Chapter 2

CONTENTS GAUGE INDICATORS, S.149 SERIES

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LIST OF ILLUSTRATIONS

Introduction

1. The information contained within this Chapter deals with contents gauges applicable to liquid oxygen systems.

2. The basic principle of electrical gauges employed in these indicating systems; is the ratiometer movement which measures the ratio of two currents.

3. The current is provided from a capacitance bridge system which depends for its action on the difference in dielectric constant between gaseous and liquid oxygen which may be measured as a difference in capacitance according to level of liquid in the container. The electronic equipment described in Chap. 1 interprets this change of capacitance into variations of current which is used to control the moving coil of the contents gauge.

4. The S149 indicator is normally panel mounted by means of a clamp attached to the rear of the panel. Provision is made for adaption to SAE pattern by means of a threaded reinforcement around the periphery of the casing. A further adaption is provided on these instruments which consists of a back-nut and O-ring as illustrated in fig. 3.

5. Each instrument (fig. 4) has a manufacturer's code number and a B.O.C. number. The manufacturer's number is made up of three parts. A typical code is S149/3/157 where S149 is the model number, /3 is the 'form' of this model, and /157, the suffix number, represents the application to which the instrument is adapted.

6. Three forms of this indicator are in Service use; form 1 is a ratiometer type movement measuring

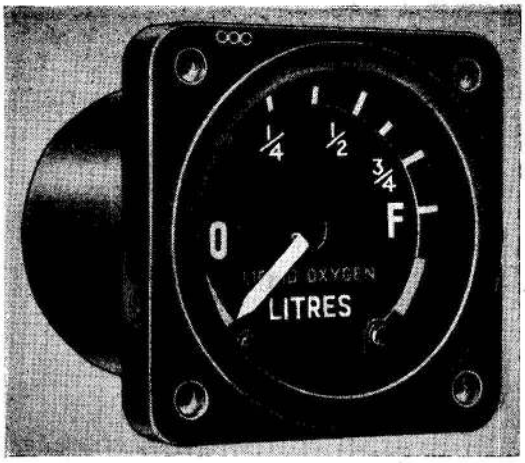

Fig 1. Contents indicator

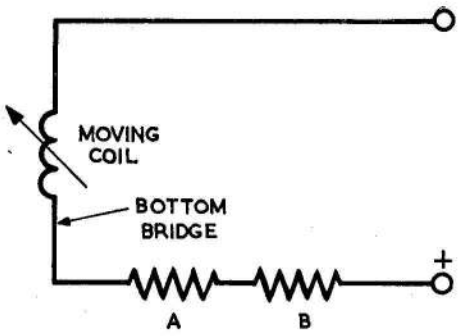

Fig. 2. Circuit diagram, contents indicator

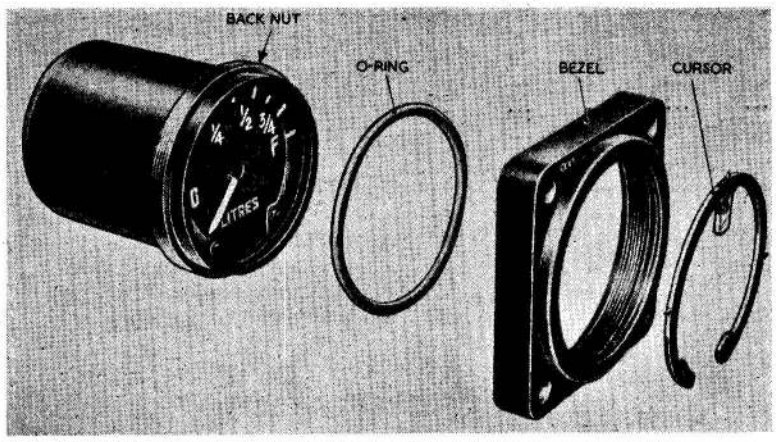

Fig. 3. Indicator, Type S.149 with adapters

the ratio of two currents ; forms 2 and 3 are standard moving coil voltmeters or ammeters depending upon the use to which they are applied.

PRINCIPLE

Form 1

7. The principle employed in the form 1 indicator is that of the ratiometer which measures the ratio of two currents. They differ from the normal design in that the magnetic circuits are so arranged, that the field in the gap, between the core and the pole-piece, in which the coils rotate, is not uniform. This non-uniformity is achieved by the shaping of the centre core. Two coils mounted on a common former (fig 4) are connected so that the torques produced in each coil are in opposition.

8. Due to the shaping of the centre cores, the coil in which the greater current flows is in a weaker part of the field than that in which the lesser current flows. Therefore, the assembly will always rotate until the torques on the coils are equal and opposite. In this position a state of equilibrium is reached.

9. Theoretically, the instrument is substantially independent of the supply voltage, since any change in voltage will not alter the ratio of the currents in the two coils on the former. Assuming that the ligaments which conduct the current into and out of the coils exert no controlling torque, then no change in pointer indication will occur. In practice, the ligaments exert a small torque, but this has little effect on the pointer at operating voltages.

10. At the rear of the movement the current is transferred from the two cables to the moving coils by two ligaments which exert a small torque on the pointer assembly. The common return circuit is conducted by a low torque hairspring at front of the assembly which also functions as a pointer return spring.

Form 3 (fig. 5)

11. In this form, the principle is that of the normal voltmeter or ammeter where the movement of the moving coil in relation to the field of the permanent magnet is proportional to the voltage or current applied to the coil. For currents or voltages in excess of the rating of the instrument, resistances in shunt or series connection are mounted internally. The pointer return unit is not required in these instruments.

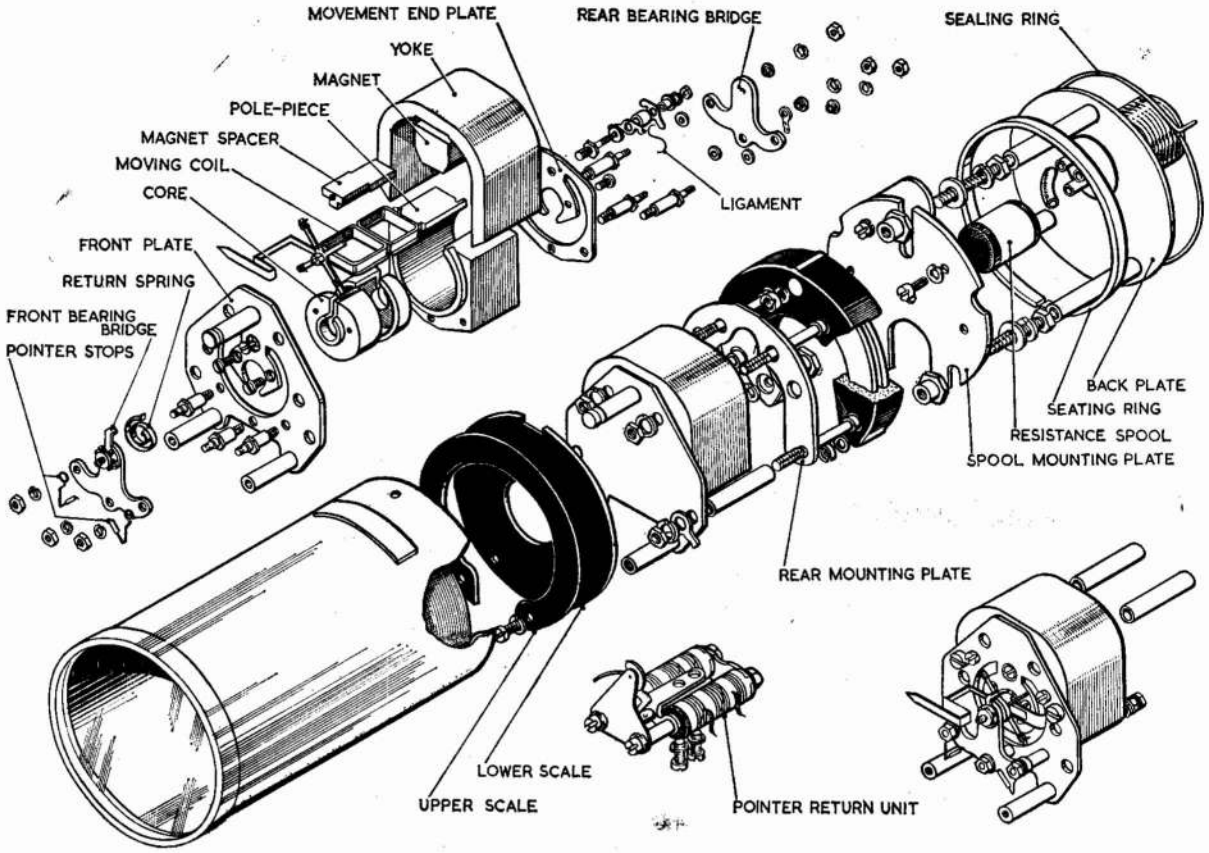

Fig. 4. Indicator, Type S.149 (detailed view)

DESCRIPTION

12. The movement is enclosed within a sealed 2 in. casing terminated by a Mk. 4 plug located in the back plate ; the front of the casing is threaded to accomodate an adapter for conversion to S.A.E. pattern.

Magnet and movement assembly

13. This assembly (fig. 4) consists of a permanent magnet and yoke, two moving coils mounted on a common former, a rear bearing bridge, front bearing bridge, and a pointer return unit. The block magnet, over which is fitted the U-shaped soft iron yoke is of high field strength, the north pole face of the magnet being in contact with the yoke.

14. Each of the two bearing bridges are supported by three pillars secured to the soft iron pole-piece. The coils are pivotally mounted between spring-loaded jewel screws located in the bridges. The pointer attached to the coil former, is balanced by two weights and limit of travel is governed in both directions by spring stops set at approximately 0·07 in. beyond the scale limits. The scale is secured in position by the pillar riveted to the front plate and also by two screws at the bottom of the scale.

Pointer return unit

15. The pointer return unit consists of an electro-magnetic device incorporating two iron cored coils (fig. 4), connected in series or parallel according to range, and a soft iron armature. The pivoted armature is connected by quadrant and pinion gearing to a fine copper-beryllium arm which bears against the vertical arm of the pointer when the unit is de-energized.

16. When the indicator is energized, the coils of the pointer return unit provide a field which attracts the armature thus withdrawing the copper-beryllium spring arm from contact with the pointer mechanism ; the pointer is thus free to travel over the scale in response to current variations from the pressure transmitter. When the indicator is de-energized (no current flows) the armature returns and the pointer is swept off the scale in a direction according to the application of the indicator

Form 3 (fig. 5)

17. The casing in this form is identical with the form 1 model (except that the overall length of the casing is shorter by 0·97 in.), but it differs in that connection is made by means of a terminal block attached to the back plate.

Magnet and movement assembly

18. This assembly (fig. 5) comprises a magnet, a soft iron pole-piece, a core, a coil winding mounted upon a former, a rear bearing bridge and a front bearing bridge Each bridge is supported by three

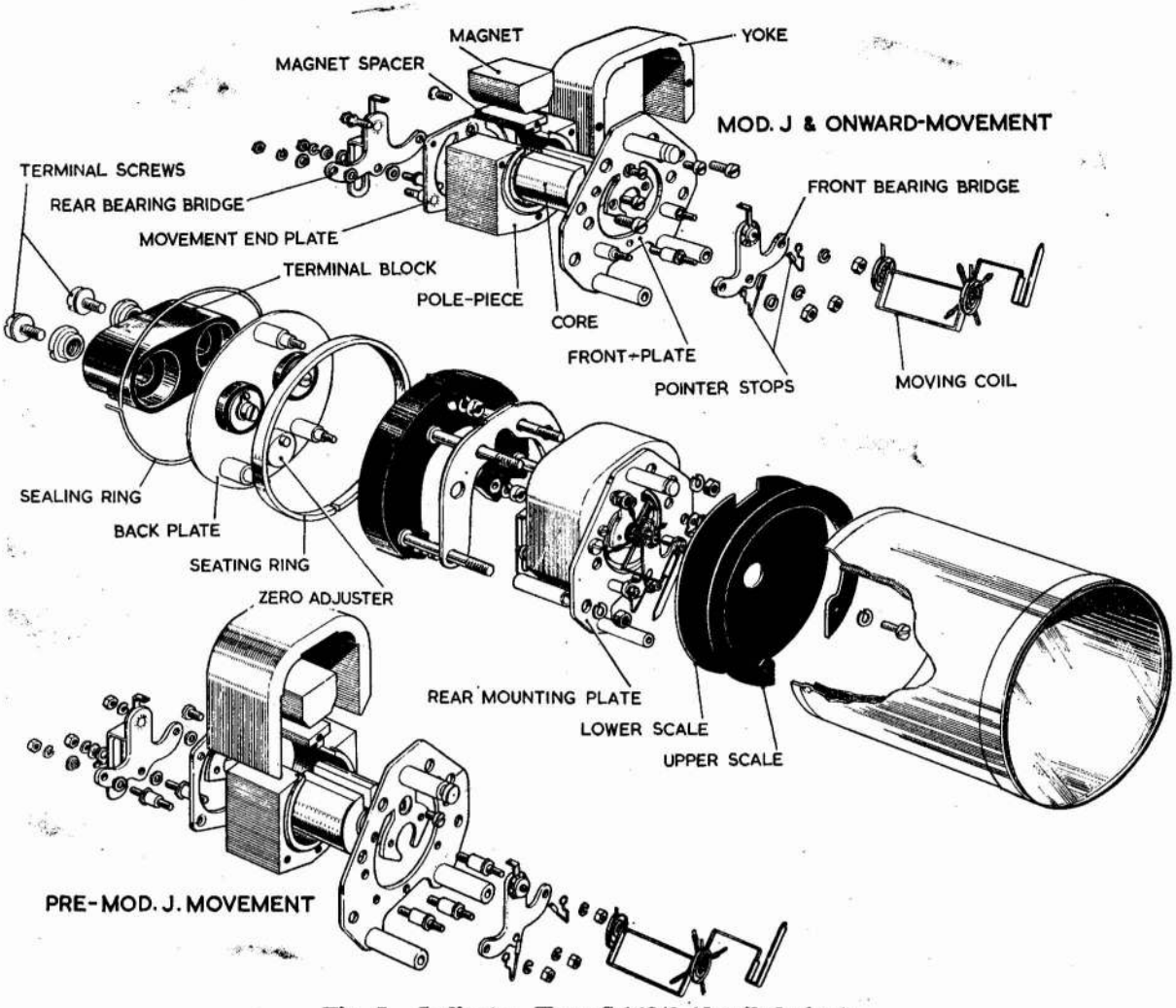

Fig. 5. Indicator, Type S.149/3 (detailed view)

pillars secured to the soft iron pole-piece. Pivots attached to the coil former are mounted between spring-loaded jewel screws which are located in the front and rear bridges. The pointer, attached to the coil former, is controlled by the interaction of the magnetic flux with the field surrounding the coil winding, and is positioned at zero when no current flows. Balance of the pointer is maintained by weights, and pointer travel is limited in both directions by spring stops.

19. The scale is secured in position by the pillar riveted to the front plate and also by two screws at the bottom of the scale. Connections to the moving coil system are made by one cable connected to the rear bearing bridge, which is insulated from the magnet assembly by bushes, and the second cable is earthed to the front plate by a tag and securing screw. Final connection to the coil is made by two hairsprings which also function as pointer return springs.

Form 2

20. The form 2 instrument movement is identical with the form 3 but the casing differs in the length, being the same length as the form 1.

Sealing

21. All forms of the S149 indicators are sealed by the same method, therefore, the following instructions apply in each variation of form and suffix number.

Pre-sealing treatment

22. Any tests which have to be made on the instrument (see relevant appendix to this chapter) must be applied with the instrument assembled into its casing, but before the following drying and sealing process.

(1) After the instrument has been tested, ensure that all excess solder is removed from the casing; place the seating ring (fig. 3) over the back of the instrument and down inside the casing.

(2) Withdraw the internal mechanism from the casing by approximately $\frac{1}{2}$ in. and place the whole instrument in an oven at 70°C for approximately sixteen hours.

Cover to back plate sealing

23. This operation should be performed within one hour of the removal of the instrument from the drying oven. If this is not possible, the instrument must be kept in a dry atmosphere. Failure to comply with this instruction will necessitate a re-drying period as detailed in para. 22.

(1) Replace the internal components fully into the casing so that the rim of the back plate is resting on the seating ring.

(2) Fit the sealing wire into the gap between the back plate and the edge of the casing. The wire should fit into the space without distortion.

(3) Using a solder having a melting point of 180°C and a flux that does not require neutralizing, solder the sealing ring in position.

24. The soldered joint must be flat, level with the back plate and form a complete seal between the back plate and the casing. At the overlap point ensure that such a seal is obtained, but that the external overlap is not completely embedded in solder and is readily removable when it is required to unseal the instrument for repair.

25. Sealing of the casing is best achieved by using a large soldering iron to apply local heat and progressively flowing the solder around the casing. It is essential that the casing temperature should be kept as low as possible and the soldering operation be completed in the shortest possible time.

Sealing test

26. The vent at the rear of the case must be connected to a vacuum pump which will remove air from the casing, reducing the pressure to 0·1mm Hg. By the use of a change-over valve the evacuated casing must now be filled with dry nitrogen gas to a pressure of 30 lb/in² (i.e. approx. atmospheric + 15 lb/in²) taking care not to exceed this pressure. The instrument must be wetted in a suitable agent (Teepol) and the pressure reduced to 25 lb/in²; while still connected to the nitrogen supply, immerse the instrument in a solution of 99% distilled water and 1% Teepol. There must be no sign of any bubble formation from the instrument due to the applied pressure over a period of five minutes. After satisfactory completion of this period, the vent must be sealed by the use of a suitable length of copper wire inserted into the vent and solder applied to the joint. Final presure in the indicator is approx. atmospheric.

Suffix number

27. The suffix number represents the instrument application; each instrument will have a different number if used for more than one purpose. It should be noted that where indicators have been provided by the aircraft manufacturer the relevant spare indicator provided by Service Stores will bear a different suffix number. Both suffix numbers for interchangeable indicators are shown under the heading of para. 35.

General information

28. When an indicator bears the inscription MOD J, which designates that it has a special pole-piece unit, the assembly of this unit requires a special technique not available in Service Instrument Sections, therefore, no attempt should be made to dismantle the pole-piece.

Cursor

29. When a contents indicating instrument is used at the filling point of an aircraft fitted with a stabilized liquid oxygen system, it should be equipped with a cursor, in order to simplify the filling process. Filling must stop at a given contents indication; and the cursor, which takes the form of a circlip and is inserted into the bezel of the instrument, is set so that the white tongue coincides with the pointer at that indication.

30. The cursor (Ref. No. 6D/2709), BOC No. 802874, is shown in fig. 3; the level to which the system must be filled varies according to the aircraft installation and the cursor is set to the correct position using the procedure as follows:—

(1) Disconnect the aircraft connection cables from the filling point contents indicator.

(2) Connect the indicator to a circuit as shown in fig. 3 under the appropriate instrument in this chapter.

(3) Adjust the variable resistance to produce a current flow appropriate to that value given in the aircraft handbook.

(4) Using suitable circlip pliers, insert the cursor under the rim of the indicator so that the tongue rests on the glass.

(5) Adjust the cursor until the tip of the indicator pointer appears in the centre of the hole in the cursor tongue.

(6) Disconnect the indicator from the test circuit, and re-connect the aircraft cables.

31. The cursor may be fitted to the instrument before installation in the aircraft; typical settings are given as follows:—

Cursor adjustment

Aircraft	*Filling level (litres)*	*Adjustment point (mA)*
Lightning Mk. 2 and 3	3	1·77
Gnat	2·8	1·69
Buccaneer	2·7	1·65
Sea Vixen	2·8	1·69

INDICATOR, TYPE S149/3/157 BOC No. 802169

Dial presentation

32. This indicator (fig. 6) Ref. No. 6D/2164 is a contents indicator calibrated in litres of liquid oxygen from 0 to 3·75. The indicator is controlled by a capacitance measuring instrument which supplies current to the d.c. milliameter movement of the indicator. A current of 2·5mA will give full-scale deflection of the pointer.

Circuit and connections

33. The circuit diagram is shown in fig. 7 and

connection to the indicator is made via two terminals at the rear of the casing.

Testing and calibration

34. When testing an indicator for serviceability, a circuit must be connected as shown in fig. 8 ; the calibration values are given as follows :—

Calibration values

Scale position	*Current (mA)*
F.s.d.	2·50
F	2·00
3·0	1·77
2·5	1·59
2·0	1·42
1·5	1·23
1·0	1·02
0·5	0·81
0	0·40
End scale	0·00

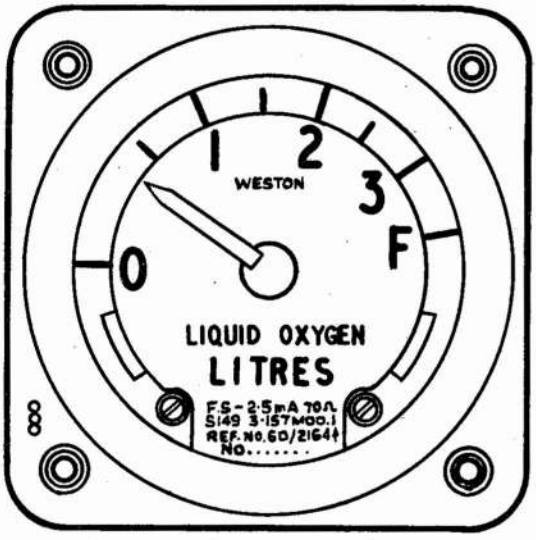

Fig. 6. Indicator, Type S.149/3/157

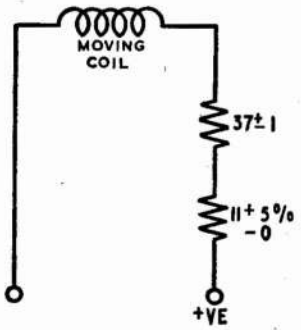

Fig. 7. Circuit diagram

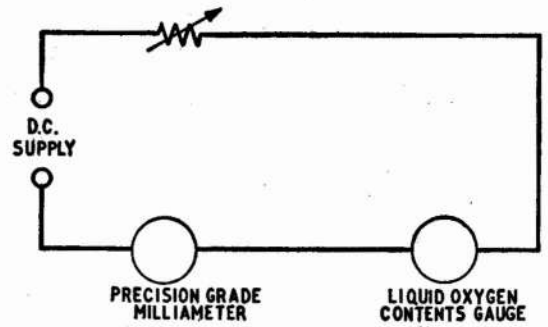

Fig. 8. Test circuit diagram

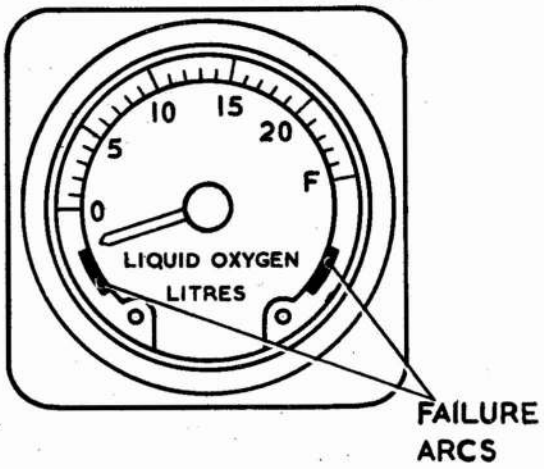

Fig. 9. Indicator, Type S.149/3/224 or 340

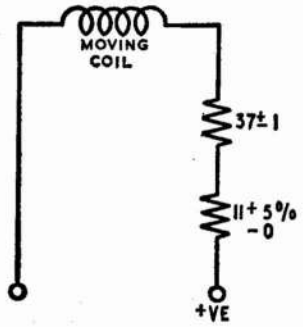

Fig. 10. Circuit diagram

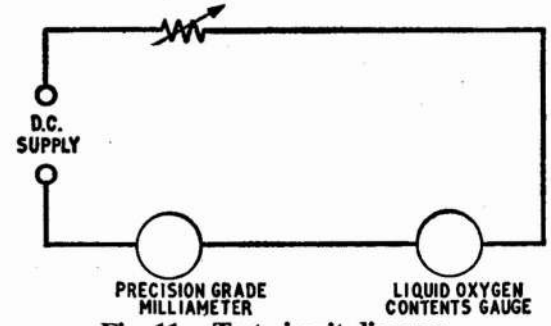

Fig. 11. Test circuit diagram

INDICATOR, TYPE S149/3/224 or 340
BOC No. 802169, 802828

Dial presentation

35. This indicator (fig. 9) Ref. No. 6D/2495 is a contents indicator calibrated in litres of liquid oxygen from 0 to 25. The indicator is controlled by a capacitance measuring instrument which

supplies current to the d.c. milliameter movement of the indicator. A current of 2·5mA will give full-scale deflection of the pointer.

Circuit and connections

36. The circuit diagram is shown in fig. 10 and connection to the indicator is made via two terminals at the rear of the casing.

Testing and calibration

37. When testing an indicator for serviceability, a circuit must be connected as shown in fig. 11 ; the calibration values are given as follows :—

Calibration values

Scale position	*Current (mA)*
Full scale	2·50
F	1·96
20	1·68
15	1·38
10	1·07
5	0·74
0	0·40

General information

38. The S149/3/340 indicator is identical with the S149/3/224.

INDICATOR, TYPE S149/3/341 BOC No. 803161

Dial presentation

39. This indicator (fig. 12) Ref. No. 6D/2605 is a contents indicator calibrated in fractions of tank capacity from 0 to FULL. The indicator is controlled by a capacitance measuring instrument which supplies current to the d.c. milliameter movement of the indicator. A current of 2·5mA will give full-scale deflection of the pointer.

Circuit and connections

40. The circuit diagram is shown in fig. 13 and connection to the indicator is made via two terminals at the rear of the casing.

Testing and calibration

41. When testing an indicator for serviceability, a circuit must be connected as shown in fig. 14 the calibration values are given as follows :—

Calibration values

Scale position	*Current (mA)*
Full scale	2·5
F	1·97
$\frac{3}{4}$	1·60
$\frac{1}{2}$	1·31
$\frac{1}{4}$	0·95
0	0·46

General information

42. The dial has two red sectors known as " failure arcs ", when the indicator circuit is energized the pointer should read zero or above according to the contents level. If the system is unserviceable and less than the zero current is applied, the pointer will remain in the red sector below zero. If more current than that required for the F position is applied, the pointer will be moved toward or into the top " failure arc. "

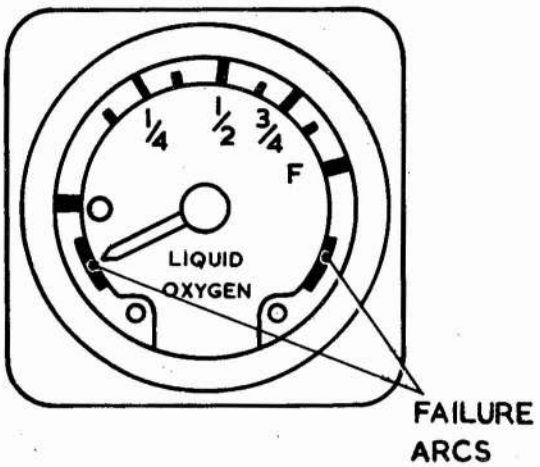

Fig. 12. Indicator, Type S.149/3/341

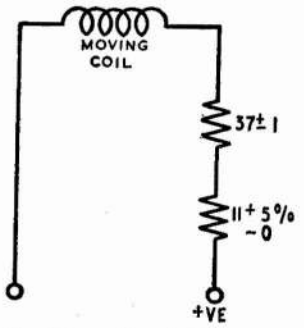

Fig. 13. Circuit diagram

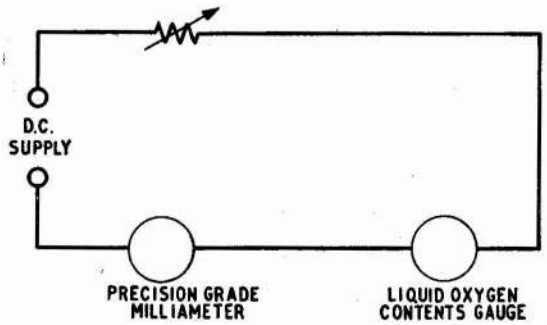

Fig. 14. Test circuit diagram

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