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THERMOMETER EXHAUST GAS TEMPERATURE, 0 TO 800 Deg. C. (3·6 OHMS EXTERNAL RESISTANCE)

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AMENDMENT RECORD SHEET

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LIST OF CHAPTERS

Chapter 1

THERMOMETER, EXHAUST GAS TEMPERATURE, 0 to 800 DEG. C. (3-6 OHMS EXTERNAL RESISTANCE)

Introduction

1. This thermometer consists of an indicator and a thermocouple and is used on jet-engined aircraft to provide the pilot with an indication of the temperature of the exhaust gases, in order that the engine may be operated under conditions of maximum efficiency and to ensure that the safe working temperature under various conditions is not exceeded.

Principal of operation

2. The instrument operates on the principle of the thermocouple whereby in a circuit formed by two lengths of dissimliar metals joined together at both ends, the application of heat to one end, called the hot junction, will produce a small e.m.f. and so cause a current to flow through the circuit. The magnitude of this e.m.f. depends upon the difference in temperature between the hot and cold junctions and the mutual characteristics of the two metals forming the thermocouple.

3. The hot junction is placed in the exhaust gas stream, the cold junction being located in the indicator, which is a sensitive millivoltmeter compensated for variations in temperature of the cold junction and suitably calibrated to read the temperature of the hot junction direct in degrees Celsius.

Equipment available

4. The following equipment is available:—

(1) Thermocouple, Foster Type (*Ref. No.* 33*KK*/902)

(2) Indicator, 0 to 800 deg. C., fluorescent (*Ref. No.* 6*A*/2191).

DESCRIPTION

Thermocouple hot junction unit

5. Referring to fig. 1, the thermocouple unit consists of two conductors, one (5) of nickel-chromium and the other (6) of nickel-aluminium, the junction between the two being located at the tapered extremity of the thermocouple head (1), which is also of nickel-chromium and forms the positive element of the hot junction.

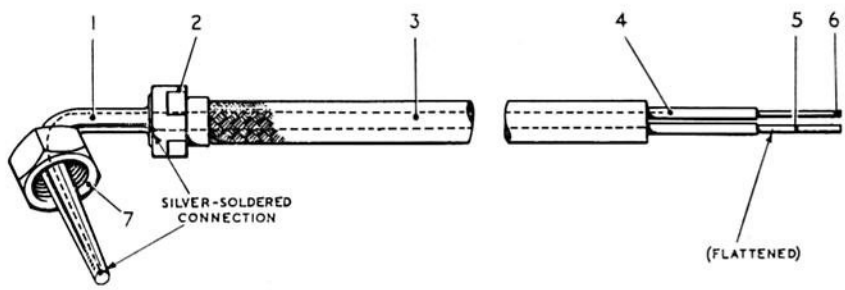
6. The nickel-chromium conductor (5) is silver-soldered to a threaded collar as shown in fig. 1, the collar being integral with the head, whilst the nickel-aluminium conductor (6) is passed through the bore of the thermocouple head and silver-soldered at the tip, which is chamfered off at approximately 45 deg. The nickel-aluminium conductor is insulated from the internal surface of the head by ceramic beading.

7. The leads to the hot junction are insulated by fireclay-impregnated asbestos sleeving (4) and are protected by an oil-resisting armoured flexible conduit (3). This conduit carries a nut (2), which is first screwed on to the threaded collar and then silver-soldered to effect a permanent joint.

8. At the other end, the leads extend 3 in. beyond the armoured conduit.

Note . . .

For identification purposes, the bared end of the nickel-chromium, or positive, conductor is flattened. The nickel-aluminium conductor is susceptible to magnetism and may easily be distinguished with the aid of a small magnet.



1 THERMOCOUPLE HEAD
2 CONDUIT CASING NUT
3 CONDUIT CASING
4 ASBESTOS SLEEVING
5 NICKEL-CHROMIUM CONDUCTOR (POSITIVE) WIRE
6 NICKEL-ALUMINIUM CONDUCTOR (NEGATIVE) WIRE
7 THERMOCOUPLE HEAD CONNECTING UNION NUTS

Fig. 1 View of thermocouple hot junction unit, showing internal wiring

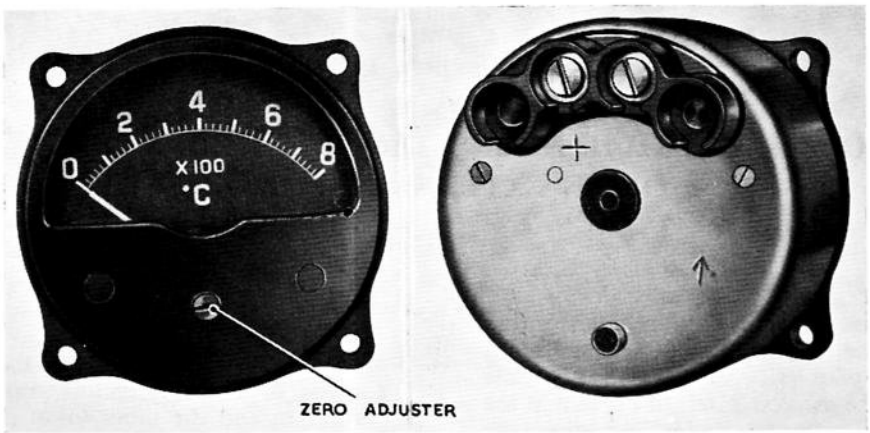


Fig. 2 Indicator, exhaust gas temperature thermometer, 0 to 800 deg. C.

9. A $\frac{9}{16}$ in. B.S.F. union nut (7) is provided for securing the thermocouple head (1) to a threaded boss on the exhaust tail-pipe of the engine. The overall length of the thermocouple and leads is approximately 7 ft. The resistance of the thermocouple is 2·68 ohms $\pm$ 0·03 at 20 deg. C.

Indicator

10. The indicator, shown in fig. 2, consists of a sensitive moving coil millivoltmeter, the scale of which is graduated from 0 to 800 deg. C. in increments of 20 deg., the pointer and main scale markings at every 100 deg. being treated with fluorescent compound.

11. A zero adjuster on the front of the case serves to adjust the pointer to read the ambient temperature of the instrument. To avoid errors due to change of cold junction temperature, a compensating device is fitted. This compensator consists of a bi-metallic spiral which acts on the hairspring controlling the pointer.

12. In addition, compensation is provided for variation of moving coil resistance due to change in ambient temperature; this is achieved by one of the two following methods.

(1) By means of a neutralizer connected in series with the moving coil, the material of the neutralizer having a negative resistance temperature coefficient. The neutralizer is so adjusted in value that its change of resistance with temperature is equal and opposite to that of the moving coil.

(2) By means of a temperature-sensitive magnetic shunt. This is so arranged as to cause the magnetic flux in the working gap to change at a rate proportional to the rate of change of resistance of the moving coil.

13. The mechanism may be housed in a case either of pressed metal or of moulded material. If a moulded case is used, a metal screening cover is fitted. The case is provided with four fixing holes, one at each corner, on a P.C.D. of $3\frac{1}{2}$ in. Two shrouded terminals are provided at the rear of the case, to which are secured the ends of the compensating leads from the hot junction. A + sign is marked on the case adjacent to the positive terminal.

Compensating leads

14. Each compensating lead consists of a length of twin cable provided with tag connections at both ends, one conductor being of copper and the other of constantan. The polarity of the leads is identified by colour-coded insulating sleeves at both ends, red (positive) for the copper conductor and blue (negative) for the constantan conductor. The resistance of the leads is 0·92 ohms $\pm$ 0·02 at 20 deg. C.

15. The copper conductor of the compensating leads is connected to the nickel-chromium conductor of the thermocouple hot junction, and the nickel-aluminium conductor of the thermocouple to the constantan conductor of the compensating leads. It should be explained that, although in this instrument the continuity of similar metals for each conductor is not preserved throughout from the hot junction to the cold junction, the thermal/e.m.f. characteristics of copper and constantan are similar to those of nickel-chromium and nickel-aluminium.

16. There are two types of cable used for the compensating leads. In the older type the two conductors are insulated with rubber which is taped and braided and finally treated with cellulose varnish. The insulating material on the later type of cable is of polyvinyl chloride resin which forms a sheath of figure eight cross-section round the two conductors.

17. In both types of cable the conductors, which consist of bunched or stranded wires, are sweated to soldering tags, a copper tag being fitted to the copper conductor and a constantan tag to the constantan conductor.

18. The insulation is divided at the ends for a distance of $1\frac{1}{2}$ in. and bound with yellow sleeving to prevent further separation of the covering. This sleeving also serves to identify the lead as "copper-constantan" and is additional to the red and blue polarity identification sleeves previously mentioned.

INSTALLATION

19. The thermocouple system will be found installed in the aircraft; the thermocouple head is secured to the exhaust tail-pipe of the jet engine beneath the tail-pipe fire guard, and the indicator is mounted on the dashboard in the pilot's cockpit.

20. When installing the thermocouple, it is essential to arrange for good contact with the jet pipe to ensure correct temperature indication. The underside of the flange at the head of the thermocouple, and the top of the attachment boss for the thermocouple on the jet pipe, should be polished with emery paper. Also, the nut holding the jet pipe to the thermocouple head should be fully tightened. Further, the protective metal braiding covering of the thermocouple leads is to be securely clipped to the jet pipe and to the fire guard so as to give good electrical contact.

21. Connection between the thermocouple leads and the compensating leads is made at a 2-way terminal block, the other end of the compensating leads being connected to the indicator.

22. When replacing compensating leads, ensure that the correct polarity of the leads is maintained so that positive is always connected to positive, and negative to negative. For purposes of identification, the positive conductor is flattened at the exposed end on the thermocouple hot junction unit, and is marked with a red sleeve on the compensating leads.

Note . . .

It is essential that no alteration be made to the length of the leads, otherwise the resistance of the circuit will be incorrect, resulting in inaccurate readings of the indicator.

23. When fitting a new indicator, the instrument pointer should be set to read the value of the ambient temperature by altering the zero adjuster.

24. To perform this adjustment, proceed as follows. Put the indicator on open circuit by disconnecting the leads to the terminals at the back of the instrument case. Attach a mercury-in-glass thermometer to the indicator in a position as close as possible to the cold junction compensator of the instrument. The two should be left for an hour, after which the pointer of the indicator should be set to read the same temperature as that shown on the mercury thermometer. This adjustment is made by rotating with a screwdriver the slotted head of the zero adjuster in the front of the indicator.

SERVICING

25. No attempt should be made by units to repair a faulty indicator or thermocouple; defective items should be replaced by new ones of the same type.

26. Whenever an indicator is removed from an aircraft, the two terminals should be shorted with a piece of wire to damp the pointer movement.

27. Zero correction of the indicator pointer should be made at the periods specified in the relevent aircraft servicing schedule in the manner described in para. 23 and 24.

28. A Standard Serviceability Test is given in Chap. 2.

Chapter 2

STANDARD SERVICEABILITY TEST
for
THERMOMETER, EXHAUST GAS TEMPERATURE, 0–800 Deg. C. (3·6 ohms EXTERNAL RESISTANCE)

Introduction

1. The following tests are to be carried out on the above-mentioned system immediately prior to installation in aircraft and at any time that its serviceability is suspect. The specified tolerances must not be exceeded.

2. During the tests outlined below, the indicator is to be mounted with the dial upright and on the vertical plane. Light tapping of the indicator is permissible during the tests.

3. An overall test of thermocouple, compensating leads and indicator should be carried out. If this test does not prove the system to be satisfactory the components of the system should be tested individually.

Test equipment

4. For the separate tests as well as for the overall test, the exhaust gas temperature thermometer test set (Ref. No. 6C/966) is required.

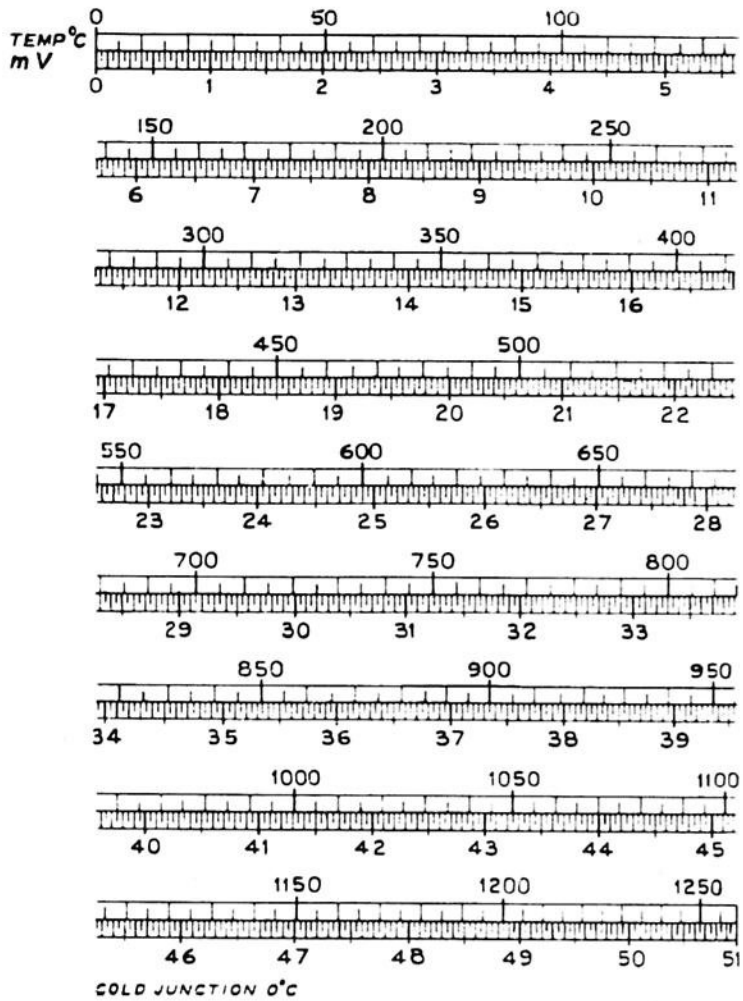


Fig. 1 Temperature-millivolt equivalents (nickel-chromium/nickel-aluminium couples)

Overall check of thermocouple system

5. To effect an overall check of the 0 to 800 deg. C. exhaust gas temperature thermometer system (3·6 ohms external resistance), the following operations should be carried out:—

(1) With the switch A in the OFF position, check that the instrument reads zero, adjusting, if necessary, by means of the zero adjuster.

(2) Set switch A to IND.50 and switch B to 0 ohms.

(3) Note the cold end temperature reading on the indicator, and set to 0 deg. C.

(4) Break the positive side only of the thermocouple compensating lead at the terminal connector, near the wing root.

(5) Connect the test set across the break (positive to the lead going to the indicator).

(6) press the button and set the rheostat controls to inject 24·9 millivolts into the circuit the indicator should read 600 deg. C.

(7) Re-connect the leads.

(8) Re-set the indicator to the cold end temperature reading, noted in (3).

Resistance of thermocouple and compensating leads

6. To test the resistance of a thermocouple together with its compensating leads, the following operations should be carried out.:—

(1) With the A switch in the OFF position, check that the instrument reads zero, adjusting if necessary, by means of the zero adjuster.

(2) Set switches A and B to R.

(3) Press the button and adjust the rheostat until the pointer indicates exactly 2 ohms.

(4) Set switch A to R and switch B to 2.

(5) Disconnect the compensating leads at the indicator.

(6) Connect the test set to the compensating leads.

(7) Press the button and read the resistance of the couple with its compensating leads, which should be 3·6 $\pm$ 0·05 ohms.

(8) Re-connect all leads.

Should the test not prove satisfactory, the resistance of the thermocouple and the compensating leads should be checked individually. Resistance of the thermocouple should be 2·68 ohms $\pm$ 0·03 and of the leads 0·92 $\pm$ 0·02.

Accuracy of indicator

7. To test the accuracy of an indicator (*Ref. No. 6A/2191*), the following operations should be carried out:—

(1) With the A switch in the OFF position, check that the instrument reads zero, adjusting, if necessary, by means of the zero adjuster.

(2) Plug in the resistor marked 3·6.

(3) Set switch A to IND.20 and switch B to EXT RES. IND.

(4) Disconnect the leads at the indicator.

(5) Connect the test set to the indicator, ensuring correct polarity.

(6) Set the indicator to read 0 deg. C.

(7) Press the button and vary the injected e.m.f. by means of the rheostat, calibrating the indicator to the following figures.

Test set reading Millivolts	Indicated reading in deg. C.
4·1	100
8.13	200
12·21	300
16·39	400

Release the push button. Change switch A to IND.50 and resume pressure on the button.

Test Set Reading Millivolts	Indicated Reading in deg. C.
20·64	500
24·9	600
29·14	700
33·31	800

If the indicator reads within $\pm$ 2 per cent of these figures it should be considered serviceable.

(8) Re-connect all leads.

(9) Re-set the indicator to the ambient temperature.

General

8. Should the system still be suspect, the thermocouple should be checked by applying heat at a known temperature and measuring the millivolt output. Fig. 1 shows temperature millivolt equivalents for nickel-chromium/nickel-aluminium couples.

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