CONSTRUCTION AND HEAT IN-LEAK MEASUREMENTS OF A LONG CRYOGENIC TRANSFER LINE

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1. INTRODUCTION

An ultra-high-vacuum-insulated transfer line (about 43 m long) was designed and constructed as a part of a cryotrap system utilized for experimental Tokamak thermonuclear fusion system or high energy particle accelerators. The main purpose of the present design is to make a low-heat-loss and reliable transfer line by the use of ultra high vacuum techniques.

In the present paper, the results of performance test on the transfer line are described.

2. DESIGN AND CONSTRUCTION

Figure 1 shows a cross-sectional view of the transfer line. Three stainless-steel pipes (23 mm i.d.) are located in an annular space surrounded by the outer stainless-steel pipe (152.4 mm o.d.;3 mm thick). This annular space is evacuated for thermal insulation. Cold helium gas goes through one of the inner pipes and returns through other one. Liquid nitrogen flows through the third inner pipe. An aluminum cylinder is inserted between the inner pipes and the outer one. This cylinder is thermally anchored to the L-N line, and serves to shield the inner pipes from room-temperature radiation.

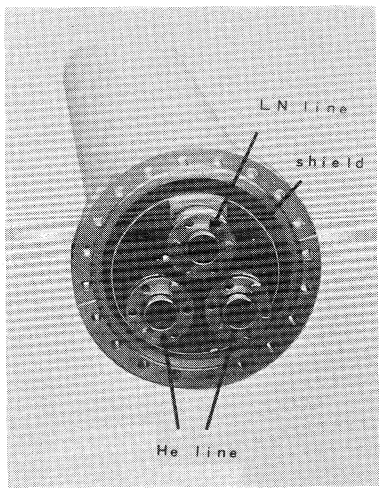

Fig. 1: Cross-sectional View of the Transfer Line

The transfer line consists of eight elbow units, six straight units, a U-turn unit, and an inlet-outlet unit. All couplings between these units are composed of bellows and metal-gasket

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flanges. All joints inside each unit are welded. Total length of the test line is about 43 m.

3. EXPERIMENTAL ARRANGEMENT

Figure 2 shows a block diagram of the experimental arrangement. The temperature of cold helium gas was measured at the inlet and the outlet of the transfer line (denoted as T_i and T_o). A flowmeter is located between the refrigerator and the compressors. Temperature measurements are made with two silicon diode sensors of the same type. The outputs from the flowmeter and the two thermometers are recorded by a micro-computer.

4. RESULTS AND DISCUSSION

Experimental results are summarized in Table I. We can derive total heat flux (Q_h) to the helium line as

$$Q_h = C_p Q_f (T_o - T_i) \quad ,$$

where T_i is the temperature of helium gas at the inlet of the transfer line and T_o is that at outlet. The specific heat of helium gas and the flow rate of the circulating helium gas are denoted by C_p and Q_f , respectively. The averaged heat flux to unit length of the helium line is estimated to be about 0.2 W/m.

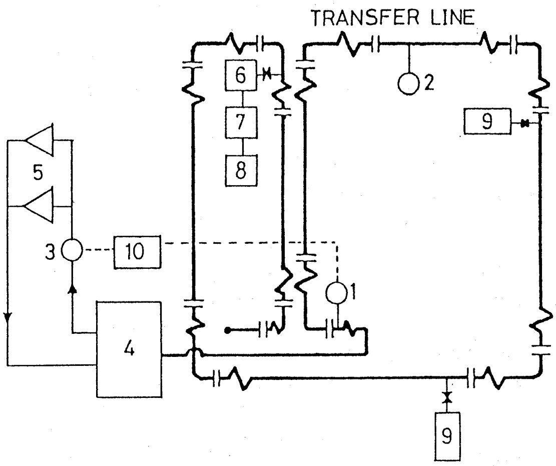

Fig. 2: Block Diagram of the Experimental Arrangement
1: Thermometers
2: Pressure Gauge
3: Flowmeter
4: Refrigerator
5: Compressors
6: Turbomolecular Pump
7: Mechanical Booster Pump
8: Rotary Pump
9: Sorption Pumps
10: Micro-Computer

Table I. Heat Flux to the Helium Line

TEMPERATURE (K)		FLOW RATE	HEAT FLUX	
at INLET	at OUTLET	(g/s)	TOTAL (W)	UNIT LENGTH (W/m)
14.0	14.8	3.98	16.6	0.2