Control for Temperature Fluctuation

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INSTRUMENTATION for a relatively simple project — Controlled Temperature Fluctuation of a Low-Temperature Refrigerator can have many pitfalls to overcome before reasonable operating perfection is accomplished with the usual budget limitations.

The usual fluctuating conditions can be created by adjusting the rate of cooling and rate of warmup of the refrigerator between a top and bottom limit. If the project is well financed, a proportional control system can be developed using a cam-operated controller that will duplicate any desired cycle. A less expensive approach to the problem is the use of two thermostats — one set at the high temperature and the other at the low temperature.

The rate of temperature change within the refrigerator will depend on the mass and rate of heat transmission of the refrigerator. A low-heat transmission rate combined with a high refrigerator capacity will result in rapid cooling and slow warmup. The rate of warmup may be increased by opening the door, but this method can result in erroneous findings, because of changes in ambient air conditions and the chance of human error. A large electric heater (1 to 1.5 kw per 100 ft^3) installed in the refrigerator eliminates these problems, and the warmup cycle can be completely controlled by varying the output of the heater. For short warmups the heater operates during the entire warmup period. The rate of cooling can be varied by changing the speed of the compressor.

Frozen food can be seriously damaged in a few hours if the refrigeration system fails and the heater continues to operate. A limit thermostat inserted in the control circuit of the heater provides the necessary protection in case of refrigeration failure.

The timing of the fluctuation cycle must be accurate as well as continuous. The cam-operated controller fulfills this requirement ideally but expensively. In the two-thermostat method, cycling is accomplished by switching from the low to the high-temperature thermostat. This can be performed manually, but for long-term experiments it is not practical. Commercial timers that will perform various cycling operations are available; during the test an Eagle Flexopulse cycling timer provided the necessary versatility and accuracy required in the simulation of actual conditions.

Fenwal thermostats were used in the installation: The temperature controlling thermostats open with a decrease in temperature for refrigeration operation, whereas the safety thermostat opens with an increase in temperature. The control system is fused separately to give the control devices additional protection.

A wiring diagram of the control system is illustrated in Fig. 1.

Data obtained with a Leeds and Northrup potentiometer and 30-gage copper-constantan thermocouples indicated that the time required for the circulating air in the refrigerator to go from −5 F to +10 F was 5 min, with 6 min required to reduce the air temperature from +10 F to −5 F.

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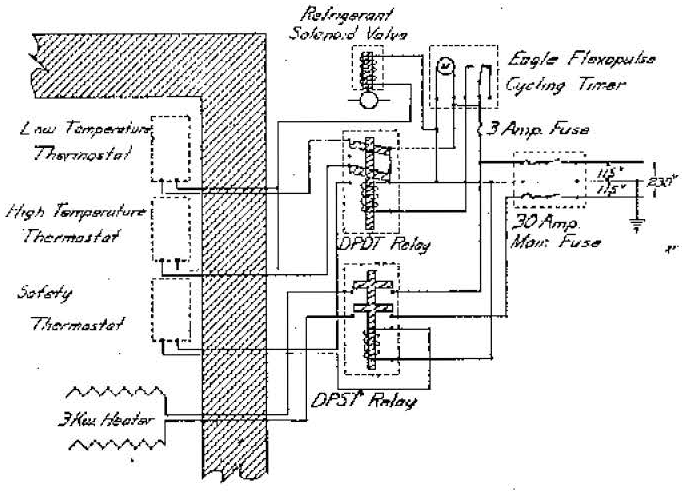

Fig. 1 Control system for automatically fluctuating the temperature of a refrigerator

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