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Electronic Remote Temperature Indicator

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ABSTRACT. This paper describes an instrument designed for measurement of temperature at any point far from the observatory or meteorological office where direct reading from the thermometer cannot be taken conveniently. Thermistors are used as a temperature sensitive element in a phase shift oscillator. The frequency of oscillation of the oscillator changes as the thermistor resistance changes with temperature.

1. Introduction

The runway temperature is a very important meteorological element for the Jet pilots before they take off. It is rather inconvenient to supply the temperature recorded in the Stevenson Screen to meet the demands of the pilots. Besides the temperature recorded in the screen is not representative of the runway temperature. In order to avoid these drawbacks, an instrument has been developed which can give a continuous record of the temperature of any point, where the sensitive element of the instrument is placed. The instrument is also suitable for measurement of temperature of agricultural farms from the observatories. The recorder part of the instrument can be placed on the observer's desk in the observatory or the Terminal Building whatever be the distance between this point and the sensitive element. The instrument uses thermistors in a phase shift oscillator circuit so that the change of resistance of the thermistor with variation of temperature, changes the frequency of the oscillator. The oscillator output is transmitted by means of a cable to the recording head. The instrument gives a continuous record of temperature within an accuracy of $\pm 0 \cdot 5$°C.

2. The equipment

The instrument consists of three different parts : (1) Transmitter, (2) Frequency meter and (3) Recorder. Fig. 1 shows the instrument. Fig. 1 (a) is the photo of the transmitter with temperature sensitive element 'X' while Fig. 1 (b) is that of the frequency meter and the recorder. The transmitter consists of a phase shift oscillator, a cathode follower and their power supply system and is shown in Fig. 2. The tube 6AC7 is the oscillator tube. The phase shifting network consists of three sections having three ·01 microfared capacitors and resistors R_1, R_2 and R_3. R_1 is a fixed 10 Kohm resistance while R_2 and R_3 are thermistors. This network shifts the phase of the voltage at the plate of the amplifier tube 6AC7 and feeds it to the input of the tube. At the frequency of oscillation the phase shifting network produces a phase shift of 180° of the plate voltage of this tube and thus the feedback to its grid from the output terminal 'A' of the network is in phase with the input voltage, because already 180° phase change exists between the grid and the plate voltage of the tube. The amplifier gain compensates the attenuation caused by the network and thus the oscillation is maintained. With R_2 and R_3 changing, the value of the frequency for which 180° phase shift condition is satisfied by the network, changes and therefore the frequency of oscillation changes. The thermistors are made of suitable semi-conductor materials having large negative coefficients of resistance, *i.e.*, the resistance R of the thermistor decreases with the increase of temperature T according to the relation—

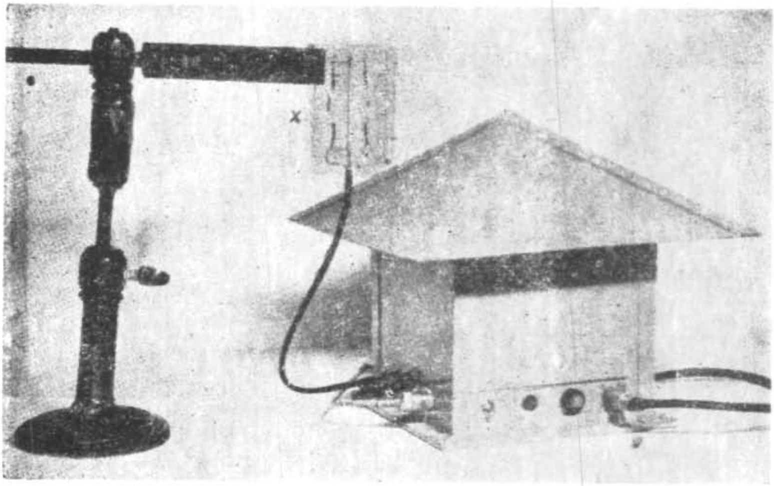

Fig. 1(a)

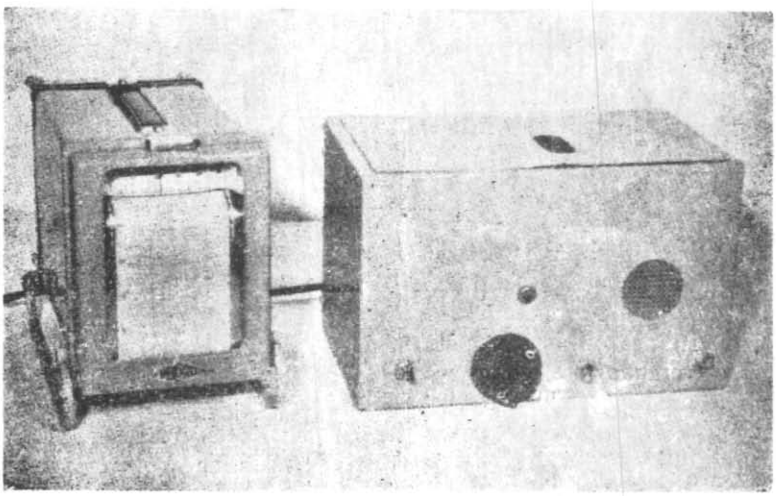

Fig. 1(b)

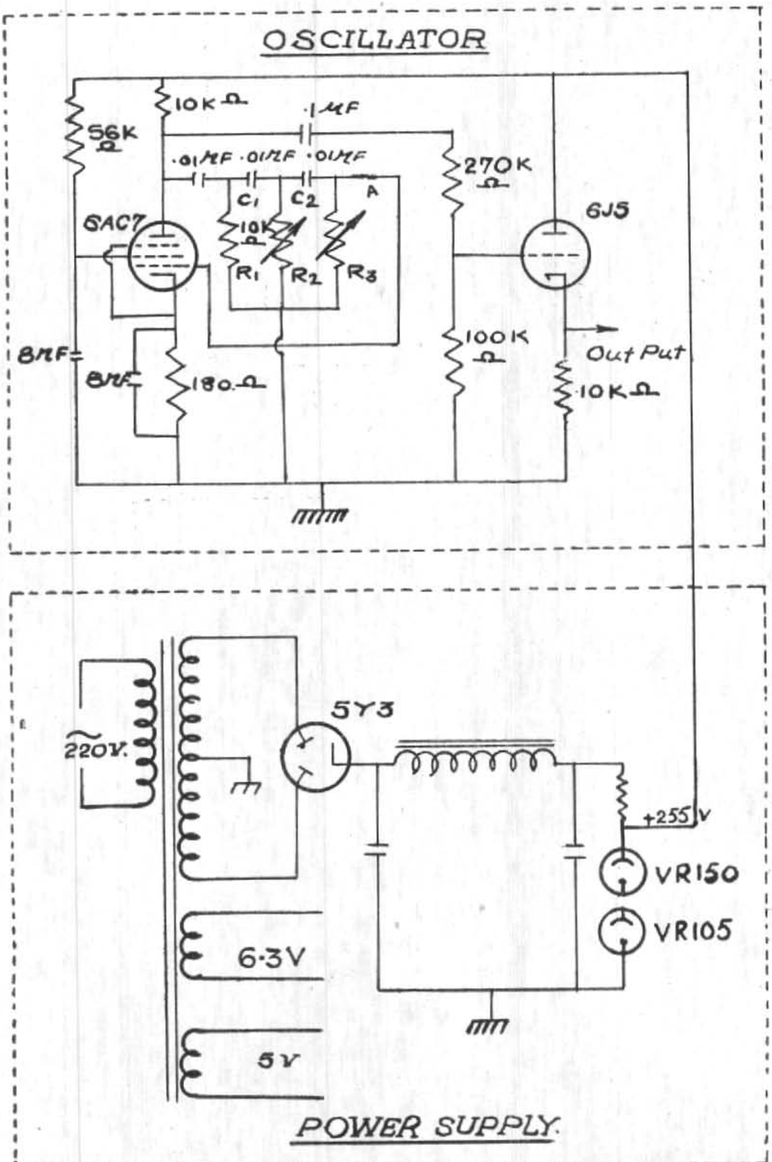

Fig. 2. Transmitting equipment for Remote Temperature Indicator

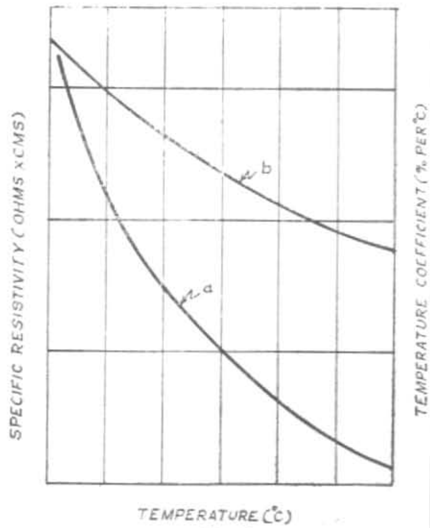

Fig. 3

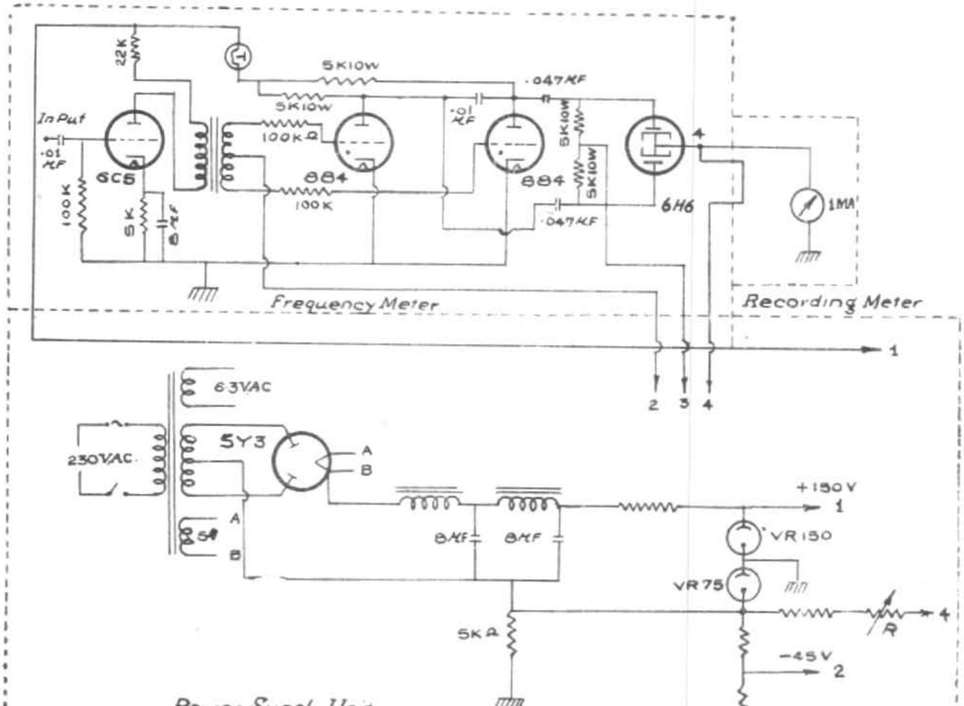

Fig. 4. Receiving equipment for Remote Temperature Indicator

$$R = A \exp(B/T)$$

where A and B are constants and T is expressed in degrees absolute.

The temperature coefficient of resistance is therefore $1/R \times dR/dT = -B/T^2$ and changes inversely as the square of the absolute temperature.

The thermistors used in the circuit are those manufactured by the National Chemical Laboratory, India and holds good the above characteristics. The characteristic curve of the thermistors as supplied by the manufacturers is reproduced in Fig. 3. The curve (*a*) gives the relation between R and T and the curve (*b*) shows that the temperature coefficient changes inversely as the square of the absolute temperature.

The thermistors R_2 and R_3 used in the circuit have a resistance of the order of 50 Kohms at 0°C and 8 Kohms at 50°C. This range of resistance change gives a frequency variation of the order of 425 cps. In northern India the variation of temperature throughout the year is normally covered by this range, *i.e.*, 0°C and 50°C.

The tube 6J5 is the cathode follower tube to match the impedance of the transmission line to the output of the oscillator.The double diode rectifier tube 5Y3 supplies power to both oscillator and cathode follower.

Fig. 4 shows the circuit diagram of the frequency meter. The circuit is that of a standard frequency meter. The provision for variable negative bias supply has been kept in the power supply system in order to balance the initial current at the recorder to set it to the desired range. The terminal 4 of the power supply gives the variable negative voltage which is connected to the positive terminal of the recorder. By adjustment of the potentiometer R the current through the meter can be adjusted to set the meter in the desired range.

The recording instrument is a DC-milliameter (recording type) of one milliampere range. Fig. 5 shows the calibration curve of the instrument. It may be seen from the calibration curve that for a change of 30°C the output current of 6H6 tube covers the range of the milliameter. The response of the frequency meter is linear and its sensitivity is of the order of ·004 milliampere per cycle. By adjustment of the potentiometer R the instrument can be set in any one of the three ranges of temperature shown in the temperature axis of the calibration curve and the temperature directly read from the curve.

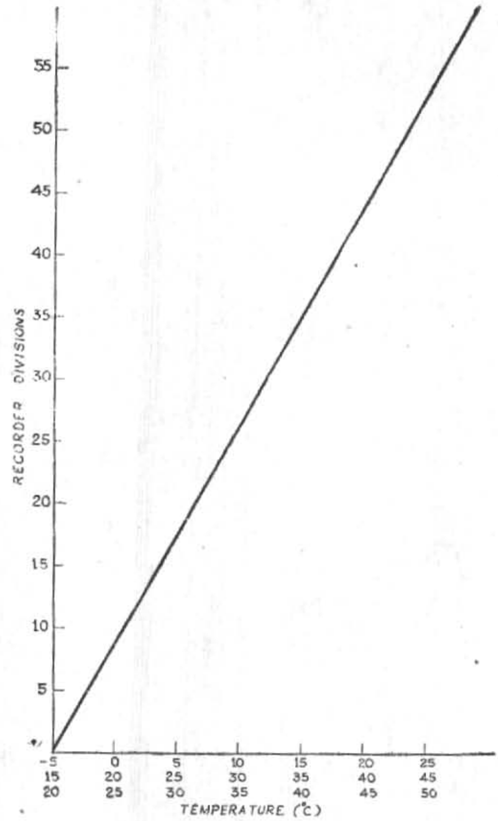

Fig. 5. Calibration curve

3. Result

The instrument was put to rigorous field trials and the readings were compared with the temperature indicated by a thermometer placed side by side to the sensitive element.

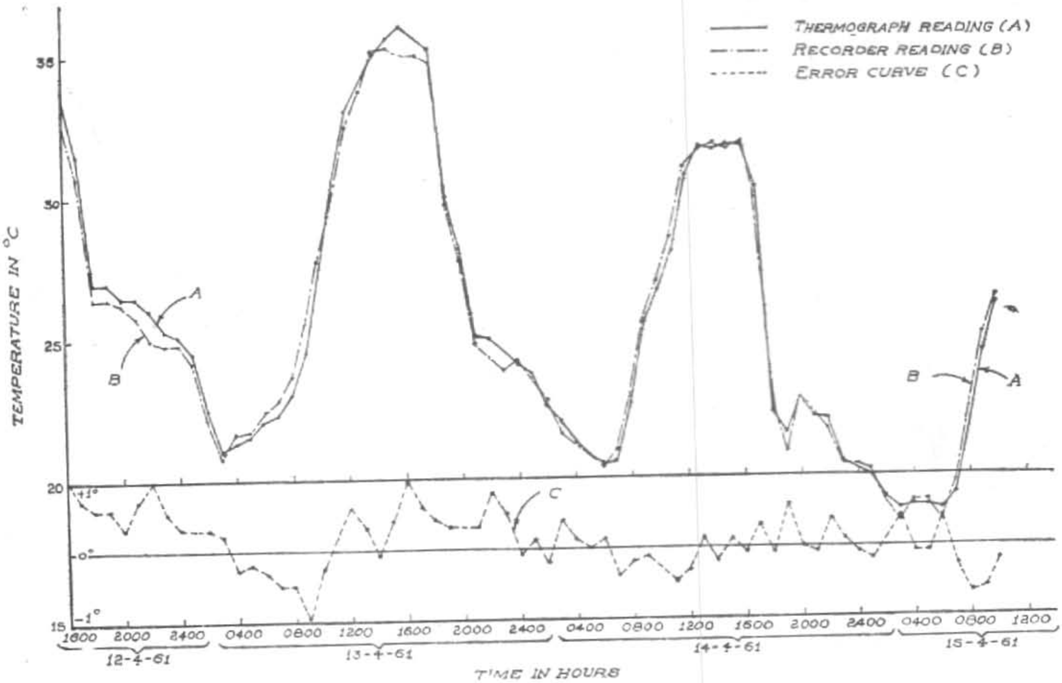

Fig. 6

The temperatures recorded by the instrument and the thermometer agree quite well except for sudden change of temperature when the temperature changes suddenly by a few degrees as those associated with squalls or showers. In such cases the temperature recorded by the electronic instrument have an error in the range 0·5°C to 1°C. This is a defect inherent to the thermistors.

Comparisons with thermograph have shown that this instrument has a lag factor much less than the bimetallic type thermograph. Four days' records of both the instruments are reproduced in Fig. 6. The curve A and B of Fig. 6 are those of thermograph and electronic equipment respectively. It may be seen that whenever the temperature is falling the thermograph temperature is higher than the electronic instrument's temperature while whenever the temperature is rising the thermograph temperature is lower than the electronic instrument temperature. This shows that thermograph takes more time to attain the temperature of the environment than the electronic instrument. The curve C of Fig. 6 shows the plot of the difference of the thermograph readings with respect to the electronic instrument.

4. Acknowledgement

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