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ABSTRACT

This paper describes a versatile cooling and housing design and several methods for mounting lithium-drifted silicon and germanium detectors. Since considerable care must be exercised to keep non-encapsulated germanium detectors in their best operating condition, greater emphasis is placed on mountings for germanium detectors than on mountings for silicon detectors. Developmental problems, materials, and methods of evacuating the housings are discussed in detail.

INTRODUCTION

During the past 18 months refinements in the development and production of lithium-drifted semiconductor detectors have resulted in increasing demands for the use of these detectors, particularly in beta- and gamma-ray spectroscopy. The sudden popularity of these detectors led immediately to the demand for a dependable, inexpensive, and versatile mechanical system for housing and protecting them. Beginning with an initial set of design requirements, such a mechanical system has been developed.. The development proceeded in conjunction with the use of semiconductor detectors for experimental research. As more experience was gained in using the detectors, design requirements changed and many modifications and variations have resulted; however, the basic design has changed very little. Figure 1 is a photograph of the first unit built.

BASIC DESIGN REQUIREMENTS

(1) Both silicon and germanium detectors must be protected from surface contamination.
(2) Germanium detectors require low-temperature storage and operation; hence cooling must be provided.
(3) Cold volumes must be insulated well enough to prevent condensation of water on outer walls.
(4) Detectors must be well supported without contaminating active surfaces.
(5) The detector support must be easily accessible and must permit detector installation with minimum time delay.
(6) Both silicon and germanium detectors require low contact resistance ground and bias contact mechanisms.
(7) Capacitance between bias and ground must be kept to a minimum.
(8) The bias circuit must carry 500 to 1000 V dc without sparking and without measurable current leakage.
(9) As much area as possible of the active surface of the detector must be unobstructed by mounting and contact mechanisms, etc.
(10) The design must accommodate varying sizes and shapes of detectors.

BASIC DESIGN

To satisfy design requirements (1), (2), and (3) it was decided to mount the detector within a vacuum envelope, adjacent to a surface cooled by liquid nitrogen (LN). As a further insurance against contamination and to minimize outgassing, all vacuum joints are sealed with Viton O-rings. No vacuum grease of any kind is used in making the seals.

To satisfy design requirements (4), (5), and (9) the bias contact was made to serve as the detector support mechanism. This in turn satisfied design requirement (6) so far as the bias contact was concerned. Design requirement (10) was satisfied by providing a relatively large backing surface for the detector and by spring-loading the bias contact in such a way as to provide considerable travel for the contact.

Germanium detectors with ohmic contacts were grounded by positioning them directly against the backing surface.[1]

Design requirements (7) and (8) were satisfied by utilizing large spacings between the bias circuit and ground, with fine wire and as low a capacitance vacuum feed-through as we could find for the bias circuit, and by mounting the preamplifier as close to the detector as conveniently possible.

COMPONENTS

Figure 2 is a cross-section elevation drawing of the basic assembly.

The liquid-nitrogen container, Fig. 3, consists of a 1-in. -o. d.×0.020-in. -wall × 4-1/8-in. -long stainless steel tube hard-soldered into a 1-1/2-in.-diameter copper piece which serves as the detector backing surface. The opposite end of the tube is welded to a stainless steel flange which is sealed to the vacuum jacket on the tube side and to the liquid-nitrogen reservoir on the opposite side. The low thermal conductivity of the stainless steel tube limits the leakage of heat into the LN container.

The vacuum jacket, Fig. 4, consists of a 2-1/4-in. -o. d.×1/8-in.-wall × 3-3/8-in. -long brass tube hard-soldered at one end to a brass flange which mates with and seals to the flange of the LN container. Mounted on the side of this brass flange is a bellows-sealed evacuation valve. At the opposite end of the brass tube is hard-soldered another flange with at least one side port for mounting the bias circuit feed-through. To this flange is also mounted the end cap, which completes the vacuum envelope.

The bias contact assembly, Fig. 5(a), which also serves to hold the detector in place, consists of three parts: arm, insulator, and contact.

The arm is made up of a 4-40 NC brass machine screw about 1-in. long with a 0.050-in. hole drilled along its axis to form a threaded tube. This tube is captured on a 0.0465-in. -diameter stainless steel spring wire bent as shown in Fig. 5(b). A ring is hard-soldered to the wire end which terminates at the end of the screw in order to retain the screw. A boss about 3/64 in. long is machined at the opposite end of the wire. This boss is sized to a push fit in the contact insulator.

The contact insulator, Fig. 5(c), is a 3/32-in. -o. d.×0.034-in. -i. d. ×3/16-in. -long dense alumina tube with a 1/32" diameter cross hole to permit evacuation. One end of this ceramic tube is pushed onto the bossed end of the arm and the contact is pushed into the other end.

The contact, Fig. 5(d), is a copper cylinder between 0.040 and 0.045 in. diameter by 3/32 in. long. One end is pointed with about 120 deg included angle and the other end has a boss identical to that of the arm so that it may be pushed into one end of the contact insulator. A 0.0135-in. cross hole is drilled through the contact so that a 0.010-in. -diameter copper wire may be inserted. The contact is then crimped onto the wire.

This contact assembly minimizes contact-to-ground capacitance by keeping facing surfaces small, spaced well apart, and separated primarily by vacuum. The length of the screw permits its use with detectors of varying shapes and of thicknesses from 1 mm to about 13 mm. The contact is made and the detector retained by adjusting the arm screw in a tapped hole in the backing plate as shown in Fig. 6.

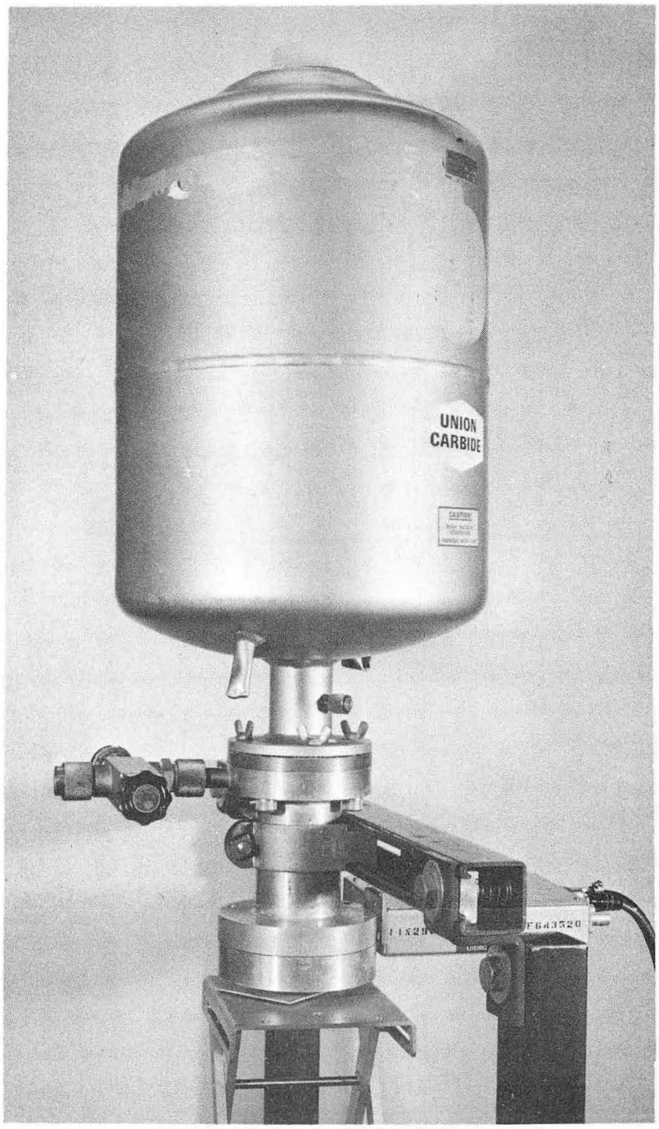

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Fig. 1. First basic unit—built and operated in December 1963.

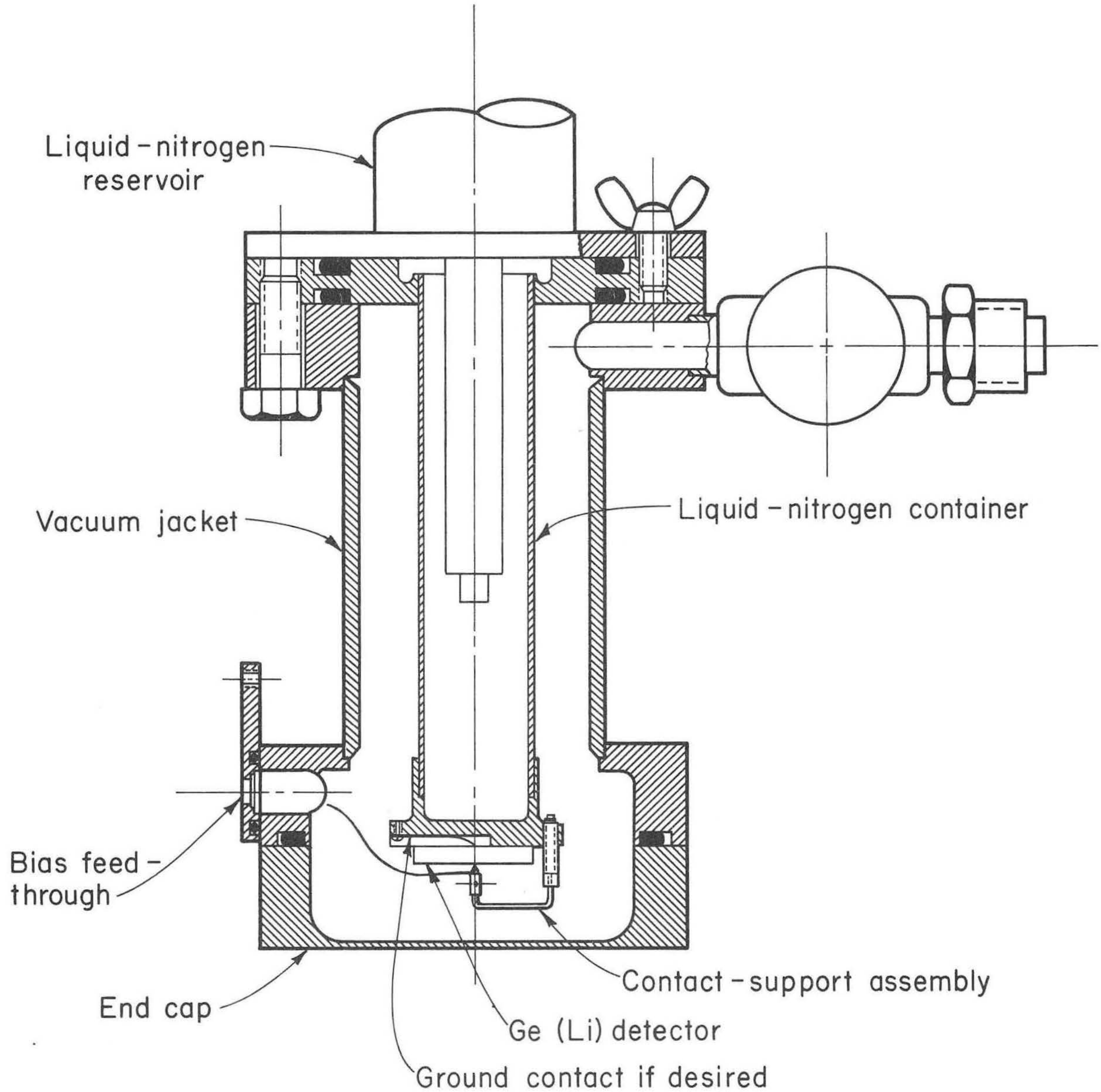

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Fig. 2. Cross-sectional view of basic assembly.

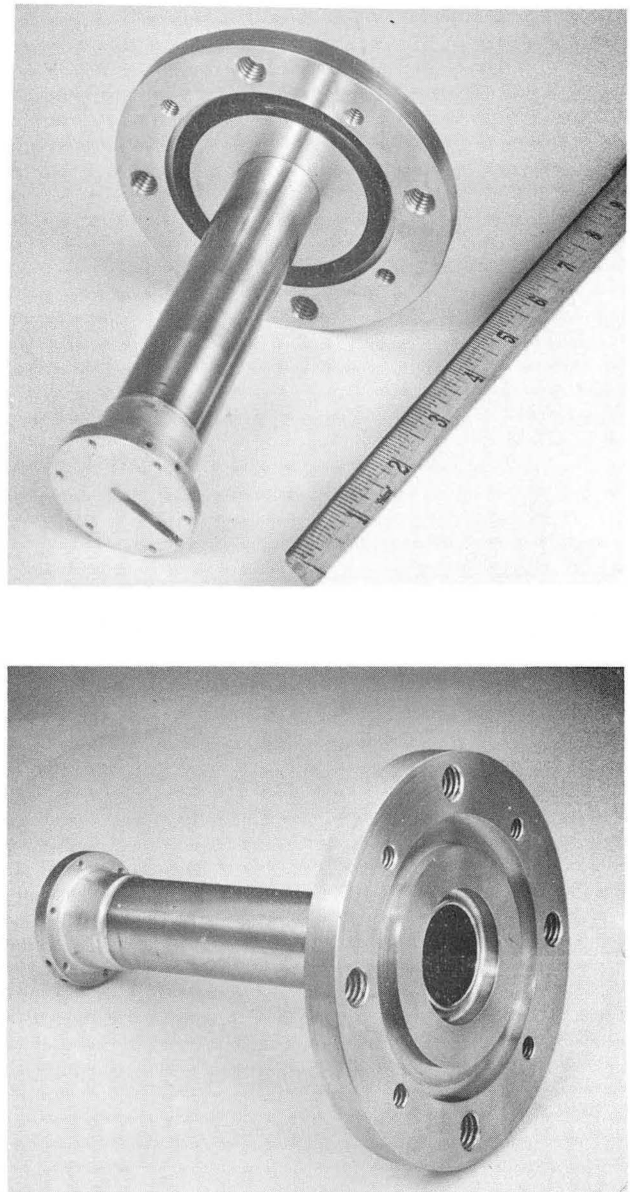

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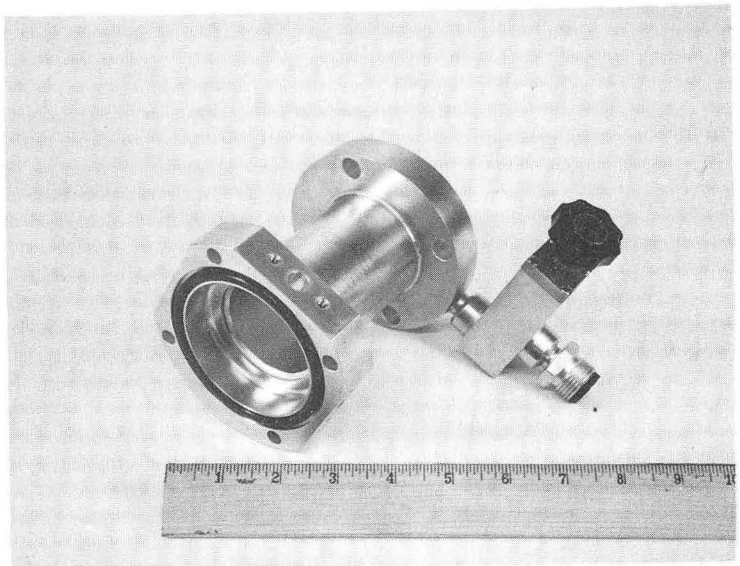
Fig. 3. Liquid-nitrogen container.



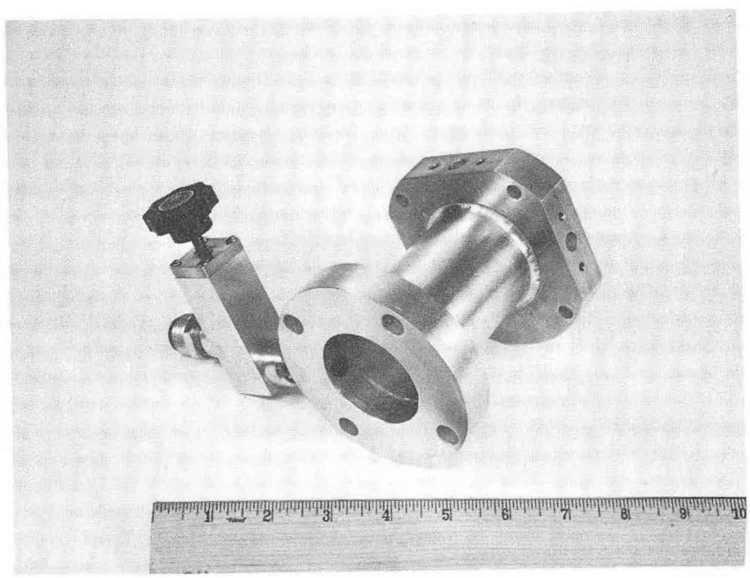


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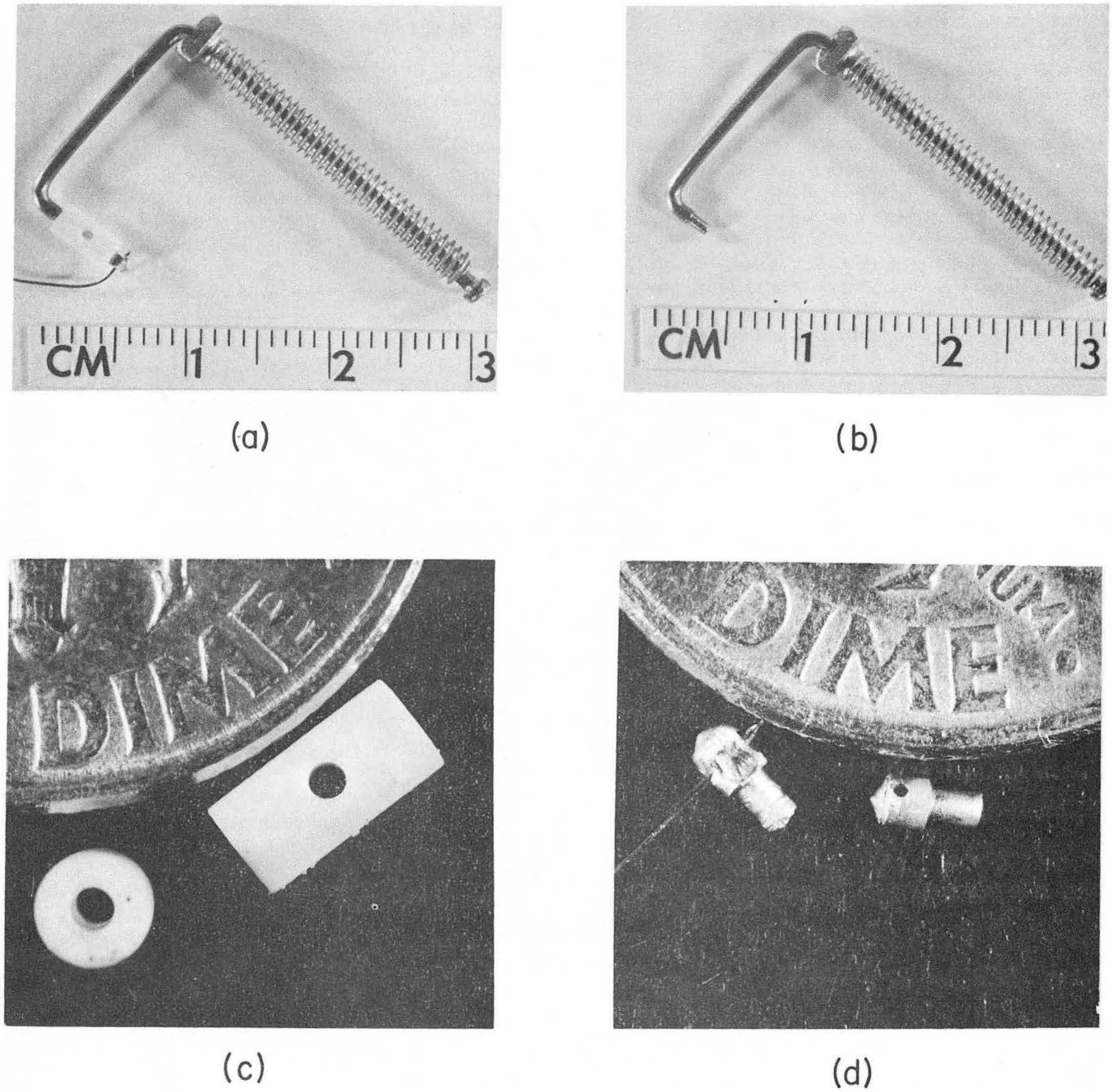
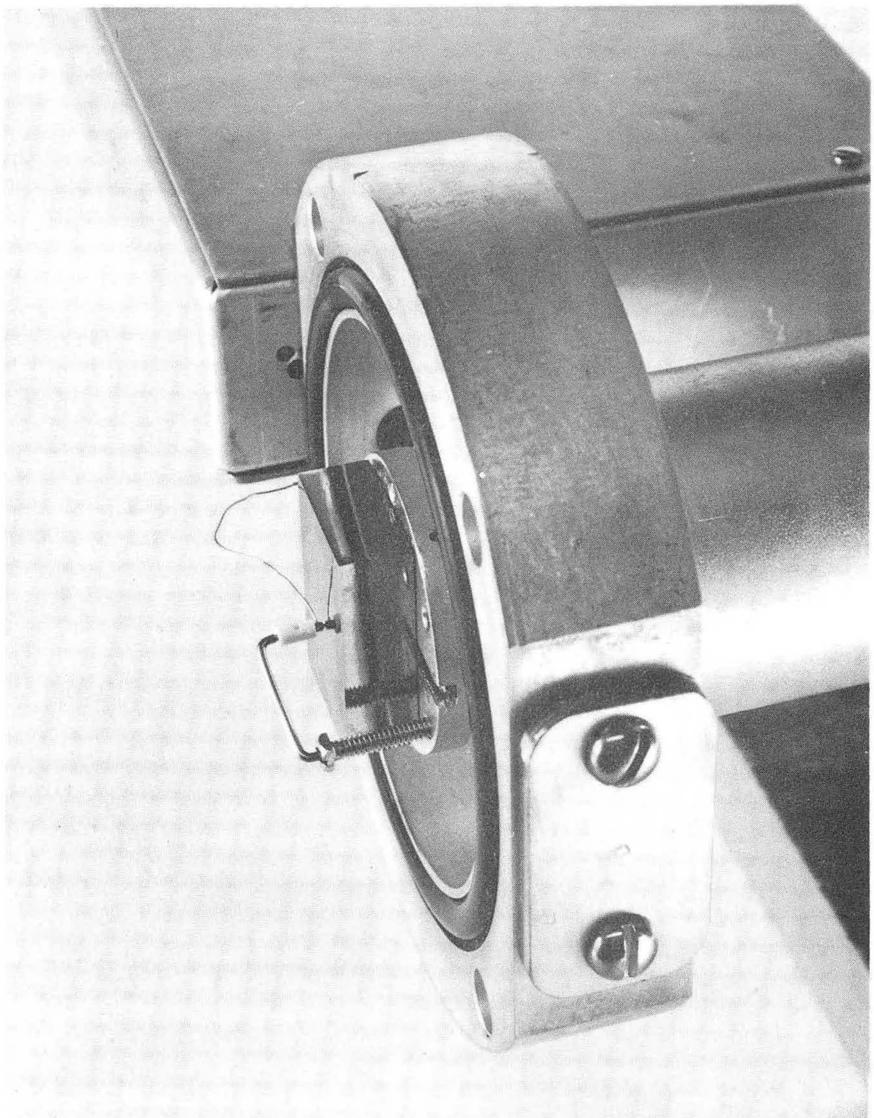
Fig. 4. Vacuum jacket.



ZN-4760

Fig. 5. Bias contact assembly.
(a) Arm, insulator, and contact assembled.
(b) Arm.
(c) Low-capacitance contact insulators.
(d) Contact with 0.0135-in. cross hole for inserting wire, and contact after crimping onto wire with round-nose pliers.



ZN-4738

Fig. 6. Bias contact assembly supporting detector.

The bias feed-through, Fig. 7, consists of a kovar-glass, three-wire terminal[2] soft-soldered into a 1/8-in. -thick brass plate. The two outer wires of the terminal are clipped off at both sides of the glass insulator as close as possible to the glass. The brass plate seals against the side port of the vacuum jacket and is designed so that the preamplifier mounting plate can be attached to it in any of four different positions.

The preamplifier mounting plate, Fig. 8, is a 1/8-in. -thick brass plate of the same general outline as the bias feed-through plate. It is attached to the preamplifier as close as possible to the bias input terminal. Attaching the preamplifier mounting plate to the feed-through plate completes the ground circuit from the detector to the preamplifier case.

The end cap, Fig. 9, is made of aluminum alloy. The surface facing the active surface of the detector may be varied in thickness for use as an absorber or may support a beryllium window as described later in the section on variations.

The liquid-nitrogen reservoir, Fig. 10(a), is a Linde[3] model CR-10 gravity-feed device which holds 10 liters of LN. It is mounted—and sealed against internal pressure—directly to the flange on the LN container. The feed tube of the CR-10 extends about 3 in. into the LN container. When the liquid level in the container rises to the end of the feed tube, a pressure—equal to atmospheric pressure plus the head produced by the depth of LN in the CR-10—is built up in the vapor-phase volume of the LN container. The vapor-phase volume, Fig. 10(b), is the volume enclosed by the liquid surface, the wall of the LN container, and the flanged outer wall of the CR-10. As boil-off of LN in the LN container causes the pressure to increase within the vapor-phase volume, the liquid level is depressed slightly and gas is permitted to escape up the feed tube and out of the CR-10 until the pressure in the vapor-phase volume again reaches equilibrium with atmospheric pressure plus the liquid head in the CR-10. A simultaneous exchange of escaping gas and supply liquid occurs in the feed tube of the CR-10. Consequently, the liquid level in the LN container is regulated and held relatively constant as long as liquid is being supplied from the CR-10. A 4-psig relief valve which communicates with the vapor-phase volume is supplied as an integral part of the CR-10. This relief valve protects the LN container from overpressure in case of plugging of the feed tube of the CR-10. With a reasonably good insulating vacuum surrounding the LN container, the CR-10 gives it a pot life of at least 5 days on one 10-liter filling of LN.

The vacuum system, Fig. 11, consists of a 1-liter/sec sputter-ion pump[4] connected to the vacuum jacket through a 3/4-in. -brass, bellows-sealed vacuum valve.

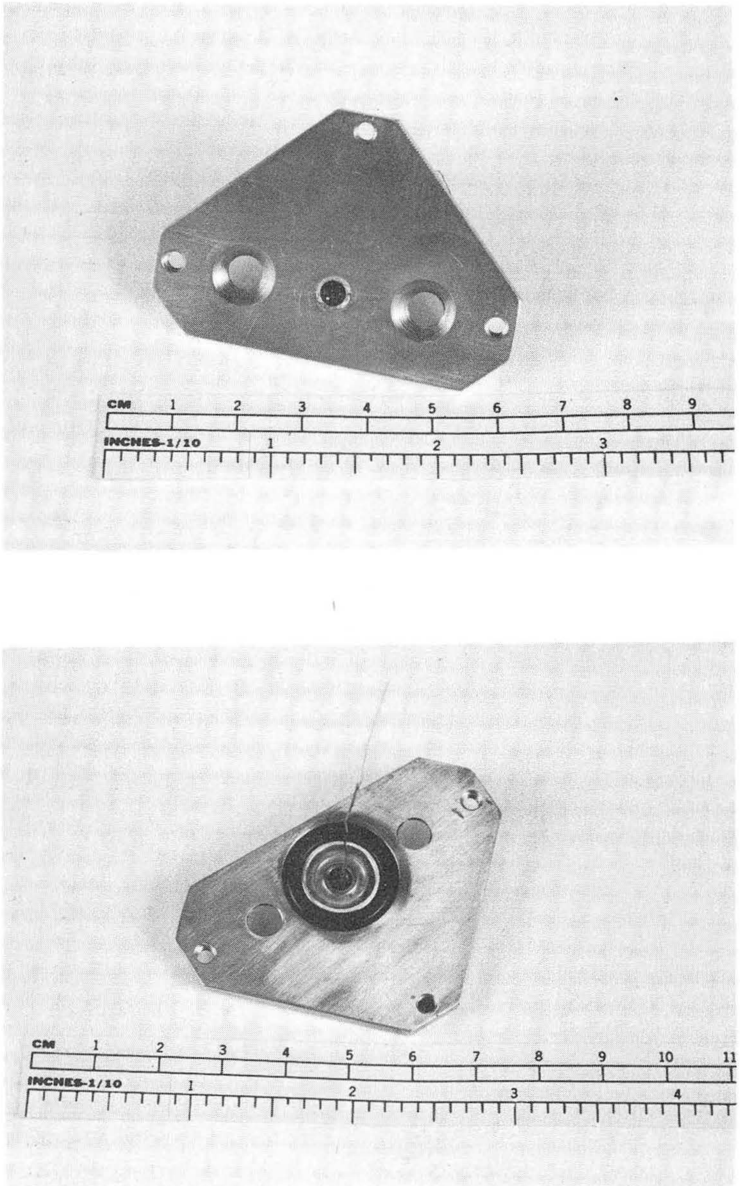


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Fig. 7. Bias feed-through mounted in brass plate.

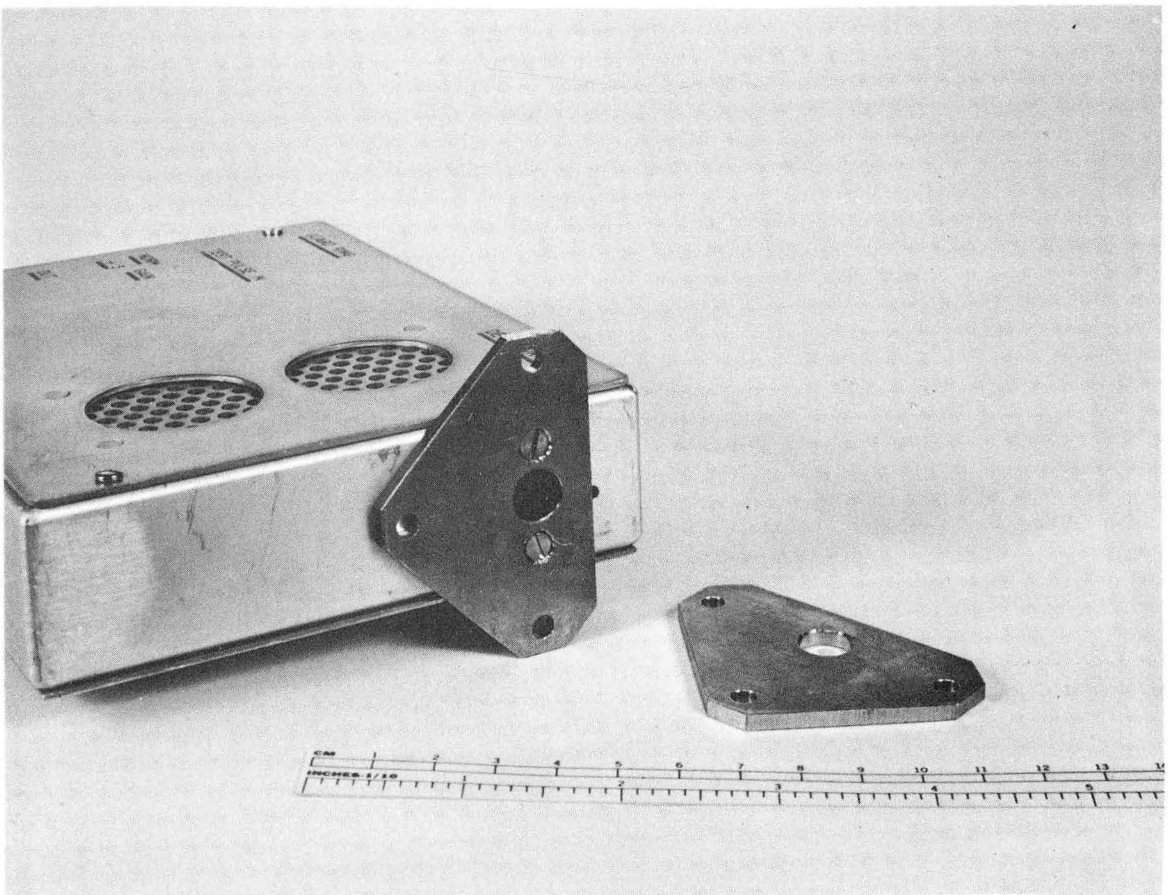

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Fig. 8. Preamplifier mounting plate and a typical plate mounted on a preamplifier.

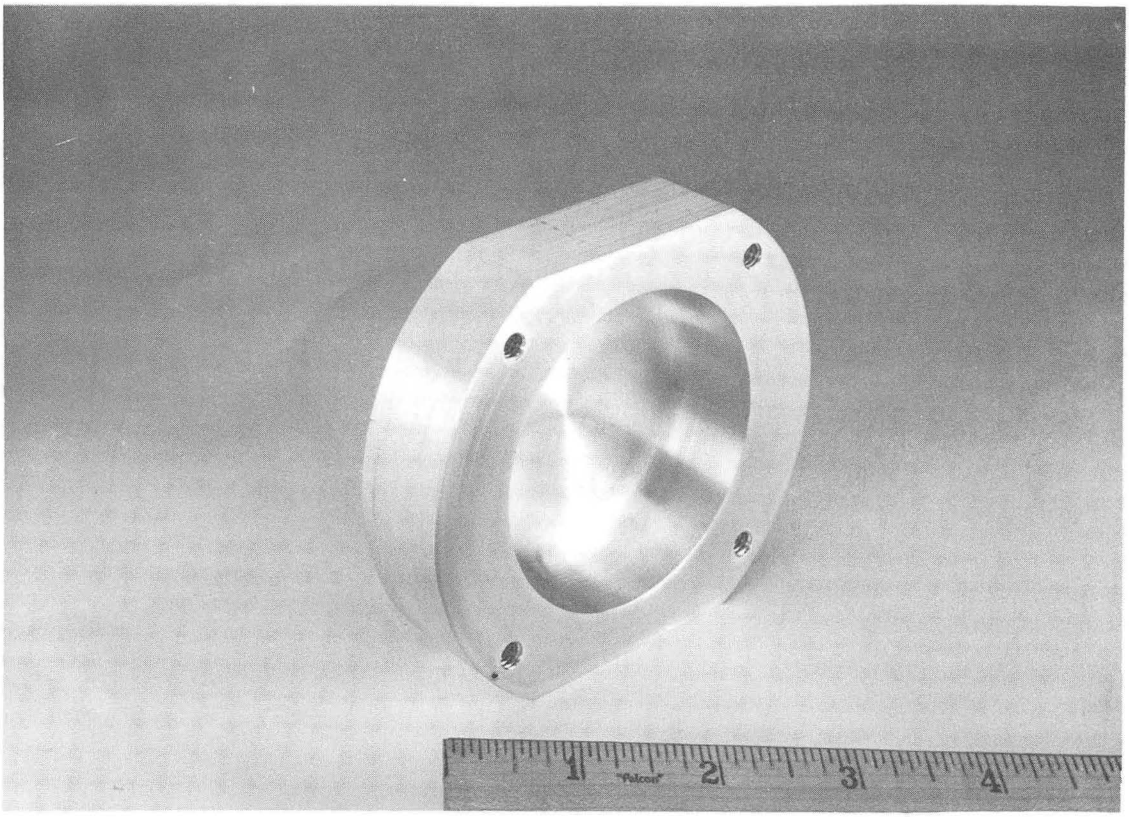

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Fig. 9. End cap.

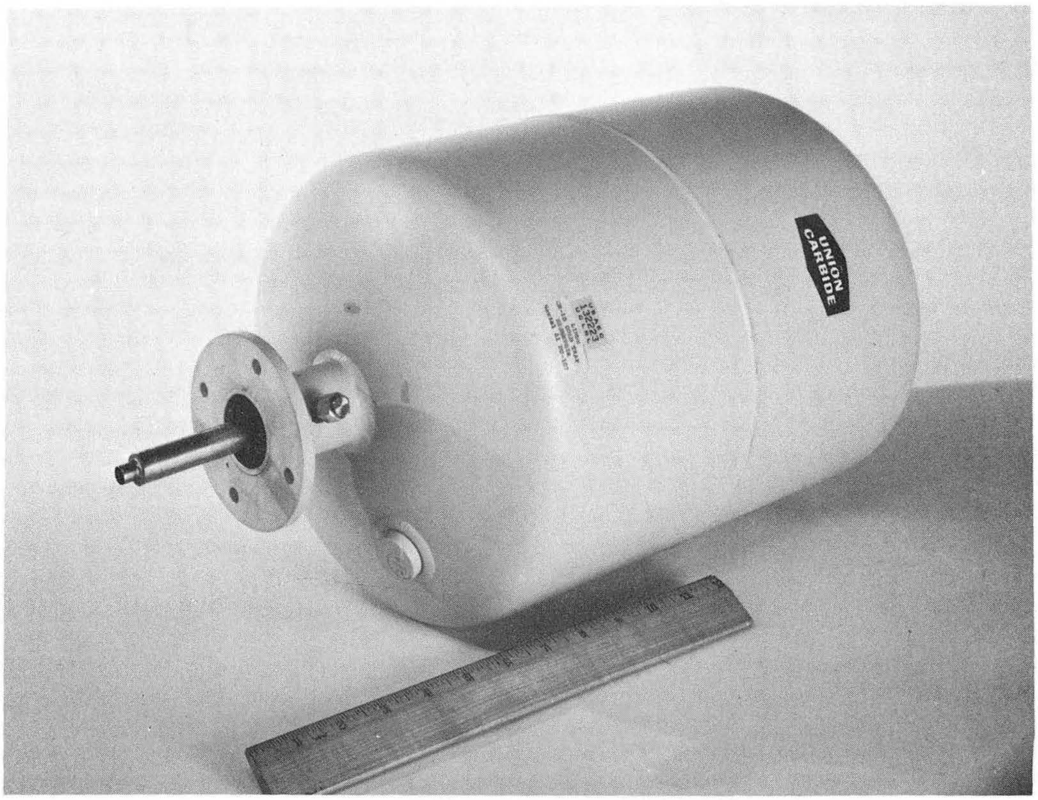

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Fig. 10(a) Liquid-nitrogen reservoir showing feed tube and mounting flange.

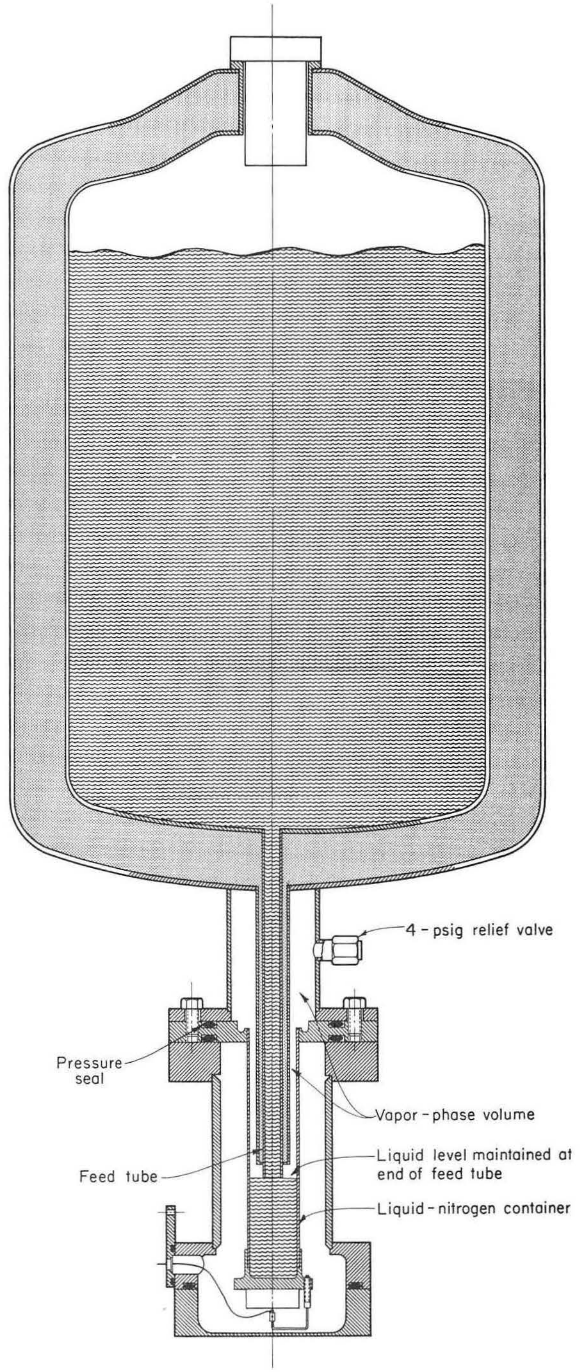
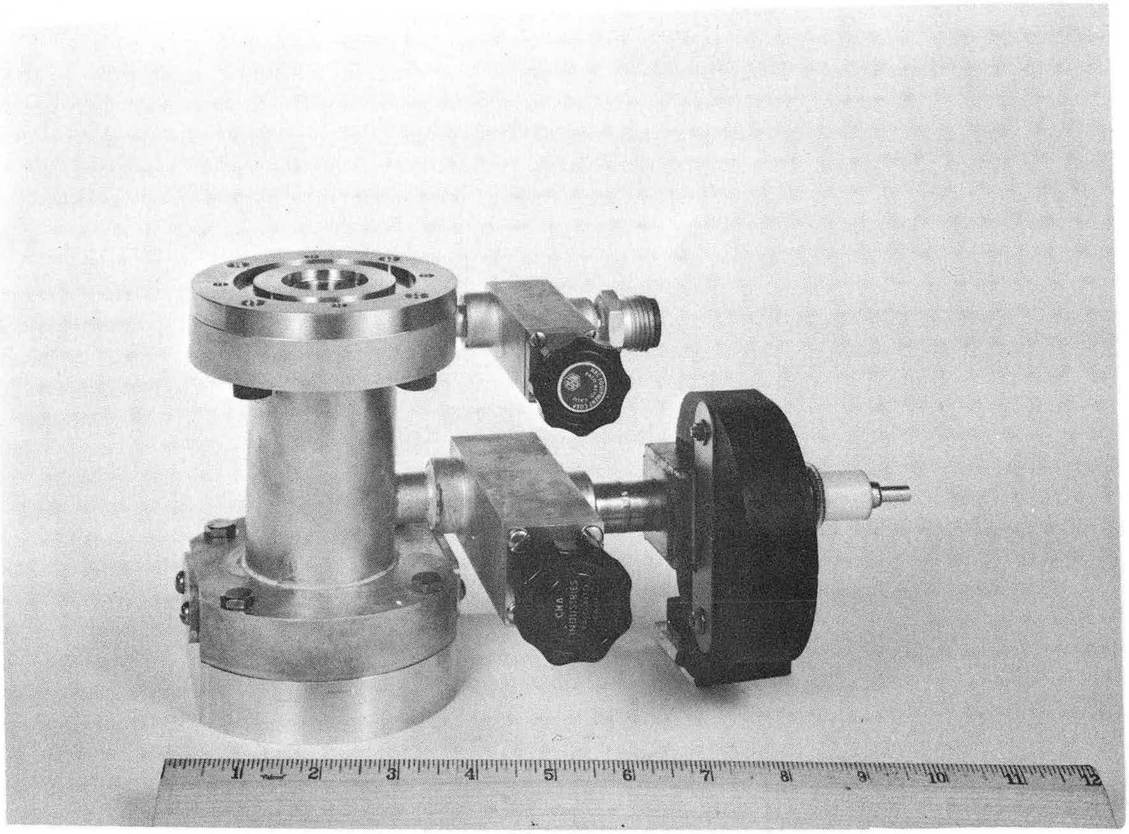


Fig. 10(b) Cross-sectional view of the liquid-nitrogen reservoir mounted on the basic unit.



ZN-4739

Fig. 11. Ion pump connected to the vacuum jacket through a 3/4-in. valve.

PROBLEMS AND DEVELOPMENT

The method of placing the detector directly on the backing plate to complete the ground circuit was quite satisfactory for small detectors, but as their size increased the detectors showed signs of chipping or cracking because of differential thermal expansion between the detector and the backing plate. Indium-mercury amalgam and gallium-indium eutectics are relatively high-strength solids at 77°K and will transmit thermal strain to the detector.

The differential-expansion problem was solved by using Dow-Corning 200 fluid between the detector and the backing plate.[1] Ground contact was maintained by incorporating a spring-loaded ground contact into the backing plate.[1] This method has two disadvantages. The first is that the Dow-Corning 200 fluid is of low enough viscosity at room temperature to run down the sides of the detector and contaminate the active surface. The second is that the fluid may contain air bubbles which can cause vacuum problems as they slowly migrate to exposed surfaces and burst.

Another method[5] solves the problem by utilizing a layer of indium foil between the detector and the backing plate. This permits relative slippage between the detector and the backing plate while maintaining the ground contact.

There are at least three possible disadvantages in the bias circuit feed-through that we are now using. First, its capacitance is about 0.6 pF. This seems satisfactory at present, but as detectors and amplifiers continue to improve, it may become a serious limiting factor in the signal-to-noise ratio. Second, kovar-glass junctions can produce measurable, but unstable, voltages under strain; hence they are capable of inducing considerable noise into the bias circuit. Third, the glass leaks sufficient light to produce a measurable leakage current in the bias circuit from secondary electron emission, which is picked up by the detector. Currents of several nanoamperes have been measured under direct light, but it is probable that the preamplifier prevents much light from reaching the feed-through. To eliminate this possibility, some feed-throughs have been made opaque by covering the exposed glass with black polyethylene electrical tape. When these feed-throughs were exposed to direct light no measurable leakage currents were observed.

The vacuum in the first unit constructed was maintained by pumping continuously with a mechanical vacuum pump. This was undesirable for several reasons. It was annoying to have to depend upon power and the functioning of mechanical apparatus to preserve the integrity of the vacuum envelope. The problem of the possibility of mechanical pump oil contaminating the detector had to be solved. Mechanical pumps are expensive, are relatively noisy, and they limit severely the portability of the detector holder.

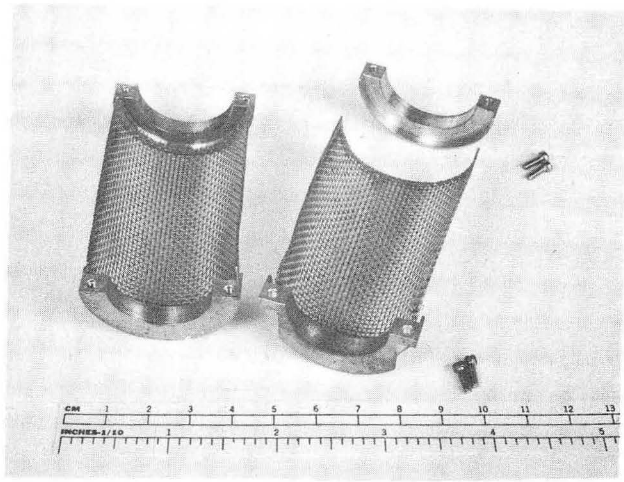
Most of the above arguments apply equally well to diffusion-pump systems, which were not seriously considered because of added complexity and expense.

A better solution to the vacuum problem was provided by the incorporation of a container of molecular sieve within the vacuum envelope. The molecular sieve container, Fig. 12(a), consists of two pieces of 20-mesh copper screen shaped to fit inside the collars of two copper split rings in such a way that the edges of the screens overlap about 1/4 inch. Three pieces of the two split rings are soldered to the ends of the screens, but the fourth piece is left loose to permit filling with molecular sieve. The two halves thus formed are clamped together by means of one split ring around the tube of the LN container. The container is then filled with a charge of 1/16-in.-diameter Linde type 5A molecular-sieve pellets,[6] and the loose ring half is clamped in place to retain the charge. The molecular sieve operates best when outgassed by pumping on the assembled holder, less the detector, with a well-trapped diffusion pump or ion pump. The outgassing can be expedited by heating the sieve while it is being pumped. Exposure of the outgassed sieve to air while the detector is being installed has no serious degrading effect as long as the exposure time does not exceed about a half hour. Once the detector is installed the holder should be pumped to the lowest pressure that time will permit, then valved off and cooled by filling the LN container. Figure 13 is a photograph of one of our operating holders which was evacuated and cooled, as described above, in February 1964. It has shown no indication of deterioration of the vacuum, which we believe is in the low 10^{-5}-torr range.

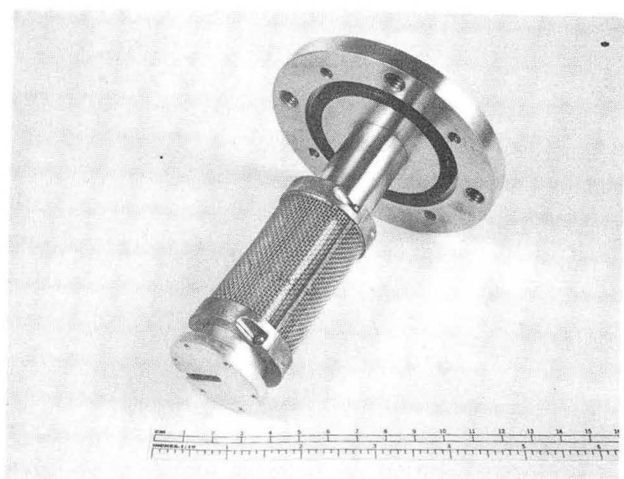
This method of maintaining vacuum has two distinct disadvantages. If the detector holder springs a vacuum leak, it does not become evident until the molecular sieve is entirely saturated. If the leak is repaired, the holder must be pumped with some auxiliary system to remove gas that comes off the now-saturated sieve at a relatively high rate for a long period of time—perhaps months. The sieve cannot be warmed without warming the detector. The second disadvantage is that this method includes no means of measuring pressure, and hence there is no way of knowing what is occurring within the vacuum envelope.

If one wishes to eliminate this second disadvantage by adding an ion gauge to the system, then he is far better off to eliminate the sieve and to use a sputter-ion pump. A 1-liter/sec ion pump will maintain the vacuum of a tight, operating holder at 2 or 3×10^{-7} torr, and when used with a metered control unit will indicate the pressure reasonably accurately. The cost of a small sputter-ion pump and power supply is comparable to the cost of an ion-gauge tube and power supply. One disadvantage of the ion pump is that it gets us back to power dependence for pumping. However, the ion pump is a closed unit and a tight, clean holder will hold a satisfactory vacuum for a day or two in the event of power interruption.

An inconvenience associated with small sputter-ion pumps is that one must go through a regular ritual to insure their proper performance. Those we use at present are Varian Vacion pumps with 3/4-in. o.d. stainless steel tubulation. To protect the titanium elements of the pump we cut off a portion of this tubulation and hard-solder the cut off portion into the solder cup of the 3/4-in. bellows-sealed vacuum valve mounted on the vacuum jacket of the holder. The vacuum jacket is then thoroughly cleaned, bright-dipped, etc. and leak-tested. The pump is cleaned ultrasonically with the tubulation facing downward to permit dirt to escape. The ultrasonic cleaning is done in trichloroethylene followed by acetone and then by ethyl alcohol. Following an



(a)



(b)

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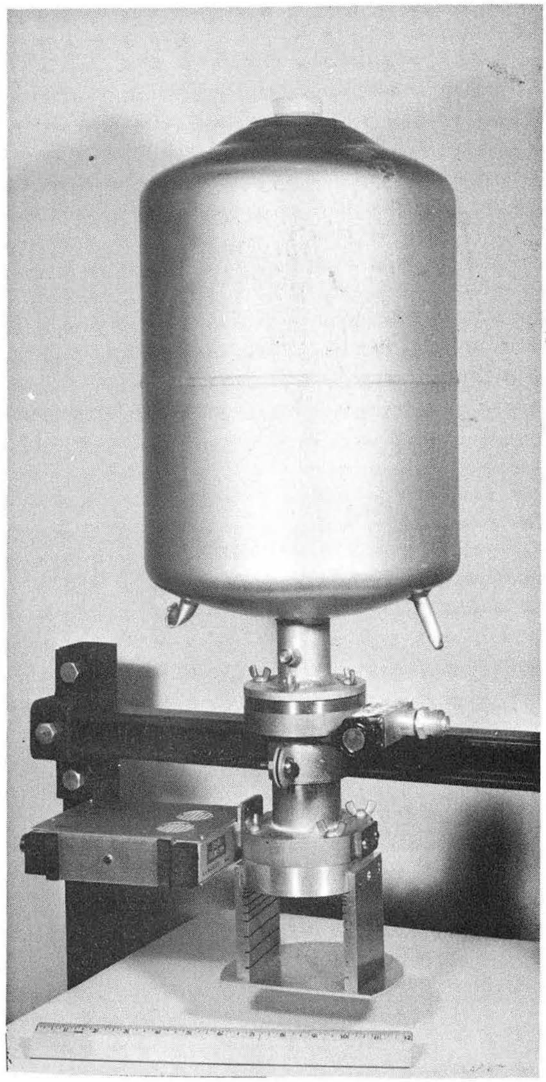
Fig. 12. Molecular sieve container.
(a) Halves and removable split ring section.
(b) Molecular sieve container assembled on the liquid-nitrogen container.



ZN-4740

Fig. 13. Unit pumped by molecular sieve only. This vacuum system is literally inside the unit.

oven dry at 300°F, the pump is heliarc welded back to the piece originally cut off from it. The vacuum jacket is then sealed and the body of the ion pump is baked at 225°C for 24 hr into a well-trapped diffusion-pump system. After being allowed to cool, the pump is started while still being pumped by the diffusion-pump system. After the ion pump has attained a pressure of 1×10^{-6} torr, the valve which separates it from the vacuum jacket is closed, and it is kept pumping as long as time will allow. If a holder with a small ion pump on it must wait for several days for a detector to be installed, it is desirable to keep the ion pump in operation so that it is ready to pump once the detector is installed and the remainder of the holder is evacuated. Once a detector has been installed in the holder and cooled, the ion pump should not be started with its valve open. After lying dormant for a period of time these pumps are capable of regurgitating a large quantity of gas which can easily contaminate a cold detector. There is some indication, however, that a detector which has lost resolution under such circumstances can be cured by pumping on it for a few days.[7]

The molecular sieve pump and the ion pump used together make an excellent combination, since the molecular sieve pump requires no power to maintain vacuum and a metered ion pump will indicate immediately any pressure changes within the vacuum envelope.

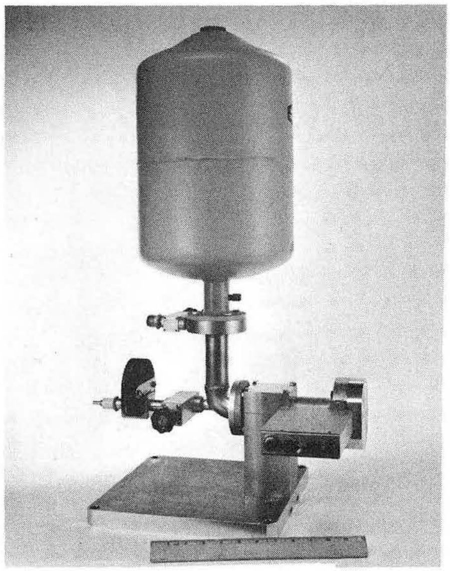
A desirable feature of small ion pumps is that metered control units are available which will operate as many as ten pumps simultaneously. This is of particular value where a number of holders are being used in the same general area, because it represents a significant reduction in cost of the pumping and pressure-indicating systems.

VARIATIONS

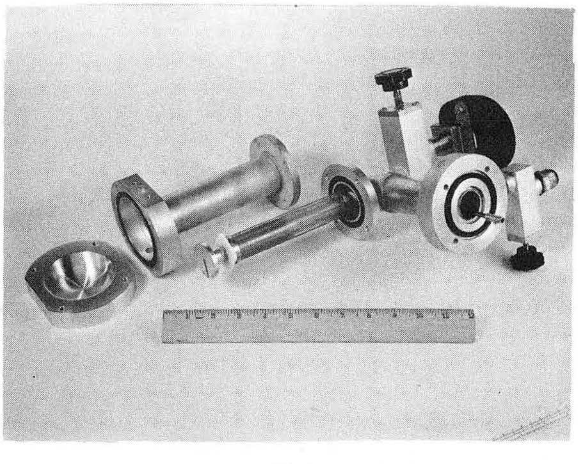
Within the limitations determined by low-temperature and cleanliness requirements, the housings can be made of various materials. We have, for instance, built several holders with aluminum alloy vacuum jackets for use where neutron scattering is a particular problem. The first variation of the basic holder came about because its vertical arrangement prevented its being used conveniently for coincidence and angular correlation work: A horizontal version, Fig. 14, was developed. This version is much more convenient to use and is highly recommended as a standard general-purpose configuration.

Mountings for "home-made" as well as commercial silicon detectors were developed so that the basic holders could be used for these detectors as well as for germanium detectors. Figure 15 shows a sectional view and parts of such a mount for a home-made silicon detector. Figure 16 shows similar details of such a mount for a transistor-cased silicon detector purchased from Technical Measurement Corporation.

The resolution of lithium-drifted silicon detectors is best at reduced temperatures. The optimum resolution temperature for our home-made silicon detectors varies from detector to detector, but it usually lies between -30 and -70°C.[8]



(a)



(b)

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Fig. 14. Horizontal version of basic unit.
(a) Assembled unit on a typical stand.
(b) Major components of this unit including a molecular sieve container.

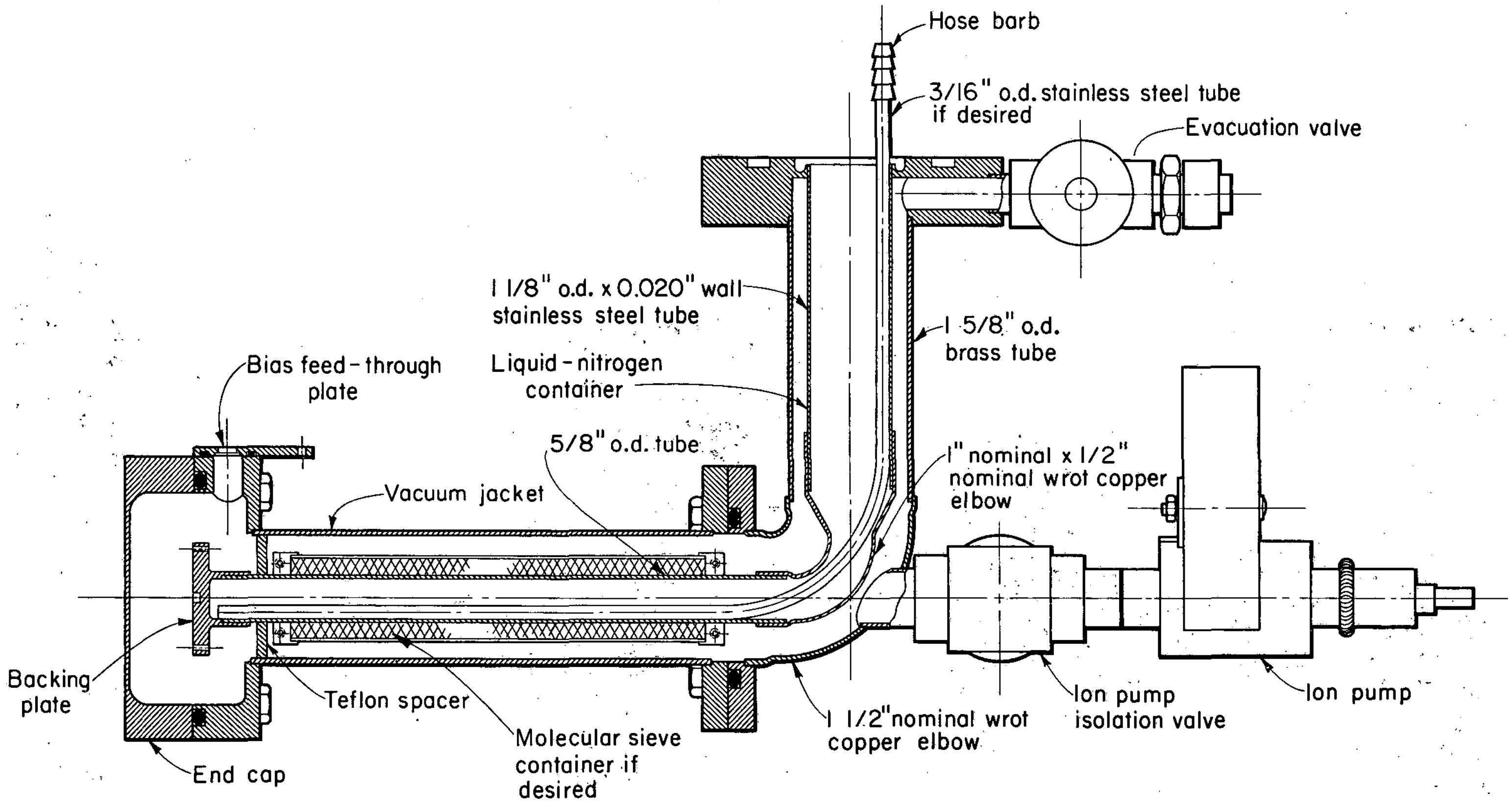

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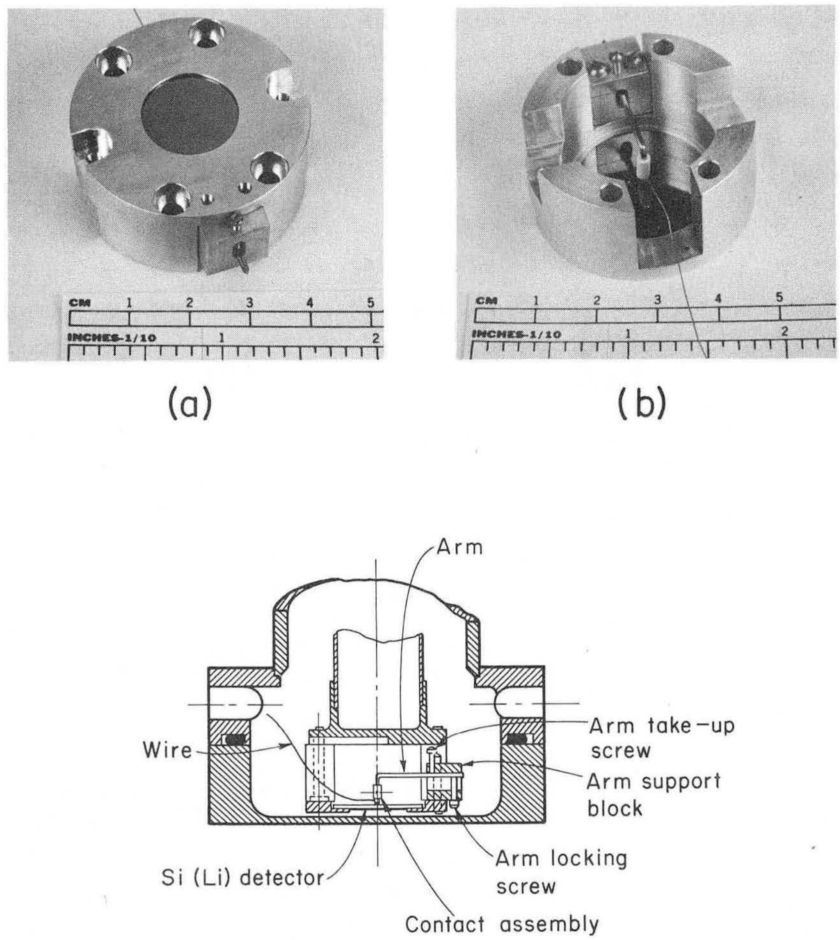
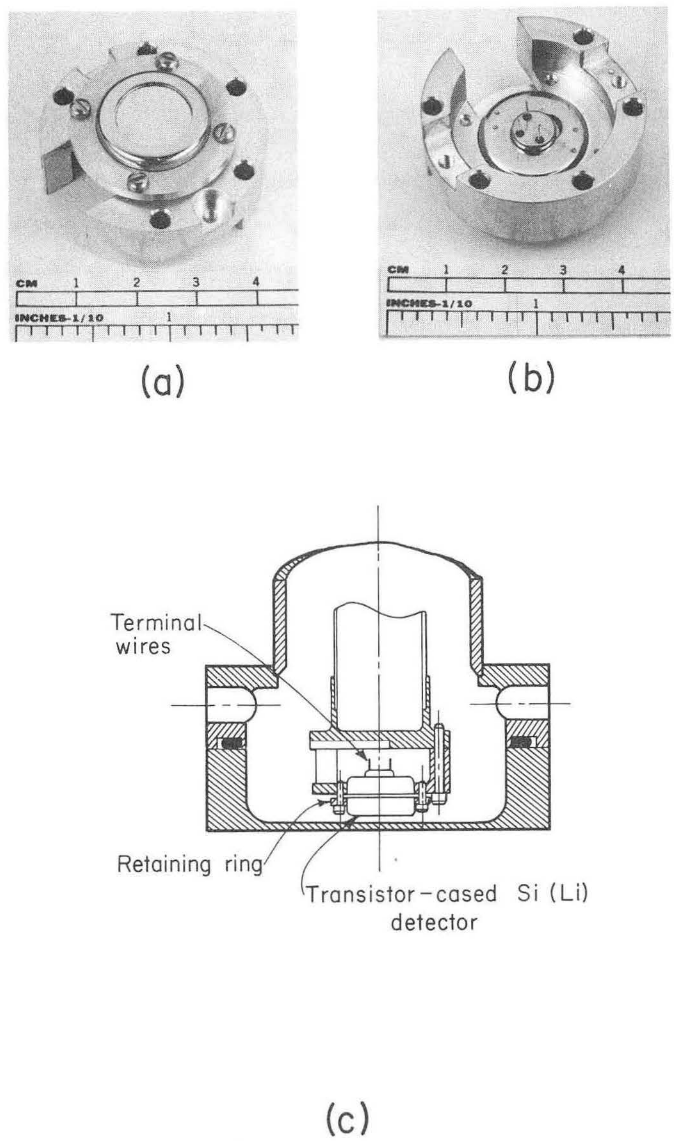
Fig. 14(c). Cross-sectional view of horizontal version of basic unit. An open-ended stainless steel tube extends from the hose barb shown to the region of the liquid-nitrogen container immediately behind the backing plate. By blowing warm air or nitrogen gas through this tube, one can quickly and conveniently exhaust the liquid nitrogen from this unit. This is a convenience, not a necessity.



(c)

ZN-4765

Fig. 15. Typical mount for a "home-made" Si(Li) detector.
(a) Front view showing the arm support block and the arm locking screw.
(b) Rear view showing contact assembly and arm take-up screw.
(c) Cross-sectional view.



ZN-4766

Fig. 16. Typical mount for a commercial transistor-cased Si(Li) detector.
(a) Front view showing the retaining ring.
(b) Rear view showing terminal wires.
(c) Cross-sectional view.

Many methods for cooling silicon detectors are available. Some are:

- Refrigeration
- Dry-ice baths
- Thermoelectric devices
- Gas-expansion cryostats
- Flowing nitrogen boil-off gas
- Liquid nitrogen.

Refrigeration involves too much mechanical equipment to be practical for this purpose.

Dry-ice baths have the advantage that they operate in the right temperature range, but they require frequent attention, close scrutiny, and a relatively large open container in order to avoid blocking and stratification.

Thermoelectric semiconductor devices show some promise, but are limited in convenient sizes by low load capacity and by power-supply requirements.

Gas-expansion cryostats are also limited by low load capacity and by pressure-tank dependence.

The use of boil-off gas from a pressurized nitrogen dewar[9] shows great promise and will, it is believed, permit the use of a vertical-configuration holder in the horizontal position.

For those who use the Union Carbide CR-10 LN reservoir regularly for cooling germanium detectors, LN can be used quite successfully for cooling silicon detectors.

A method we use regularly involves thermally insulating the detector mount from the backing plate, introducing a controlled heat leak to the detector mount, and monitoring the temperature of the mount adjacent to the detector.[10]

Thermal insulation is accomplished by placing three or four layers of 0.001-in.-thick Mylar film between the detector mount and the backing plate, as shown in Fig. 17. Two stainless steel screws tightened just enough to maintain ground contact hold the detector mount in place. If these screws are not too tight the temperature of the detector mount adjacent to the detector will be between -50 and -60°C.

The controlled heat leak, Fig. 18(a), consists of a 1/8-in.-diameter soft-copper wire hard-soldered into a ceramic-to-metal, cable-end-seal feed-through that is hard soldered to a 1/8-in.-thick brass plate. One end of the wire is inserted through a second side port in the vacuum jacket and attached firmly to the detector mount. A Viton O-ring in the brass plate seals the port. A thermally insulated copper housing containing a 40-W, 110-V cartridge heater is clamped to the opposite end of the wire. The heater cord is plugged into a laboratory powerstat. The powerstat permits temperature variation over a range of from 10°C to about 20°C above the temperature achieved by use of the Mylar-film insulators.

The temperature is monitored by means of a copper-constantan thermocouple, Fig. 18(b), attached securely to the detector mount. The thermocouple, sealed in a kovar-glass thermocouple feed-through soft-soldered into a 1/8-in. -thick brass plate, is inserted through a third side port in the vacuum jacket.

Parts (c) and (d) of Fig. 18 show silicon detector mounts with thermocouple and heat-leak wires attached. Figure 18(e) shows an assembled unit with powerstat and thermocouple pyrometer.

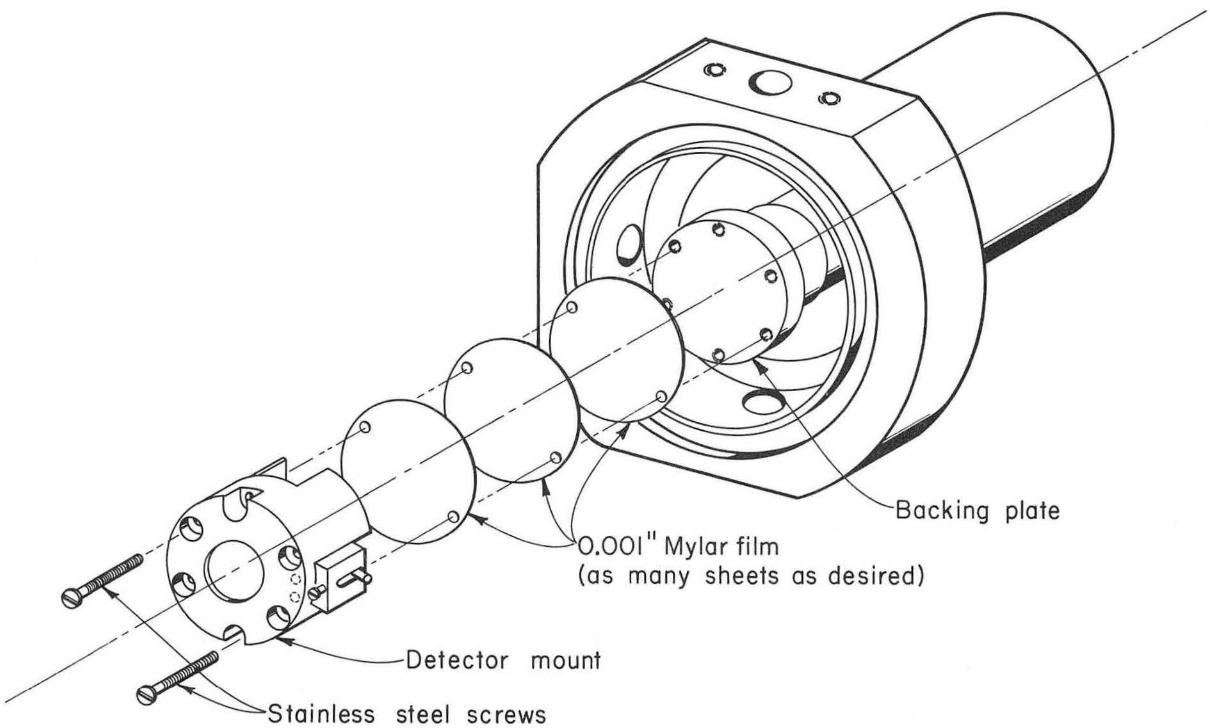
Since this method incorporates both sensing and variation of temperature, it lends itself well to electronic regulation of the temperature of the detector.

Some experiments require closer source-to-detector spacing for germanium detectors than is permitted by the basic contact-support mechanism. A simple, but rather awkward, high-geometry contact arrangement is shown in Fig. 19. The contact is the slug obtained from punching a 3/32-in. -diameter hole in a sheet of 0.020- to 0.030-in. -thick copper. A 0.010-in. -diameter wire is hard-soldered to the concave side of this slug and inserted through a pin hole in a 1/4-in. -wide ×0.002-in. -thick Mylar strip. The strip has a long slot near one end. The plain end of the Mylar strip is clamped to the edge of the backing plate. A screw with a washer flatted on one side is inserted through the slot and loosely engaged in a tapped hole near the diametrically opposite edge of the backing plate. When the detector is installed, the tape is pulled tight to make the contact and to hold the detector firmly in place. The screw is then tightened to lock the tape in place.

A more elegant but more versatile high-geometry arrangement is shown in Fig. 20. It consists of a C-shaped copper extension that is mounted on the backing plate. The protruding surface of this extension piece has a cutout as large as the detector will permit. The detector should overlap the cutout by about 1/16 in. on each side. The contact-support is similar to the basic contact mechanism. The surface against which the detector is mounted is 0.020 in. thick. Our general practice in using this mount for germanium detectors is to ground the active surface of the detector and to carry negative polarity in the bias circuit.

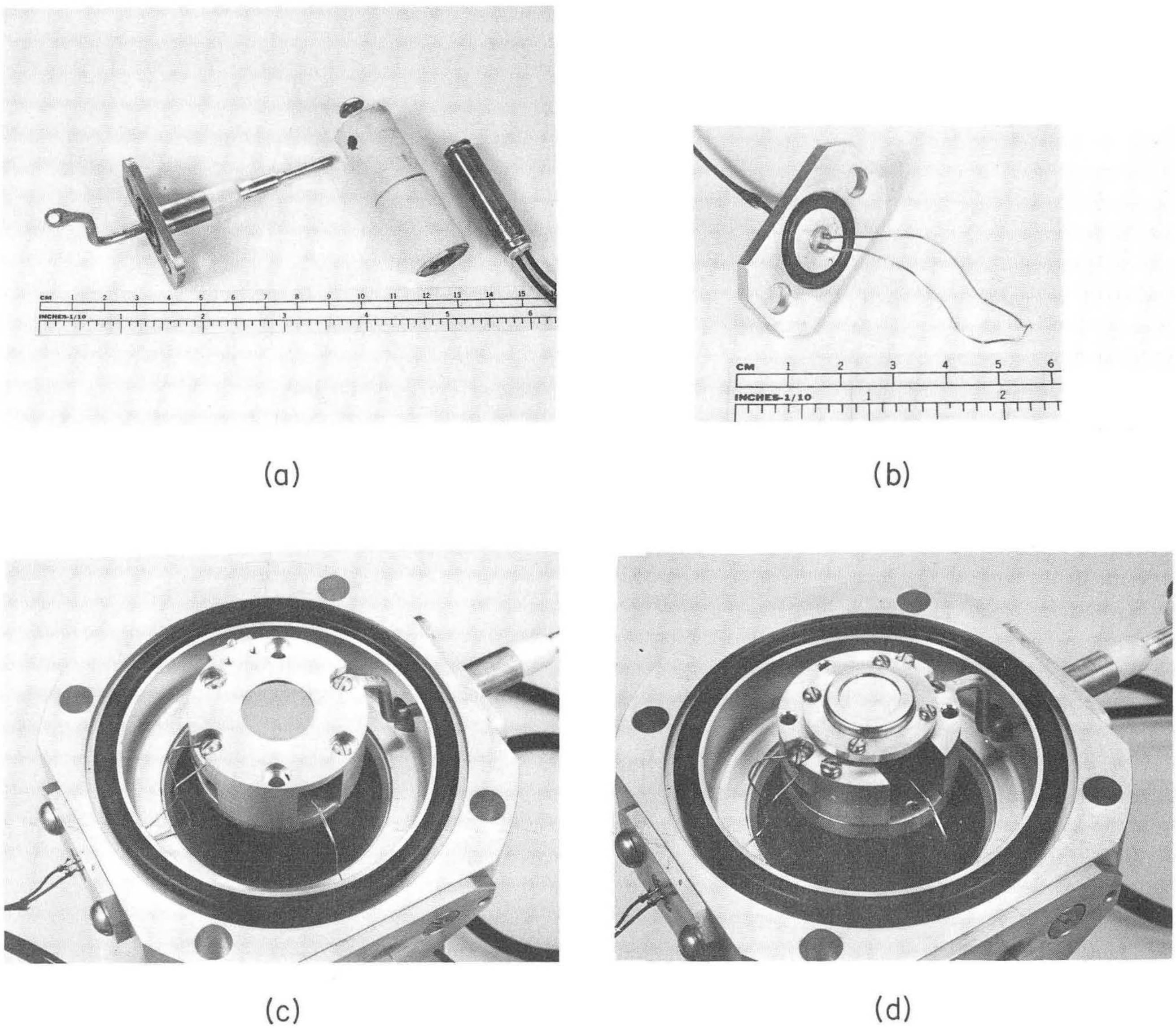
To minimize absorption by the end cap we generally use a thin window in conjunction with high-geometry configurations. If 0.010 in. of aluminum is tolerable, such a window can be machined in the end cap itself. In this case the window is limited to about 1 in. in diameter.

For lower absorption and larger diameter windows, a 0.010-in. -thick beryllium disk is mounted in the end cap as shown in Fig. 21. The disk is 1-15/16-in. diameter and covers a 1-1/2-in. -diameter opening in the end cap. A 1-31/32-in. ×0.070-in. -deep counterbore in the end cap positions the window and provides a large-area shoulder for vacuum sealing. The counterbore is grooved 1/32-in. ×1/32 in. about 0.010 in. from the bottom. The disk is glued to the shoulder with epoxy resin, with an internal fillet and a large external fillet which fills and covers the groove. When the epoxy sets it is keyed into the groove, producing a high-strength joint which prevents motion of the periphery of the disk when subjected to vacuum loading.[11]



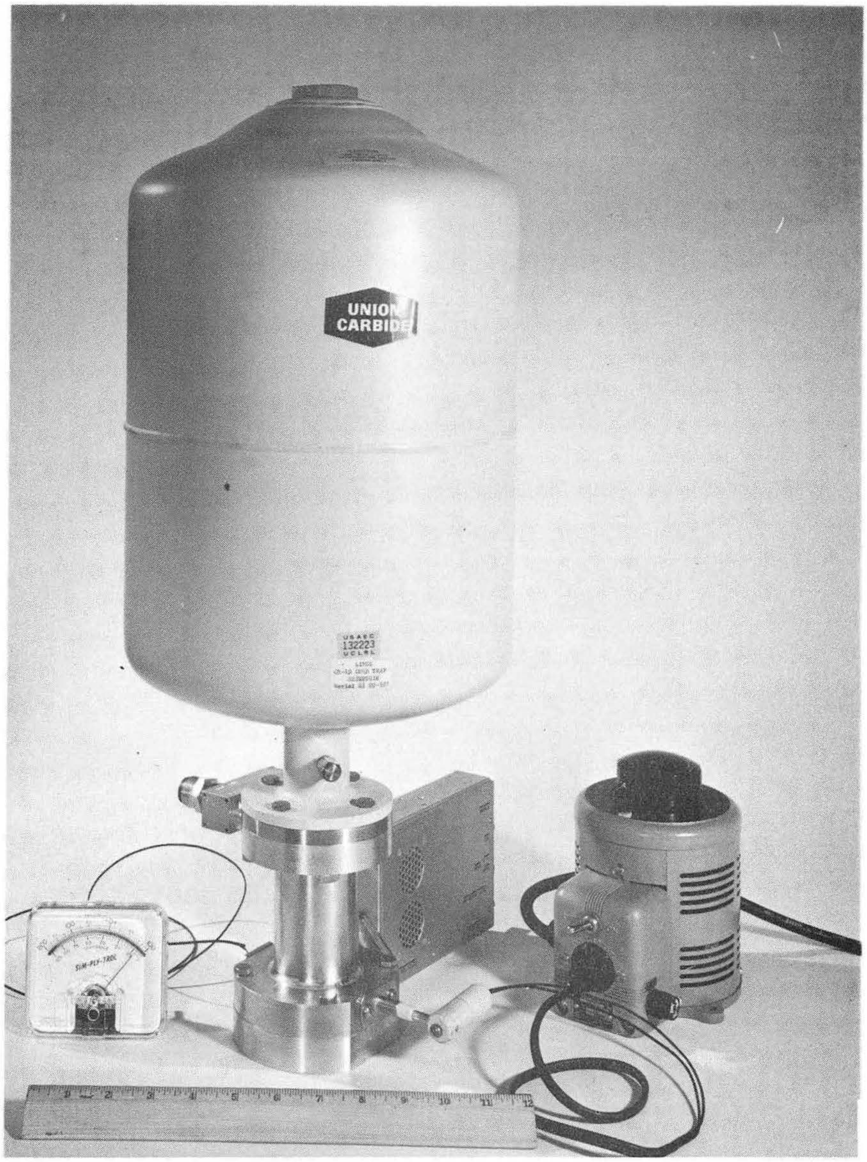
MUB-5550

Fig. 17. Exploded-view drawing showing method of insulating Si(Li) detector mount from liquid-nitrogen-cooled backing plate.



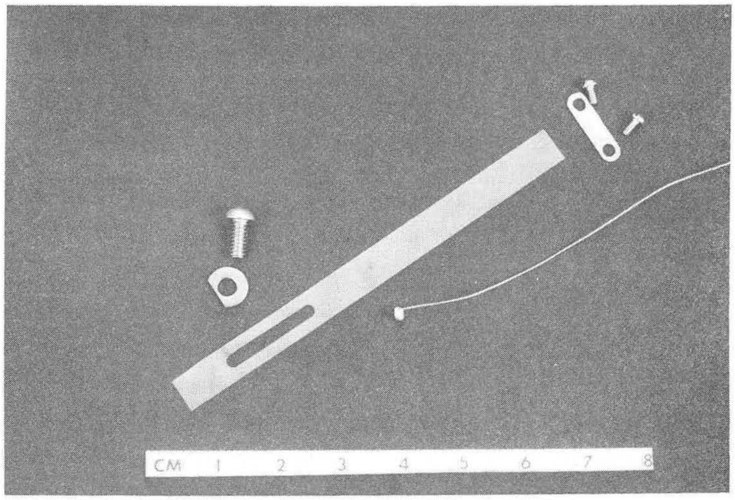
ZN-4763

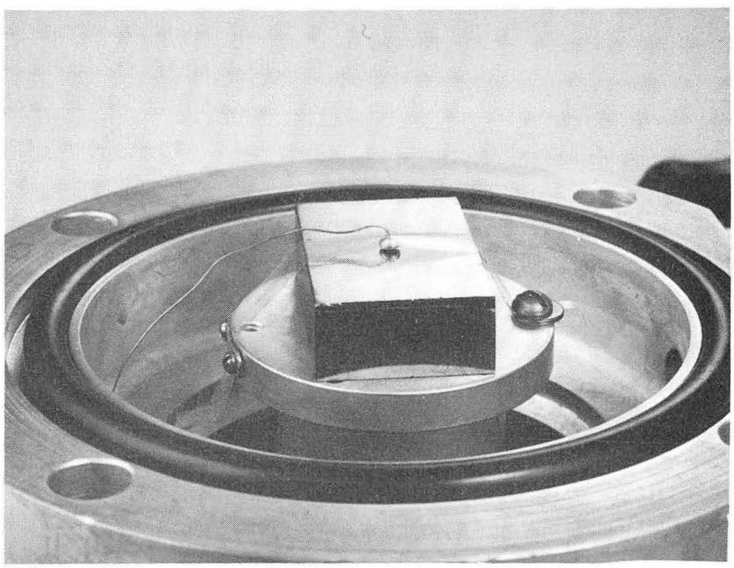
Fig. 18. Temperature-control system for Si(Li) detector.
(a) Heat-leak wire assembly, insulated heater housing, and heater.
(b) Copper-constantan thermocouple.
(c) Mount for home-made Si(Li) detector with thermcouple and heat-leak wire attached.
(d) Mount for commercial transistor-cased Si(Li) detector with thermocouple and heat-leak wire attached.



ZN-4735

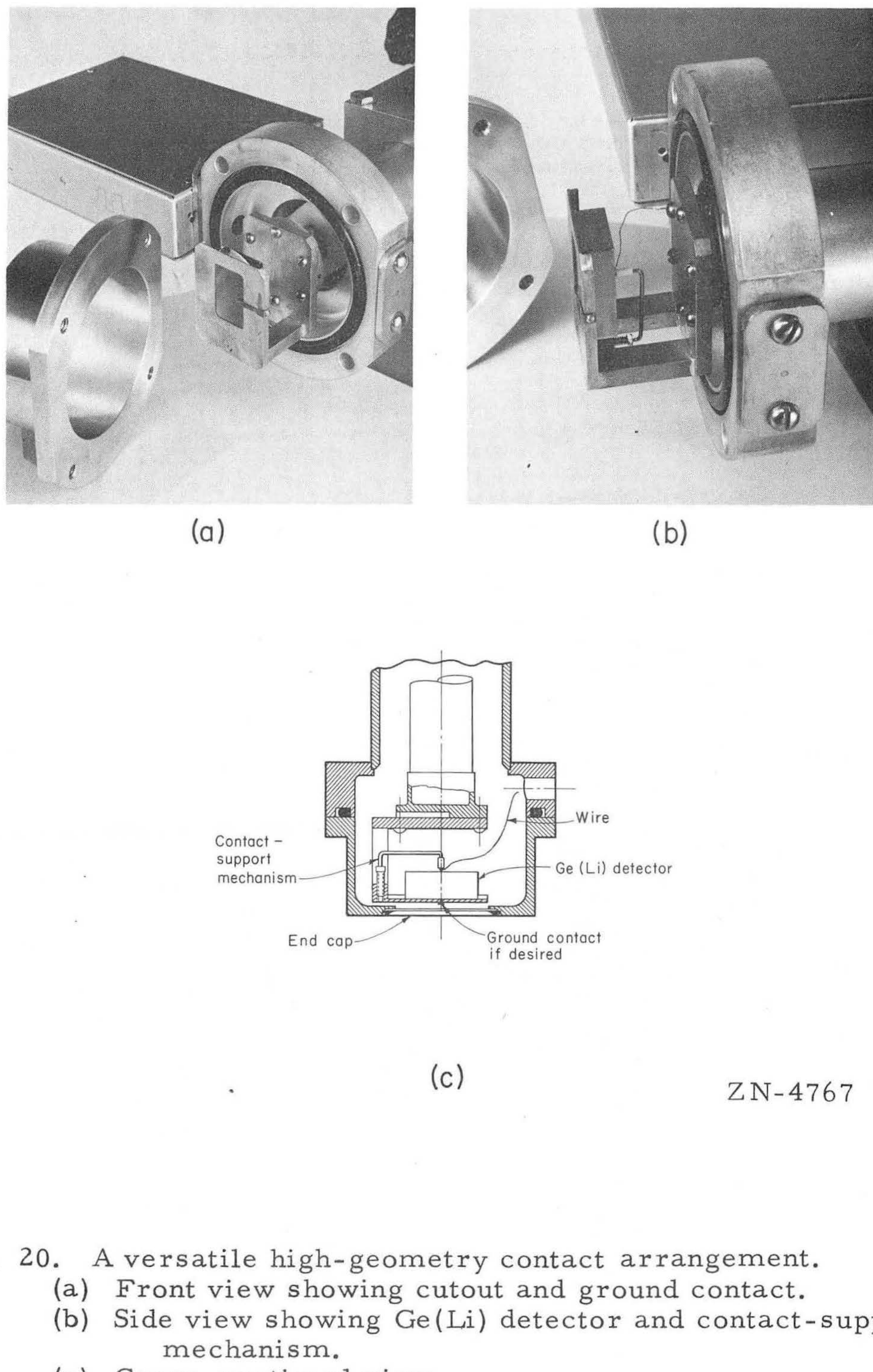
Fig. 18(e). Assembled system with pyrometer and powerstat.





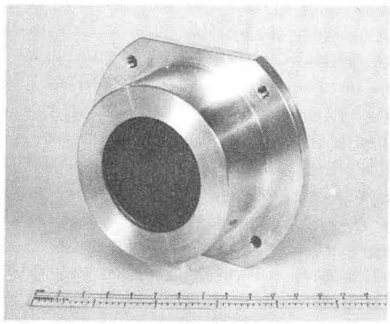
ZN-4745

Fig. 19. Parts and assembly of a simple high-geometry contact arrangement for a Ge(Li) detector.

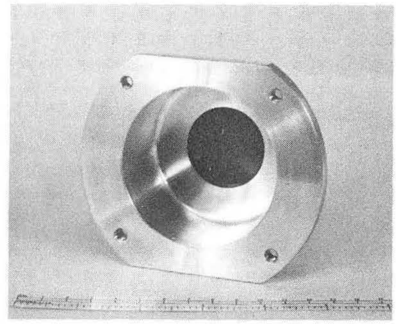


ZN-4767

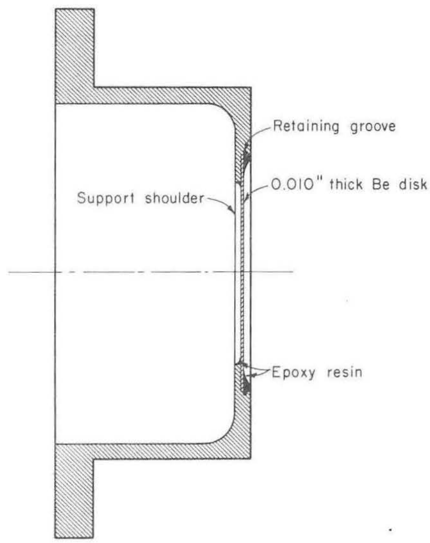
Fig. 20. A versatile high-geometry contact arrangement.
(a) Front view showing cutout and ground contact.
(b) Side view showing Ge(Li) detector and contact-support mechanism.
(c) Cross-sectional view.



(a)



(b)



(c)

ZN-4768

Fig. 21. End cap with beryllium window.
(a) Front view.
(b) Rear view.
(c) Cross-sectional view showing the retaining groove and sealing shoulder.

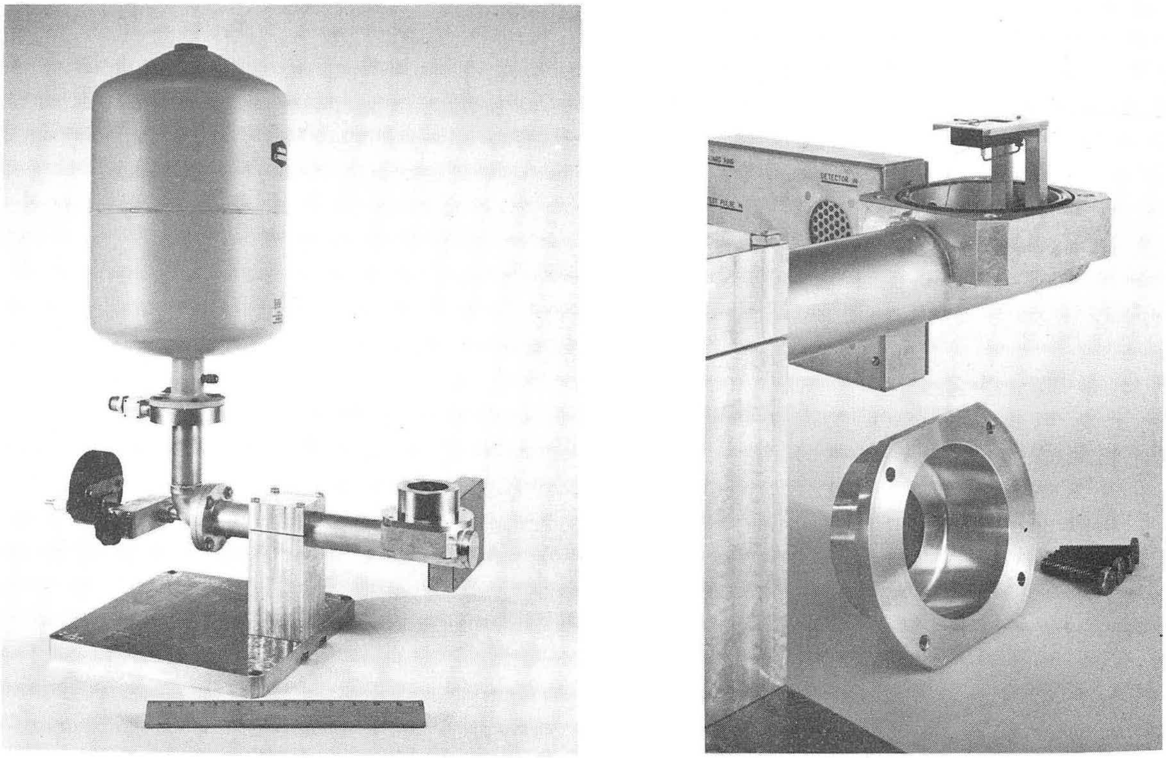
SPECIAL CONFIGURATIONS

The basic holder and mounting design lends itself well to a wide variety of arrangements and configurations. The holder shown in Fig. 22 permits the detector to "look up" into a recoil-free resonant absorption dewar.

Certain experimental work, such as beta-gamma coincidence measurements, requires a silicon detector exposed directly to the active source, and one or more germanium detectors located near the source. A dependable and convenient way to set up such an array is to mount the silicon detector in a chamber together with the source, which can be introduced and removed through a vacuum lock. A well, terminating in a thin window, extends from the wall of the chamber to the source position. A holder with an extended backing plate and end cap arrangement houses the germanium detector and permits its insertion into the well to achieve the desired geometry.[12] Figures 23, 24, and 25 show, respectively, a schematic diagram of such an array, an extended holder, and an actual array.[12]

FUTURE CONSIDERATIONS

As the resolving power of lithium-drifted semiconductor detector systems improves and as more is learned about the characteristics of the detectors themselves, increasingly stringent demands will be made on holders. Within a short time a new, lower-capacitance feed-through will have to be found or developed for the bias circuit, or perhaps the input stage of the preamplifier will have to be incorporated into the vacuum envelope. Thermoelectric effects produced by dissimilar metal joints may force the development of a monometallic holder or an isolated ground circuit. The present work represents a significant beginning, the "model-T" stage, but semiconductor detection is a young field and it is certain that each growth stage will produce new requirements, numerous applications, and exciting results.



(a) (b)

ZN-4746

Fig. 22. A special unit designed to "look up."
(a) Assembled unit.
(b) End cap removed to show detector mount.

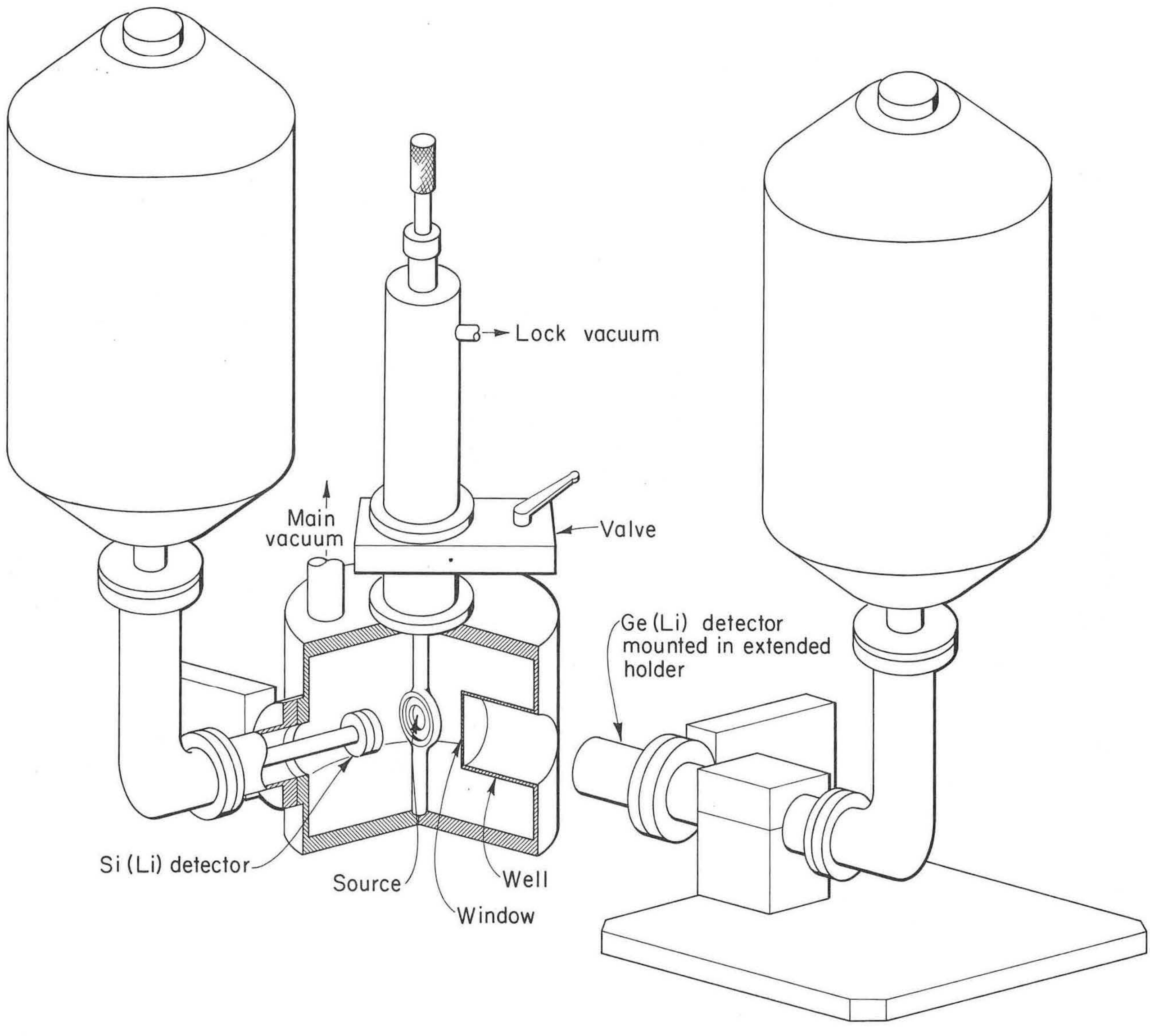
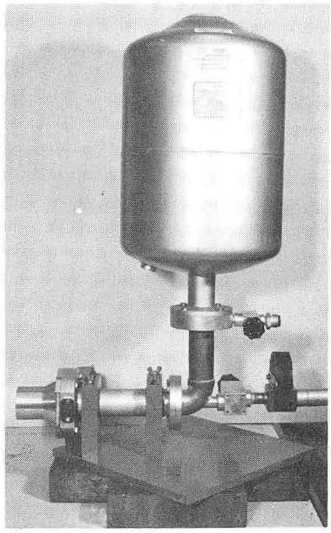
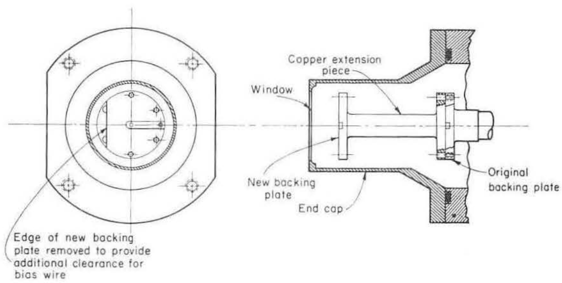


Fig. 23. Schematic diagram of an array incorporating a Si(Li) detector and a Ge(Li) detector.



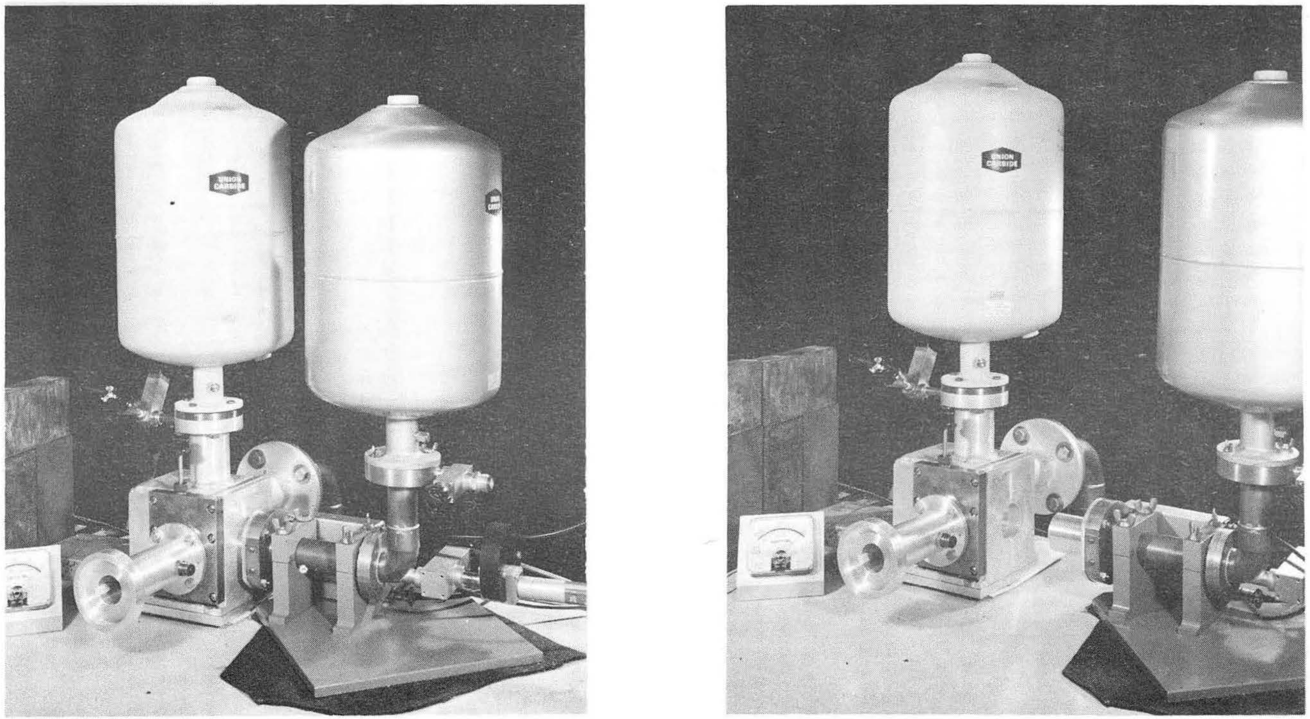
(a)



(b)

ZN-4769

Fig. 24. Entended Ge(Li) detector holder.
(a) Assembled unit.
(b) Extension configuration.



(a) (b)

ZN-4764

Fig. 25. An electron-gamma coincidence array.
(a) Extended Ge(Li) detector holder in place.
(b) Holder removed from well.

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