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AN AUTOMATIC TEMPERATURE CONTROL SYSTEM FOR TELESCOPE PILLBOXES

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The objective of this report is to present a method for automatically controlling the temperature inside the telescope pillboxes. Experience has shown that the stability of a very sensitive receiver is degraded by temperature variations of only a few degrees Centigrade. In order to reduce this problem an attempt has been made to stabilize the temperature of the pillboxes. At present, this is done by monitoring the pillbox temperature, and manually adjusting the heating or cooling current to keep the temperature reasonably stable. However, since the atmospheric temperature continues to vary, the telescope operator must keep a constant check on pillbox temperature and make adjustments accordingly. Furthermore, if large fluctuations in atmospheric temperature occur it may be very difficult to keep the pillbox temperature stability within reasonable limits.

The system to be described operates as a proportional controller, thereby eliminating interference generation and temperature cycling as would result in the case of a switched system. It is fully automatic and selects either a heating mode or a cooling mode as required to keep a constant temperature as measured with the sensing thermistor.

In figure 1 is shown the schematic diagram of the system. As can be seen, thermistor R_T, the temperature sensing device, is mounted in the pillbox and connected to the system with shielded cable to prevent hum pick-up. The thermistor forms one leg of a 60 cps, AC bridge which is balanced if the total resistance of the Temperature Adjust Potentiometers, $P_1 + P_2$, is equal to that of the thermistor. If an unbalance does exist, the output of the bridge will be a function of the difference between R_T and the sum of P_1 and P_2. Furthermore, the phase of the output will be either in phase or 180° out of phase with the applied reference voltage.

By amplifying the signal developed across the output of the bridge and then passing the amplified signal through a phase sensitive detector circuit, a DC error signal can be obtained. The magnitude of the DC error signal will then be a function of the difference between R_T and the sum of P_1 and P_2, and its polarity will depend on whether R_T is greater than the $P_1 + P_2$ or vice versa. Since R_T is a function of temperature, the polarity sensitive, DC error signal can be used to proportionally control both a heating system and a cooling system.

As shown in the schematic diagram, the signal developed at the output of the bridge is amplified by a preamplifier, Q_1 in a common emitter configuration, and an audio amplifier. The amplified signal is then applied to the input transformer, T_5, of the phase sensitive detector. The phase sensitive detector is a conventional ring demodulator formed by diodes D_3, D_4, D_5 and D_6. Reference voltage is applied to the ring demodulator through transformer T_2. The polarity sensitive, DC error voltage, developed between the center tap of T_5 and ground, is filtered by L_1 and C_1. Depending upon the polarity of the DC error signal, the signal is applied either to the remote sensing terminals of the DC power supply or the control winding terminals of the magnetic amplifier via steering diodes d_1 or d_2. The DC power supply and the magnetic amplifier, in turn, control cooling and heating current, respectively.

Heating of the pillbox is accomplished by the use of a 115 v., 60 cps, cone-type heater. In extremely cold weather the heat output of this unit may not be sufficient to bring the pillbox temperature up to the desired temperature. However, by adding an auxiliary heater, connected directly to a 115 v. circuit, and retaining the automatically controlled heater, sufficient heating will result.

Cooling of the pillbox is provided by number of semiconductor, thermoelectric heat pumps connected in series. The number of heat pumps required naturally depends on the amount of cooling required. Hence the maximum output of the DC power supply must be adjusted according to the number of pumps used and their respective voltage ratings; potentiometer P_4 serves this purpose by adjusting the level of DC error voltage applied to the remote sensing terminals.

Two sets of tests have been made to determine the temperature stability provided by this system. One test was made in the laboratory, and another test was made using the pillbox at the 40-foot telescope. Results of these tests show that this system provides adequate temperature stability.

In the test made at the laboratory an insulated wooden box was used to simulate a pillbox. Inside the box was mounted a thermoelectric cooler, a cone heater, the thermistor, and a fan which provided air circulation. This equipment was connected into the automatic temperature control system and operated at 20 °C for about three days with the box located outdoors and subjected to changes in atmospheric temperatures. Atmospheric and pillbox temperatures were monitored with recorders and the curves thus obtained are shown in figure 2. It can be seen that during the test period the atmospheric temperature varied between +16 °C and +29 °C, but the pillbox temperature remained within ± 0.3 °C of the initial setting.

A similar test was made by controlling the temperature of the pillbox at the operating 40-foot telescope. After several days of operation, temperature records of the pillbox indicate that the pillbox temperature had not varied more than ± 1 °C from the initial setting.

Since the results of these tests show that this method of temperature control provides adequate temperature stability, five more systems of this type will be built in the near future.

Material List

Amplifiers:

Audio, 3 watt, Heath Kit

Magnetic, 600 watt, 120 v., 60 cps, West Instrument

DC Power Supply:

36 v., 25 amps, remote sensing, Harrison Model 520A

Potentiometers:

P_1 0-100 ohms, 10 turn helipot

P_2 0-5000 ohms, 10 turn helipot

Resistors:

R_1, R_2	5,000 ohms, ± 1%, 1/2 watt
R_3, R_4, R_5, R_6	450 ohms, ± 5%, 10 watt
R_7	200 ohms, 20 watts
R_8	36,000 ohms, ± 5%, 1/2 watt
R_9	1,000 ohms, ± 5%, 1/2 watt

Rectifiers:

D_1, D_2, D_3, D_4, D_5, D_6 4C 24 84

Transformers:

T_1	115 v:6 v., 300 ma - Triad F91-X
T_4	115 v:9.5 v., 200 ma - Triad F91-X
T_2, T_5	115 v:220/115 - Triad N68X
T_3	15k:80 k - UTC A-19

Material List (Continued)

Transistors:

Q_1 2N652

Thermistors:

R_T - negative temperature coefficient, 2 K at 25 °C, Fenwald GB 32P2

Filters:

L_1 -- 2.3 henry, 53 ohm, 250 ma

Capacitors:

C_1 25 μf - 50 v.

C_2 100 μf - 6 v.

C_3 0.2 μf

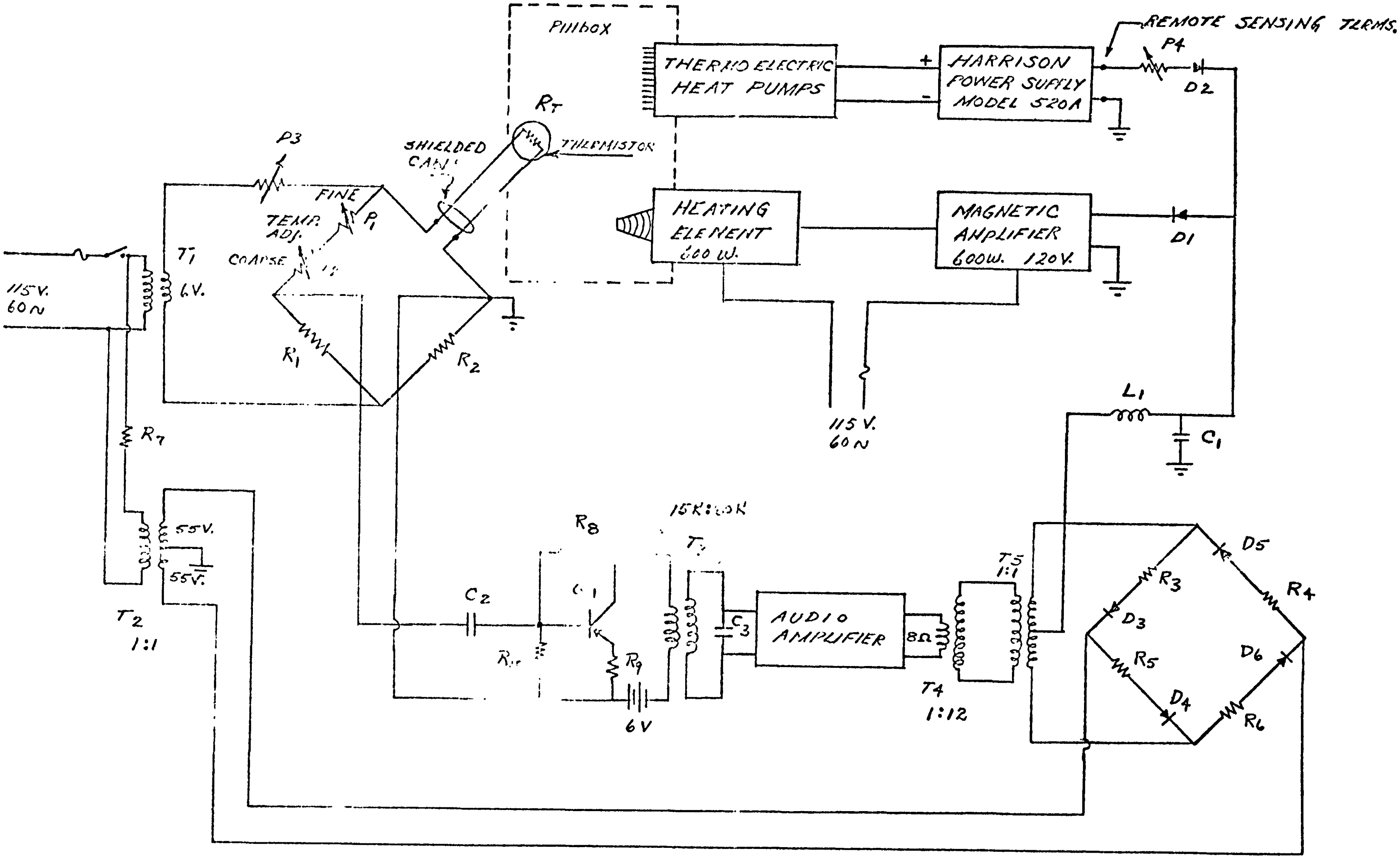

FIG. I SCHEMATIC DIAGRAM OF THE AUTOMATIC TEMPERATURE CONTROL SYSTEM.

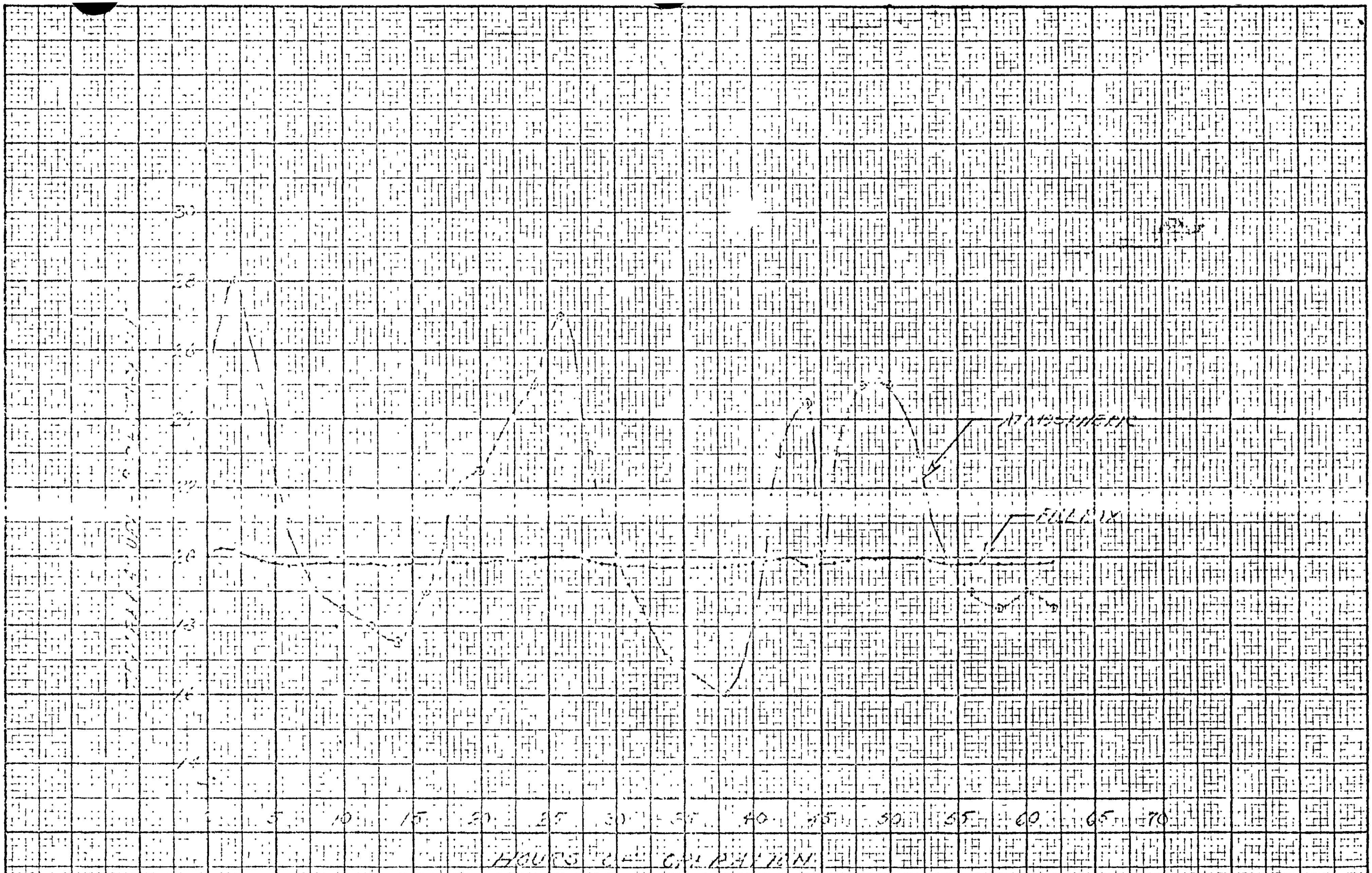

FIG. 3 [illegible] AS A FUNCTION OF TIME