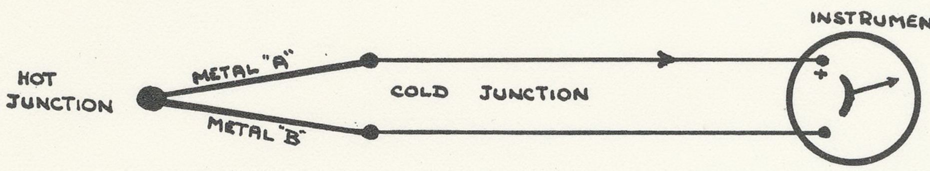
PYROMETRIC EQUIPMENT.

The purpose of the pyrometric equipment is to indicate to the pilot, by means of a cockpit instrument, the internal temperature of the engine and so prevent overheating and consequent probable engine failure. The temperature measured is that of the stream in the jet pipe or exhaust unit (as convenient) which bears a direct relationship to the more critical temperature of the turbine assembly.

Principle.

An electric current is created in a closed circuit of two dissimilar metals if the junctions of the metals are kept at different temperatures. This simple arrangement is called a thermocouple. The Electro Motive Force (E.M.F.) generated by the thermocouple is small, ranging from 1 to 7 millivolts (mv) for a temperature difference of 100° Centigrade (°C). Its actual value depends on what pair of metals is used.

The junctions are referred to as the "cold", or "reference junction" and the "hot", or "measuring junction". An instrument can be coupled into the circuit to the cold junction by a pair of leads - usually copper. The instrument itself then becomes, in effect, the cold junction.



But if the temperature of the cold junction changes it will cause a change in instrument reading and therefore an error in the reading of the hot junction temperature. This can be offset by the use of a device called a cold junction compensator.

Materials.

(1) The Thermocouple.

The metals used are CHROMEL and ALUMEL.

CHROMEL = 90% NICKEL + 10% CHROMIUM.
ALUMEL = 95% NICKEL + 5% ALUMINIUM, SILICON, AND MANGANESE.

These are more resistant to oxidation than other base metal types, and have a life of approximately 1000 hours.

The E.M.F. generated for various temperatures are:-

°C.	mv.
100	4.10
400	16.39
700	29.14
1000	41.31

(2) Protection Tubes.

Two tubes are used, one primary tube of porcelain protecting against gases at high temperatures, inside a secondary tube of nickel chrome for protection against shocks and corrosion.

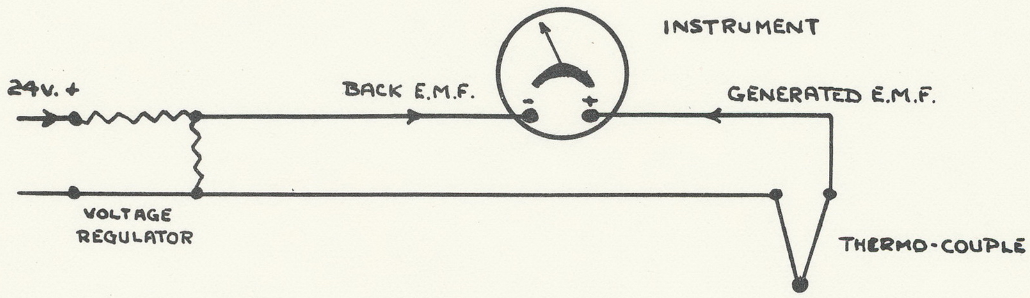
/Continued

Engine Equipment.

Four couples are connected in series to an indicator, i.e. a moving coil voltmeter. The scale is graduated from 400°C to 750°C, this covering the essential temperature range of the engine. The zero scale marking is immediately adjacent to the 400°C mark.

A single CHROMEL ALUMEL couple would generate 16.4 mv. when at a temperature of 400°C, but to enable a more robust instrument to be used the E.M.F. is boosted up to 65.6 mv. (4 x 16.4) by using four couples wired in series. This E.M.F. would cause the instrument to show a much higher temperature than 400°C, since 400°C represents the 0 mv. position on the scale, i.e. no current flowing.

Therefore to prevent any E.M.F. reaching the indicator until 400°C is reached, a back E.M.F. of 65.6 mv. is supplied via a voltage regulator from the aircraft system. It will now require a generated E.M.F. of more than 65.6 mv. to overcome the back E.M.F. and cause a reading on the scale.



Simple Circuit without Cold Junction Compensator.

At maximum Jet Pipe Temperature of approximately 700°C an E.M.F. of 29.14 is generated by each couple giving a total of 116.56 mv. This is opposed by a back E.M.F. of 65.6 mv. allowing the indicator to receive 51 mv. which corresponds to 700°C on the scale.

Voltage Regulator.

The voltage regulator used in the system gives a constant output of 1.5 v. despite changes in battery voltage, which may vary from 18 - 24 v. It consists of temperature sensitive resistances and two "Barreter" lamps. It is designed to be used with either single or twin installations by means of a removable dummy load link.

Cold Junction Compensator.

The 1.5 v. output from the voltage regulator is reduced to 65.6 mv. in the cold junction. But this may be subject to variations in air temperature. It is therefore necessary to compensate the indicator reading according to these changes to ensure that the correct hot junction temperature is recorded, and not the difference in temperature between hot and cold junctions.

This is done by the use of a Wheatstone bridge with one resistance exposed to local temperature changes, so that the resistance value alters permitting the voltage from the bridge to change, e.g. more voltage as the temperature falls and vice versa. This compensator gives the correct scale reading within 1% at all altitudes.

/continued.

FAULTS.

ERRATIC TEMPERATURE READINGS.

(1) Loose connections on the thermocouples.

(2) Shorting of one or more couples. Sometimes cures itself as the engine is warmed up since the joint may be made good.

LOW TEMPERATURE READINGS.

(1) Broken or disconnected thermocouple will give constant 400°C because the couples are in series, and no E.M.F. will be generated.

(2) Faulty voltage regulator giving too high an output.

(3) Faulty cold junction compensator.

HIGH TEMPERATURE READINGS.

(1) Failure of aircraft electrical supply (No back E.M.F.)

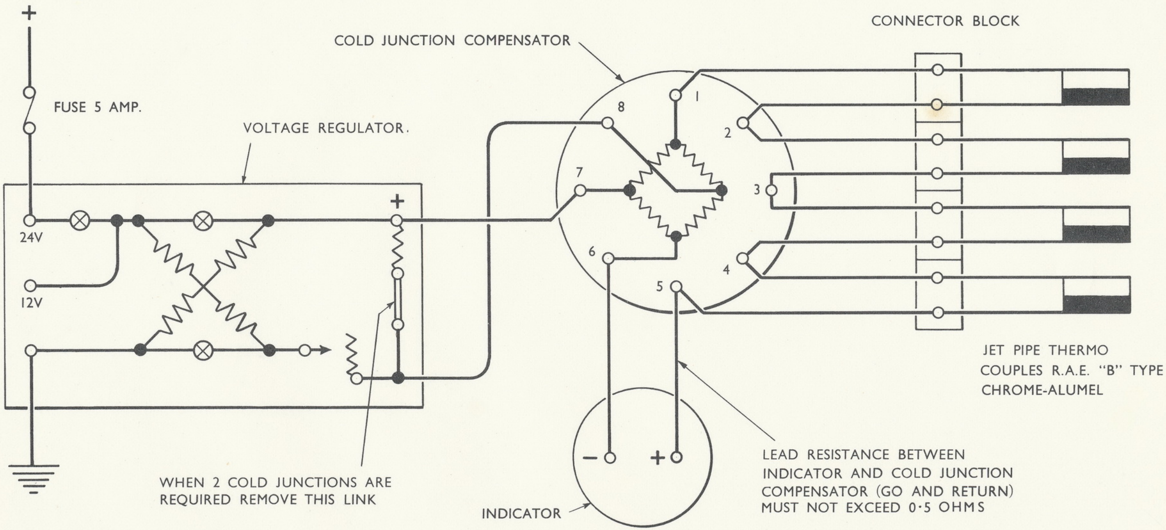
(2) Blown fuse in feed line to voltage regulator (No back E.M.F.)

(3) Too low an output from voltage regulator.

(4) Faulty cold junction compensator.

N.B. (a) If one voltage regulator is used on a multi-engine installation (e.g. Meteor) a fault in this would affect readings from all engines.

(b) If the "ground/flight" switch is not turned to "flight" before the external accumulator is switched OFF or disconnected after engine starting, no back E.M.F. will be received by the pyrometric equipment, thus causing very high readings which might damage the instrument.



TYPICAL JET TEMPERATURE RECORDING UNIT

[PYROMETRIC EQUIPMENT]

AVON.

TOP TEMPERATURE CONTROL.

FUNCTION.

The top temperature control system automatically limits the maximum jet pipe temperature (J.P.T.), thus relieving the operator of the responsibility. If the engine J.P.T. exceeds the datum value, the engine throttle valve lever is automatically closed by an electrically operated actuator until the datum J.P.T. is restored.

The movement of the actuator is taken through a bell crank mechanism interposed between the engine and cockpit throttle levers. This mechanism enables the actuator to move the engine throttle lever without movement of the cockpit lever.

The system endeavours to produce the datum J.P.T. at all throttle positions, therefore at idling R.P.M. the actuator will be at full travel in an effort to produce maximum throttle opening. As the throttle valve is manually opened the actuator will remain in this position until the datum J.P.T. is exceeded.

LOCATION.

(a) The actuator is mounted on the lower half of the compressor case adjacent to the engine throttle lever.

(b) The magnetic amplifier which supplies the motive power for operating the actuator is located in the airframe.

(c) Eight thermocouples connected in parallel are positioned in the jet pipe.

OPERATION.

The voltage difference between the engine and the datum J.P.T. is amplified and supplied to either an "open" relay or a "close" relay.

These relays energise and determine the direction of movement of the actuator spindle.

If an excessive J.P.T. is experienced the amplifier energises the "close" relay which causes the actuator spindle to extend.

The spindle movement when taken through the bell crank lever mechanism has the effect of increasing the radius of the engine throttle lever. The aircraft pick-up rod is fixed at the far end by the friction damping of the cockpit throttle lever. The effective increase in length of throttle linkage thus closes the engine throttle lever until the datum J.P.T. is obtained.

The maximum "trim" that can be given to the throttle valve is 30° at full throttle, and progressively less at smaller throttle openings.

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BASIC SETTING.

The splined throttle lever is engaged on the hub of the shaft with the pinch bolt boss running in a true horizontal plane in the fully opened position.

Connect up the aircraft pick-up rod and throttle lever and adjust as necessary with the object of obtaining the usual "spring", approximately 1/16" to $\frac{1}{8}$" in the quadrant slot when the lever is on the idle stop, but contrary to usual practice, no spring when in the fully open position. The latter point is necessary in order that the actuator push rod re-action is immediately transmitted to the throttle lever, tending to close the throttle, and thus limit the J.P.T.

A suggested method is to adjust the controls with a .005" feeler gauge interposed between the throttle lever and the full open stop until a nip is obtained. Remove the feeler and recheck with a .002" feeler for freedom.

If it is found impossible to obtain the full range by adjustment on the aircraft controls, further small adjustment can be made on the link (actuator to bell crank lever), but it is important that finally a clearance of .125" is present in the bell crank lever machined recess when the throttle is fully closed.

Finally, ensure that all controls and levers are free from fouls throughout the range, and that control rods are screwed in safely. Tighten all lock nuts.

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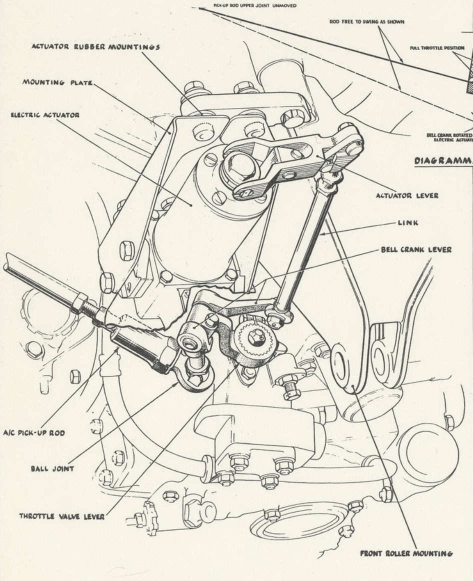
FULL THROTTLE POSITION

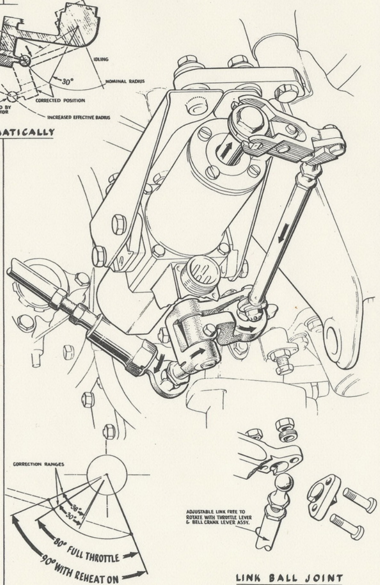
- THROTTLE LEVER AT FULL OPEN (I.E. 80° FROM IDLING) & J.P.T. WITHIN LIMITS (ACTUATOR RETRACTED)



VIEW ON UNDERSIDE OF ENGINE, LOOKING AFT

THROTTLE CORRECTED (CLOSED 30°)

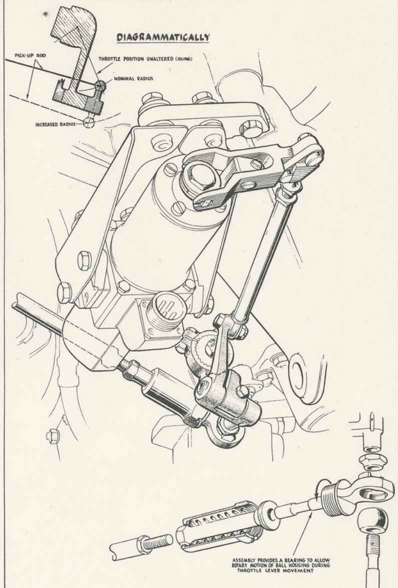
- THE MAX. J.P.T. HAS BEEN EXCEEDED & THE ACTUATOR IS EXTENDED BY AN AMPLIFIED SIGNAL FROM THE JET PIPE THERMOCOUPLES. THE BELL CRANK LEVER MOUNTED ON THE THROTTLE LEVER IS ROTATED SUCH THAT IT INCREASES THE EFFECTIVE RADIUS OF THE AIRCRAFT PICK-UP POINT FROM THROTTLE LEVER CENTRE. THE PILOT'S LEVER BEING FIXED, THE AIRCRAFT PICK-UP ROD CAN NOT MOVE EXCEPT BY SWINGING DOWNWARDS ABOUT ITS UPPER JOINT (NOT SHOWN) & SO ACCOMMODATING THE INCREASE IN T.V. LEVER LENGTH (RADIUS). THE RESULT OF THIS IS A THROTTLE LEVER CLOSURE OF 30°. APPROX. SIMILAR POSITION RESULTS IF THROTTLE LEVER WAS IN REHEAT POSITION (SEE FOOT OF PAGE)



LINK BALL JOINT

IDLING POSITION

- IN THIS POSITION THE ACTUATOR MOVEMENT WOULD HAVE NO EFFECT ON THROTTLE SETTING BUT WOULD ONLY SWING THE AIRCRAFT PICKUP ROD ABOUT ITS UPPER JOINT.



PICK-UP ROD BALL JOINT

AVON — AUTOMATIC TOP TEMPERATURE CONTROL

1.2.56

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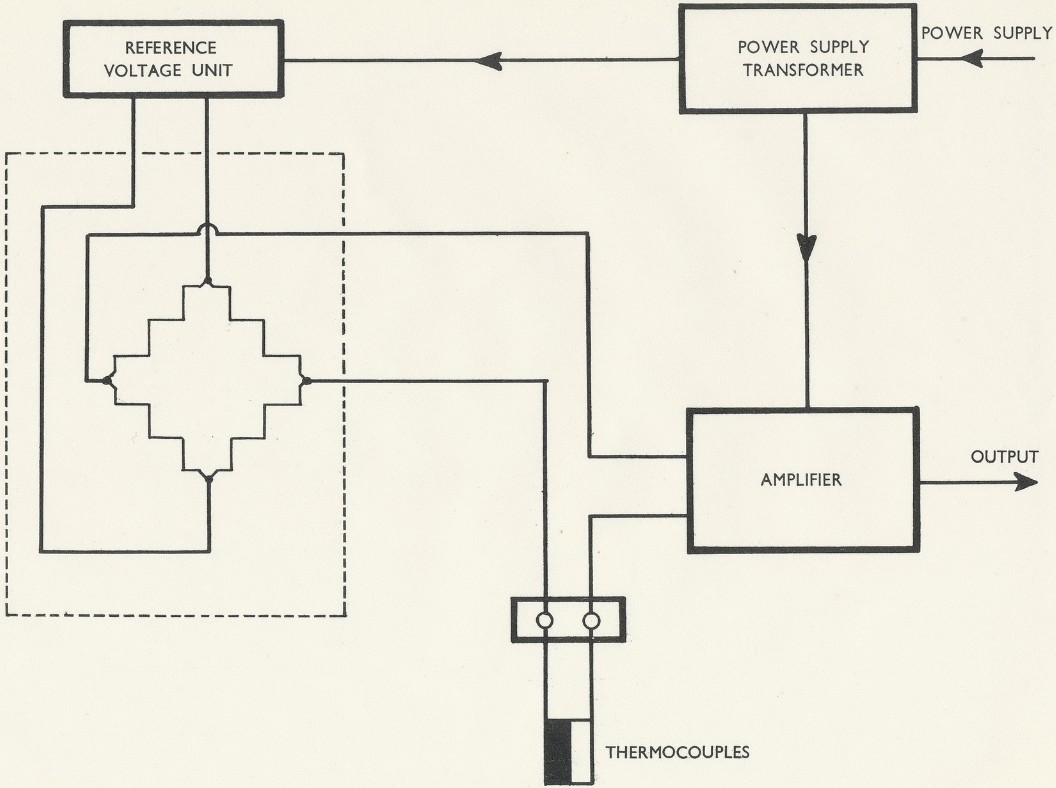

AVON - TYPICAL TOP TEMPERATURE CONTROL CIRCUIT

1.12.55

AERO ENGINE SCHOOL
COURSE NOTE
No TAv.167