Table I. Electrode parameters and ion currents 10 mm from the emitter.

p(Torr)	I_c	V_c	I_{ion}
2×10^{-4}	1.00 A	290 V	0.9 mA
2×10^{-4}	0.95 A	320 V	1.5 mA

temperature can reach 1450°C. The accelerating electrode is hemispherical in shape ($R=28$ mm). A hole ($r=10$ mm) lets the ions pass into the drift tube. On the back of the filament a stainless steel reflector was placed to prevent overheating of the source head flanges.

The ion beam was first monitored by a polarized (~400 V) Faraday cup placed 10 mm from the emitter. Ion current and electrode parameters are tabulated in Table I.

To focus the beam into the cyclotron vacuum chamber, a doublet of electrostatic quadrupoles was mounted behind the extractor. Each quadrupole is formed by four aluminum rods ($\phi=30$ mm, $l=180$ mm), supported by PTFE spacers.

Table II. Electrode parameters and ion currents at the cyclotron port.

V_E	V_c	V_{Q1}	V_{Q2}	Cup diam	I_{ion}
14 kV	450 V	270 V	670 V	32 mm	500 μA
				10 mm	180 μA

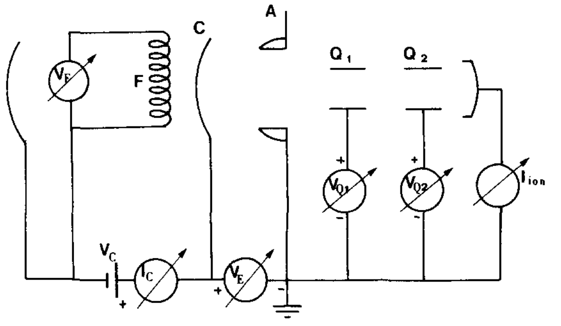

Fig. 2. Electric diagram: F—Filament; C—Emitter; A—Extractor; Q_1, Q_2—Quadrupoles.

The beam was monitored first by a Faraday cup 32 mm diam and then, to test the beam emittance, by a 10 mm cup placed at the cyclotron port. The collected current and electric parameters are shown in Table II. The reproducibility of currents with a sequence of five targets was within 10%. The current did not show appreciable variations after turn off and 72 h target exposure to air. The target lifetimes were always longer than 30 h of continuous run.

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[1] Centro Studi e Applicazioni in Tecnologie Avanzate, Bari, Italy.

[2] J. P. Blewett and E. J. Jones, Phys. Rev. 50, 464 (1936).

[3] G. Couchet, Ann. Phys. 9, 731 (1954).

Extraction of images from a very low temperature cryostat using fiber optics

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A cryostat is described in which optical images are transmitted from a helium-filled chamber at 0.3 K up to room temperature, using coherent fiber optics. A superfluid-tight glass to metal seal is used to seal the fiber optics rod into the cryostat.

In the course of an experiment to photograph quantized vortex lines in superfluid helium,[1] we have developed a method of extracting a coherent image from a helium-filled experimental chamber maintained at 0.3 K. In this note we describe the considerations and problems which were faced in the development of this method.

From the optics point of view, there are two obvious approaches to this problem, i.e., either use a lens system or else some sort of coherent fiber optics. In our experiment the expected image brightness would be very small and hence we desired very fast optics. There are several difficulties associated with using low f number lenses to transmit an image from a cryostat to room temperature. One problem is that thermal contraction of the cryostat requires the ability to focus the system once it has cooled down rather than at room temperature. A second problem arises from vignetting losses that will accompany the long optical path (~1 m) between room temperature and the object. This can be solved by using intermediate field lenses (such as in a periscope system) but this is an additional complication.

Fiber optics inherently do not have the problems mentioned above so we decided to use a commercially available fused, coherent, fiber bundle.[2] One can obtain fiber optics with an effective f number of at least $f/1$. An image can be

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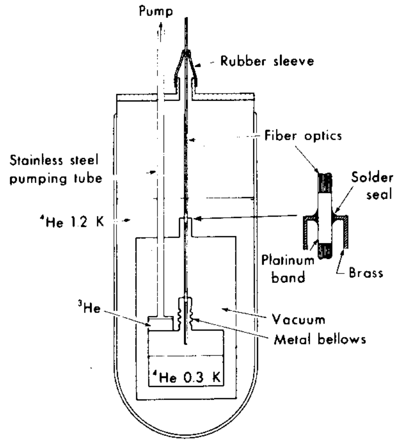

FIG. 1. Schematic view of the cryostat showing details of the fiber optics seals.

transmitted from one end to the other of such a fiber optics rod without any need of focusing and without any vignetting losses. (The absorption losses are ~30%/m in the visible). One can easily achieve resolutions of ~40 lp/mm which was adequate for our experiment. Fiber optics were particularly convenient in our experiment since the object we wanted to view was a luminous pattern on a phosphor screen. The screen was deposited on a fiber optics faceplate which was butted against the image conduit. Thus no lenses were used at low temperatures.

One problem is the question of how much heat is introduced by the fiber optics bundle into a ^{3}He refrigerator, either from thermal conduction down the glass or from room temperature radiation transmitted down the bundle. Figure 1 shows the essential geometry we used. Assuming that the thermal conduction of the fiber optics is not too different from Pyrex glass, we estimate that the heat leak from the 1.2 K bath to the 0.3 K chamber is less than 3 μW. The glass of the coherent bundles does not transmit an appreciable amount of the room temperature black body radiation. In actual practice we found that the over-all heat leak due to the fiber optics was probably less than 1 μW. (We have also used fiber optics in a dilution refrigerator at 70 mK and found no appreciable heat leak.)

Another problem to contend with is that of making superleak-tight vacuum seals to the glass bundle. Although it is not obvious that the fused glass bundle would be internally leak-tight, we never found any evidence of leaks down the bundle axis. As seen in Fig. 1, differential contraction between the glass bundle and the ^{3}He pumping tube can place considerable stress on the two low temperature glass-to-metal vacuum joints. In order to minimize this stress we placed a flexible metal bellows between the lower seal and the ^{3}He chamber. Initially we used epoxies[3] to seal the fiber optics, but these seals always eventually failed after several thermal cycles. A successful seal was finally achieved by using the technique of bonding platinum to the glass and then soldering to the platinum.[4] Such seals are known to be quite useful in room temperature applications; we have found them to remain leak-tight down to liquid helium temperatures. For these seals, platinum paint[5] is first applied to the glass and then baked at 600°C (the softening point of the glass). Then the platinum is tinned with soft solder, and soldered into brass bushings in the cryostat. Making reliable seals took a great deal of trial and error but once they were successfully made they were reliably thermally cycled many times.

The optical characteristics of coherent fiber optics and their adaptability to a low temperature apparatus can now permit the experimentalist to make direct inspection of a very low temperature chamber. This technique would seem to permit a great variety of applications.

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[1] R. E. Packard and G. A. Williams, to be published.

[2] We used a 3 mm diam image conduit of total length 1.3 m, obtained from the American Optical Corporation, Southbridge, MA.

[3] Stycast 2850 GT manufactured by Emerson and Cuming, Canton, MA., and "Two Ton" epoxy manufactured by Devcon Corp., Danvers, MA.

[4] F. Rosebury, *Handbook of Electron Tube and Vacuum Techniques* (Addison–Wesley, London, 1965), p. 205.

[5] Liquid Platinum #130-A manufactured by the Hanovia Division of Englehard Industries, East Newark, NJ.

A simple, high current gold ion source

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A simple, compact ion source has been developed capable of producing a continuous, uncontaminated beam of singly ionized gold with intensities up to 0.75 mA. Electron-impact ionization is used in a gold plasma; no support gas is used.

A simple, compact ion source has been developed capable of producing a continuous, uncontaminated, high current beam of singly ionized gold. In the application for which this source was developed, it was necessary to avoid the complexities of magnetic focusing and mass separation. It was decided to use electron-impact ionization as an ion

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