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Title: ELIMINATION OF ELECTRICAL GROUND LOOPS CAUSED BY HELIUM SUPPLY LINES IN CRYOGENIC RECEIVER SYSTEMS

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# ELIMINATION OF ELECTRICAL GROUND LOOPS CAUSED BY HELIUM SUPPLY LINES IN CRYOGENIC RECEIVER SYSTEMS

A. R. Kerr, N. Horner, and S.-K. Pan
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In cryogenic receiver systems using closed-cycle refrigerators, we have found that electrically conducting (stainless steel) helium supply lines between the receiver and a remote compressor can introduce a large ground loop whose effect on low level bias and control circuits can be serious, especially when the receiver and its instrumentation are in separate racks. As shown in Fig. 1, the ground loop in question is completed by the power company grounds at the two ends of the helium lines — at one end through the compressor, and at the other end through the receiver dewar and instrumentation rack. 60 Hz magnetic fields threading this low impedance loop will induce a large circulating current unless the loop is interrupted by a relatively large impedance.

To open-circuit such ground loops, we have made G-10 glass epoxy fittings, as shown in Fig. 2, which can be connected between the refrigerator and the helium lines. These isolators were tested on an SIS test receiver in the CDL which was connected to compressors 150 feet away. Initially, the 60 Hz open circuit voltage between the receiver and the (disconnected) helium lines was 0.4 V (peak to peak), with a source impedance of 0.23 ohm. The corresponding short-circuit current was 1.7 A. Connecting the helium lines to the receiver without isolators caused a 12 mV 60 Hz voltage between the dewar and the equipment rack connected to it by a copper braid of resistance 0.007 ohm (1.7 A in 0.007 ohm gives 12 mV). When an SIS bias supply mounted in the equipment rack was connected to the dewar, the junction voltage monitor indicated a 60 Hz component of 0.5 mV — an unacceptably high level for an SIS mixer. With the helium line isolators installed, the 60 Hz voltage between dewar and instrument rack was reduced from 12 mV to ~60 μV (a factor of 200), and no 60 Hz voltage was visible on the SIS bias monitor.

The (uninterrupted) helium line ground loop may also be a potential hazard to SIS mixers. With the helium lines connected to the dewar, but without a very low impedance ground strap between the dewar and the instrument rack, a substantial 60 Hz voltage may exist between the dewar and rack (in the above example, 0.4 V). Connecting a bias cable between the bias box and dewar could then be fatal, depending on the order in which the pins make contact. To eliminate this hazard without electrically isolating the helium lines would require a very well connected milli-ohm ground strap between the dewar and instrument grounds. It is possible that the lack of a good enough ground strap has been the cause of the unexplained SIS mixer failures in the CDL "rocket" test receiver.

Two concerns about these helium line isolators are helium leakage, and possible long-term contamination of refrigerator helium supplies. A He leak detector with a sensitivity of ~$10^{-10}$ std. cc/sec indicated no measurable leak at the metal to G-10 O-ring seals. The possibility of contamination of the refrigerator by the vapor pressure of the G-10 material is not known, but it is believed that G-10 components are used in CTI Gifford-McMahon refrigerators with no apparent complications. Of course, it is conceivable that JT valves in 4 K refrigerators will not be so tolerant.

The capacitance of each isolator was measured to be 6.1 pF.

We have now installed these isolators in all helium lines to the two SIS test receivers in the CDL.

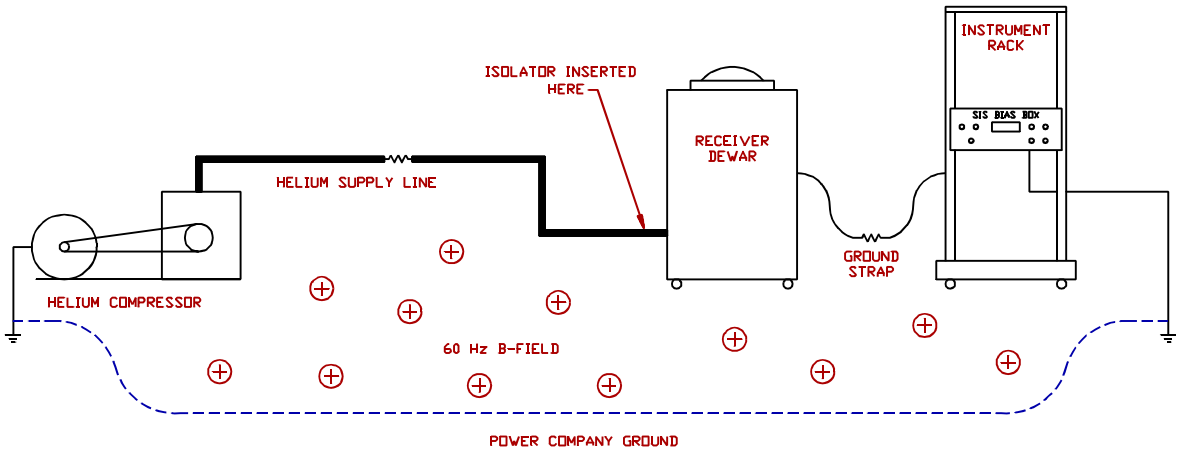


Fig. 1. Diagram showing the ground loop formed by the helium supply lines and the power company ground path.

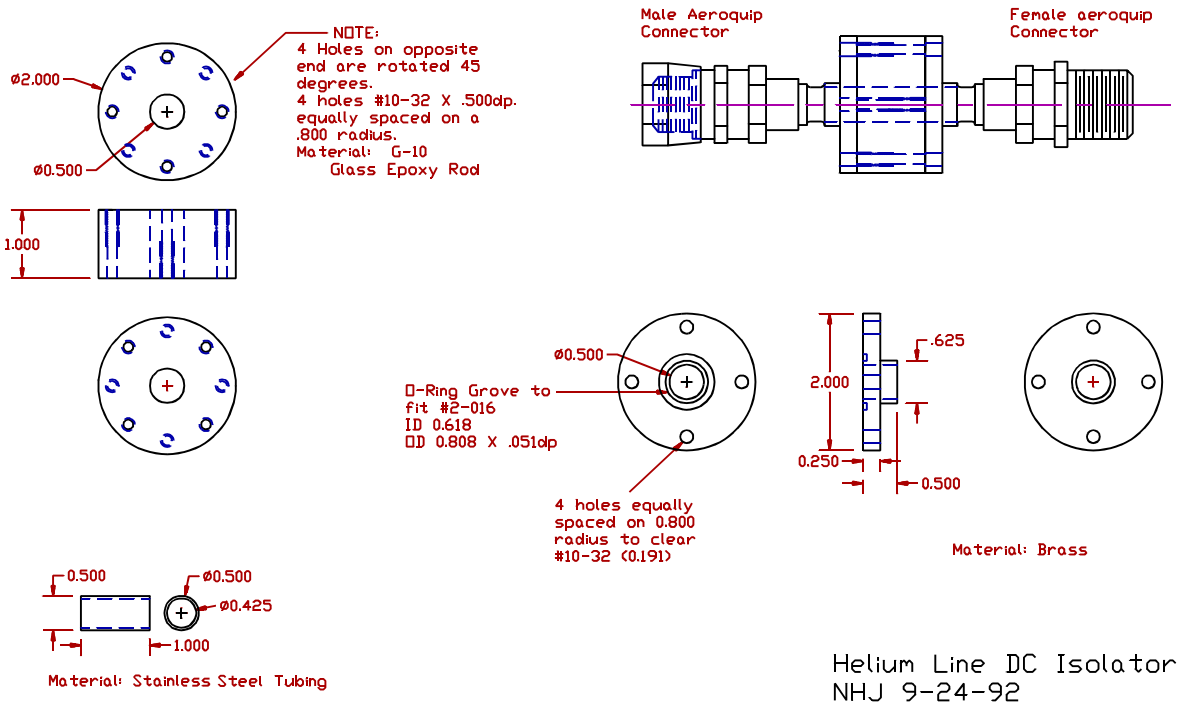


Fig. 2. Details of the helium line isolator. Dimensions are given in inches.