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An Electronic Multi-channel Counter-type Time Interval Meter for Mass Calibration of Chronometric Radiosonde

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ABSTRACT. An electronic equipment for mass calibration of chronometric radiosonde has been described. Instead of measuring the linear displacements recorded on the chart, the reference contact of the radiosonde has been utilised to open an electronic gate and the element contact to close it. The duration of the gate is measured by pulses derived from a standard oscillator. Three gates are employed for each radiosonde, one each for pressure, temperature and humidity. Compact and versatile and with 72 channels, the equipment is capable of calibrating 24 radiosondes at a time, saving manpower and space.

1. Introduction

During recent years, after opening of a large number of radiosonde stations which take two soundings daily, the output of calibrated radiosondes had to be increased considerably to meet with the increased demand. A new calibration chamber with a capacity of calibrationg 36 clock-type instruments was, therefore, installed for the purpose. In the old calibration method, one mechanical recorder was used for each radiosonde. It consists of an endless chain driven by a synchronous motor of 2 r.p.m. The chain contains four stylus with printing roller at their ends. A relay actuated by signals from the meteorological elements presses these rollers and a mark is printed on a chart. The four stylus are spaced six inches apart so that the distance between the marks corresponding to any two pair is also six inches. Thirtysix recorders are, therefore, required for thirtysix radiosondes for each batch of calibration. The construction of accurate mechanical recorders requires time and due to their bulky size large space is required for installation. It becomes difficult for one operator to attend to all these thirtysix recorders spread over the room. As a consequence, the whole recording system for calibration becomes extremely unwieldy, requiring large space and a number of operating personnel for handling the recorders simultaneously. The electronic calibrator has been designed to overcome these difficulties resulting in saving of space and number of operating personnel. With its help only two persons can handle efficiently the calibration of 24 instruments simultaneously.

2. Principle

The chronometric radiosonde (Mathur 1946) operates on Olland time cycle principle in which the time interval between a reference contact and a variable contact actuated by meteorological elements is a measure of the magnitude of that element. The period of one complete cycle is thirty second which is converted into a linear displacement of six inches on the chart paper so that a displacement of one tenth of an inch from the reference contact is equivated to half second. The main principle underlying the present method in the new calibration is that instead of measuring the linear displacement from reference mark, the time interval is measured directly by comparing it with the period of a standard oscillator. The pulses from the standard oscillator are fed to low speed frequency counters and if the counting is done

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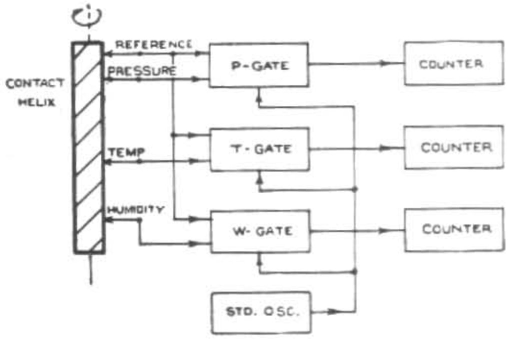

Fig. 1

at a uniform rate, the number of counts in the desired interval would be proportional to the corresponding displacements, thus enabling one to draw calibration curves after obtaining the time intervals from the number of counts. The rate of counting has been determined from the accuracy required in measurement of displacements which is $\pm 0{\cdot}05$ inch equivalent to $0{\cdot}25$ sec. One counting interval should at least, therefore, be equal to $0{\cdot}25$ sec which is equivalent to a counting rate of 4 times per sec.

To measure the time interval between the reference and contacts from other elements, three electronic gates are employed. The reference contact opens all the three gates for pressure, temperature and humidity simultaneously and the three low speed mechanical counters start counting the pulses from the standard oscillator. Contacts from other elements close the respective gates. The operation is shown in the block diagram in Fig. 1.

3. Circuit description

3·1. *Gate Circuit and Counters*—The schematic circuit diagram of the gate and counter circuit is shown in Fig. 2. Two thyratrons, V1 and V2 are employed to generate the gate by means of two pulses derived from the reference and any one of the P, T or W contacts. The tube V3 is normally cut off and conducts during the gating period allowing pulses from the standard oscillator to pass through it. A mechanical counter placed in the plate circuit counts these pulses. The operation is similar to circuit described by Tooley (1946).

The grid of both the thyratrons are returned to high negative potentials; they are, therefore, maintained in the cut off condition. Similarly, the grid of the gating tube V3 is also returned to negative potential cutting it off. A momentary positive pulse from the reference contact applied at A, lowers the grid potential and fires the thyratrons V1. The potential at point C is lowered, allowing the tube V3 to conduct. The pulses from the standard four cycle oscillator fed to its grid operate the counter placed in the anode circuit.

After the tube V1 has fired, its grid loses control. To close the gate and to restore the circuit to its original condition, the tube V2 is fired by applying another positive pulse at B derived from either P, T, or W. Firing of V2 raises the potential at point C, cutting off the tube V3 and the counter in the plate circuit stops counting. The time interval between the two pulses is, therefore, measured in terms of frequency from the standard oscillator.

It may be noted that application of positive trigger at B prior to A would have no effect on V2 due to absence of H. T. at the plate of V2. Moreover, once both V1 and V2 fire after completing one cycle of operation, subsequent application of positive trigger voltages at A and B would have no effect. To begin a fresh cycle of operation a reset switch provided in the anode circuit of V1 must be opened to remove the H. T. momentarily from the tubes. The potentiometer P adjusts the queiscent voltage on the grid of V3 to ensure stable operation. The neon tube I has been used for indicating the condition of the circuit. When V1 is non-conducting, voltage at the plate of V1 is sufficiently high to make it glow. As soon as V1 fires, voltage at the place is brought down sufficiently to extinguish the neon indicating that the circuit has completed one cycle of operation. When the reset switch is pressed, it again

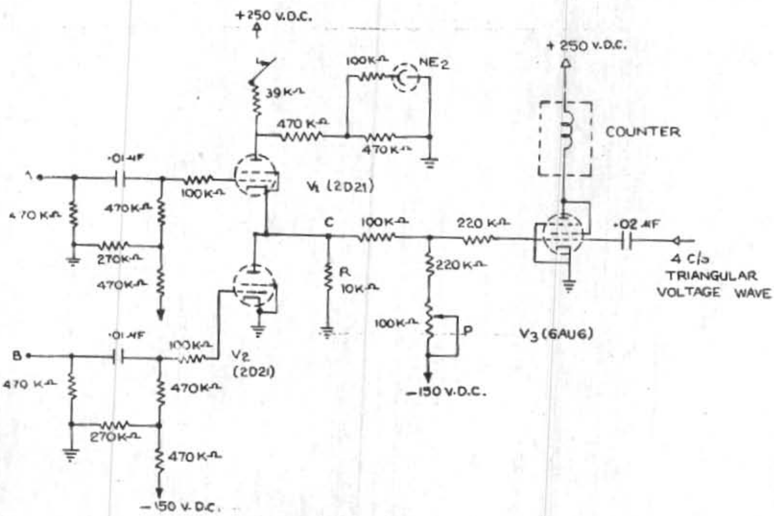

Fig. 2

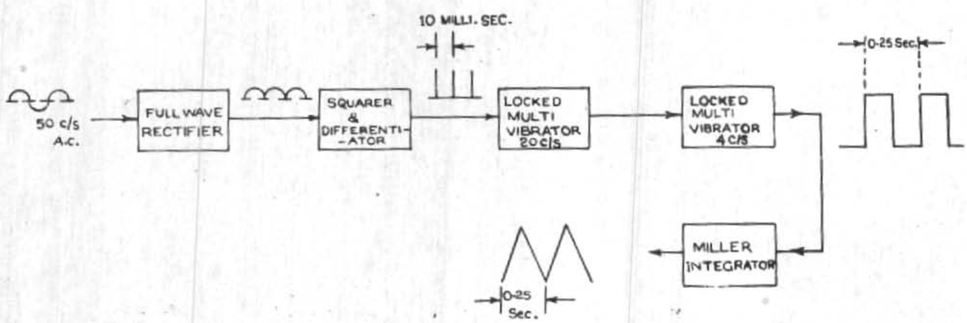

Fig. 3

glows indicating that the circuit is ready for another cycle of operation.

3·2. *Standard Oscillator*—The block diagram of the oscillator is shown in Fig. 3. The triangular voltage wave form of 4 c/s is derived from the 50 c/s main frequency from which pulses at a rate of 100 per second are generated by full wave rectification and are subsequently squared and differentiated. Two stages of frequency division in the ratio 5 : 1 in each stage by locked and stable multivibrators bring down the frequency to 4 c/s with approximate square wave output. This voltage is applied to a Miller Integrator circuit to generate triangular wave for feeding into the counters. This method of obtaining 4 c/s voltage wave form ensures stability and frequency drift; frequent checking of the actual frequency is also not required.

A voltage of triangular wave form was necessary as it was not possible to provide D.C. coupling to all the gate circuits in order to keep the grid of V3 tube isolated from all other D.C. potential except that due to the above gate. Moreover, a square wave with a low frequency of 4 c/s when fed through a condenser of nominal value would result in differentiation and consequent unstable operation of the counter, whereas a triangular wave form after differentiation would generate a rectangular wave form at the grid of V3 ensuring more stable performance.

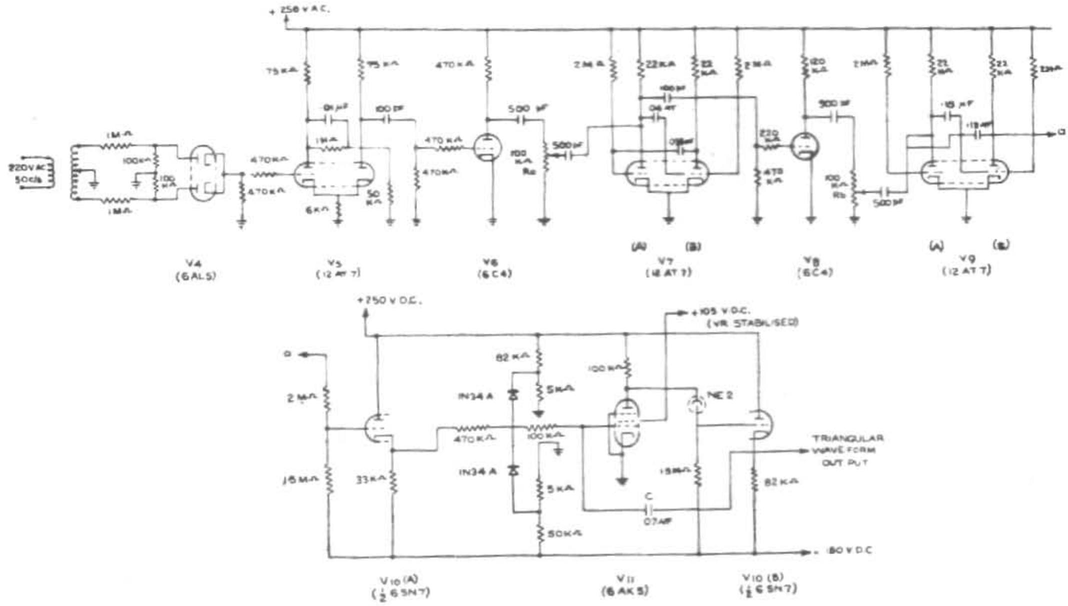

Fig. 4.

The schemetic circuit diagram is shown in Fig. 4. A fraction of balanced 50 c/s voltage from the secondary of the power transformer is fed to a double diode V4, generating 100 c/s half sinusoids at the common cathode load of V4. The double triode tube V5 acts as a schmitt discriminator circuit where both the sections are turned 'off' and 'on' alternately as the voltage at the grid of V5A goes above and below certain level. Due to the half sinusoids at the grid of V5A, a narrow pulse of 100 c/s with steep edge appear at the plate of V5B and are subsequently differentiated and fed to the grid of V6. The tube V6 is operated with zero bias, as a consequence, positive triggers are clipped off due to grid current conduction and only negative pulses appear inverted at the plate. A fraction of the voltage is fed to the next multivibrator stage for synchronization.

The tube V7 acts as an astable multivibrator having natural frequency slightly less than 20 c/s. The amplitude of the synchronizing pulses are adjusted by the potentiometer Ra to lock the multivibrator at 20 c/s, by applying them to one of the plates. The output of V7 is again differentiated and positive trigger pulses are obtained at the plate of V8. The tube V9 is an astable multivibrator having a free running frequency slightly less than 4 c/s. It is locked to 4 c/s by adjusting the potentiometer Rb. The circuit constants are so chosen that the output voltage wave-form is approximately square.

A fraction of the output voltage from the plate of V9B is fed to the cathode follower V10A whose cathode is returned to — 150 volts D.C. The fraction has been so chosen by returning the point to - 150 volts through two resistances that the cathode of V10A swings more or less symmetrically with respect to ground. The purpose of the crystal diodes is to clamp the point B alternately to equal positive and negative excursions of the cathode of VI0A.

The wave form at B is integrated by the Miller Integrator consisting of amplifier V11 and cathode follower V10B. The screen voltage of V11 has been derived from a regulated supply in order to keep its fluctuation with respect to cathode to a minimum.

The plate of V11 is D.C. coupled to the grid of the cathode follower V10B through a neon tube returned to —150 volts D.C. to ensure a D.C. voltage drop of 60 volts without reducing the amplitude of voltage variation at the grid of V10B. The output of V10B is coupled to the grid of V 11 through the condenser. When the point B is clamped to +14 volts, the grid of V10 would only rise a fraction of a volt due to high negative feed back and thus keep the current through R almost constant. This constant current would charge C linearly with time and cathode of V10B and plate of V 11 would fall at a linear rate. When B is clamped to —14 volts, reverse action takes place and as a consequence cathode of V10B and plate of V 11 rise at a linear rate. A triangular waveform of approximately 150 volt amplitude is obtained at the cathode of V10B due to one cycle of square wave voltage at B.

The slope of the linear rise and fall is mainly determined by the C and R which are so chosen that after coupling through condenser to the gate circuits, a square wave voltage of sufficient amplitude is generated through differentiation at the grid of V3 for stable operation of this counter.

3. General layout of the equipment

The whole equipment has been constructed on a sub-assembly basis, keeping in view ease of replacement and servicing. All the counters along with the reset switch and neon indicators of the gate circuit are arranged on a front panel in six columns, two each for pressure, temperature and wet bulb. The reset switch and the indicator neons are placed on either side of the corresponding counter. Gate circuits have been constructed one each on a bakelite strip and are arranged on trays, each tray containing six such strips. All connections to the gate circuit are made through an eight pin plug and socket so that the strip is easily detachable for servicing or replacement. One filament supply transformer fitted on each tray supplies the filament power for all the tubes of the gate circuit. The contacts of the radiosonde instrument are not directly employed to trigger the gate circuits. These contacts operate miniature 2 volt relays, one each for reference, pressure, temperature and wet bulb. These relays in turn supply the necessary triggering voltages to the gate circuits and thus avoid the necessity of applying higher voltages to the instruments themselves ensuring safety to the operating personnel. Ten stabilized power supplies, each capable of delivering 180 m.a. at 250 volts D.C. have been constructed to supply all positive high tension requirement, for 72 channels. These units employ standard series tube stabilization. All the controls of the equipment are mounted on the front panel. One power supply for —150 volts D.C. employing series tube stabilisation supplies the whole requirement of negative H.T. For applying power to various units automatically in proper sequence to avoid any damage a power control and distribution unit with relays has been constructed. The main switch puts on A.C. power to the negative power supply unit which is turn actuates a relay for supply A.C. power to all other positive H.T. units and filament transformers. Care has been taken to ensure that A.C. power to the negative power supply unit is withdrawn last when the main switch is put off. Three push button switches, one each for pressure, temperature and wet bulb, have been utilized to reset all of the corresponding gate circuits, simultaneously by breaking the H.T. supplies to the gate circuits through relays. There is also provision for keeping the gate circuits of pressure or temperature or wet bulb either permanently 'on' or 'off' by three corresponding toggle switches.

4. Operation

The operation of the equipment is simple and requires only one non-technical person. The pressure and temperature inside the chamber is lowered continuously approximately simulating the atmospheric conditions. Readings are however taken when either pressure or temperature is constant

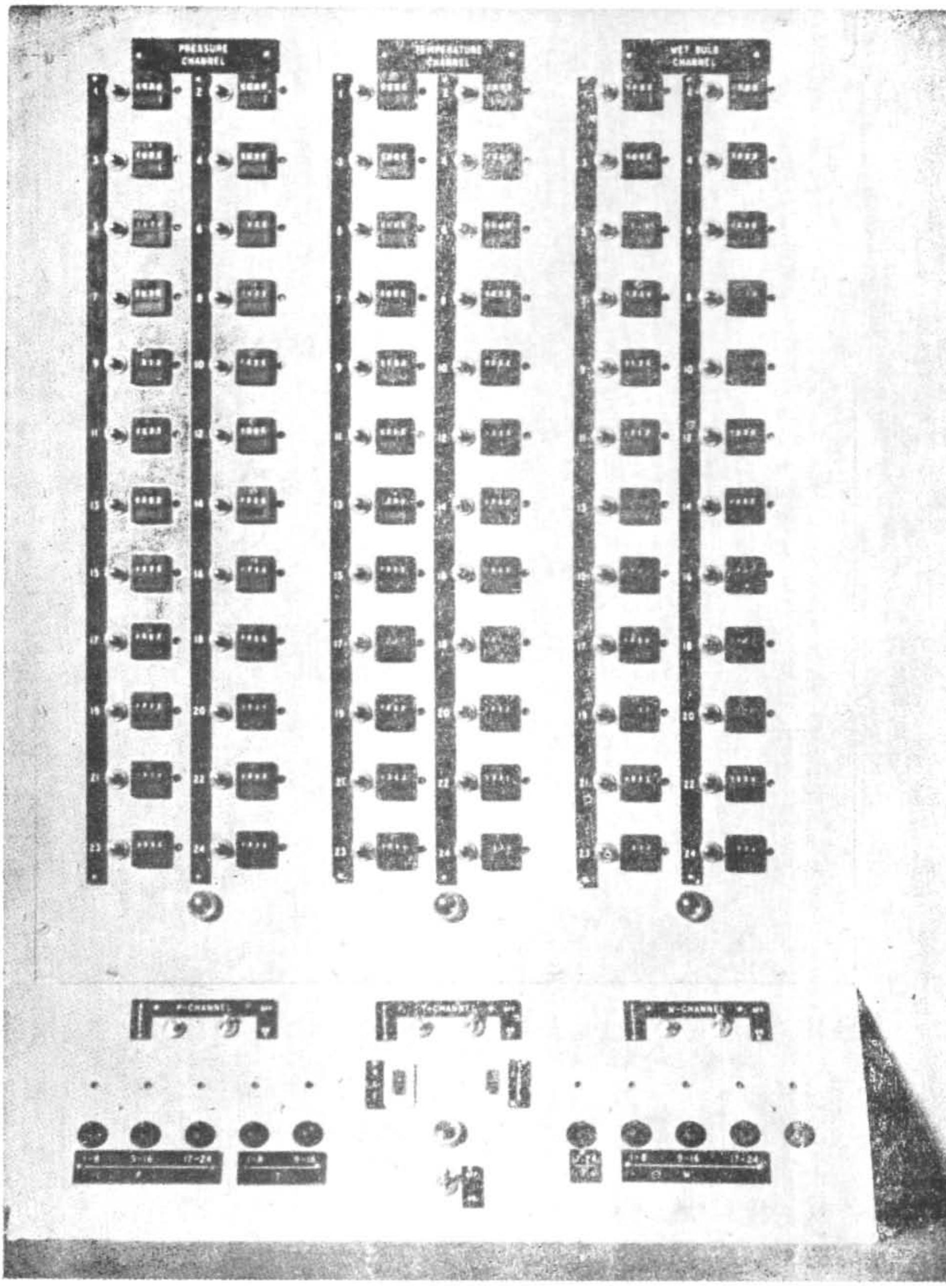

Fig. 5.

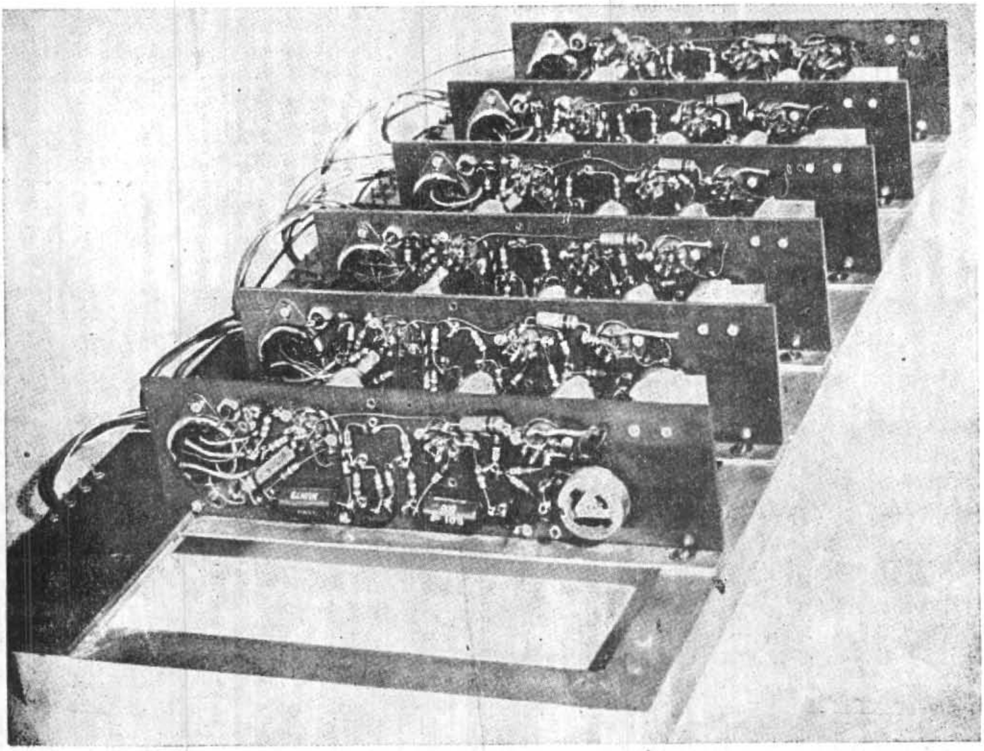

Fig. 6

within the chamber. When the requisite condition has been achieved, the operator takes down the reading of all the counters and then presses the 'count' button. The counters then register time interval for one cycle of operation. These readings are 'frozen' until the 'master reset' button is pressed enabling the operator to take down the readings of all the 72 channels. If necessary, he can repeat the number of registers so that average for a number of cycles can be recorded. He can reset all P, T or W channels simultaneously, on a group, then on each one individually, if so desired. Neon indicators tell him in what condition the channels are. A continuously flashing neon from 4 c/s oscillator indicates whether the standard oscillator is functioning properly.

With a calibration unit, all the channels are checked once everyday before routine calibration to ensure that these are functioning normally. This consists of a timing unit from which pulses spaced accurately at 5, 10, 15, 20, 25 and 30 seconds interval are generated. These are fed to each channel and its reading compared.

A photograph of the front panel of the equipment may be seen in Fig. 5. Fig. 6 also shows assembly of one channel together with associated tubes, components and relays.

5. Conclusion

The equipment is being used for routine calibration of radiosonde instruments at the Meteorological Office, New Delhi. It is compact in size, simple in function, easy to operate and requires only one personnel who can handle 24 radiosondes simultaneously. A sample calibration curve drawn with the help of this unit together with points from the mechanical recorder is shown in Fig. 7.

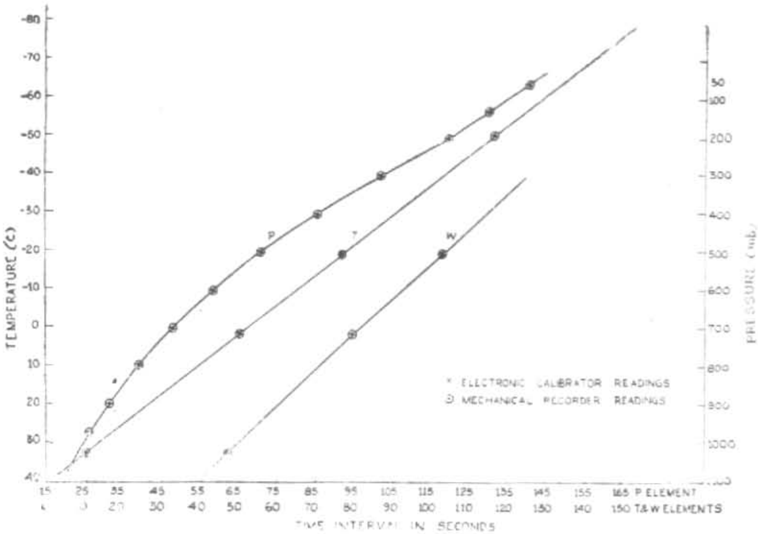

Fig. 7. Calibration curve for R.S. No. 2864/60

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