Chapter 90

ACTUATOR, ENGLISH ELECTRIC, TYPE AE4023, Mk. 1

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LEADING PARTICULARS

Actuator, Type AE4023, Mk. 1	**Ref. No. 5W/2386**
Rated voltage	28*V d.c.*
Speed of motor	11000 *rev/min*
Output of motor	356 *watts*
Maximum working load	13000 *lb*
Normal working load	3000 *lb*
Static load (as an aircraft strut)	27000 *lb*
Clutch slip load	14800—18000 *lb*
Normal working stroke	1·547 *in*
Stroke between mechanical stops	1·76 *in*
Time of normal working stroke	16 *sec*
Distance between centres (closed on stop)	14·615 *in*
Minimum brush length	$\frac{7}{16}$ *in*
Brush spring pressure	11—15 *oz*
Brush grade	*E.G.O. (H.A.M.)*
Weight	$25\frac{1}{4}$ *lb*

Introduction

1. The linear actuator, Type AE4023, Mk. 1 (*fig.* 1), has been designed to provide variation in the angle of incidence of the tailpiece under all conditions of flight. It is a single speed actuator operating under a normal load of 3000 lb, but is capable of handling loads of up to 13000 lb maximum under working conditions. Acting as a strut in the airframe it can withstand loads up to 27000 lb both in tension and compression.

DESCRIPTION

2. The actuator consists of a compound wound 28V d.c. motor, fitted with a magnetic brake to ensure accurate positioning of any point during the stroke. The drive from the motor to the ram is provided by an arrangement of spur and epicyclic gear trains. The final spur gear is attached to a combined acme nut and ball screw, which, through the mated thread on the ram, provides linear movement.

3. No limit switching arrangement is incorporated in this actuator. The switches are fitted to the aircraft structure, and form part of the aircraft electrical system. The actuator is fitted with mechanical stops so that, in the event of limit switch failure, no damage is caused by excessive travel.

4. With no limit switches incorporated in this type of actuator, it can be seen that the actuator must not be operated unless it is installed either in an aircraft, or in a test rig, incorporating a suitable arrangement of limit switches.

Motor and brake assembly

5. The motor is a 28V d.c. machine of 356 watts output at 11000 rev/min. The field windings are compound wound, and reversal of rotation is effected by external switch gear (i.e., the current through leads 1 and 2 is reversed; see fig. 4).

6. The gun metal brush boxes are mounted on a moulded rocker. This is adjustable for setting to the neutral position. The brushes are E.G.O. (H.A.M.) type, and are held in contact with the commutator, by coiled wire springs. Brush spring pressure must be 11—15 oz.

7. A brake drum is fitted to a flange on the armature shaft, and the brake yoke is fitted in the endplate. With the current off, four brake shoes are held against the brake drum thus preventing any rotation of the armature.

Housing and covers

8. The actuator comprises a series of alloy castings. The motor consists of two castings, and a brush gear and commutator inspection cover. One casting holds the motor field system and the brush gear mounting. The other forms the brake housing and driving end endplate. Both castings are held together by four steel bolts, four spring washers, and four locknuts. Positioned on the motor frame casting is a cable gland on which is mounted a Breeze plug.

9. The motor is located through an auxiliary gearbox on the rear casing assembly of the gearbox, and is secured by four steel bolts and four stiff nuts.

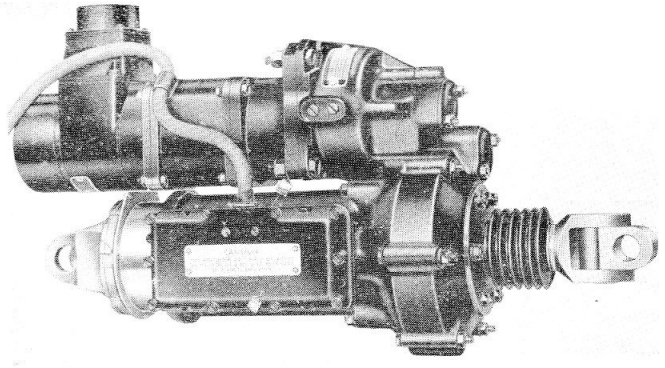

Fig. 1. General view of actuator, Type AE4023, Mk. 1

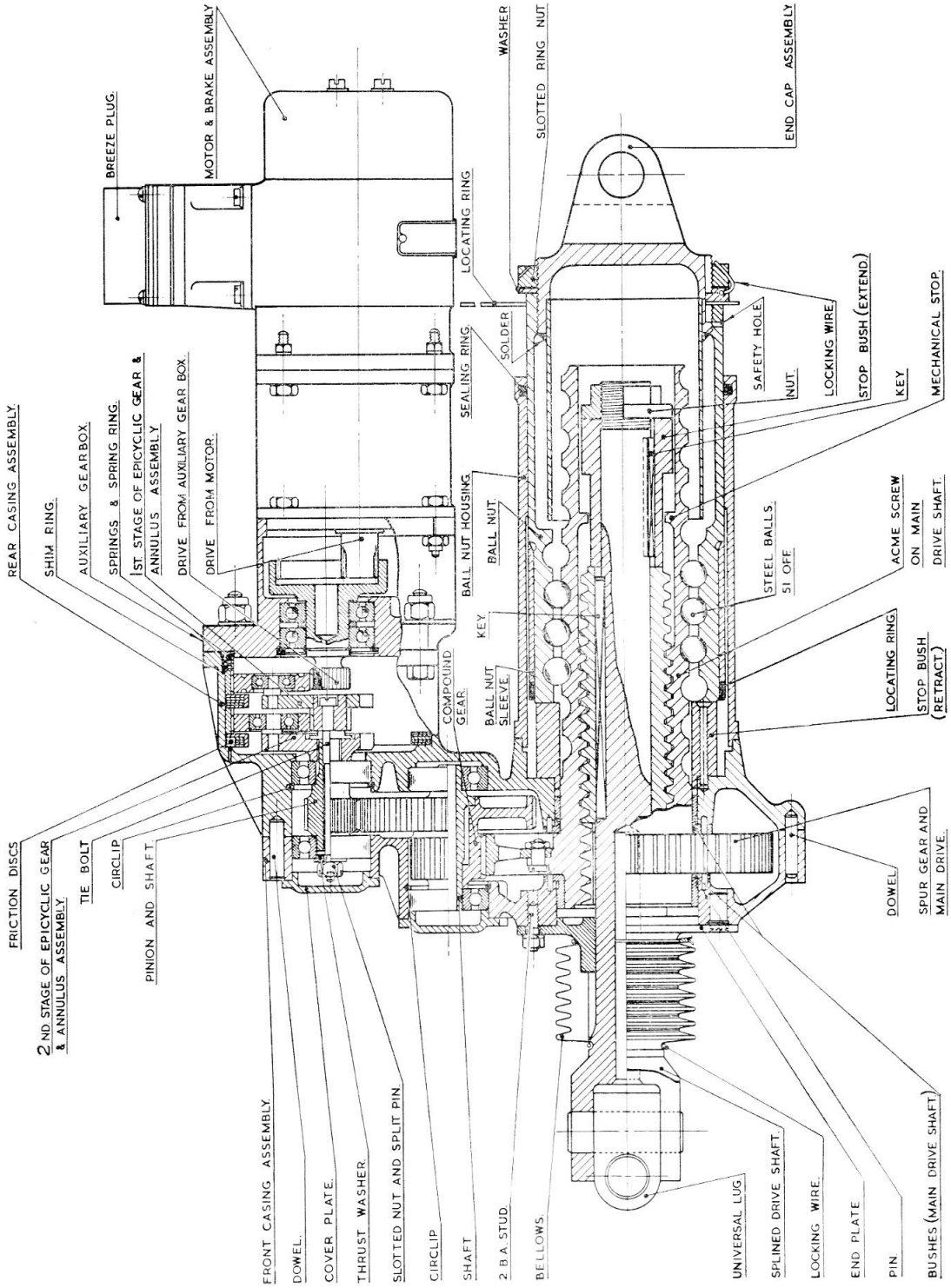

Fig. 2. Sectional view of actuator, Type AE4023, Mk. 1

10. The main gear trains are enclosed in a housing made up of the rear casing assembly and the front casing assembly, and together these form the structure which connects the motor to the ball nut or ram housing.

11. The ball nut (or ram) housing encloses the ball nut, the main drive shaft, and also the potentiometer assembly. A sealing ring is fitted in the end of the housing to prevent the ingress of foreign matter to the ball nut mechanism.

12. All the working parts are thus fully enclosed, though readily accessible for routine inspection, without need for dismantling.

Gearbox and drive

13. The auxiliary gearbox contains a spur gear train which provides the drive from the motor to the main gearbox.

14. The main gearbox consists of a reduction gear arrangement incorporating two trains of epicyclic gearing, and two trains of spur gearing. The epicyclic trains are accommodated in the rear casing assembly.

15. The sun pinion of the first epicyclic gear train is integral with the output shaft of the auxiliary gearbox, whilst the planet gears are mounted on spindles which are brazed to the planet carrier. The sun pinion of the second epicyclic train is also brazed to this carrier.

16. The annulus gear of the second epicyclic train acts as a slipping clutch, and safeguards the actuator and motor in the event of overloading. The clutch setting may be altered by varying the number of clutch springs. If this is not sufficient for setting the clutch correctly, special shim plates may be added or removed as required.

17. Passing through the sun pinion of the second epicyclic train is a tie bolt. This bolt bears against a thrust washer that seats in the planet carrier of the second epicyclic train. The bolt then passes through the shaft of the first spur gear pinion, which mates with an internal gear on the planet carrier of the second epicyclic gear train. A nut and split pin on the end of the bolt secures these parts.

18. The pinion and shaft of the first spur gear train is supported at both ends by ball bearings. Endfloat is prevented by a circlip located against the bearing face. The other bearing (in the front casing) is located by the shoulder on the pinion and shaft and is held in position by a thrust washer and the nut on the end of the tie-bolt.

19. The pinion of the first spur train mates with the wheel on the compound gear to form the first spur train. The pinion on the compound gear meshes with a pinion attached to the main drive shaft, thus completing the second stage of spur gearing.

Drive shafts and ball nut mechanism

20. The main drive shaft is of high tensile steel, and is supported by bushes which fit into the front and rear casing assemblies. On the outside of the main drive shaft is cut a high efficiency ball thread, and on the inside, a left-hand acme thread is cut, thus giving simultaneous linear movement to motor and gear box ends of the ram.

21. The ball nut, which converts the rotary movement of the main drive shaft into linear movement (together with the acme screw), is fitted with a re-circulating device. This consists of fifty-one $\frac{3}{8}$ in. diameter balls with three deflectors fitted in the ball nut. The ball thread provides an almost frictionless drive throughout the stroke.

22. The torque reaction set up by the rotating parts and transmitted through the ball nut to the endcap assembly, is absorbed by the aircraft structure. At the opposite end of the actuator, the torque reaction is transmitted through the acme thread to the splined shaft, and is absorbed by the splines on the endplate which correspond to those on the shaft. As on the other end, the final reaction is absorbed by the airframe.

23. A yellow index line is painted on the face of the ball nut housing, and axially on the ball nut. This is to indicate that, during any adjustment of the mounting points centre distance, the ball nut position may not be disturbed.

24. The acme thread is keyed to the splined shaft and engages with the internal acme thread cut on the main drive shaft. On the inner end of the splined shaft is keyed a stop bush, held in position by a flanged nut. This bush acts as a mechanical stop in the event of limit switch failure when the actuator is

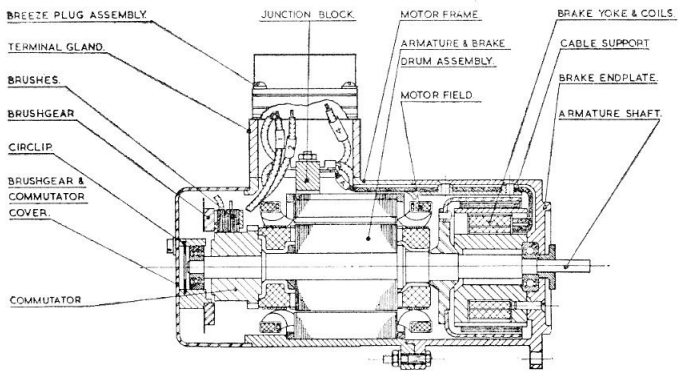

Fig. 3. Sectional view of motor and brake assemblies

extending. Further extension of the ball nut is prevented when a mechanical stop (*fig.* 2) on the inside of the main drive shaft comes in contact with the stop bush, which causes the clutch to slip.

25. If the limit switch fails when the actuator is retracting, the end of the ball nut comes in contact with a stop bush (*fig.* 2), which is located in the rear casing assembly. Further movement of the ball nut is prevented, and the clutch slips.

26. The splined shaft, providing extra extension through the medium of the acme screw, is surrounded by rubber bellows to prevent the ingress of dirt or any other foreign matter to the splines, when the actuator is in the extended position.

27. A locating ring is fastened to the ball nut to prevent rotating accidentally when the unit is not held in some form of mounting.

Limit switches

28. No limit switches are fitted to this actuator; instead they are incorporated in the tailpiece of the aircraft (*para.* 3 *and* 4).

Potentiometer

29. The position of the ram is constantly indicated by a Desynn indicator, which is connected to the potentiometer housed in the actuator.

30. Between the train coils of the potentiometer, move sliding contacts. A small spring holds the contacts against the coils, thus providing constant pressure and good electrical contact. The sliding contacts are moved along the coils by a carrier riveted to the ball nut assembly.

31. Full stroke of the actuator is indicated by a full scale deflection of the indicating needle on the Desynn indicator. If the potentiometer supply circuit is broken, the indicating needle moves immediately to its "pull off" position, which is clear of the working part of the scale.

INSTALLATION

32. The mounting points on this actuator are in two positions, the universal lug, and the end cap assembly (fork end). Care should be taken to ensure that these are correctly aligned prior to installation. During installation the actuator should only be inched at a reduced voltage of 14 volts.

33. The distance between centres of the mounting points, when the actuator is fully retracted against the mechanical stops, should be 14·615 in., the stroke being 1·76 in. + 0·020 in. between the mechanical stops. The working stroke is normally 1·547 ± 0·01 in.

34. An adjustment to the mounting points centre distance of $\pm \frac{1}{8}$ in. is available for the final setting of the tailplane incidence. This is obtained by removing the locknut and shrouded washer on the endcap assembly, and screwing the end cap assembly (mounting point) either in or out as required.

Note . . .

It is possible to screw out the end cap to a point at which there is insufficient effective thread length on the endcap to carry the loads on it during normal operation. Therefore the following procedure must be adopted. On the ball nut are three safety holes (fig. 2). Always ensure that the screwed portion of the end cap is screwed sufficiently in the ram to cover these holes. To check this, pieces of $\frac{1}{16}$ in. diameter wire should be pushed through two safety holes. If any one penetrates to a depth greater than 0·1835 in., the end cap is not sufficiently engaged in the ram, and should be re-adjusted.

35. A practical wiring diagram is provided in fig. 4, for the motor connections.

36. When the actuator is installed in the aircraft, a functional check should be carried out, together with a final check of security on all external screws, nuts and bolts, etc.

OPERATION

37. It is assumed now that the actuator is installed in the aircraft with limit switches in the supply circuit.

38. With the actuator in the fully retracted position, i.e., on the electrical stop (external "retract" limit switch), the "retract" limit switch will be open and the "extend" limit switch closed.

39. When the supply is switched on, the brake coils will be energized, lifting the brake shoes clear of the brake drum, and with the motor fields energized, the armature will rotate.

40. The drive from the armature is made through a pinion on the armature shaft driving a compound gear in the auxiliary gearbox, thus setting in motion the epicyclic, and spur gear trains. The last pinion of the spur gear train is riveted to the main drive shaft.

41. As the main drive rotates, it causes linear movement of the ball nut and splined shaft, through the medium of the high efficiency ball thread and the acme thread respectively, both of which extend.

42. As soon as the ball nut leaves the fully retracted position, the "retract" limit switch will close. Now both limit switches are closed, and the actuator may be reversed simply by altering the position of the circuit selector switch, so that the current through the armature is reversed.

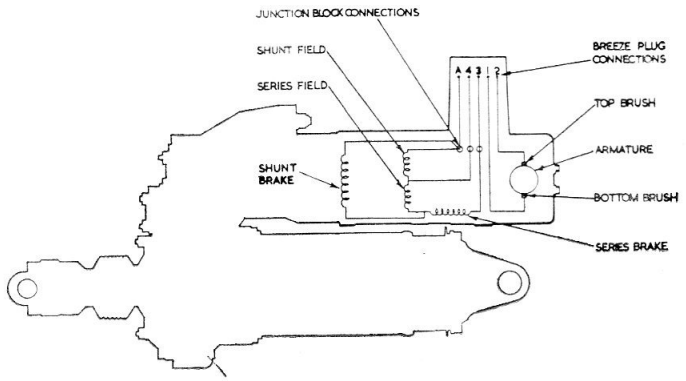

Fig. 4. Practical wiring diagram

43. When the actuator reaches its fully extended position, or if the supply current is switched off during the stroke, the brake will be de-energized. Consequently, the brake shoes will be forced against the brake drum under the action of the brake springs. This stops the armature rotating, so bringing all the moving parts to a standstill.

44. Should the load applied to the actuator exceed 16500 lb at any time during its stroke, the clutch will slip, and the ram mechanism come to rest. The sustained heavy current will cause an external fuse to blow, and cut off the supply to the motor.

SERVICING

Functional check

45. Operate the actuator, either on the aircraft, or in a test rig fitted with suitable limit switches. When installed on the aircraft, a check should be made on no load current. If this has increased considerably over the value obtained in the original test rig, then the airframe linkage should be checked. If the linkage is found to be in order, the actuator should be removed to the test rig mentioned above, and the same test carried out to see if it is the actuator that is at fault.

Brush gear

46. The brush gear should be examined at the periods stated in the relevant Servicing Schedule. The brushes may be examined by the removal of the end cover on the motor. Each brush should be a free fit in its box. Any accumulation of carbon dust should be carefully blown away with dry compressed air.

47. Worn brushes should be replaced with new ones before the minimum brush length ($\frac{7}{16}$ in) is reached, so ensuring that the actuator will operate satisfactorily until the next inspection. The type of brush used in this actuator is the E.G.O. (H.A.M.) type.

48. New bushes must be bedded down to the contour of the commutator for at least 80 per cent of their contact area.

49. The brush spring tension should be checked and should be between 11 and 15 oz. This may be checked by using a spring balance, Ref. No. 1H/97.

Lubrication

50. The actuator is lubricated during manufacture and should need no further attention other than at the periods laid down for this service in the appropriate Servicing Schedule.

Potentiometer

51. Insulation check between the coils and frame should not be less than 2 megohms using a 250V insulation resistance tester. Due to the humidity prevalent in aircraft at dispersal points the minimum permissible insulation resistance must not be below 50000 ohms.

52. Check for correct setting of the 'neutral position'; mid-stroke position in the case of the actuator, half scale deflection for the Desynn indicator. Should the 'neutral position' not be correctly indicated, the potentiometer transmitter may be adjusted by altering the positions of the three triangular contacts on the potentiometer assembly.

53. The contact faces should be free from dirt, grease, dust, etc., and should these appear the faces should be cleaned with crocus paper backed with a wooden block. Any dust remaining should be carefully blown away with dry compressed air.

54. A final check of security of all nuts, bolts, screws, and external electrical connections, should be made after all other servicing is completed.

Note . . .

It should be noted that this actuator contains mated assemblies, before replacing any component.

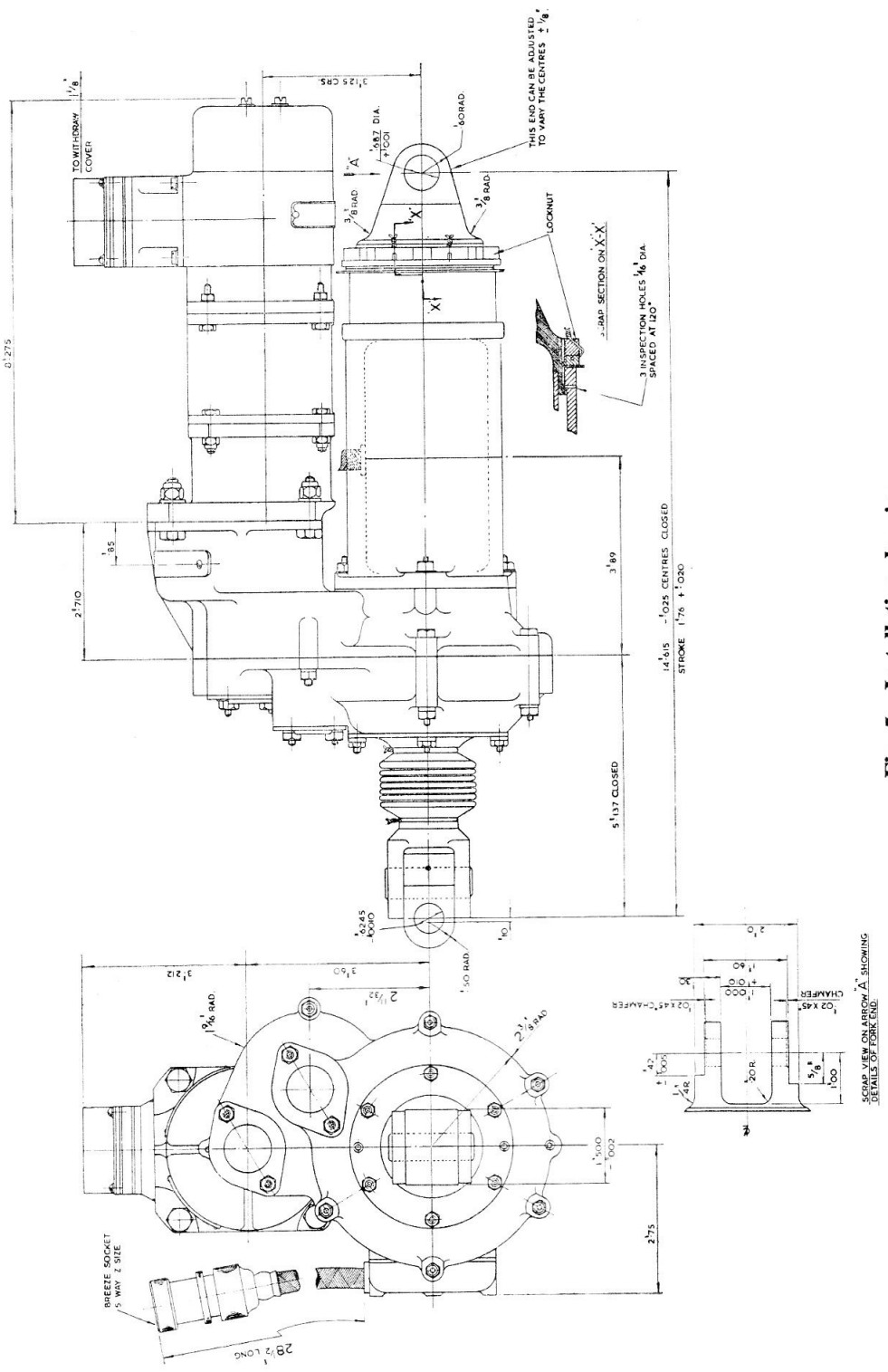

Fig. 5. Installation drawing