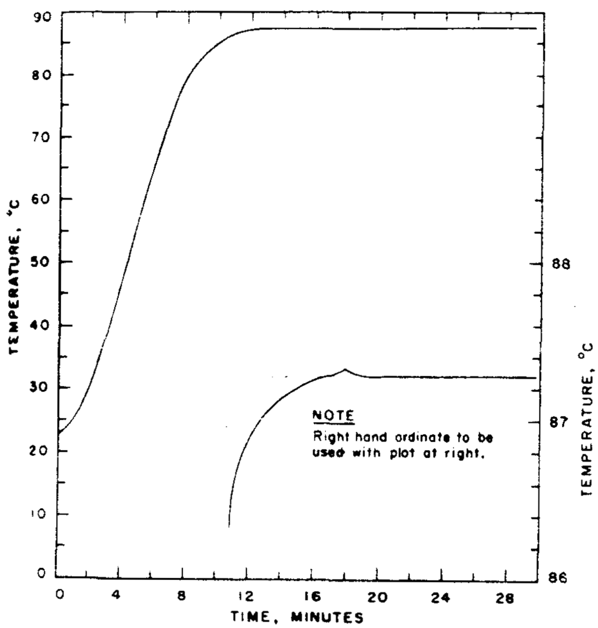
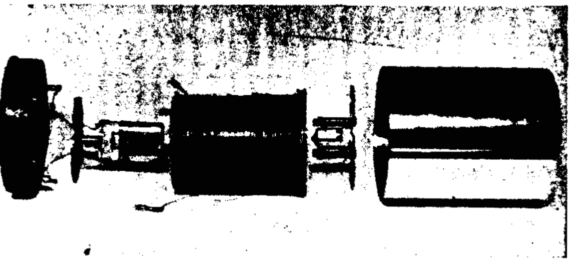
Constant-Temperature Oven for Quartz Crystal Oscillator

THE BUREAU has developed a simple, compact oven that stabilizes the temperature of a quartz crystal for precise oscillator frequency control. This oven utilizes the heat of fusion of an extremely pure organic compound—*p*-dibromobenzene—to hold the oven temperature within 0.01 degree of 87.31° C. Power requirements are low: 10 watts for normal operation and 20 watts during the brief warmup period. The instrument was developed for the Army Signal Corps by R. Alvarez and C. P. Saylor of the pure substances laboratory.

Quartz crystals are widely used as frequency standards, as filters in receiver circuits, and as frequency stabilizing elements in oscillator circuits. As a temperature change in a crystal will produce a change in its frequency, common practice has been to control the temperature of the crystal in precise frequency applications. Such close temperature control is usually achieved only by relatively large and complex systems. The special-purpose oven eliminates the need for much of the complex, bulky equipment ordinarily used.

Although the Bureau's instrument was designed specifically as a quartz crystal oscillator oven, it can be applied wherever a simple, compact thermostat for close temperature control is required. It can, for example, provide a constant temperature for a reference thermojunction for extended temperature measurement and control. The oven uses *p*-dibromobenzene in its particular application, but other substances with different melting points provide other operating temperatures. Phenoxybenzene, for instance, has been employed in maintaining quartz crystals at a constant temperature of 26.88° C where the ambient temperature is low.





Unassembled view of constant-temperature oven that stabilizes the temperature of a quartz crystal for precise oscillator frequency control. Parts (r to l) housing: can, switch, heater, wire, crystal holder, and octal socket.

When a substance is partially molten, its latent heat of fusion provides thermal ballasting. That is, a heat loss causes crystallization of the material with evolution of the latent heat of fusion. A heat gain, on the other hand, results in absorption of heat as the solid phase melts. The melting temperature at the solid-liquid interface remains unchanged, provided that the material is pure and that the pressure is constant. A substance used for temperature control in this way must possess (1) a melting temperature within the desired operating limits, (2) chemical stability when in contact with oven components, (3) a high heat of fusion, and (4) a high velocity of crystallization. *p*-Dibromobenzene meets these requirements.

The oven is contained in a cylinder $3\frac{1}{32}$ in. high and $2\frac{11}{32}$ in. in diameter, mounted on an octal base. Inside the oven is a vacuum-tight container into which a quantity of *p*-dibromobenzene has been sealed. During operation of the oven, the material is about half liquid and half solid, and completely fills the container. At the top of the container is a metal bellows that is linked to a spring-loaded miniature switch. The volume changes occurring during phase transformations are transmitted to the bellows, turning a heater on or off to keep the chemical partially molten. Spring-loading the switch provides a pressure relief system in case a greater proportion of liquid is formed during the warmup period than would be present at the normal operating point. A second heater provides rapid warmup. It is controlled by a bimetallic element that cuts off the power when the substance is about 7 degrees below the melting point. A copper vane system distributes that heat rapidly throughout the container and reduces any temperature gradients that might exist if solid and liquid become separated during operation. The crystal and its holder fit into a well within the container.

Temperature stability data on the instrument were obtained by fastening a calibrated thermistor to a dummy crystal inside the crystal holder. The total temperature variation during a 6-day period of continuous operation did not exceed 0.007 degree C.

Time-temperature curve of oscillator crystal oven as it warms up and stabilizes its temperature. Total variation during 6 days operation did not exceed 0.007° C.