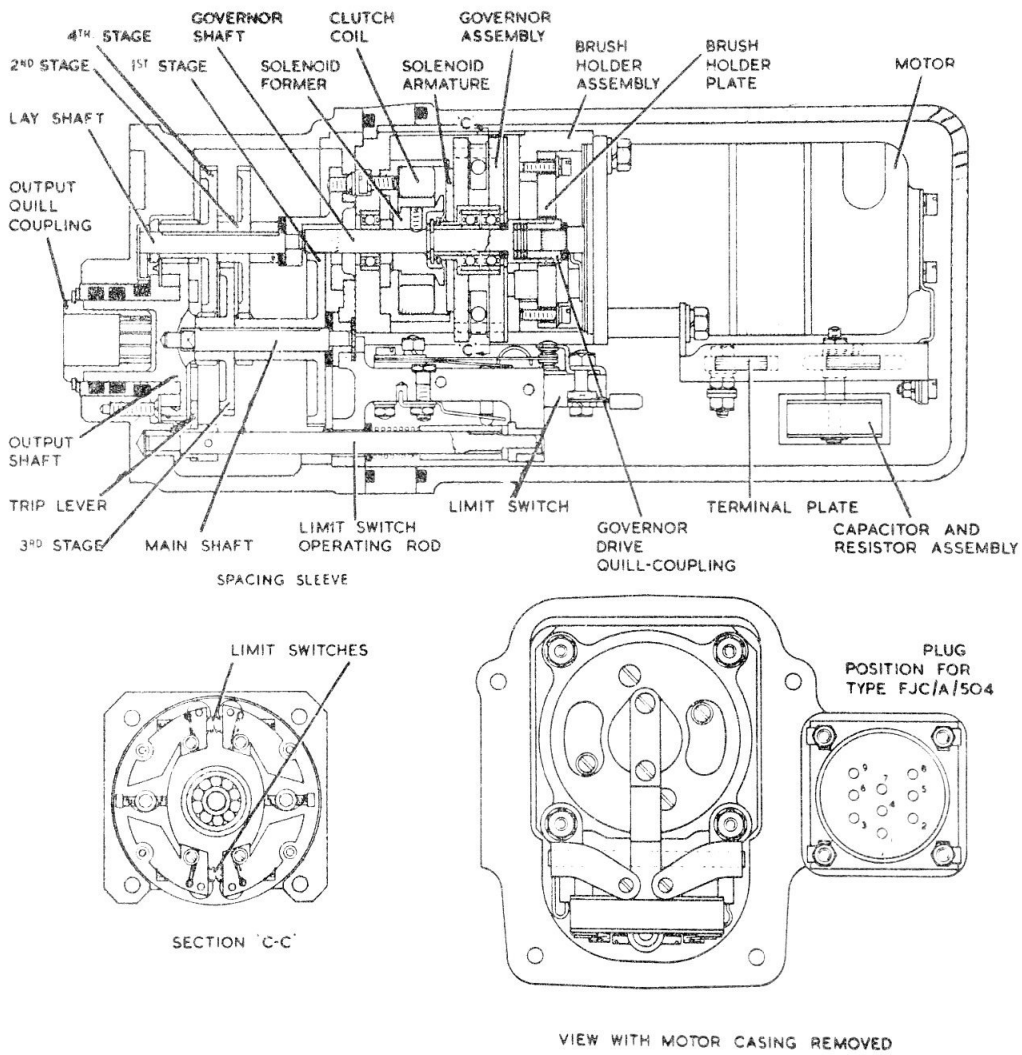

Fig.2. Sectional view of actuator

14. Fitted to the flange of the output shaft bush is a locking pin with a slot machined diametrically across it; this slot fits over and traps a blade located in a recess in the gear housing. The blade also lies across a hole in the flange, and the intermediate or lay shaft passes through this hole, with its slotted end engaging the blade, to prevent rotation. Housed inside the output shaft and located by a dog and slot arrangement is a quill coupling which, with the shaft, is retained at the outer face of the gear housing by a circlip fitted over a spacing washer and located in an annular groove in both components. Shims and a spacing sleeve are fitted to the shafts to limit axial movement of the pinion and gear assemblies.

15. A switch operating rod which passes through a clearance hole in the top plate is supported between a bush fitted in the angled section of an extension arm, cast integrally with the outer face of the plate, and a similar bush fitted in a stepped portion of the internal face of the gear housing at its closed end; at this end the operating rod has pinned to it a fan-shaped trip lever, the arms of which are finished hard chrominium plate. Two pins, riveted to the face of the output gear, bear on these arms at either extreme of travel, to transmit rotary movement to the rod. The other end of the operating rod carries a spline-fitted butterfly shaped plate, the arms of which are saw cut.

Limit switches

16. With their operating plungers lying directly above the grub screws, two snap-action limit switches are fitted to the extension arm and are secured by two 6 B.A. hex.hd. bolts, over spring washers, which also retain cable cleats. Two leaf springs secured to the extension arm by a single 6 B.A. screw, nut and tab-washer, have forked ends which locate, respectively, in grooves machined in the switch plungers, thereby biasing them in an extended position.

17. The two limit switches are so designed that after opening they will instantly close upon releasing the load on the plunger, so that only at the extremes of travel are the contacts open. Consequently, both limit switches are closed over virtually the full arc of travel, allowing control in either direction at any position between the limits.

Centrifugal switch and governor assembly

18. The governor housing is a rectangular, aluminium alloy frame with one closed end, on the outer face of which is a spigot locating in a recess in the gearbox top plate. At the inner face of the top plate, a hole centrally drilled for governor shaft clearance, is counterbored to house a ball race on which the shaft rotates. A circular pot former containing a toroidal clutch coil is located by a spigot which fits in a recess on the inner face of the top plate, the coil pot being secured to the face by three 6 B.A. ch.hd. screws and spring washers, which engage, through the housing with tapped holes in the spigot.

19. The governor shaft is gear-cut at one end and engages, through the gearbox top plate, with the first stage reduction gear. It carries the governor assembly and a former of mild steel coated with copper, which rotates inside the clutch coil to form a solenoid core. This former is secured to the governor shaft by two grub screws, has one end flanged, and the other end machined, to produce a spigot which fits inside the shaft clearance hole in the coil pot, thus forming a bearing for the shaft.

20. The governor assembly is made up of two circular synthetic resin bonded paper plates, friction mounted on the larger diameter of a stainless steel hub machined on two diameters. The hub is mounted to the shaft over two identical ball races, side by side, and located axially by a circlip which fits in an annular groove machined in the shaft. The plates are se-

parated by four spacing bars and clamped together by 8 B.A. csk.hd. screws, which thread into holes drilled and tapped in the bars; these bars also act as limit stops for four governor bob weights fitted between the plates, and secured by rivets through their pivot points.

21. The weights are in pairs, each pair being biased in a contracted position by a spring blade, the tension of which can be adjusted by a ch.hd. screw which passes through a tapped hole in a pillar riveted to one of the plates. Arched leaf springs through which they pass lock the screws. Each weight has a hole drilled and tapped through it to house a tungsten-tipped contact screw so arranged that two closed pairs of contacts are formed when the weights are in the contracted position. Two semi-circular copper segments, separated from each other by a narrow gap, are riveted to the outer surface of the plate, remote from the gearboxes, and each segment is connected to one bob weight in each pair by copper-braided wire, which is held clamped in a slot in each weight by a ch.hd. screw and washer.

22. Between the other plate and the solenoid core is a circular armature, free to move axially, but prevented from radial movement relative to the governor assembly by the heads of the two 8 B.A. ch. hd. screws which thread into the plate after passing through clearance holes in the solenoid armature. The central hole in the armature is a clearance fit over the lesser diameter of the hub, and is held against the governor plate by a circular dished spring which is retained by a circlip located in an annular groove machined in the hub.

23. The motor end of the governor shaft is turned on a larger diameter, and is bored to take a quill which drives through a dog and slot arrangement.

24. At the open end of the governor housing, and of similar outline to it, is fitted a brush holder assembly located by means of a spigot. The brush holder is recessed on its outer side, and its centre is cut away. A circular synthetic resin bonded paper plate fits inside the recess and is secured by four 8 B.A. ch.hd. screws, over spring and plain washers, threaded into tapped holes in the brush holder. The plate carries two hollow tube brush housings with drilled and tapped flanges through which pass 6 B.A. ch.hd. screws over plain washers for securing purposes. The pigtails of the round carbon brushes are soldered to terminal tags with spiral springs for tensioning. The brushes and springs fit inside the hollow housings, and the terminal tags are secured over the shanks of the housing retaining screws by nuts and spring washers. The brushes bear on the segments riveted to the governor plate.

Capacitor and resistor assembly

25. This assembly is supported on two angled aluminium alloy strips which are attached at the angled ends to an aluminium alloy strut by two 8 B.A. ch.hd. screws, nuts, spring washers and plain washers. The strut is secured to the end plate of the motor by utilising one of the motor ball race cover plate screws. The other ends of the strips have spacing tubes riveted to them, and through these pass two of the long screws which extend from the gearbox. Two 4 B.A. nuts, plain and spring washers, retain the strips on the screws.

26. The capacitor is totally encased in Araldite casting resin "B" from which protrudes two 6 B.A. bolts for connection and mounting purposes. Over these fits a Mycalex rectangular plate on which is wound the required length of Eureka wire terminating in tags which also fit over the bolts. Two 6 B.A. nuts and spring washers secure the whole together. The Mycalex plate has rectangular spigots

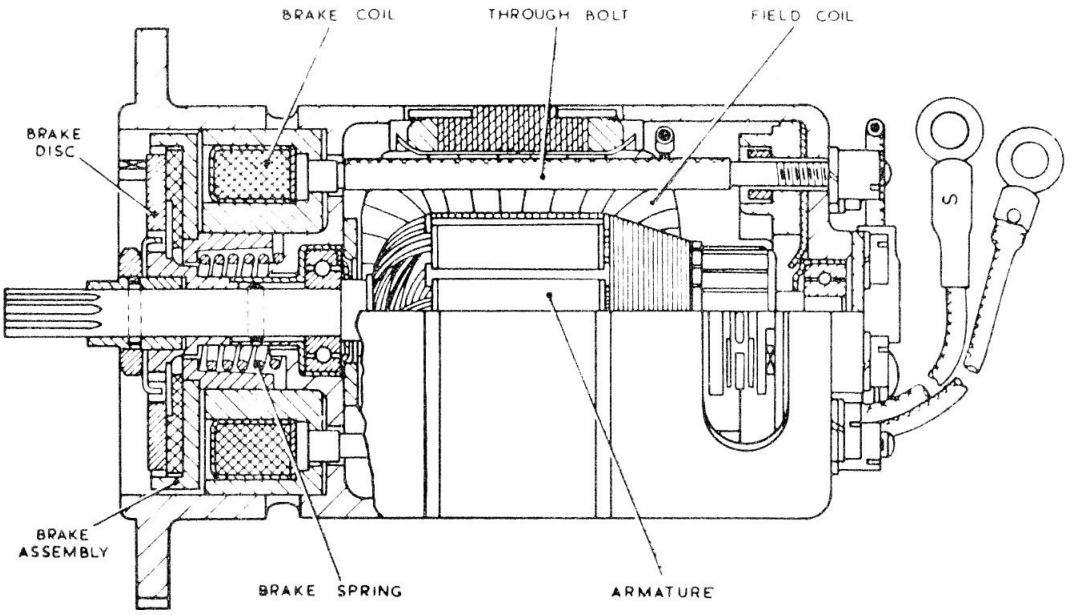

Fig.3. Sectional view of motor

projecting at each end, and these fit into slots in the mounting strips *(para. 21)*, thus holding the capacitor and resistor in position.

27. Adjacent to this assembly is a plate, similarly mounted between the strips, and this carries a 6 B.A. screw, nut, plain and spring washers for connection purposes.

Motor

28. The motor is designed for operation from a 28-volt d.c. supply, and has split series field windings for reversible operation. The drive end incorporates an electro-magnetic brake mechanism, the coil of which is in series with the armature. Braking action is thus automatically applied to the armature when the motor is de-energized.

29. The motor comprises four main units, the brake housing with mounting flange integral and brake components, the yoke which carries the field system, the brushgear housing and brush gear, and the armature assembly. The armature is supported by ball bearings located in the brushgear and brake housings. The drive-end bearing is located within the web of the brake housing and held in position by a retaining plate. A 0·005 in. shim. is interposed between the outer race and the housing and end-play is taken up by shims between the gearing and its retaining plate. The commutator-end bearing is located in the web of the brush gear housing.

Yoke

30. The pole-pieces are integral with the yoke, the whole being built up from suitable stampings, and the two through bolts which are integral with the brake coil assembly pass within the yoke assembly and between the field coils; these coils encircle the pole-pieces and are held against the interior of the yoke by wedges passing through the pole-pieces.

Brushgear

31. The brushgear housing locates on the yoke assembly in like manner to the brake housings; the former housing encloses the brushgear carrier. The two brush holders are secured to a moulded annulus. An insulating washer lies be-

tween the carrier and the housing web; the carrier is secured to the web by two screws which thread into nut-plates. These plates are restrained within projections on the moulding so that the annulus may be rotated through an arc, in order to obtain the required commutating position. A second hole in the nut-plates, and two corresponding holes in the housing, permit the two long studs of the brake coil assembly to protrude beyond the housing. Nuts threaded on to these secure the two housings and yoke together.

32. The carbon brushes are a loose fit in machined brass holders, and held under a pressure of 3½ to 4½ oz. by means of clock type springs and levers. Bushes on the brush carrier protrude through slots in the housing and carry terminal screws.

Armature

33. The commutator is of moulded construction. The shaft journals are ground to close limits, and the bearings are selectively assembled to obtain the necessary fit. The drive pinion is integral with the armature shaft.

Electro-magnetic brake assembly

34. The brake disc is secured against its driving pin on the armature shaft by a special nut; this nut threads on to a short collar which is a sliding fit on the shaft, but which is prevented from moving on it by a pin passing through both shaft and collar. The brake disc is counterbored to accept a portion of the collar, and is provided with holes for the outer tabs of the locking washer, held beneath the nut.

35. Behind the brake disc is a floating annulus called the attraction plate; this plate carries the friction lining, and is restrained against the rotation by two projecting lugs at its periphery, which pass into corresponding slots in the brake housing. The inner diameter of the attraction plate is such that it clears the armature shaft, and it is located axially between the brake disc attached to the armature shaft and the brake coil assembly, enclosed within the brake housing.

36. A coil spring, embracing the armature shaft and co-axial with it, butts against the bearing housing at one end, and the attraction plate at the other, thus forcing the latter into contact with the brake disc. The brake is housed in an annulus of "U" section, and is held by two long diametrically opposed studs against the web of the brake housing. "U" shaped brake adjustment shims are interposed between brake coil housing and web, in order to obtain the required brake clearance. Upon energizing the motor, the annulus is attracted to the brake coil housing, and clear of the brake disc, against the action of the brake coil spring. The armature is then free to rotate. On de-energizing the motor the loaded brake coil spring forces the annulus against the brake disc, and the machine stops with a minimum of over-run.

OPERATION

37. These actuators are designed to operate at two speeds; some at two speeds in either direction and others at two speeds in one direction only. Actual speeds of operation are determined by the choice of gear ratios and the governor setting, when functioning under slow conditions. The change in speed is achieved by a relay, which is external to the actuator for models rotating fast or slow in either direction. Actuators having fast rotation in one direction only are controlled by a manual switch only. Reference to the circuit diagrams in Appendix 1 to this chapter will assist in the appreciation of the operation.

Fast speed regulation

38. When the actuator is selected for fast running, the electrical circuit con-

sists of the motor armature and appropriate field winding, the electro-magnetic brake which when energized releases the friction pad, and the relevant limit switch. Under these conditions the motor drives the gear train through the governor shaft; the governor is not in the electrical circuit, or rotating, at this selected speed. When the limit of operation is reached, one pin on the output gear bears on, and depresses, one side of the fan-shaped lever pinned to the switch-operating rod, which is thus rotated. As a result, one of the screws in the trip lever plate at its other end depresses the plunger of the appropriate limit switch to open the electrical circuit and stop the actuator, over-run being virtually eliminated by the friction brake.

Slow speed regulation

39. When the actuator is selected for slow running, the motor drives the reduction gear train through the governor shaft, clutch coil and the governor contacts; the contacts being shunted by a capacitor and resistance for suppression purposes. The clutch coil, being now energized, pulls the armature attached to the governor assembly, until it bears against the flange of the solenoid former, which is grub-screw located on the governor shaft, causing the armature to rotate, and with it the governor assembly.

40. When the desired speed of operation is attained, the governor bob weights, under the influence of centrifugal force, overcome the bow spring load, and open the tungsten contacts integral with them, thus bringing into the electrical circuit the shunt resistance which causes the motor to reduce speed. With the resultant drop in speed the weights draw in again to close the contacts and re-energize the motor. By continuous functioning in this manner, the required speed regulation is obtained.

INSTALLATION

41. The actuator is mounted on four 2 B.A. studs which pass through clearance holes drilled in the gear housing mounting flange and is located by a spigot machined on the mounting face. Before mounting to the valve to be controlled it is most important to check that the arc of rotation of the actuator is identical in sense and direction to that of the unit to which it is to be coupled.

SERVICING

42. These actuators should be serviced in accordance with the general chapter in A.P.4343, Vol.1, Sect.17, Chap.1 and the instructions contained in the relevant Servicing Schedule. Dismantling instructions for these actuators will be found in A.P.4343D, Vol.6, Book.5, Sect.16, Chap.45.

43. Information on the removal of the actuator from the aircraft and its subsequent servicing, will be found in the appropriate aircraft handbook.

Bonding test

44. Measure the resistance between the body of the electrical plug and the actuator body with a Bonding tester, Type B (Ref. No. 5G/2126). The resistance must not exceed 0·025 ohm.

Note . . .

If the actuator is used in conjunction with a relay, it is emphasized that relay Type S3 is not suitable. Relay Type Q3 must be used.

Appendix 1

LEADING PARTICULARS

Table 1

Actuator Type FJC/A	Operating time (sec.) Fast	Slow	Applied Torque (lb. in.) Fast	Slow	Max current consumption (amperes) Fast	Slow	Minimum operating voltage	Rotary arc of travel (degrees) Fast	Slow
501	4±1 open and close	100±10 open and close	6	120	2·5	3·5	25	180±2	+0 180–6
503	5±1·5 close only	120±12 open only	6	120	2·5	3·0	21	180±2	180±2
504	5±1.5 open and close	120±12 open and close	6	120	2·5	3·0	21	+6 180–0	180±2
505	3 (max) open and close	88±8 open and close	6	60	2·5	3·0	25	+0 180–2	+0 180–8
514	3 (max) close only	45±15 open only	6	60	2·3	3·0	21	90±2	90±2
518	3 (max) open and close	90±10 open and close	6	60	2·0	3·0	20	+4 180–0	+0 180–4
529	5±1 close only	113+10 open only	60	60	2·3	3·0	21	90±2	90±2

Table 2
(Quick reference table)

Type FJC/A/	Ref. No.	Ambient Temp. Range	Type of Motor	Remarks
501	5W/1034	-55°C to 150°C	4CZ 93327 (5W/2823)	Circuit B
503	5W/2399	-55°C to 150°C	4CZ 93327 (5W/2823)	Circuit A
504	5W/1035	-55°C to 150°C	4CZ 93327 (5W/2823)	Circuit B
505	5W/980	-55°C to 150°C	4CZ 93327 (5W/2823)	Circuit B
514	5W/2633	-55°C to 150°C	4CZ 93327 (5W/2823)	Circuit A
518	5W/2830	-55°C to 150°C	4CZ 93327 (5W/2823)	Circuit B
529	5W/6014	-30°C to 120°C	4CZ 93327 (5W/2823)	Circuit A but with two flying leads connected across clutch coil and governor.

Table 3
(Motor details)

Type of motor	4CZ 93327
Type of brush	5W/1041
New brush length (in)	0.385
Minimum brush length (in)	0.25
Brush spring pressure (oz) (gm)	3.5 - 4.5 100 - 125
Commutator	
New Diameter (in)	0.49
Min. dia for re-use after skim	0.45
Mica width (in)	0.024 - 0.026
Mica undercut (in)	0.020 - 0.025

Table 3 *(continued)*

Type of Bearings (Drive end)	HOFFMAN 4666
Type of bearings (Commutator end)	HOFFMAN N 463
Bearing grease.	D.T.D. 900 - 4342
Rating (minutes)	1½
Brake coil resistance (ohms)	0·908 - 1·0
Field coil resistance (ohms)	1·85 - 2·06
Armature across diametrically opposed segments (ohms)	0·85 - 0·95

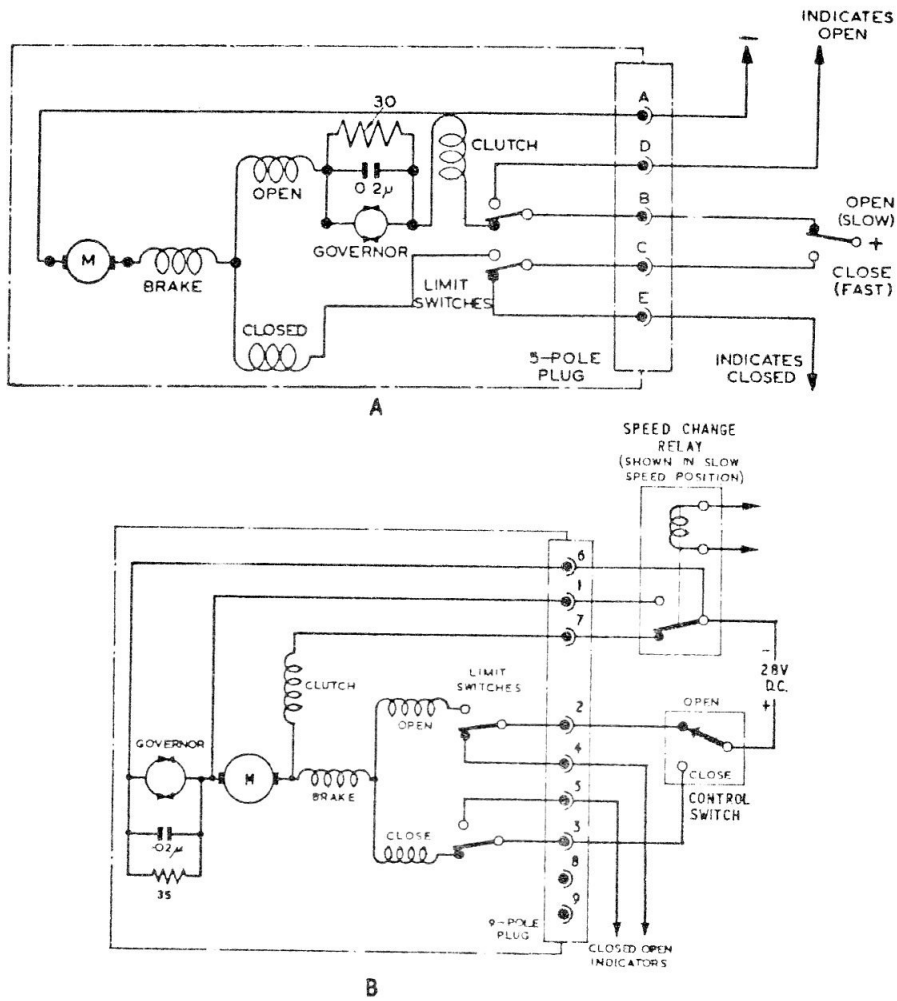

Fig. 1. Circuit diagrams

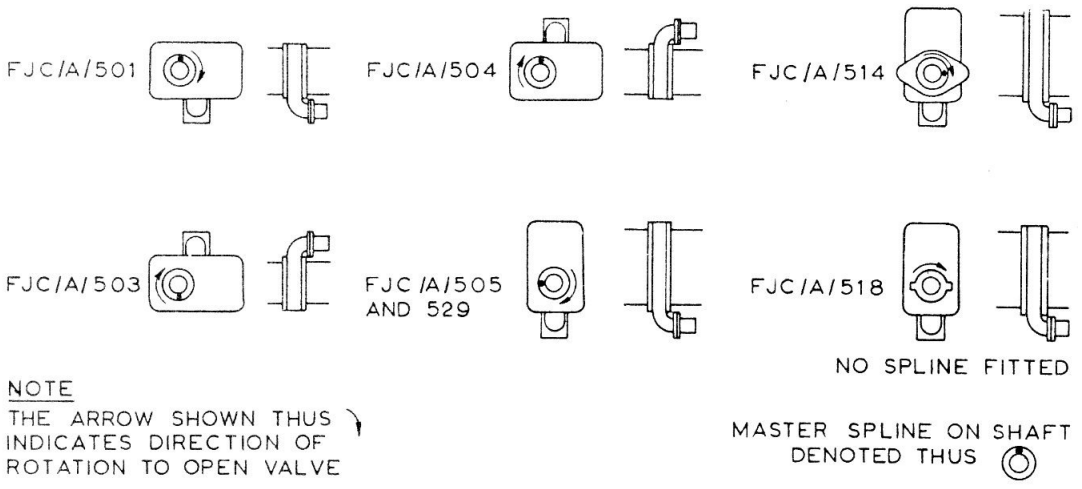

Fig. 2. Diagram showing relative position of plug and master spline

Appendix A (NAVAL)

STANDARD SERVICEABILITY TEST
for
ACTUATORS, TEDDINGTON FJC/A SERIES
(TWO SPEED)

Introduction

1. The tests detailed in this appendix are to be applied to an actuator before its installation in an aircraft, at any time when the serviceability of the actuator is in doubt, and at the appropriate re-examination periods at Second Line.

Test equipment

2. The following items of test equipment are required.

(1) Power Supply Unit 5G/3637 or 6130-99-101-8342.

(2) Insulation Resistance Tester, Type C (Ref. No. 5G/152).

(3) Avometer, Model 8 (Ref. No. 6625-99-943-1524).

(4) Either single pole changeover switch and suitable relay or two single pole changeover switches (as available,

(5) Stop Watch 6B/910-1001.

(6) Tension Gauge 1H/59.

Test conditions

3. All Tests are to be applied at normal room temperature.

Procedure

4. (1) Connect the actuator to the variable supply, set to 28V connected as in Fig. 1 of Appendix 1 to the main chapter for the appropriate type of actuator.

Note. . .

The speed change relay in circuit B may be simulated by a single pole changeover switch.

(2) Run the actuator over its full range of travel in both directions, at both speeds (as applicable) and check that the rotary arc of travel in degrees in both directions is as laid down in Table 1 of Appendix 1 to the main chapter.

(3) Using the Avometer set to the OHMS scale, check the operation of the indicator micro switches by running the actuator to its limits in both directions.

(4) Check brush length and brush spring pressure, with reference to Table 3 of Appendix 1 to the main chapter.

Minimum operating voltage

5. Reduce the d.c. supply to the value laid down in Table 1 of Appendix 1 to the

main chapter, and observe that the actuator operates smoothly in both directions at both speeds.

Insulation resistance

6. The insulation resistance between each pin of the electrical plug and the actuator body shall be not less than 500, 000 ohms at 250V d.c. The test voltage shall be applied for at least 15 seconds.

Appendix A (R.A.F.)

STANDARD SERVICEABILITY TESTS
for
ACTUATORS, TEDDINGTON, FJC/A/SERIES
(Two Speed)

Introduction

1. The tests detailed in this Appendix are to be applied to an actuator before its installation in an aircraft, at any time when the serviceability of the actuator is in doubt and at the appropriate re-examination periods at Equipment Depots.

Test equipment

2. The following test equipment is required:-

(1) Rotary actuator test rig (Ref. No. 4G/6591).

(2) Insulation resistance tester, Type C (Ref. No. 5G/152).

Test conditions

3. All tests are to be applied at normal room temperature.

Procedure

4. (1) Mount the actuator to the rotary test rig as detailed in A.P.4343S, Vol.1, Book.2, Sect.8, Chap.7.

(2) Set the actuator supply to 28 V and run the actuator to the conditions detailed in Table 2, App.1 of the chapter.

Minimum operating voltage

5. Set the actuator supply to the minimum operating voltage specified in App.1, Table 1 and the applied torque to the value specified in App.1, Table 1. Under these conditions the actuator must operate over its range at fast and slow speeds but not necessarily to the times laid down.

Insulation resistance

6. The resistance between the pins of the electrical plug and the actuator body must not be less than 0·05 megohm at 250V d.c. The test voltage must be applied for at least 15 seconds.