Microwave Maser Development: Automatic Monitoring of Closed Cycle Refrigerators for Masers

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A method for automatically monitoring the reserve capacity of a closed cycle refrigerator (CCR) has been developed and tested. The principal feature of the present design is that the measuring device adds negligible thermal load to the CCR. The instrumentation is particularly applicable to automated tracking station operation.

I. Introduction

In the past, the performance capability of a CCR was measured by actually applying a thermal load (by electric heaters) to the 4.2K station of the CCR. When the applied load was equal to the CCR capacity, the refrigerator warmed, and the measurement was complete. During a mission, when it is important to monitor the CCR, the above method cannot be used.

A new technique is described here which overcomes the above disadvantage. The new method consists of measuring the temperature gradient in the heat exchanger between the 15K and 4.2K stations.

II. Description of New Approach

Figure 1 shows a schematic diagram of a liquid-helium maser cooling refrigerator with an inset diagram of the novel condition monitoring circuit in dotted outline 10. The two temperature sensors 11 and 12 are in thermal contact with the Liquid-Helium Stage Heat Exchanger (Joule-Thomson (J-T) circuit) so as to measure the temperature gradient along its length. These resistors are preferably of the carbon type designed for operation at cryogenic temperatures and having a logarithmic coefficient of resistance. External resistors 13 and 14 together with battery 15 and galvanometer 16 (5-place digital voltmeter) complete the temperature indicating bridge.

Figure 2 shows a typical calibration chart for a CCR. In this case the CCR was one equipped with an X-band TWM and superconducting magnet assembly; the heat load at 4.5K is estimated to be some 200 to 300 mW.

The strip chart recording of Fig. 2 shows the change in voltage across the bridge circuit as thermal load was applied in 100-mW steps. It is to be noted that once a traveling-wave maser (TWM)-CCR system has been calibrated as shown in Fig. 2, the output voltage may thenceforth be used as a measure of the CCR reserve capacity. Moreover, degradation in the engine portion or J-T circuit will be reflected immediately in temperature difference in the bridge circuit. In other words, the imminence of CCR problems will be apparent in the new method, but exact location of fault will not be pinpointed.

The CCR has been operated in all positions to verify that the technique is applicable in all cases.

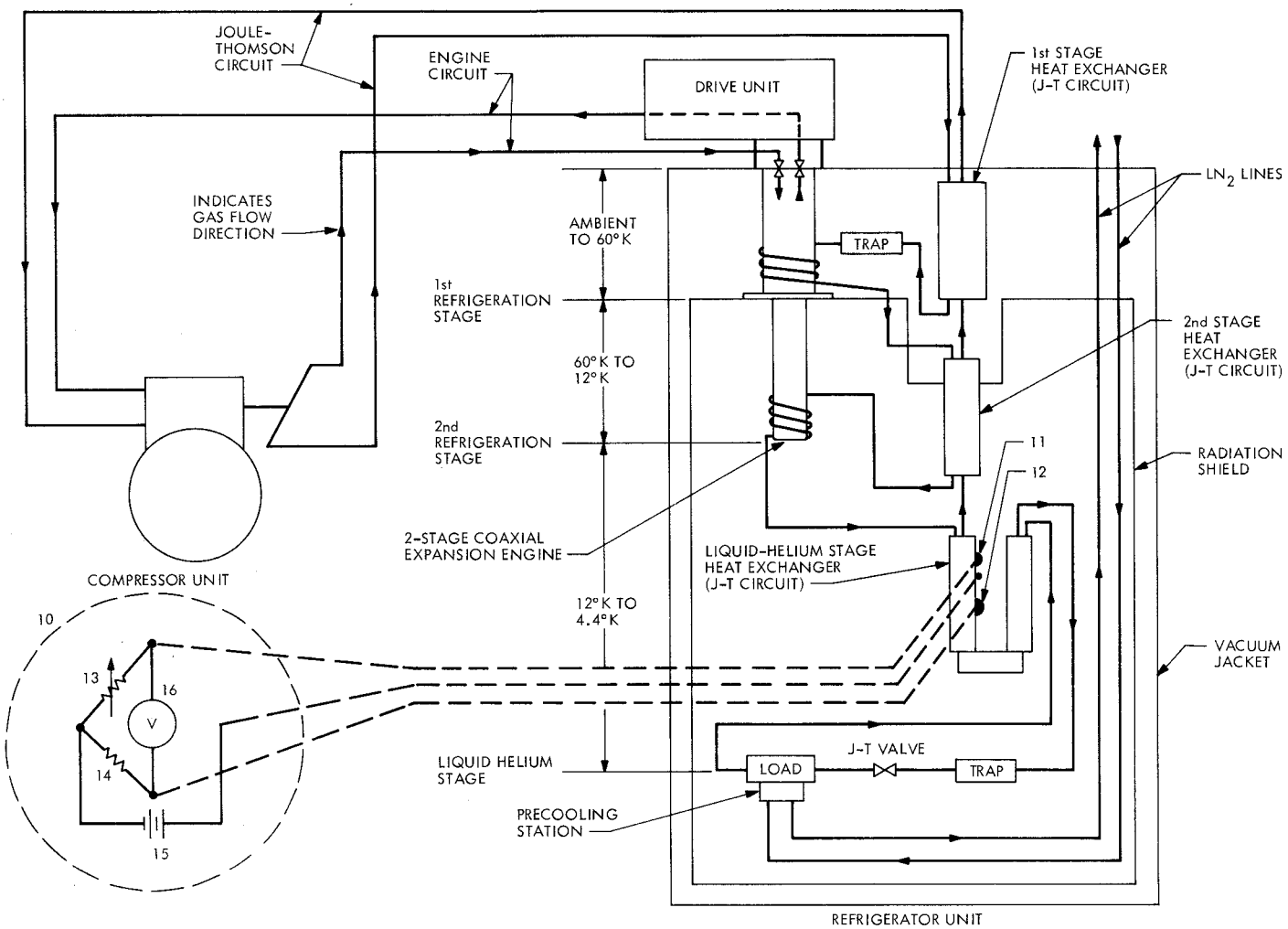

Fig. 1. System schematic for monitoring CCR capacity

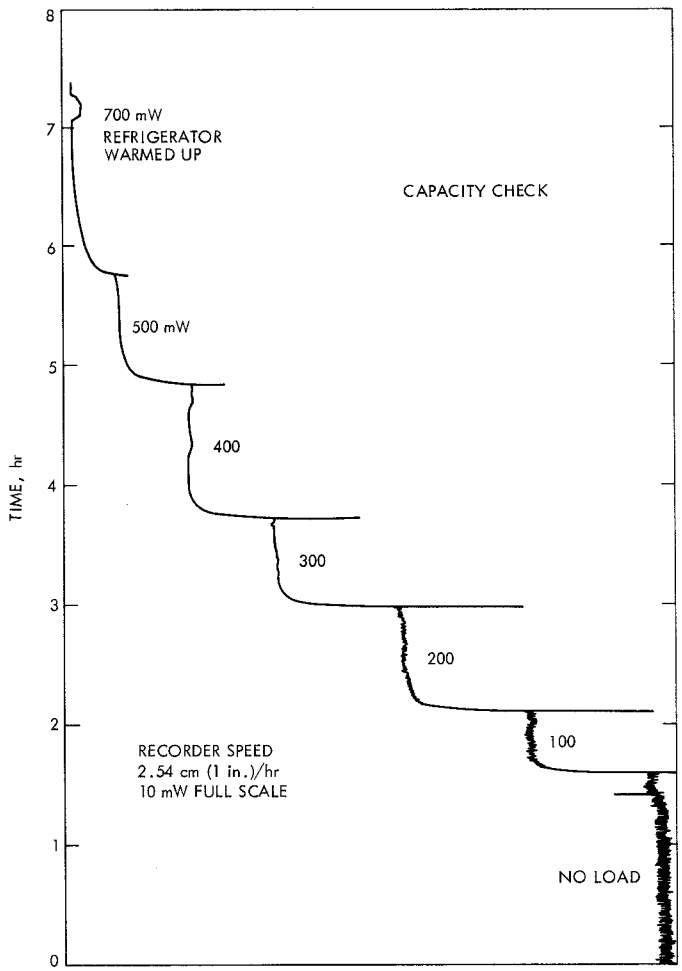

Fig. 2. Calibration chart for a CCR