NATIONAL RADIO ASTRONOMY OBSERVATORY
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300-FOOT CABIN TEMPERATURE CONTROLLER

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General

The air entering the cabin is held at the required temperature with a proportional heater and an air conditioner. The fan forces outside air by the evaporator through a flexible joint, then through the heater and into the cabin. The air is exhausted through a wall vent or the hole around the front-end box. The controller automatically varies the voltage on the heater.

The controller allows any one of three locations in the cabin to be held to a constant temperature (est. ± 1/2 °C). The set point can be adjusted ± 5 °C from nominal from the control room. The nominal temperature is 20 °C. The temperature sensors need not be in the direct air flow of the cabin fan, but thermal time constants exceeding 1 minute will require reduction of loop gain and increase of damping. The temperature sensors should be placed near critical front-end components.

Normal Operation

The operator will be required to switch the air conditioner (cooler). An alarm and light will indicate that the level of heating is low and the air conditioner is off or that the level of heating is excessive and the air conditioner is on. The cooler can then be switched at the next break in the program.

An alarm and light indicate excessive temperature. The operator should check for some malfunction, such as a frozen evaporator. At very excessive duct or room temperature the heater circuit contactor will be de-energized.

The operator may be required to switch between the three different sensors if different front-ends are used. Under this condition the gain and damping must be set for the sensor that is most difficult to stabilize.

Circuit Diagram

A reduced copy of drawing No. 2.495-1 is included as Figure 1. The left portion shows the circuits in the cabin. These circuits produce three temperature outputs and a rate of temperature change output.

The temperature outputs use a YSI (No. 44202) thermilinear thermistor network in a different circuit than those shown on the YSI data sheet. Notice in Figure 1 that the compensation resistors are used as the input summing resistors. All the sensor current is used; none bypasses the op-amp. With 2.01 volts applied, the current is 2 microamps/°C. The zero output voltage is set to 20 °C with 108.5 microamps into the summing point.

The major portion of the servo controls are in the control unit. Meter displays of three temperatures and the Variac position are provided. Operational amplifiers are used for off-set, dead-zone, over-temperature alarm, and cooler alarm.

The Variac and Variac drive relays are located in a rack in the control room. The far-right portion shows the contactors and circuit breaker required. This portion is not complete, but is included to show the protection circuits and to complete the servo loop.

Servo Discussion

The motor driven Variac is effectively an integrator in the servo loop. This type servo is called "Type I". It theoretically gives zero error for steady state and the error is proportional to rate when conditions are changing. The actual Variac drive is a three-state non-linear system. The last op-amp output is zero until the input current reaches 15 μA (voltage = 150 millivolts).

The gain pot in front of the dead zone op-amp sets the magnitude of the temperature error that is required to move the Variac. Recommended setting for tightest control is enough gain to cause Variac to be moving 10 percent of the time. For less strenuous control requirement a 1 percent duty cycle is recommended.

The op-amp that precedes the dead-zone op-amp has inputs from a temperature op-amp, the rate op-amp, and the temperature offset pot. Lead or rate is required in a Type I servo. The integrator (Variac) causes 90 degrees of phase lag and the thermal portion of the loop causes an additional 90 degrees or more. The lead network in the temperature input provides 90 degrees of lead to subtract from the 180° to 225° that already exists. But this lead is ineffective if the temperature monitor time constant is greater than 10 seconds. In order to allow the temperature monitor location to be dictated by temperature requirements and not by servo requirements, a separate rate input is provided. The rate sensor monitors cabin air near the inlet duct.

The noise (variations) on the rate signal helps to linearize the three-state Variac drive. As the sensor temperature approaches the temperature required to move the Variac, the noisy rate signal carries the control voltage over the threshold a larger percentage of the time. Therefore, the Variac average rate is proportional to temperature error minus temperature rate.

The optimum setting of gain and damping is difficult to explain. As the time constant of the temperature monitor is increased, the loop gain must be reduced and the damping increased. If the Variac duty cycle is 1-10 percent (set with gain pot), Variac motion in the same direction four consecutive times indicates excessive damping. Alternating directions indicate less than optimum damping and/or too much gain. An increase in damping may require a reduction in gain to hold the Variac drive duty cycle within the same limits. Large excursion (25 percent) oscillations of the Variac indicates too much gain. Temperature oscillations of random period and fixed amplitude indicates that dead-zone is too large (gain too low).

Alarm and Control Circuits

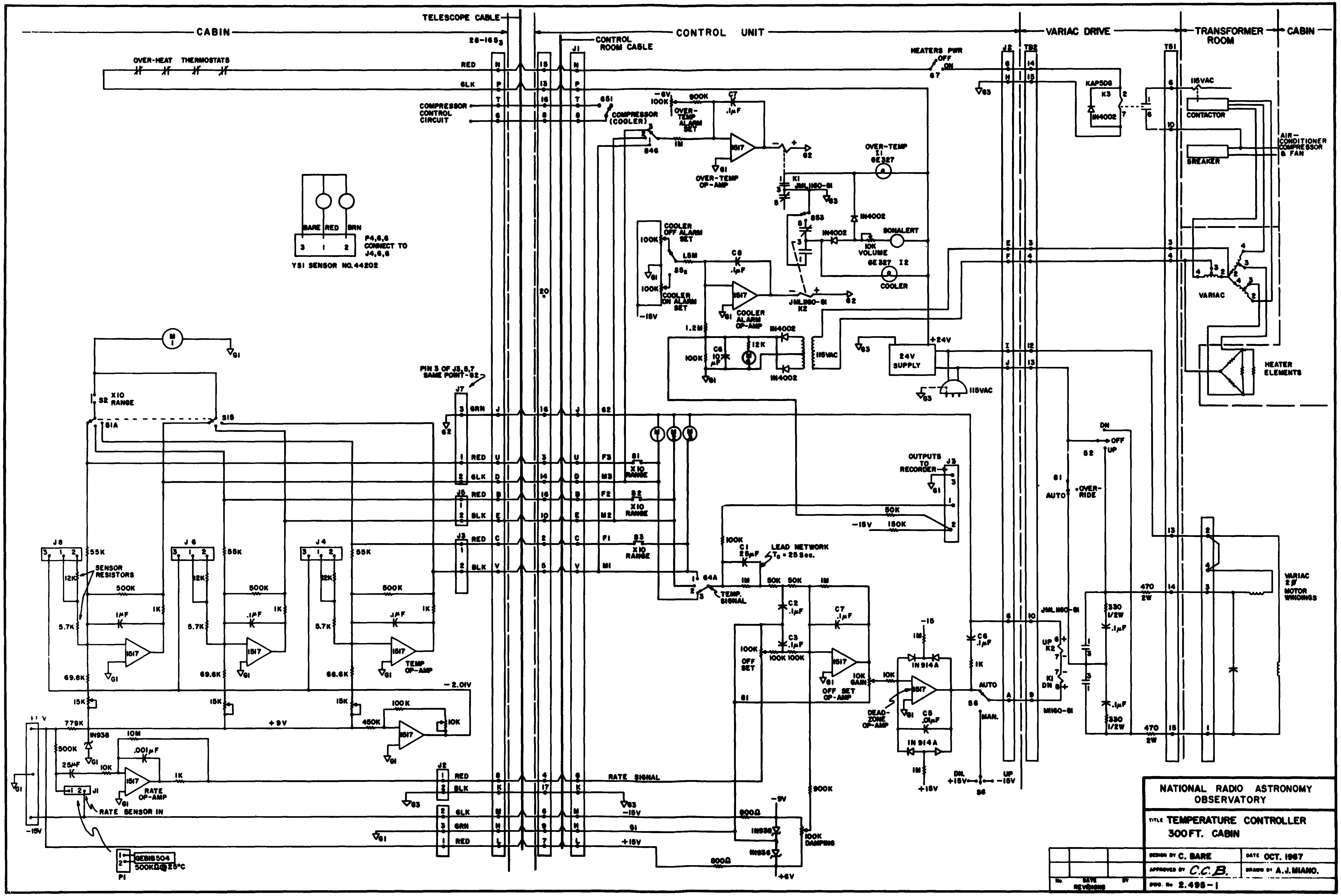
The over-temperature op-amp compares the reference pot with the selected temperature sensor. The alarm temperature can be set to any temperature between +10 and +30 °C. The normal procedure is to set the pot 4 °C (2 revolutions) above the operating temperature.

The cooler alarm circuit uses the conventional level detection circuit (similar to over-temperature) with one addition. The polarity of the op-amp output required to sound the alarm is reversed when the cooler (air conditioner compressor) switch is toggled. See Figure 1. The "cooler on" pot is set to approximately 1/20 of full scale (1/2 revolution) to cause the warning to sound before negative heat is required. The "cooler off" pot is set to approximately 0.8 of full scale (8 revolutions) since the heat required to buck-out the cooler represents a change from 3/4 to 1/10 of maximum Variac position.

The heater contactor will not operate unless the fan circuit breaker is closed and the 28 V alarm power is on. Thermostats in the heater ducts and in the cabin will cause the heater contactor to drop-out, if the temperature becomes excessive. The cooler contactor also requires fan power for it to operate.

Recorder

A recorder output is provided for monitoring the controller. One output displays the cabin temperature. The second output displays the Variac position. The two plots allow the servo to be adjusted without constant attention. The recorder output series resistors are set to drive ± 100 μA movements. The low side of the outputs must not be grounded.



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TITLE **TEMPERATURE CONTROLLER 300 FT. CABIN**

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No.	DATE	REVISIONS	BY