Chapter 75

ACTUATOR, ENGLISH ELECTRIC, TYPE AE 4513, Mk. 2

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LIST OF ILLUSTRATIONS

LEADING PARTICULARS

Actuator, Type AE 4513, Mk. 2	**Ref. No. 5W/2588**
Rated voltage	28*V d.c.*
Speed of motor	14,000 *rev/min*
Output of motor	3·7 *watts*
Maximum working load	75 *lb. in.*
Normal working load	50 *lb· in.*
Angular travel	0° —90° —180° —Continuous
Time to travel 180° *(under normal load at* 28*V d.c.)*	5 *sec*
Temperature range of operation	—65° *C* to +150° *C*
Outline dimensions	$5\frac{1}{2}$ *in* × $3\frac{13}{16}$ *in* × $2\frac{11}{16}$ *in*
Minimum brush length	0·225 *in*
Brush spring pressure	4–5 *oz*
Brush grade	*C.M.*6 (*H.A.M.*)
Weight	2 *lb* 6 *oz*

Introduction

1. The universal rotary actuator, Type AE 4513 Mk. 2, has been designed to give rotary movement to equipment such as fuel cocks, hot air valves etc. It is capable of handling a maximum working torque of 75 lb. in.

2. An important feature of this actuator is the ease with which the alteration of angular travel from the standard settings can be achieved. A cam position change (*para.* 40) enables the angular stroke to be altered in increments of 5 deg.

DESCRIPTION

3. The actuator consists of a d.c. motor and gearbox. The motor is fitted with an electro-magnetic brake to prevent excessive overrun after the limit switches have cut off the supply to the motor (*para.* 30).

4. The drive from the motor to the output shaft is provided by an arrangement of spur wheel and pinion gears.

5. The output drive of the actuator depends upon the equipment it is required to drive. Each actuator is provided with two adaptors : —

(1) a plain one, in which case the drive pin is the operating mechanism

(2) a serrated one, in which the serrations are the driving mechanism.

Housing and covers

6. The actuator housings consist of four main sections enclosing a motor, gearbox and micro-switches (limit switches); these being the motor cover, gear and switchcase, driving end cover and driving end endplate respectively.

7. The motor cover is a light alloy die-casting, and houses the motor, and the Breeze plug assembly. An 'O' ring seal is fitted in a machined recess in the cover to seal the space between cover and Breeze plug.

8. The gear and switch case is also a light alloy die casting incorporating an observation window with a cursor line engraved along its lateral axis. The nameplate is bonded to this casting, giving all the data concerning this actuator.

9. Six helicoil inserts are positioned within the gearcase to accept the 6 B.A. cheese head screws securing the motor cover.

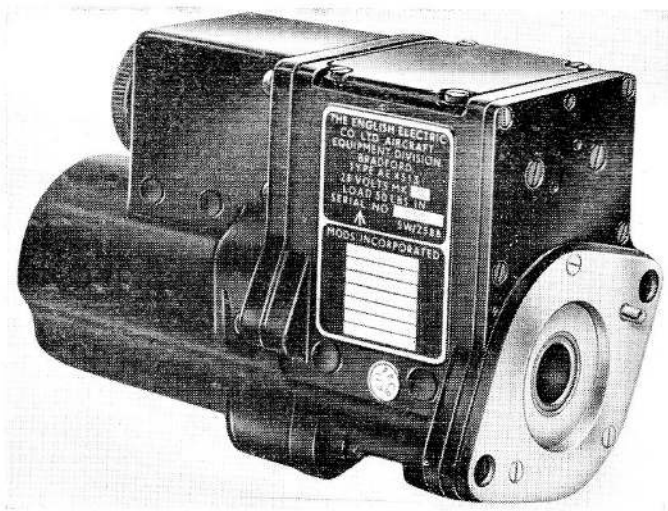


Fig. 1. General view of actuator, Type AE4513, Mk. 2.

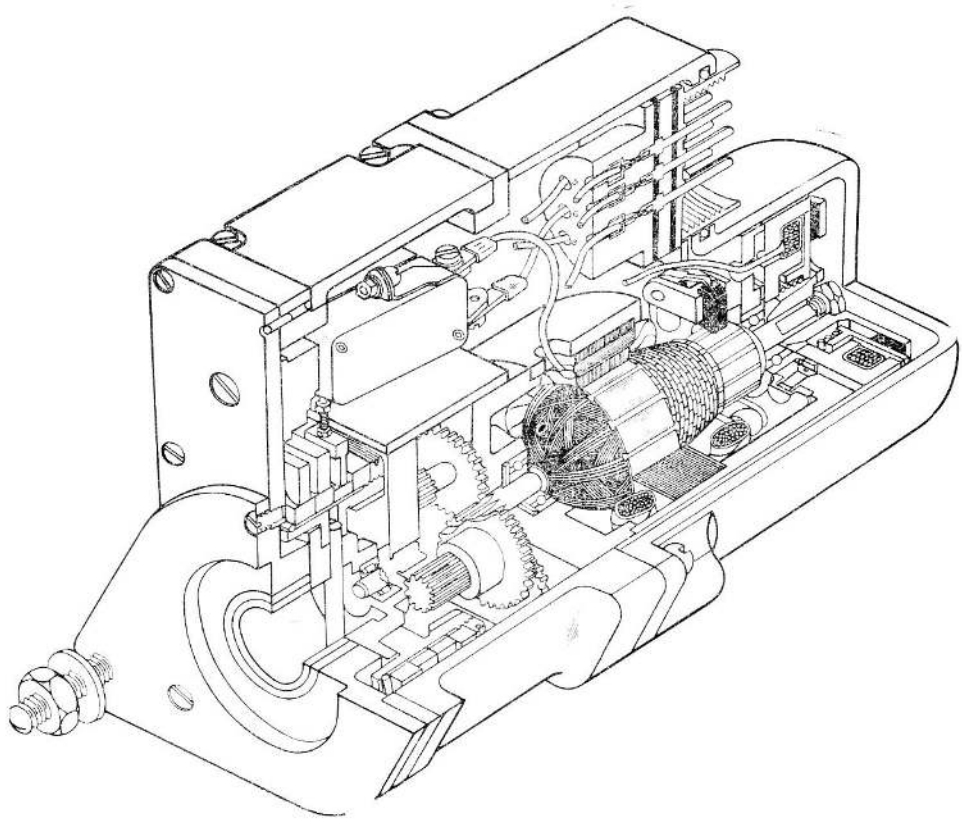


Fig. 2. Quarter section view of actuator

10. The driving end cover is of aluminium alloy and is secured to the gear and switch case by four 6 B.A. countersunk head screws. It is located in position by two dowels passing through the cover and into the gear and switch case.

11. The driving end endplate is a die-casting which locates within the driving end cover and is secured in position by three 6 B.A. countersunk head screws. The upper screw is $\frac{1}{4}$ in. long and the lower pair are $\frac{7}{16}$ in. long, the reason for this being that, in addition to securing the endplate, these lower screws pass through the coverplate and screw into tapped holes within the gear and switch case, thereby assisting the 6 B.A. screws securing the drive end cover to the gear and switch case. Pressed into position in the driving endplate is a P.T.F.E. bush which locates the output shaft at the drive end. This bush required no lubricating.

12. A dowel pin, fitted in the driving end endplate, protrudes through the outer face of the endplate. This ensures the correct fitting of the actuator to the valve or fuel cock.

Motor and brake

13. The motor is a two pole split field series wound 28V d.c. machine. The output is 3·7 watts at 14,000 rev/min. The reversal of rotation is effected by external switchgear.

14. Two alloy brush boxes are mounted on a moulded rocker which is adjustable for setting the brushes on the neutral axis. A white line is painted on the brush rocker and motor frame to indicate the correct setting of the neutral axis.

15. The brushes are C.M.6 (H.A.M.) type and are held against the commutator by

coiled springs bearing on brush fingers which are in contact with the brushes. The brush spring pressure should be between 4 – 5 oz.

16. An electro-magnetic brake is connected electrically in series with the armature, and mechanically to the motor frame at the commutator end.

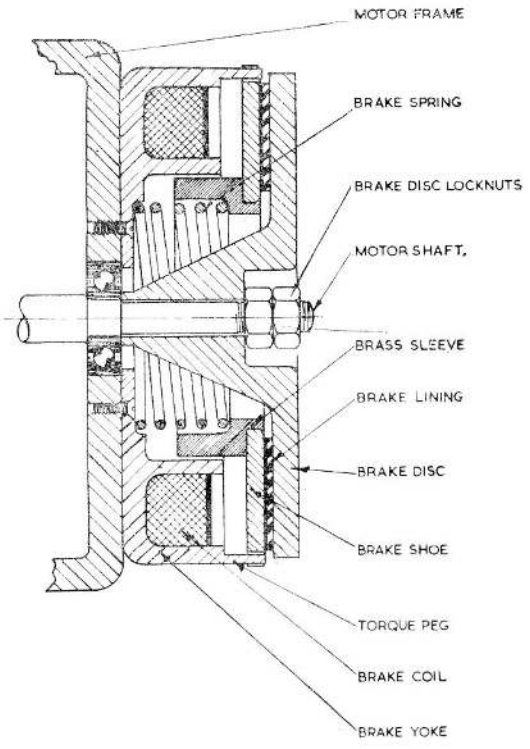


Fig. 3. Typical electro-magnetic brake (not to scale)

17. Basically the brake comprises a yoke assembly, brake shoe assembly, single brake disc, and spring.

18. The brake yoke is of high permeability alloy and houses the brake coil. Connections from this coil pass through the back of the yoke and through the end of the motor frame.

19. The brake shoe assembly is a high permeability alloy flat disc to which is riveted a brass sleeve which acts as a guide to the brake spring, and centralizes the brake shoe assembly within the yoke. Bonded to the brake shoe is the brake lining. This brake shoe assembly is prevented from revolving, when under load, by torque lugs machined on the brake yoke, which locate in slots machined in the brake shoe.

20. The brake disc is fitted to two flats machined on the armature shaft, and locked in position by two 4 B.A. nuts. These nuts tighten the brake disc against the commutator end bearing, so that the brake disc is secured to, and revolves with the armature shaft.

21. The brake spring is of helical type, and is compressed between the back of the brake yoke and the brake shoe assembly, and presses the brake shoe assembly against the brake disc.

Gearbox

22. The gearbox is assembled with the motor drive endplate as an integral part. Other components are the gearbox plate assembly, pillars, gears, and gearbox screws and their stiffnuts. These components are positionally non-interchangeable. The gear drive from the armature pinion is transmitted through five compound gears, the pinion of the fifth passing through the gearbox plate assembly, and engaging with the teeth cut on the inner circumference of the output shaft and cam assembly.

Output shaft and cam assembly

23. The major components in this assembly are : the output shaft cam cylinder, indicating ring, three cams, a fooling pin, and a drive pin.

24. The output shaft is of aluminium bronze, and is drilled and counterbored to accept the fooling pin. This fooling pin protrudes into the bore of the hollow shaft, and its purpose is to prevent the actuator being mated to a valve 180 deg. out of position.

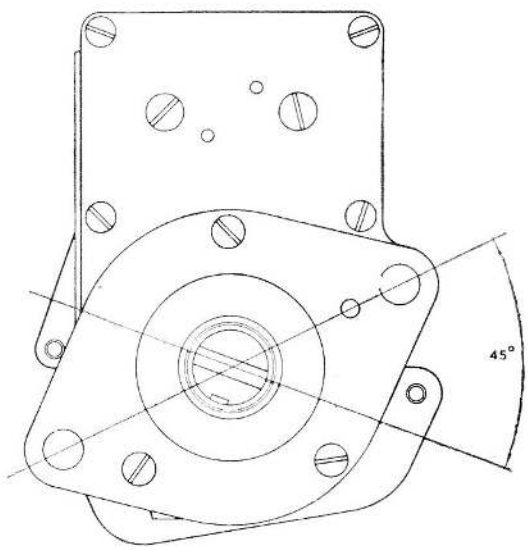
25. The output shaft is pressed into the steel cam cylinder and the two components pinned together by a $\frac{1}{8}$ in. diameter drive pin at 90 degrees to the fooling pin; this pin serving a dual purpose locks the two items together and acts as a drive pin to the valve being actuated.

26. The output shaft is located between the drive end endplate and gearbox plate by a P.T.F.E. bush (self lubricating), and needle bearings respectively.

27. The cam cylinder has internal gear teeth into which mesh the pinion of the 5th compound gear. On the outer circumference are machined 72 splines, a groove to accept a circlip, and a screw thread to accept the retaining nut.

28. The three identical cams have 72 internal splines which mate with those on the cam cylinder. The outer surface of each cam is hard anodized and lapped to prevent excessive wear both on the cam and upon the cam levers which bears on this surface. The cams each have an engraved cursor line which, when in the standard setting position, should line up with the cursor line engraved on the end of the cam cylinder.

29. The indicating ring is similar in size to the cams but has no cam contour on its outer surface; instead, on the surface is an engraved scale from 0 deg. to 180 deg. graduated in 15 deg. increments. This indicating ring is positioned so that it is visible through the observation window in the gear and switch case.



STANDARD POSITION OF DRIVE PIN AND FOOLING PIN WITH INDICATING RING AT 0° & OUTPUT DRIVE SHAFT FULLY ANTI-CLOCKWISE.

Fig. 4. Standard setting diagram

Limit switch mechanism

30. Four micro-switches are mounted side by side, located by two mounting pins passing through the switches, and clamped together between two switch brackets by four 8 B.A. screws passing through the brackets and into the ends of the mounting pins.

31. This assembly is secured to a switch block by rivets. The complete switch and switch block assembly is mounted and located on the inner face of the driving end cover by two 4 B.A. countersunk head screws and two dowel pins respectively.

32. There are three cam levers known individually as the homing cam lever, the travel cam lever, and the mid-position cam lever. The homing cam lever is mounted on a pin pressed into the driving end cover at the right-hand side (viewed from the drive end). The travel, and mid-position cam levers are mounted on a similar pin at the left-hand side, the travel cam lever being fitted nearest the driving end cover.

33. These cam levers are of light alloy, drilled and reamed to accommodate the mounting pins, and drilled and tapped to accept the adjustable switch striker bolts.

34. There is one striker on each of the homing and travel cam levers, and two strikers on the mid-position cam lever, each operating one of the two centre micro-limit switches. The four strikers are positioned in line with the operating plungers of their respective limit switches, and the levers cranked to allow each cam follower to coincide with its respective operating cam.

35. A small projection on the underside of each cam lever acts as the cam follower, and these are hard anodized to prevent excessive wear and are lapped to prevent wear of the cam contours.

36. The four micro switches are connected to operate as limit switches and also to give an indication of the position of the output shaft. When a limit switch operates, it "breaks" the circuit to the motor and "makes" the circuit to the appropriate indicator.

INSTALLATION

37. The actuator is mounted on the face plate of a valve, or component to be operated, by two $\frac{1}{4}$ in. B.S.F. studs, washers and nuts. A dowel pin, situated in the face of the actuator mounting flange, mates with a hole in the face of the valve mounting face (*para.* 12).

38. In all instances where direction of rotation is quoted, it refers to the direction of rotation of the outut shaft when viewed from the drive end.

39. Every Type AE 4513 actuator (unless specifically requested otherwise) is set by the manufacturer with the drive pin at 45 deg. to the centre line of the securing bolt holes in the driving end endplate with the fooling pin at 90 deg. to the drive pin in the lower half of the hollow drive shaft, when the actuator indicating ring is at zero and the output shaft fully anti-clockwise (*fig.* 4).

40. Variations of this setting are easily accomplished by movement of the cams and indicating ring on the output drive shaft as follows. Assume that the drive pin is required to be in line with the centre line of the securing bolt holes when fully anti-clockwise and at this position the indicating ring is to be read 0 deg., i.e. 45 deg. in an anti-clockwise direction from its original setting.

Method

41. Run the actuator to read approximately 45 deg. on the indicating ring (this figure has no bearing on the required setting but at this position none of the cams are in operation and therefore the output shaft can be easily withdrawn).

42. Remove the three 6 B.A. countersunk head screws securing the driving end endplate and remove the endplate. Withdraw the output shaft and cam assembly from the gear case.

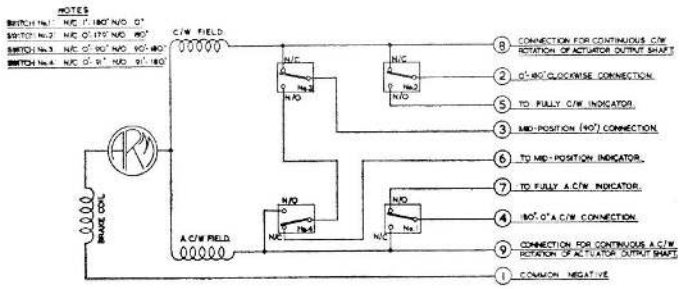


Fig. 5. Wiring diagram

43. Remove the spring clip and the retaining nut securing the indicating ring and cams on the output shaft. It will be noted that on the visible face of the indicating ring a line is scribed which coincides with a similar line on the end of the cam cylinder. All three cams are similarly scribed and when the actuator is set up in the standard position all these scribed lines are coincident.

44. Hold the output shaft in the left hand, and with the right hand remove the indicating ring and cams. To prevent any mistake, remove each cam individually and place on the bench, scribed line uppermost and in the order removed.

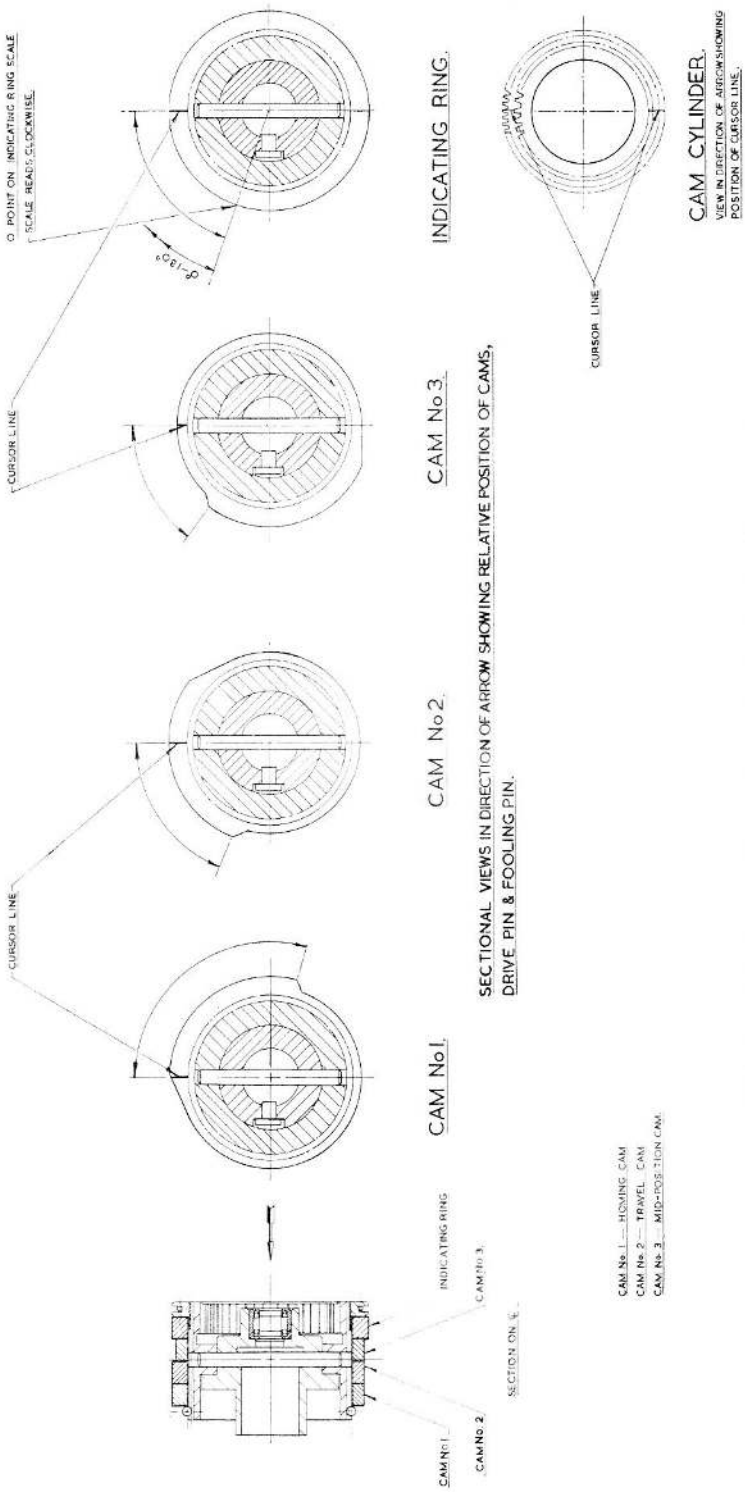


Fig. 6. Relative position of cams in standard setting position

45. Replace the last cam to be removed with its scribed line nine splines anti-clockwise from the scribed line on the cam cylinder. There are 72 splines around the circumference of the cylinder hence each spline will give a difference of 5 deg.; therefore nine will give the required variation of 45 deg.

46. Replace the second cam in the same way with its scribed line nine splines anti-clockwise of its original position and coinciding with the line on the first cam and similarly with the final cam and indicating ring.

47. Replace and tighten the retaining nut and spring clip ensuring that the tip of the tang of the spring clip rests on the root diameter of a spline.

48. Replace the output shaft and cam assembly, positioning it with 45 deg. on the indicating ring at the bottom so as to coincide with the cursor line on the inspection window when the assembly is replaced within the actuator.

49. Replace the driving end endplate and replace and tighten the screws securing the endplate. The operation is now complete. As the cams have not been changed in relation to their respective strikers and switches, but only in relation to the output shaft, which is concentric, the switch settings will remain correct.

50. Should an operating range be required other than the one provided on the standard settings of 0 deg. to 180 deg. with mid-position, this can also be accomplished with minimum additional work. Assuming a setting of 0 deg. to 90 deg. where a mid-stopping position is required with the zero position in the standard setting, proceed as follows.

51. Run the actuator to read approximately 45 deg. on the indicating ring in order to free all cam surfaces from switch tension.

52. Remove the three 6 B.A. countersunk head screws securing the driving end endplate and remove the endplate. Withdraw the output shaft and cam assembly from the gear case.

53. Remove the spring clip and the retaining nut securing the indicating ring and cams on the cam cylinder of the output shaft.

54. Holding the output shaft in the left hand, carefully remove the indicating ring and place on the bench.

55. Next remove the mid-position cam, which is the outer of the three, and place on the bench beside the indicating ring. Each cam and the indicating ring have a scribed line on their outer face. When handling, it is advisable to keep the scribed line uppermost and to place on the bench in order of removal to prevent any possibility of incorrect positioning when replacing.

56. Remove the next cam from the cam cylinder. This is the travel cam and requires to be moved 90 deg. Each spline represents 5 deg. and hence it will be necessary to turn the cam anti-clockwise until there are 18 splines difference between the scribed line on the cam and the line of the cam cylinder.

57. The mid-position cam should now be refitted. This requires to be moved through 45 deg. to give the desired new position. Place the cam on the cam cylinder with the scribed line on its face nine splines in an anti-clockwise direction from the scribed line on the cam cylinder.

58. Now replace the indicating ring. Since the zero position has not been changed this requires replacing in its original position, that is with scribed line on its outer face coincident with the line on the cam cylinder.

59. Replace and tighten the cam retaining nut and refit the spring clip, ensuring that the tang of the clip seats in the root diameter of a spline.

60. Replace the output shaft and cam assembly, positioning it with approximately 20 deg. on the indicating ring at the bottom so as to coincide with the cursor line on the inspection window when the assembly is replaced within the actuator.

61. Withdrawal and replacement of the coverplate, cam and switch assembly is normally carried out at 45 deg., but since 45 deg. is the new mid-way position the

mid-position cam will be operative at this point and it is recommended that the assembly be replaced with the output shaft and cam assembly at approximately 20 deg. when all the cams will be inoperative.

62. Replace the driving end endplate and replace and tighten the screws securing the endplate.

63. The operation is now complete. The actuator should now be checked, using a suitable test ring to ascertain that the stopping positions of the actuator are to the desired angles. The cams have not been changed in relation to their respective strikers or switches, but only in relation to the output shaft which is concentric, and hence no variation of the switch settings should be required.

64. Although the above are merely examples, it will be seen that variation of the angles of operation and magnitude are readily adjustable and that by adopting these methods any desired angle of operation can be arrived at.

Note . . .

(1) *To ease assembly of the output shaft and cam assembly to casing, a narrow strip of metal approximately* 0·006 *in. thick is desirable. This strip should be placed across the cam followers when the output shaft assembly is inserted. The action of this strip is to afford the cam followers a smooth surface to rise on when the shaft is inserted.*

(2) *Should an adjustment of less than* 5 *deg. be required, this can be achieved by adjustment of the cam lever adjustment screws. To do this the motor cover should be removed and the Breeze plug lifted from its posts. When this has been done the adjustable screws are accessible.*

65. The installation is completed by connecting the external electrical supply to the nine pole Breeze plug protruding through the motor cover.

66. After the actuator is installed, a functional check should be carried out for correct operation.

OPERATION

67. For the description of the operation it will be assumed that the actuator has its cams in the standard setting position, and that the output shaft is in the fully anti-clockwise position, i.e., the indicating ring registering 0 deg. through the observation window. The 180 deg. position will be referred to as the "open" position and the 0 deg. as the "closed" position in the following text.

68. Referring to fig. 5, in the initially "closed" position a 28V d.c. supply applied to pin 4 on the Breeze plug would pass through the normally open contacts of switch No. 2 to the "closed" indicator remotely situated in the aircraft.

69. If the circuit selector switch is put to "open" the supply is connected through pin No. 2 on the Breeze plug, the common connection and normally closed contacts on switch No. 2, the motor field, armature, and brake coil, to complete the circuit through pin No. 1 on the Breeze plug. As this takes place the brake coil is energized, releasing the brake, allowing the armature to rotate, and thus setting in motion the drive through the five stages gearing to the output shaft. The rotation continues until the "open" position is reached, when travel cam operates the cam lever and switch striker which in turn depresses the plunger on switch No. 2. This breaks the supply to the motor, de-energizes the brake coil which applies the brake, and the motor and output shaft come to an almost instantaneous stop. It also transfers the supply to the "open" indicator.

70. From the "open" to "closed" position the sequence is as follows. The supply to the motor and brake is made through pin No. 4 on the Breeze plug and the normally closed connection of switch No. 1, setting in motion the drive to the valve as in para.

69. As the cams revolve, switch No. 2 normally closed contacts "make", breaking the circuit to the "open" indicator. On reaching the "closed" position, the homing cam operates switch No. 1 through the cam lever and switch striker, thus breaking the circuit to the motor and making the circuit to the "closed" indicator.

71. To obtain "mid-position" (90 deg.) from the "closed" position, the sequence is as follows. The circuit selector switch is placed in "mid-position". The supply is now connected through pin No. 3 on the Breeze plug and the normally closed contacts of switch No. 3, to the motor field, and the output shaft revolves. When the "mid-position" is reached, switch No. 3 is operated by the cam lever switch strikers, and "mid-position" cam, causing the brake to operate and the motor field to de-energize, and also transferring the supply to the "mid-position" indicator, via the normally closed contacts of switch No. 4.

72. To obtain "mid-position" from the "open" position the sequence is as follows. The circuit selector switch is placed to "mid-position". The supply is fed via pin No. 3 on the Breeze plug through the normally open contacts of switches No. 3 and No. 4 to the motor field, and the actuator operates as before. When the 91 deg. position is reached, the "mid-position" cam allows the plunger of switch No. 4 to return to normal, and the switch contacts transfer the supply from the motor to the "mid-position" indicator.

73. It must be pointed out at this stage that it is possible that, if the settings of switches No. 3 and No. 4 are incorrect in relation to one another, hunting will occur at the "mid-position". A slight adjustment of the setting screw will obviate this.

74. Continuous rotation in either direction can be obtained by selecting the supply to either pin No. 8 or No. 9 of the Breeze plug depending upon the direction required; pin No. 8 for clockwise rotation, pin No. 9 for anti-clockwise rotation.

SERVICING

75. The actuator is to be inspected and serviced in accordance with, and at the periods specified in, the appropriate Servicing Schedule.

76. For routine inspections the external nuts, bolts, screws locking devices, etc., should be checked for security. The wiring should also be checked for corrosion and security.

77. Worn brushes should be renewed before the minimum brush length (0·225 in.) limit is reached. When this is necessary, only brushes of the C.M.6 (H.A.M.) type are to be used. These are to be bedded down to the contour of the commutator for at least 80 per cent of their contact area.

78. The brush spring tension should be checked using a spring balance (Ref. No. 1H/97) and the values obtained should be between 4–5 oz.

79. The brake lining wear should be checked by using feeler gauges between the brake shoe and the brake yoke. With the supply disconnected this gap should be 0·004 — 0·015 in.

80. The actuator is lubricated during manufacture and should require no further attention except at the periods laid down in the appropriate Servicing Schedule.

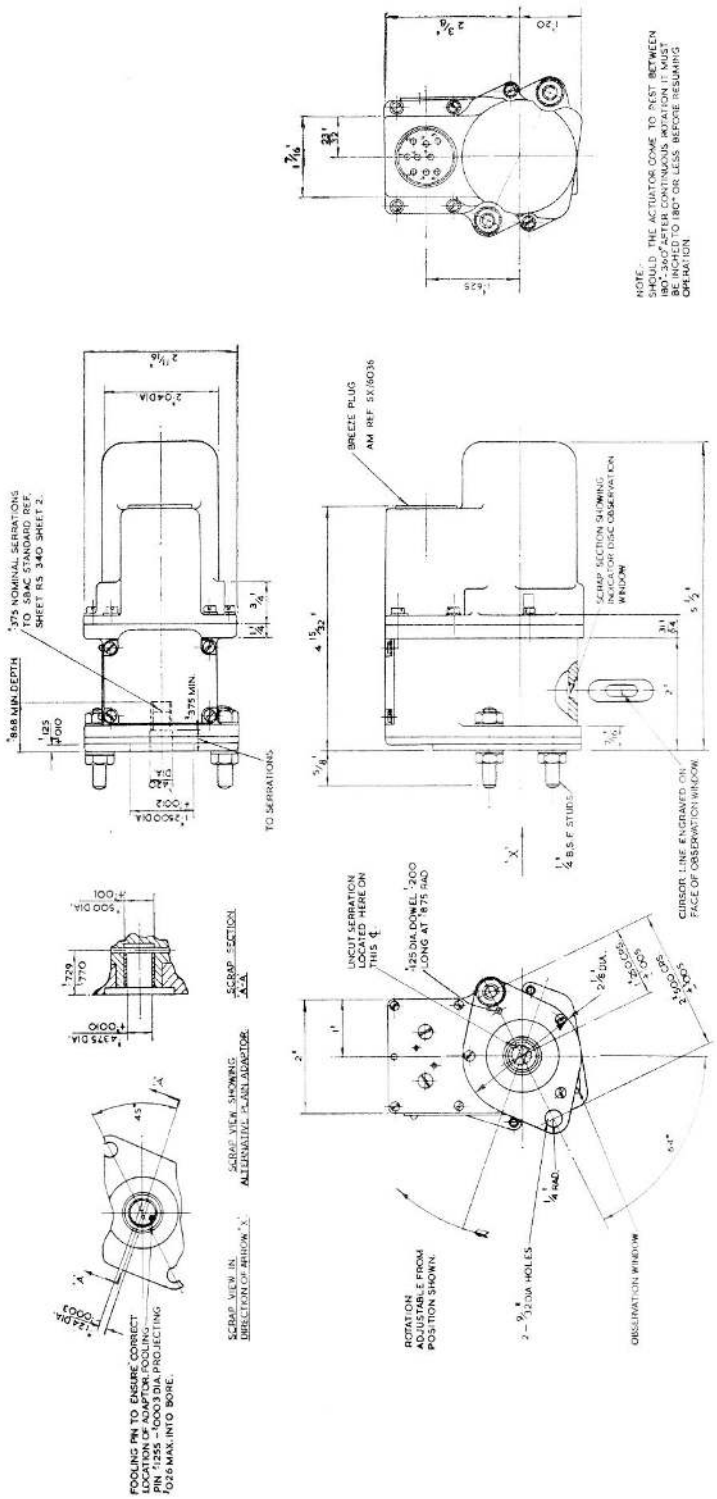


Fig. 7. Installation drawing