NATIONAL RADIO ASTRONOMY OBSERVATORY

Green Bank, West Virginia

TELESCOPE SERVICES DIVISION REPORT No. 12

3 K HELIUM REFRIGERATOR

TROY HENDERSON

APRIL 1985

CONTENTS

1. INTRODUCTION

The 3 K refrigerator is a closed cycle helium cryocooler. This cryocooler consists of a CTI model 21 or 22 coldhead, a J-T circuit of NRAO design, a single stage compressor to drive the coldhead, a two stage compressor for the J-T circuit.

The 3 K system has been designed to give continuous refrigeration at the coldest possible temperature. Using He-4 and the present heat exchanger design, a temperature of 2.9 K has been attained.

A trade off between low temperature, load capacity and compressor pressures was made in order to attain a cold station temperature colder than 3.5 K.

With supply pressure at 150 psig, J-T return pressure at 3.5 psia, and a gas flow of 0.22 scfm the cold station temperature (no heat load) is 3.1 K. A heat load of 50 milliwatts increases temperature to only 3.17 K; however, a load of 150 milliwatts will overcome cooling capacity. See figure 1 for load curve.

2. DESCRIPTION of COMPONENTS

2.1 The CTI Cryocoolers

The model 21 coldhead produces refrigeration at temperatures of 77 K and 12 K for the first and second stage cold stations. The model 22 coldhead produces colder temperatures at 35 K and 8 K. For more information see CTI Instructions Manuals.

2.2 The J-T Circuit

The 3 K J-T cooling circuit consists of three JPL/NRAO heat exchangers a Joule-Thomson expansion valve, a hydrogen gas heat switch, and the cold station. See figure 2 for flow sheet.

2.2.1 Counter Flow Heat Exchangers

The heat exchangers are built of thin wall stainless steel tubing and Ananconda bronze helical hose. Three sizes of helical hose are used for the exchangers. In the present system the first heat exchanger is a 1/2 inch I.D. by 5.3 inches long hose, the second heat exchanger is a 3/8 inch I.D. by 4.7 inches long hose, and the third heat exchanger consists of two 1/4 inch I.D. by 3.2 inch long hose.

2.2.2 J-T Expansion Valve

The J-T valve is a hypodermic needle (27G 1/2) with a nickel-chromium wire inserted for flow control.

2.2.3 Heat Switch

The heat switch is a gas gap type made of two copper cylinders enclosed in a thin wall stainless steel tube. The switch is charged with 100 psig hydrogen gas that conducts heat between the 3 K and the 15 K cold stations. The switch begins to slow conduction at 20 K and is open at about 10 K.

2.2.4 Cold Station

The cold station is made of Oxygen Free High Conductivity copper. For good thermal contact between the helium gas and copper there is a series of screens and spacers through which the gas must pass.

2.3 Compressors

2.3.1 The Coldhead Compressor

The CTI model 21 or 22 coldhead can be operated with a single stage compressor that will deliver a through-put of seven cubic feet per minute helium gas. This stage of cooling could share a model 1020 compressor with four other model 21 and 22 units.

2.3.2 The J-T Compressor

In order to produce cold at temperatures below liquid helium (4.2K). it is necessary to reduce the pressure over the liquid to below atmosperic. To accomplish this pressure reduction; a two stage compressor, with a vacuum input, has been developed.

The J-T compressor consists of two Rotorex K39A711A freon compressor motor, the oil cooling circuits, filters, and oil separators. See figure 3.

WARNING: Due to vacuum pumping of the first stage compressor, there is always a danger of air leakage into the system.

3.Specifications for J-T Components

3.1 J-T Compressor

Power: 115 Volts, 60 Hz, 1 Ph

7.0 Amps, 790 Watts

Motor: Weight = 16.5 Lbs

Locked rotor = 34.0 Amps

Displacement = 1.32 cfm helium

Pressure: Supply = 150 psig

Intermediate = 10-20 psig

J-T Return = 1.0-3.5 psia; 26-20 in. Hg

3.2 Refrigerator

Flow = 0.22 scfm Cold

Load = 0-125 Milliwatts

Cold Station = 3.1-3.5 K

J-T Valve = 0.009 in. ; 0.008 in. O.D. wire

Heat Exchangers 1st = 0.50 in. I.D. x 5.3 in. long

2nd = 0.375 in. I.D. x 4.7 in. long

3rd = 0.25 in. I.D. x 6.4 in. long

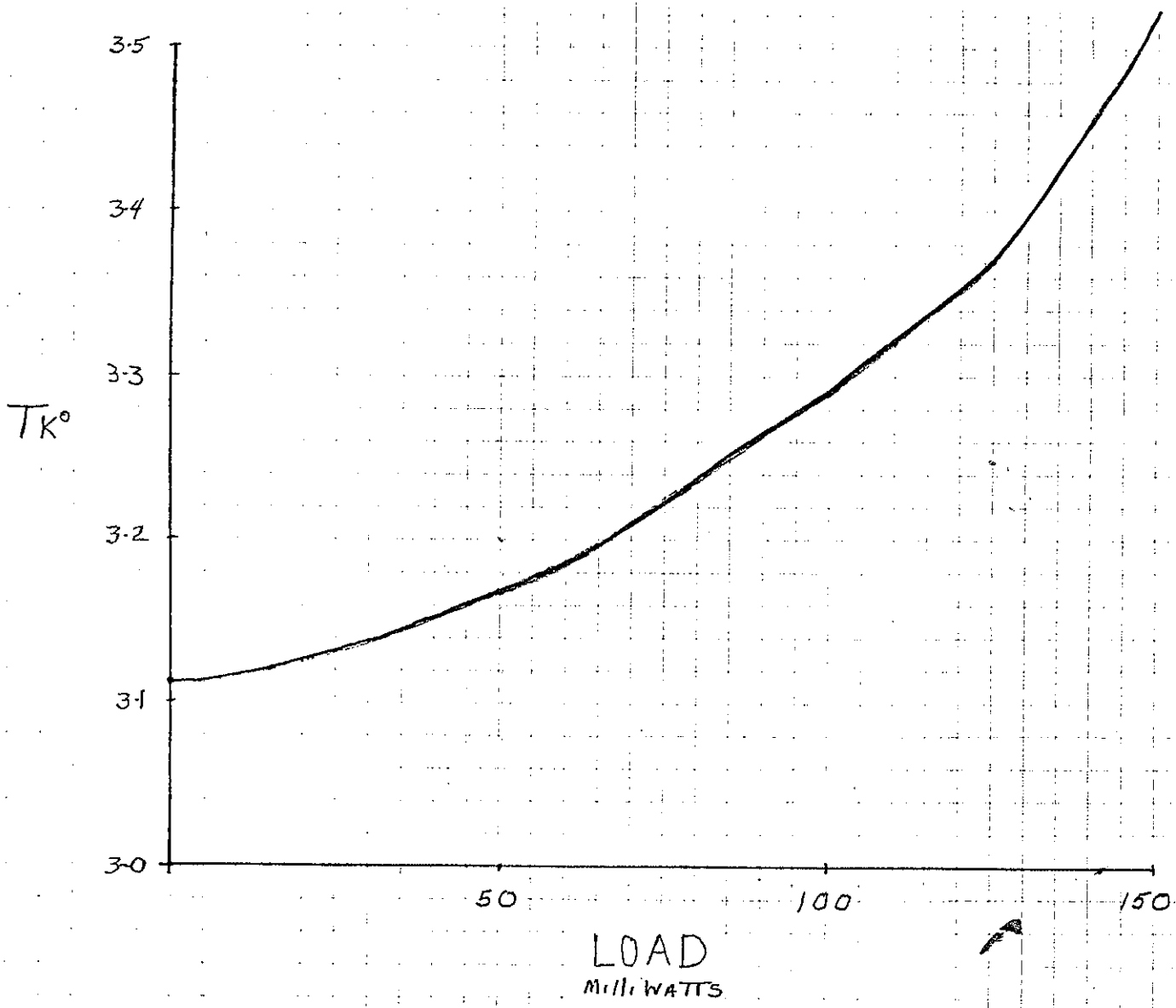
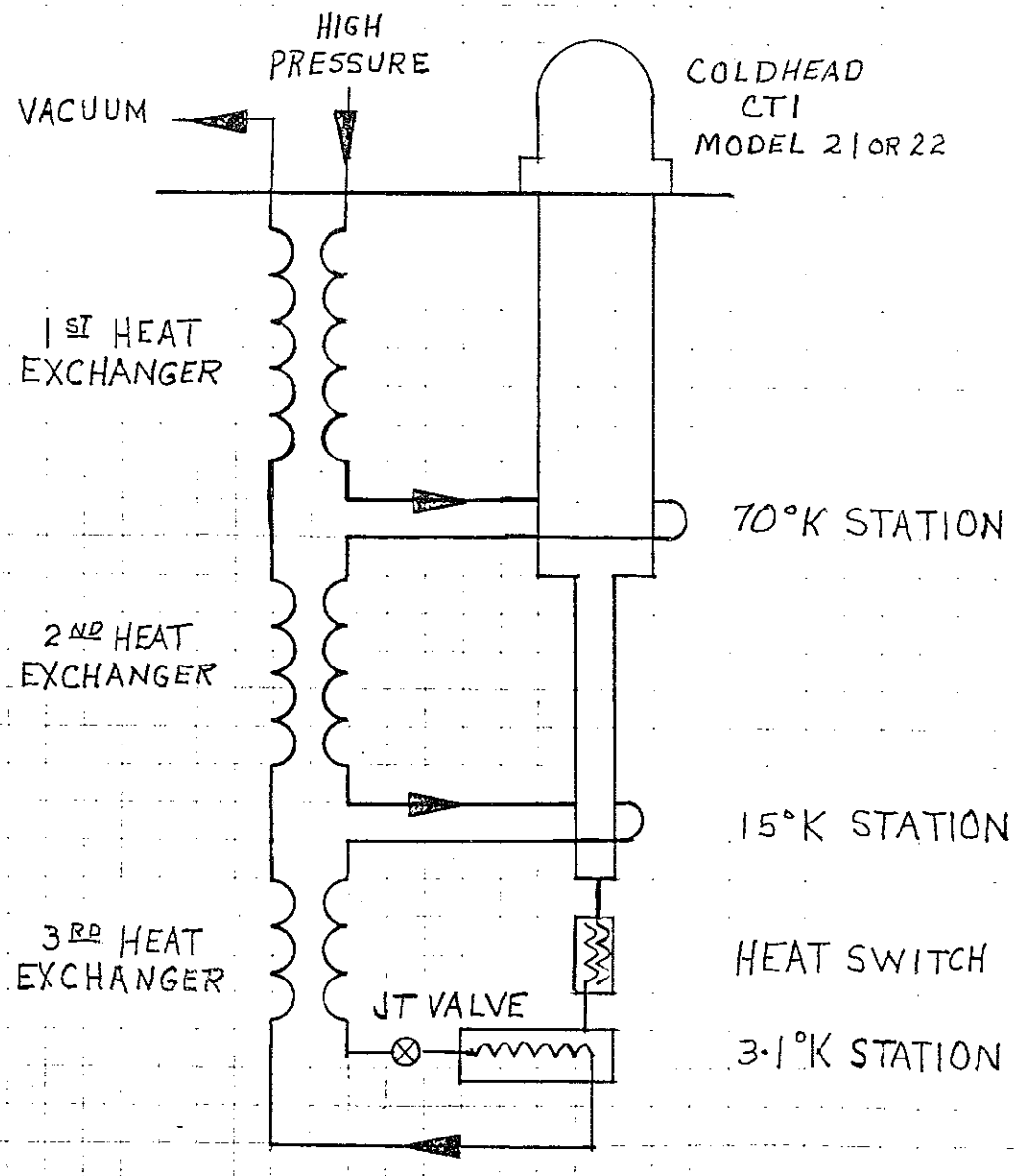
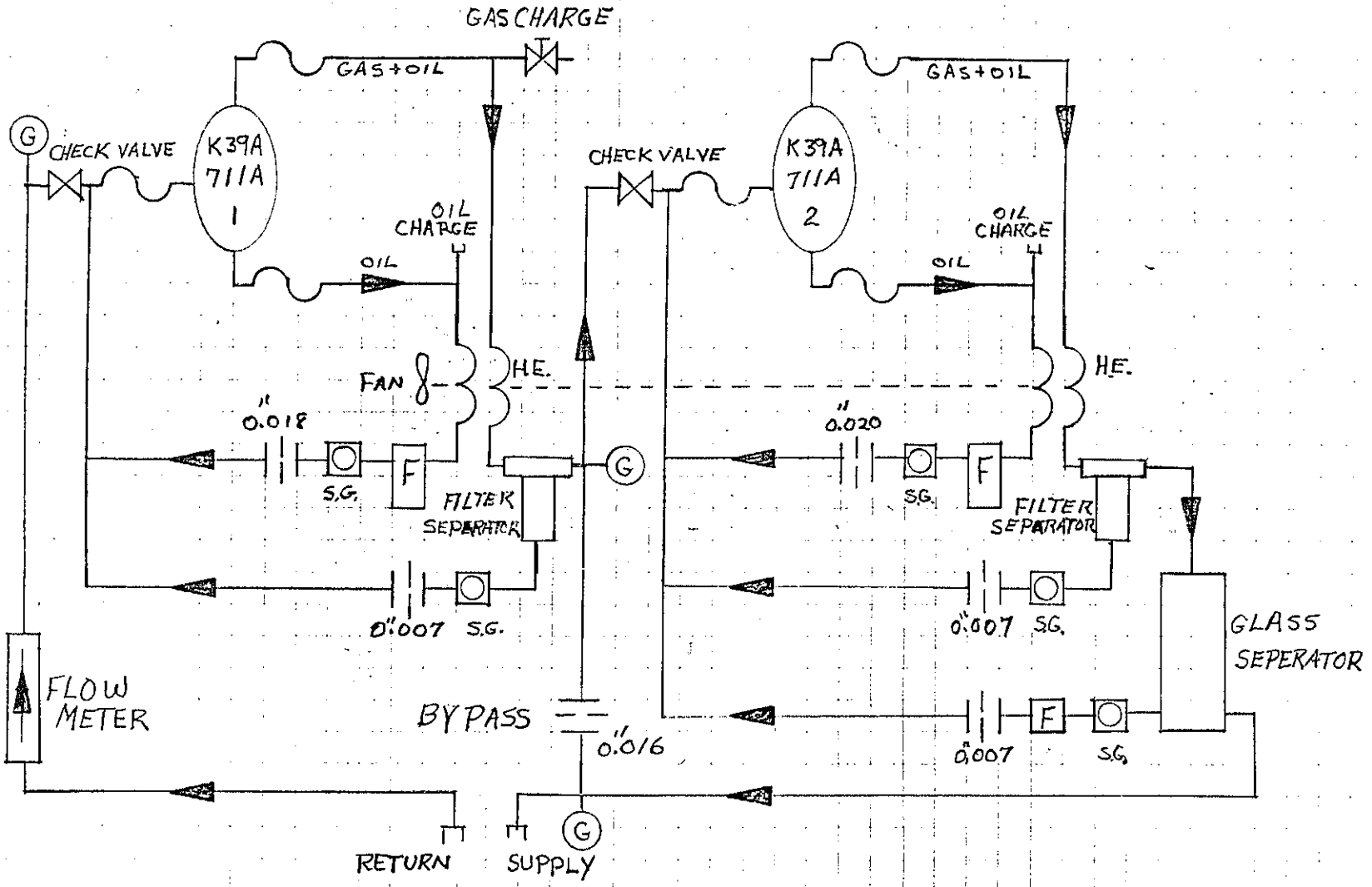


FIGURE 1



3.1K REFRIGERATOR

FIGURE 2



TWO STAGE COMPRESSOR

FIGURE 3