NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

Electronics Division Internal Report No. 33

AN AUTOMATIC TEMPERATURE CONTROL SYSTEM FOR TELESCOPE PILLBOXES

George H. Behrens, Jr.

JULY 1964

NUMBER OF COPIES: 75

Report on Automatic Temperature Control

Comments by G. Westerhout

1. In pillboxes the size of that of the 300-foot, one thermistor is not enough. Where would you put it. Close to the paramp, in the fan cooling the klystron? What if you have two paramps? Devise a circuit with at least 3 thermistors, or include in the design a really efficient air circulation system.

2. Circulation of air is extremely important to get an even temperature throughout the box. When the heater and cooler are mounted more or less arbitrarily, some parts of the equipment will change temperature depending on whether the heater or cooler are on or off. I would have thought that a strong fan, at the top of the pillbox, with all heating and cooling elements in a duct connected to the fan, would be essential.

3. I feel that provisions to keep the temperature constant in the whole box are an essential part of the temperature control system. Not just the sensor, heater and cooler.

4. Experience at the 300-foot has shown that the present cooler is not enough, even at full blast, with two paramps working. Has this been taken into consideration in determining the dimensions of the cooler?

5. How does one determine whether to switch on extra heating? In the winter, we may have temperature differences of 30°C outside. There should be a calibrated indicator showing the amount of current going into the heating element. When this indicator shows that it is going almost full blast, the operator can then switch on extra heat. But

this, of course, can be done automatically too. There should be provision' to switch in automatically a series of extra heaters, 300 W each. The control circuit should be such that an extra heater is switched on when the proportional heater gets 550 W, and off when it gets 50 W. This will prevent rapid switching and the associated transients.

Better yet of course is to use a much more powerful magnetic amplifier, so that all the heating can be done with the one heater.

6. Having seen the insulation of the pillboxes, I must say that this seems very inadequate. I propose that either a much thicker layer of styrafoam is used on the inside, or, as a temporary measure, a layer of insulating material is wrapped around the boxes on the outside. The best solution would be to have an inner box inside the outer box, with insulation in between, and connected to the outer box with low heat-conducting material. Even then, I would put a thin layer of styrafoam along the inner walls of the inner box, and paint the outer box. 300feet up in the air one has really efficient heating and cooling by sun and wind!!

7. The results of the tests seem insufficient.
   a) The lab test, with no equipment in the box, and the box, although outside, probably not very high up and always in the same position, is bound to give good results, even with a much cruder system than this. I am surprised that the variations were as large as 0.3°C.
   b) The 40-foot pillbox is small, with little equipment in it, and not very high off the ground. In order to assure stability to within ± 1°C in the 300-foot box (and I think we need at least that) I would require considerably better performance in the 40-foot.

AN AUTOMATIC TEMPERATURE CONTROL SYSTEM FOR TELESCOPE PILLBOXES

George H. Behrens, Jr.

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

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

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

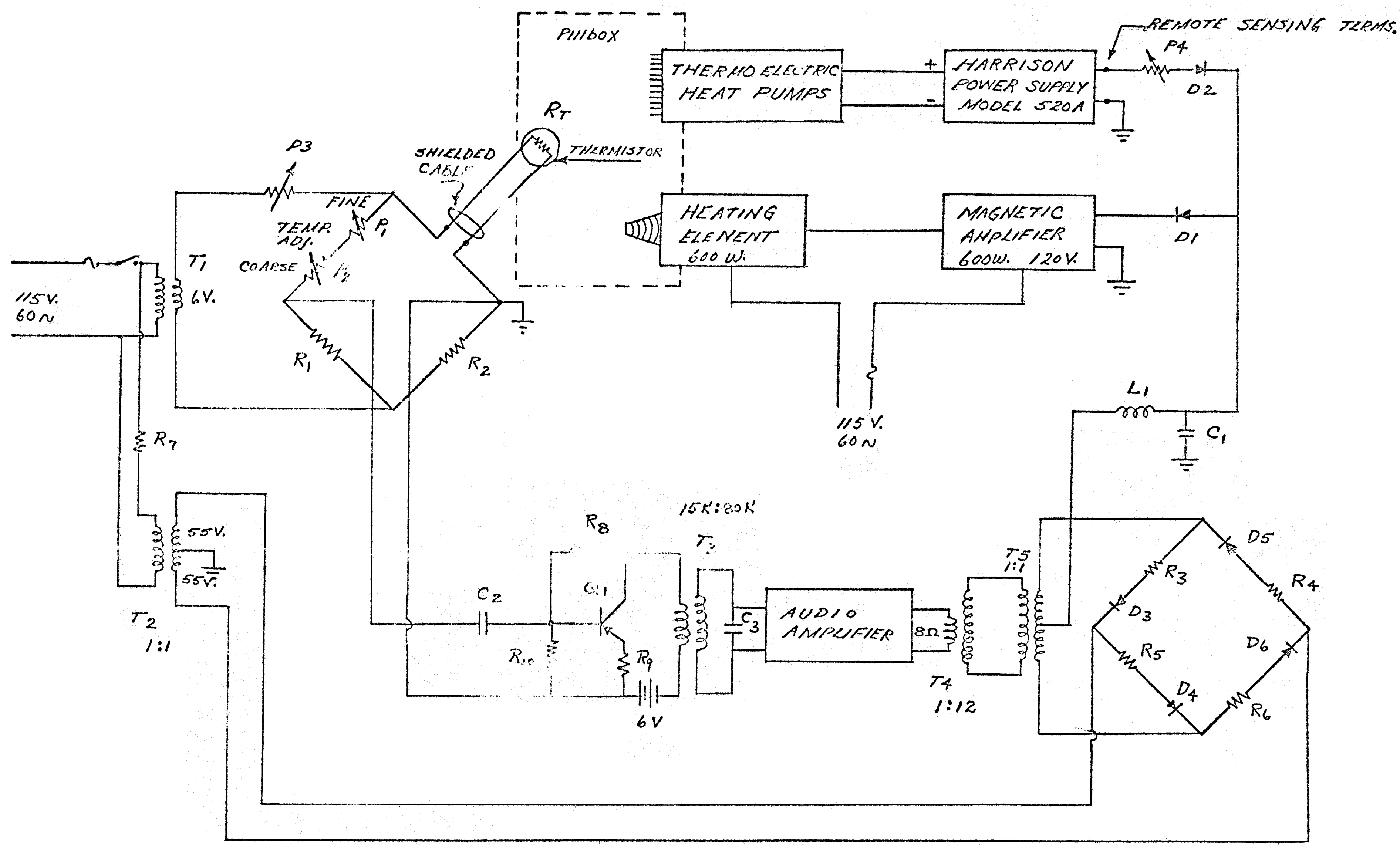

FIG. 1 SCHEMATIC DIAGRAM OF THE AUTOMATIC TEMPERATURE CONTROL SYSTEM.

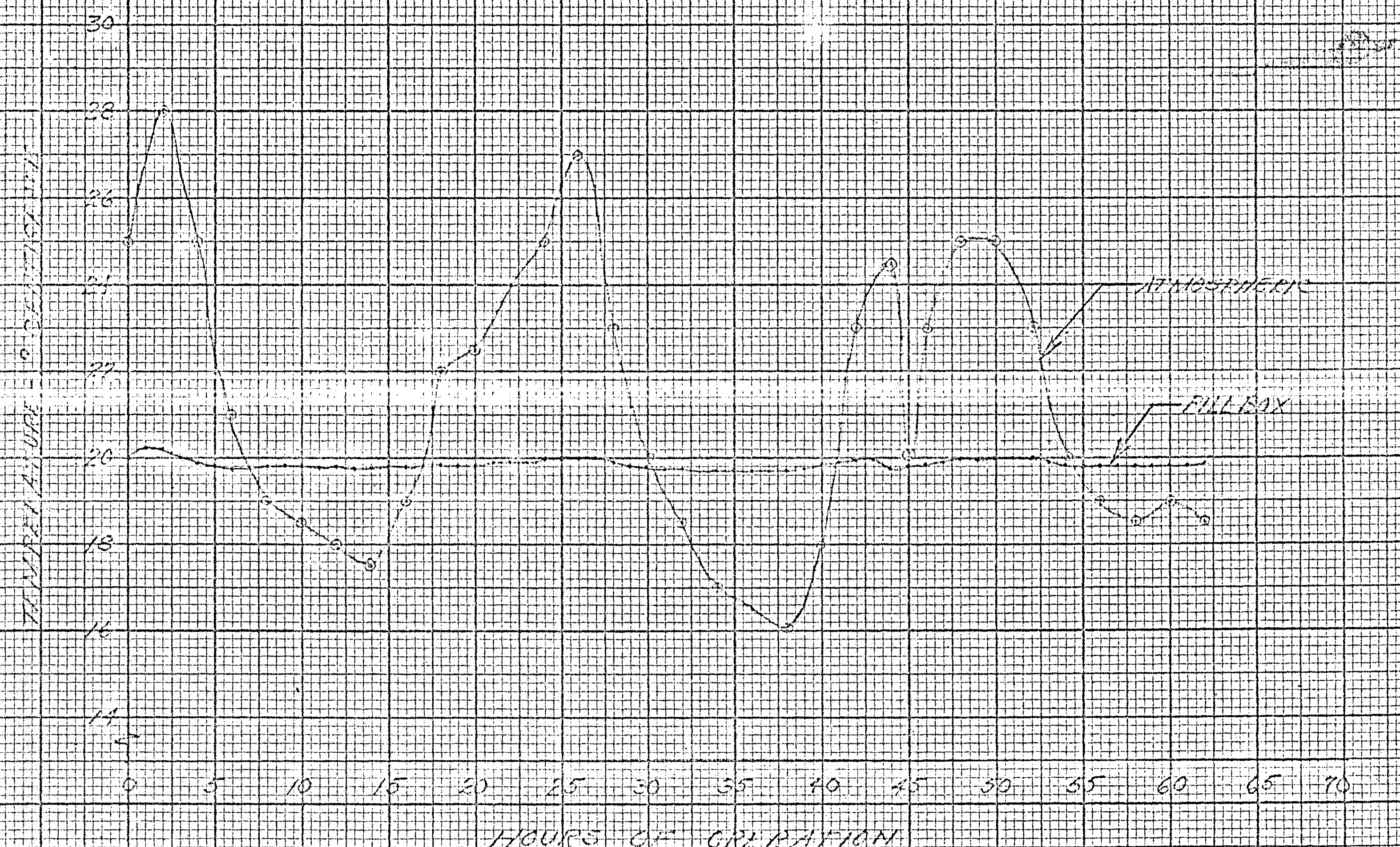

FIG. 2 ATMOSPHERIC AND PULLBOX TEMPERATURES AS A FUNCTION OF TIME