Chapter 26

TWO SPEED GEARBOX, PLESSEY, TYPE 4CZ95880

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LEADING PARTICULARS

Two speed gearbox, Type 4CZ95880A	*Ref. No. 5UA/7184*
Input speed range	2900 *to* 8000 *rev/min*
Input to output speed ratios	... 1:1 *and* 1:1·62
Gear ratio change speed	4800 *to* 5050 *rev/min*
Time limitation in 1:1·62 *ratio*	... ... 15 *min.*
Input torque between 2900 *and* 5050*rev/min* ...	... 20 *lb/ft.*
4800 *and* 8000*rev/min* ...	... ... 10 *lb/ft.*
Ambient operating temperature	−40°*C to* +150°*C*
Weight, dry	14¾ *lb.*
Lubrication system	*Oil, pressure-feed type (to be connected to main system)*
Oil	... *OX*-38 (*N.A.T.O. code* 0-149)
Flow rate required	80 *to* 160 *cc/min. through input shaft at max. inlet temp. of* 115°*C*
Input shaft spline, type and size	18*T, involute spline,* 32/64 *D.P.,* 30 *degrees P.A.*
Output shaft spline, type and size	24*T, involute spline,* 48/96 *D.P.,* 30 *degrees P.A.*

Introduction

1. The Plessey Type 4CZ95880, two speed gearbox is of the twin-spur epicyclic type, with a step-up ratio of 1:1·62 for input speeds less than 5000 rev/min. Above 5050 rev/min the disengagement of an electro-magnetic brake results in the unit adopting a 1:1 ratio. The gearbox is designed for mechanical coupling to an a.c. generator Type 165, when this is required to be used in a system where the prime mover input speed will not meet the a.c. generator requirements.

2. The gearbox must be used in conjunction with control panel, Type 48, No. 2 (sensing unit) connected into the generating circuit. The sensing unit receives signals generated by a heteropolar inductor alternator built into the gearbox, relates them to preset values and, dependent on the result, interrupts or connects the power supply to the brake unit. This arrangement ensures that the changeover from one gear ratio to the other is automatically effected at predetermined settings of the speed sensing unit.

DESCRIPTION

General

3. The gear train and the electro-magnetic brake unit are enclosed and supported in a housing in which the stator of the sensing alternator is also fitted. An accelerating clutch which functions when there is no torque reaction on the output shaft (as during no load conditions) is interposed between the gear train and the brake unit. A 4-pole plug which provides connection to the external electrical circuit is mounted on the housing. A sectional view of the gearbox is shown in fig. 2.

Gear train

4. The gear train is of the dual epicyclic type, consisting of three sets of compound planetary gears and two sun gears, the whole being enclosed by the carrier which supports the planetary gears.

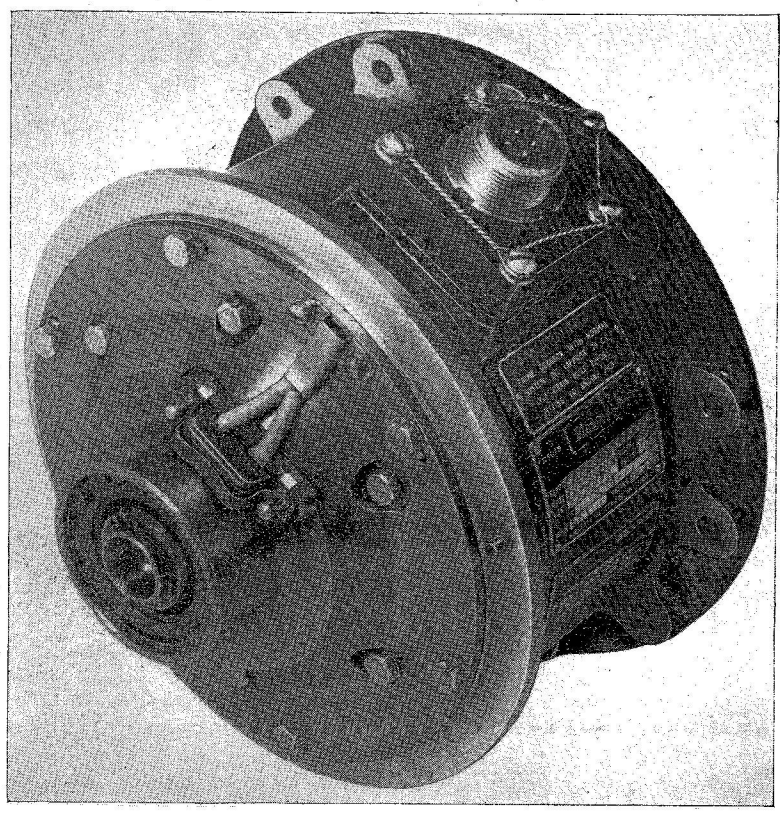

Fig. 1. General view of gearbox

5. Each compound gear is supported on two in-line needle roller bearings on a layshaft fitted to a flange integral with the planet carrier. This flange, which has a clover-shaped central aperture, separates the cylindrical planet carrier into two chambers; one encloses the gear train assembly and the other the brake unit. The planet carrier is capped at the gear chamber end by a cover plate which picks up the outer ends of the layshafts and is secured to the rim of the planet carrier by screws and washers. The wall of the planet carrier at the brake chamber end is slotted to engage with lugs on the brake friction ring.

6. The three planet gear layshafts are equally spaced around the planet carrier flange and locked at the brake chamber face by a ring which fits into cutaways in the layshaft extensions. Planet gear end float is controlled by thrust pads inserted between each gear face and the planet carrier flange at one end, and the planet carrier cover plate at the other end.

7. Each sun gear is of the spur type and is integral with a hollow shaft, one being the input shaft and the other the output shaft. These shafts have internal splined sections to provide coupling to the driving and driven members of the gearbox. The input shaft rotates within the bore of the output shaft in two in-line, needle roller bearings secured to it by a circlip; the bearings being separated from each other and the circlip by spacing rollers. The input shaft is supported by a ball bearing at the input end, retained on the shaft by a cupwasher and castellated nut.

8. Similarly the output shaft rotates on the needle roller bearings fitted to the input shaft. It extends through a sleeve fitted in the brake unit and is supported at the output end by a ball bearing also fitted in the brake unit. The input shaft sun gear meshes with the smaller diameter planetary gears; the output sun gear with the larger ones.

Brake unit

9. The brake unit comprise four main components: the coil housing, friction ring, brake plate assembly and springs. The brake coil housing encloses a d.c. solenoid whose ends are connected to insulated terminals fitted at its outer face. It is secured to the gearbox housing by screws and washers. The sleeve through which the output shaft extends is forced into a central aperture in the coil housing and protrudes from its inner face. The brake plate is mounted on this sleeve extension and is held away from the coil housing by six helical springs that locate in mating counterbores in the housing and the plate. The distance between the plate and the coil housing is determined by the position of a circlip, which fits around the sleeve and acts as a stop against which the plate is held. The position of the housing and the brake plate relative to each other is established by two rectangular keys which locate in slots in both assemblies and the sleeve. The keys also act as guides for the plate during its linear travel.

10. The brake friction ring is located between the adjacent faces of the coil housing and brake plate, in a recess around the periphery of the coil housing, and fits freely on the spigot thus formed. It has a friction lining on each face and eight lugs around its circumference which engage in a similar number of slots in the planet carrier. This arrangement causes the brake ring to be carried around by the planet carrier except when the brake coil is energised. It is then gripped between the coil housing and the brake plate and thus holds the planet carrier stationary.

11. The output shaft bearing is pressed into an aperture in the brake coil housing against the brake unit sleeve. A lipped oil seal is also fitted in the aperture and separated from the bearing by a spacer, the seal being retained by a locking ring.

12. An 'O' ring seal is fitted around the output shaft. It is contained in an annular recess in a sleeve which butts against the inner race of the ball bearing and is retained on the output shaft by a circlip.

Cam and roller clutch

13. This device is designed to lock the planet carrier to the input shaft when the gearbox operates at the 1:1 ratio. It locates in an aperture in the planet carrier cover plate and consists of a six-lobed cam, six rollers and a cage.

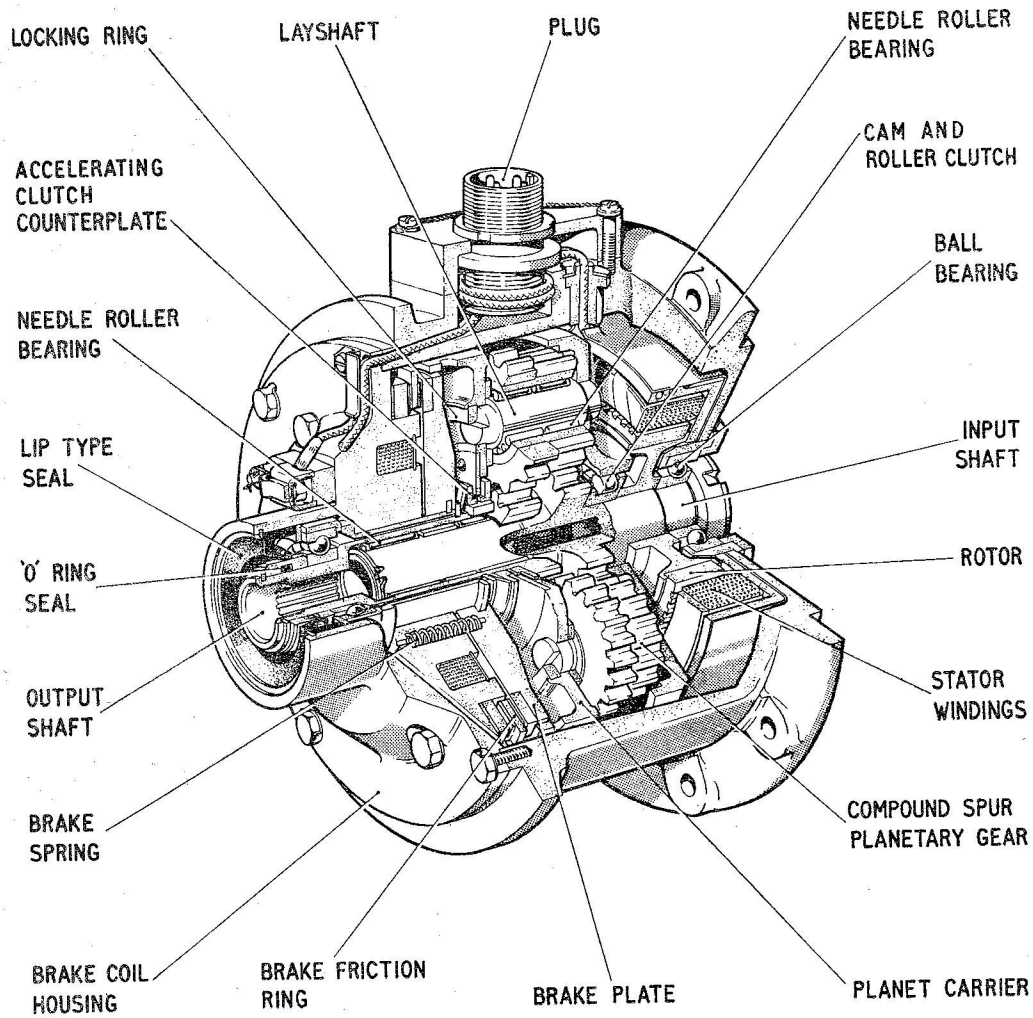

Fig. 2. Sectional view of gearbox

14. The cam is fitted on the input shaft against the sun gear, on a polygon-profiled section, and is thus effectively integral with it in a rotational sense. The roller cage is a circular plate machined so that six equi-spaced lugs are left standing on the periphery, at right angles to the surface. It is mounted against the cam on the same profiled section of the input shaft and its lugs extend over and are parallel with, the cam tracks. The six rollers are held length-ways between the cam flange and the base plate of the roller cage so that they lie one across each cam track and are segregated by the roller cage lugs. The whole assembly is contained within a central housing in the planet carrier cover plate, and is positioned so that the rollers are between the inside face of this housing and the cam tracks.

Sensing alternator

15. This unit is an orthodox alternator with laminated rotor and a wound stator. Its function is to produce an a.c. voltage varying in direct linear proportion with rotor speed.

16. The three section stator is secured to a wall at the input end of the gearbox housing by studs and nuts and the ends of the stator winding are routed through a channel in the gearbox housing to the plug recess. The laminated rotor has gear type serrations at its periphery. It is locked on the polygon-profiled section of the input shaft, between the cage of the cam and roller clutch and the inner race of the input shaft ball bearing.

Acceleration clutch

17. The purpose of this device is to create drag between the output shaft and the planet carrier and thus induce a torque reaction between the assemblies sufficient to rotate the planet carrier when there is no load on the main a.c. generator.

18. The clutch consists essentially of a friction plate and two counter plates. The friction plate is riveted to the brake chamber face of the planet carrier. It has a number of circular sintered bronze pads on each face arranged around a large central aperture through which the output shaft extends. The two counter plates are keyed to the output shaft and loaded against the rear face of the output sun gear by a disc type spring washer which is retained on the shaft by a circlip, and the friction plate locates between them. Tension of the spring washer is adjusted by shims inserted between it and the circlip.

Housing

19. This assembly encloses the gearbox components. It is a stout walled cylinder spigoted and flanged at each end with one end closed. The brake unit is assembled within the open end, and the stator of the sensing alternator is attached to the wall at the other end. The flanges are suitably adapted for attachment to the prime mover and the constant speed a.c. generator.

20. A flanged liner is secured in the closed end of the housing by bolts and tabwashers, flange outside, and the input shaft ball bearing is carried in this. A platform is provided at the periphery of the housing on which the plug assembly is mounted, and drilled passages in the wall carry the wires from the brake unit and the sensing alternator to the plug.

Plug

21. The plug is of the UK-AN-FIX-14S-2P, 4-pole, flameproof type. It is assembled on a subsidiary plate, which is secured to the platform on the housing by drilled-head screws locked with wire. The wiring diagram for the gearbox unit is shown in fig. 3. The leads from the plug are secured to the brake unit terminals by a spring clip, cover plate and two cotter pins. The leads from the sensing alternator are crimped and soldered to the appropriate plug pins.

Lubrication

22. Lubrication is bled from the prime mover system. Oil passes through the hollow input shaft and is routed to the gears and bearings via drilled passages provided in the various components. A drain hole low in the rear wall permits the gearbox to be connected into the scavenge system of the prime mover. Adequate purging must occur, as overheating will result from any build up of oil in the gearbox.

Caution . . .

Severe damage will occur if the time limit of 15 *min. maximum continuous running in the* 1:1·62 *ratio is exceeded. When this limit is reached, the unit must be reverted to the* 1:1 *ratio for* 10 *sec. in order to wet the planet gear assemblies again, before reverting to the* 1:1·62 *ratio once more.*

OPERATION

23. When the input shaft begins to turn its sun gear rotates the planet gears, which run around the output sun gear with the carrier freewheeling. The sensing alternator rotor is keyed to the input shaft so it also revolves and a voltage is generated in the stator winding which is fed to the external sensing unit. When this voltage reaches a predetermined level the speed sensing unit closes the d.c. circuit to the brake coil. This must occur before the input speed reaches 2900 rev/min. The brake coil is energized and attracts the brake plate towards the coil housing, trapping the brake friction ring which lies between them. The planet carrier is stalled by the brake friction ring lugs which are engaged in slots, and the drive from the input sun gear is then transmitted through the dual epicyclic gear train to the output shaft sun gear. This effects the step-up drive of 1:1·62 ratio.

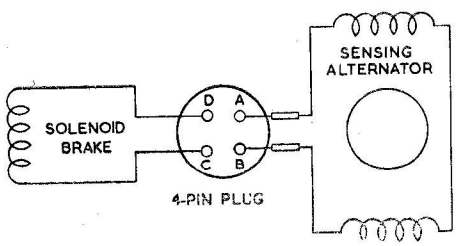

Fig. 3. Wiring diagram

24. Soon after the input shaft has begun to move the clutch rollers are thrown outwards against the inside face of the housing in the planet carrier cover plate and rotate freely against it in the space over the bottom of the cam lobes. So long as the planet carrier is moving slower than the input shaft, or is stationary, the rollers sit back against the roller cage lugs and are carried round by these in this orbit.

25. When the input speed reaches 5050 rev/min. approximately, the sensing alternator voltage, which is directly related to speed, achieves the next pre-determined value and the sensing unit reacts and open circuits the supply to the brake coil. The brake plate is thrown back by the springs, releasing the brake friction ring. The planet carrier is now free to move and, because it has been under load, the torque reaction causes it to accelerate rapidly in an attempt to overtake the input shaft. The instant it begins to overrun the input shaft however the clutch rollers are carried with it away from the cage lugs, and they wedge in the narrowing space between the cam lobes and the wall of the planet carrier housing. The planet carrier is thus tied to the input shaft and the gearbox reverts to 1:1 ratio, with the input sun gear, the planet gears, and the output sun gears rotating together.

26. If for any reason the gearbox fails to change down at 5050 rev/min for the voltage from the sensing alternator will continue to climb until, at 5300 rev/min the external speed sensing unit will trigger at its over voltage protection level. This safety facility will open circuit the negative return to the brake coil and the 1:1 ratio gear change will be obtained.

27. When the input shaft speed falls to 4850 rev/min approximately, this will be detected by the external sensing unit, which will re-connect the supply to the brake coil, initiating the change-up to 1:1·62 ratio once again. This built-in speed change differential is necessary to override any float in engine speed which could cause chatter, and positive gear change action is thus secured.

28. The foregoing is the normal sequence of operation of the gearbox when changing from one ratio to the other. It can happen however under no-load conditions, that there is insufficient torque reaction to accelerate the planet carrier when the brake is released. Gear change would then be inhibited. The acceleration clutch prevents this malfunction. The friction between the rotating counterplates, keyed to the output shaft, and the sintered bronze pads on the friction plate which is attached to the planet carrier, is sufficient to trigger-off the acceleration. The normal sequence of events then follows.

INSTALLATION

29. The gearbox is mounted so that when normally operated it is in a horizontal or near-horizontal attitude: an offset hole is provided in the mounting flange to locate the gearbox on the prime mover mounting pad. The driven equipment is secured to the gearbox by a manacle clamp. An oil drain pipe should be fitted to the gearbox connected with the scavenge system of the prime mover: the pipe outer diameter is 0·322 in., it must not extend more than 0·210 in. into the gearbox and it should slant downwards at an angle of not less than 10 degrees to the horizontal.

SERVICING

30. The gearbox must be serviced in accordance with the relevant Servicing Schedule. It should be examined for signs of damage, corrosion and deterioration, and for security of attachment. The electrical connections should be checked for tightness, and torque of the acceleration clutch should be verified.

31. If there is any doubt about the functioning of the unit, perform the standard serviceability tests detailed in Appendix A to this chapter to determine whether the gearbox operation is satisfactory.

Appendix A

STANDARD SERVICEABILITY TESTS

for

TWO SPEED GEARBOX, PLESSEY, TYPE 4CZ95880

Introduction

1. The tests in this appendix may be performed in the order detailed when the functioning of a gearbox is suspect or when the serviceability of a gearbox is required to be determined. The tests should be performed with the gearbox in a horizontal or near horizontal attitude. It is imperative that during the tests, the running time in the 1:1·62 ratio is limited to 15 minutes (maximum), as detailed in para. 22.

Tools and test equipment

2. Besides standard workshop facilities, the following special tools and test equipment will be required.

(1) Generator tester, Mk. 5 (A.P.4343S, Vol. 1, Book 2, Sect. 13).

(2) A control panel type 48 No. 2 (Ref. No. 5UC/7307) whose satisfactory operation has been established.

(3) Oil pump and sump capable of providing a pressure feed of 80-160 cm^3/min at all gearbox speeds, and drainage adequate to prevent a build up of oil in the gearbox.

(4) Torque measuring adapter: Plessey Type 4SK.11413.

(5) Spring balance with a 0-3 lb. scale and an accuracy of ±5%.

(6) 0-50 volts moving coil voltmeter.

(7) Insulation tester, 500 volts d.c.

(8) Hand tachometer with a range of 0-10000 r.p.m. and ±5% accuracy.

(9) Stopwatch.

(10) Two thermocouples and two 0-200°C recording instruments.

(11) A coupling shaft (see Leading Particulars for spline details) to engage the gearbox and rig drives.

Gearbox rotation check

3. Check that the direction of rotation is clockwise, looking at drive end.

4. With the gearbox supported on the bench and the output shaft held firmly it should be possible to rotate the input shaft in the reverse direction to the normal unit rotation. When rotated in the normal direction the output shaft will attempt to follow the input shaft.

Measurement of accelerating clutch torque

5. Clamp the gearbox firmly to a bench in a level position, with the output shaft end overhanging the end of the bench. Insert the adapter 4SK11413, into the splined drive of the output shaft.

6. Apply 24 volts nominal d.c. to plug pins C and D (polarity immaterial) to energize the brake solenoid.

7. Turn the input shaft in the direction of rotation so that one arm of the adapter is vertical. Hook the spring balance to the arm and holding it horizontal, determine the slipping torque when the input shaft is manually rotated in the direction of rotation. Repeat this operation three times and take the mean of the four readings. The torque figure obtained must be between:

(1) 90 and 140 oz ins. for a new or overhauled unit

(2) 80 to 130 oz ins. after any subsequent running time.

Sensing a.c. alternator open circuit test

8. Mount the gearbox on the test rig and couple it to the lubrication system. Plug the

bore of the output shaft to prevent egress of the lubricating oil, and prime the gearbox with the oil stipulated on the label fitted to the gearbox.

9. Drive the gearbox over the full speed range and ensure oil flow does not decrease below 80 cm^3/min at any speed.

10. Connect an a.c. voltmeter across the plug pins A and B and record the voltage readings at the speeds detailed in the following table. The readings obtained must be within the prescribed limits.

Input speed	Min. V	Max. V
1000	6·5	8·5
1500	9·5	12·5
2000	12·5	16·0
3000	19·0	23·0
4000	25·0	30·0
5000	30·5	35·5
6000	35·5	40·5
7000	40·0	44·5
8000	44·0	48·5

Overall functional check

11. Disconnect the voltmeter used during the previous test and connect the gearbox to the control panel, Type 48 No. 2, and the voltmeter as shown in fig. 1: the voltmeter in this circuit is the 0-50V d.c. moving coil instrument prescribed in para. 2.

12. Ensure that the oil supply is adequate as described in para. 9.

13. Drive the gearbox through the full range 2900-8000 rev/min observing the input and output shaft speeds. The gearbox changes ratio at an input speed range of 4800 to 5050 rev/min. Therefore, below that change point the output shaft speed must exceed that of the input and above the change point both speeds must be equal.

14. Drive the gearbox past the gear change point noting the voltmeter reading and the shaft speeds. When the voltage reduces to zero the output shaft must reduce to that of the input shaft within 3 seconds.

15. Repeat the full range operational check described in para. 13 three times and note that gearbox operation is consistent, that the change from one gear ratio to the other is smooth and without undue snatch and that the difference in the oil inlet and outlet temperatures does not exceed 60°C. Disconnect the gearbox from the control panel and voltmeter and proceed to the following test.

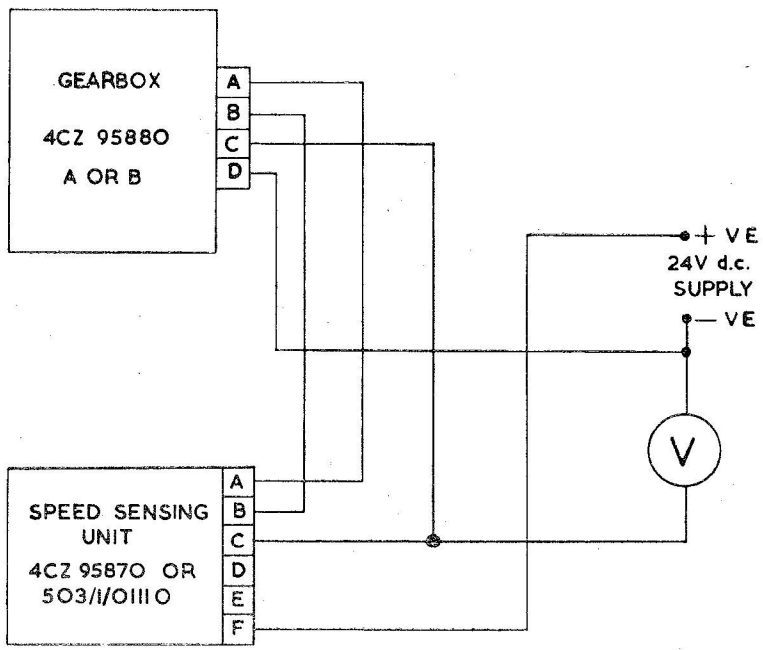

Fig. 1. Test circuit diagram

Insulation resistance (when hot)

Caution . . .

Ensure that the gearbox is not connected to external electrical equipment before proceeding with this test.

16. The insulation resistance between each plug pin and the gearbox casing must be measured with a 500 volt d.c. insulation tester on immediate completion of the foregoing tests. The readings so obtained shall be not less than 50000 ohms.