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**A SHOCK ISOLATOR FOR DIODE
LASER OPERATION ON A
CLOSED-CYCLE REFRIGERATOR**

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DIODE LASER OPERATION ON A CLOSED-CYCLE
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A SHOCK ISOLATOR FOR DIODE LASER
OPERATION ON A CLOSED-CYCLE REFRIGERATOR

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Since the introduction of semiconductor diode lasers which are broadly tuneable in temperature ¹, the use of closed-cycle helium refrigerators as cryogenic coolers for these devices has become increasingly common. The temperature at the cold-tip of a typical helium refrigerator can be set at any value above 9°K, permitting diode lasers which operate up to temperatures above 77°K to span as much as 280 cm⁻¹ ². In addition, a refrigerator allows indefinite cold periods, avoiding cycling between cryogenic and room temperatures which often changes the characteristics of the diode, and can destroy it.

The helium refrigerator introduces a new set of problems, however, mainly associated with the cycling operation of the expander module. The temperature oscillations due to the varying capacity of the refrigerator during the Solvay cycle have been dealt with successfully with various techniques ³. Equally severe, and more difficult to solve, is the problem of impact shocks delivered to the diode during the expansion phase of the cycle. These mechanical shocks produce jitter in the diode output frequency with excursions of as much as a gigahertz. The effect on spectra is that absorption features are completely washed-out for an instant during each cycle, as shown in Figure 1, and appear somewhat broadened when recorded using sufficient RC time constant to eliminate the fluctuations.

We have successfully isolated the diode laser from the impact shocks with the device shown in Figure 2. Our cooler is a Displex

Model CSW-202 manufactured by Air Products and Chemicals Inc. A loop of braided copper ground strap forms the thermal link between the diode mount and the cold-tip of the refrigerator, and a Pb-In alloy wafer (30% Pb, 1/8-inch thick) damps the temperature fluctuations at the cold-tip. The diode mount is rigidly attached to the vacuum shroud with a stand-off consisting of three sections of nylon and two intermediate sections of copper, which serve as cold-stations to improve the thermal isolation. The copper section closest to the mount is in direct thermal contact via copper braid with the cold-tip, by-passing the Pb-In damper, and is maintained at about 10.5°K . The copper section closest to the vacuum shroud is in thermal contact with the radiation shield, again with copper braid, and is maintained near 50°K . The minimum temperature of the diode mount is less than 10.5°K . The vacuum shroud is rigidly fastened to the optical bench with an aluminum pylon, and is vibration-isolated from the refrigerator with a short length of vacuum hose.

Figure 3 shows three scans of the $\text{aQ}(6,6)$ line of ν_2 , NH_3 a) as recorded before the shock isolator was installed, b) with the isolator and no thermal damper, and c) with both installed. With the isolator and no damper the diode output frequency oscillated at the rate of the refrigerator cycle, deviating by about ± 40 MHz. With the isolator and damper there was no detectable fluctuation in frequency, even when observing CCl_2F_2 lines near 920 cm^{-1} (Doppler width = 37 MHz), leading us to believe that the laser is stable to less than 5 MHz.

The actual stability should be established by heterodyning the diode with a CO₂ laser.

Variations on this design are, of course, possible, but we feel that the most important feature introduced here is the use of intermediate cold-stations in the stand-off, which permit the stand-off to be short and rigid while minimizing the thermal load at the diode mount.

References

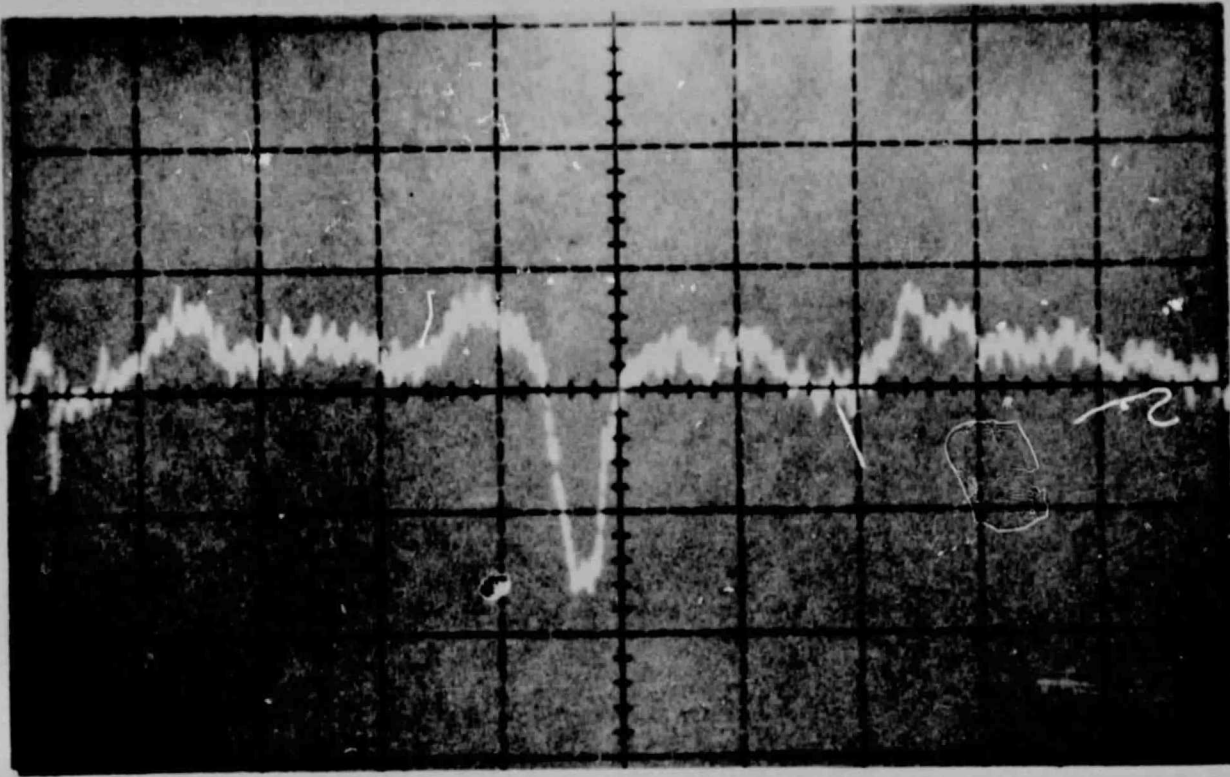
- 1) P. Norton, P. Chia, T. Braggins, and H. Levinstein, Appl. Phys. Lett. 18, 158 (1971).
- 2) S.H. Groves, K.W. Nill, and A.J. Strauss, Appl. Phys. Lett. 25, 331 (1974).
- 3) D.E. Jennings and J.J. Hillman, in preparation.

Figure 1. Detector signal during 5 msec sweeps of diode laser current in region of aQ(6,6) line of ν_2 , NH_3 : a) without shock effects, b) during expansion phase of refrigerator cycle. The diode has not stopped lasing in b), but the output frequency has become ambiguous.

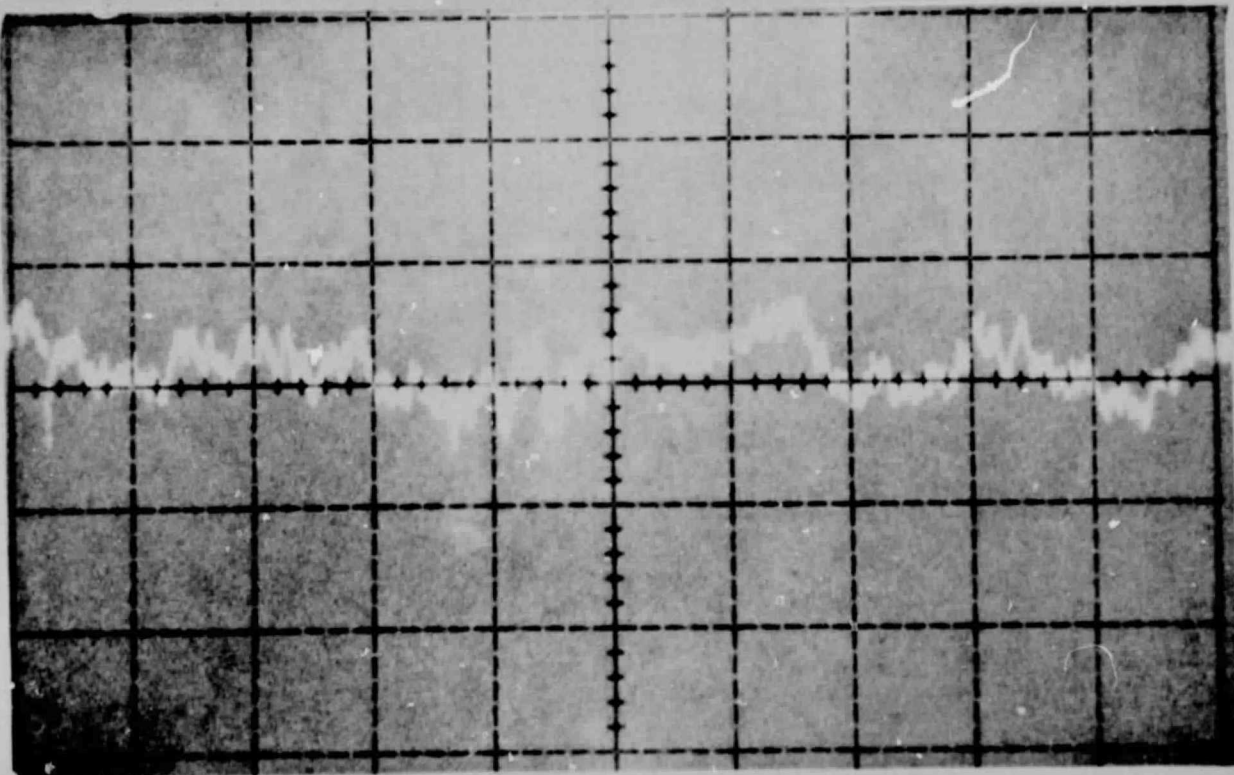
Figure 2. Details of shock isolator. Diode mount stand-off is nylon with intermediate sections of copper at 50°K and 10.5°K . Minimum diode temperature is $< 10.5^\circ\text{K}$. Vacuum shroud is vibration-isolated from refrigerator with vacuum hose. Diode mount is rigidly coupled to optical bench.

Figure 3. Slow diode current scans of aQ(6,6) line of ν_2 , NH_3 : a) without shock isolator or temperature damper; b) with damper installed; c) with isolator and damper. RC time constant = 100 msec. (scan rate for a) is faster than for b) and c)).

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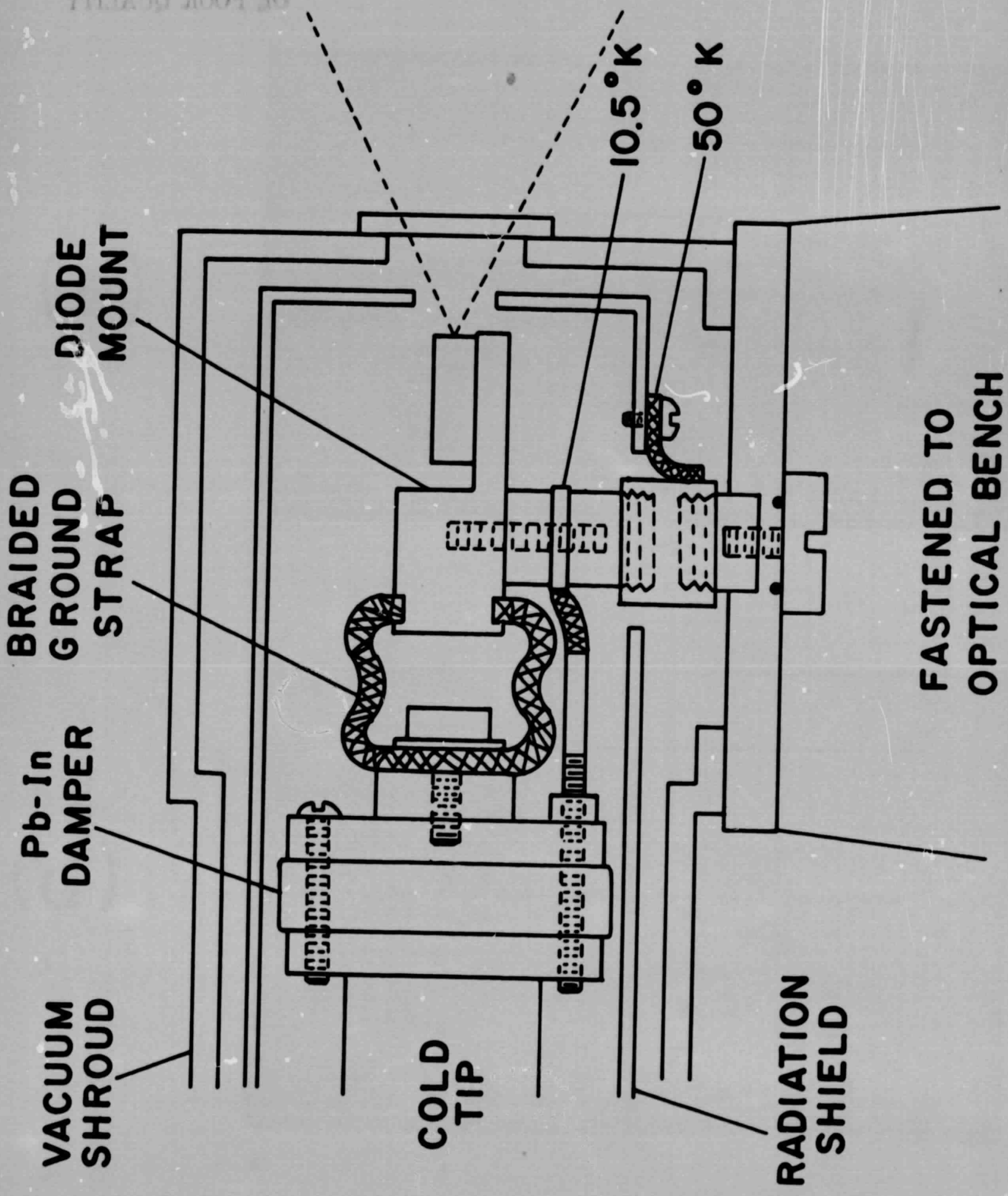


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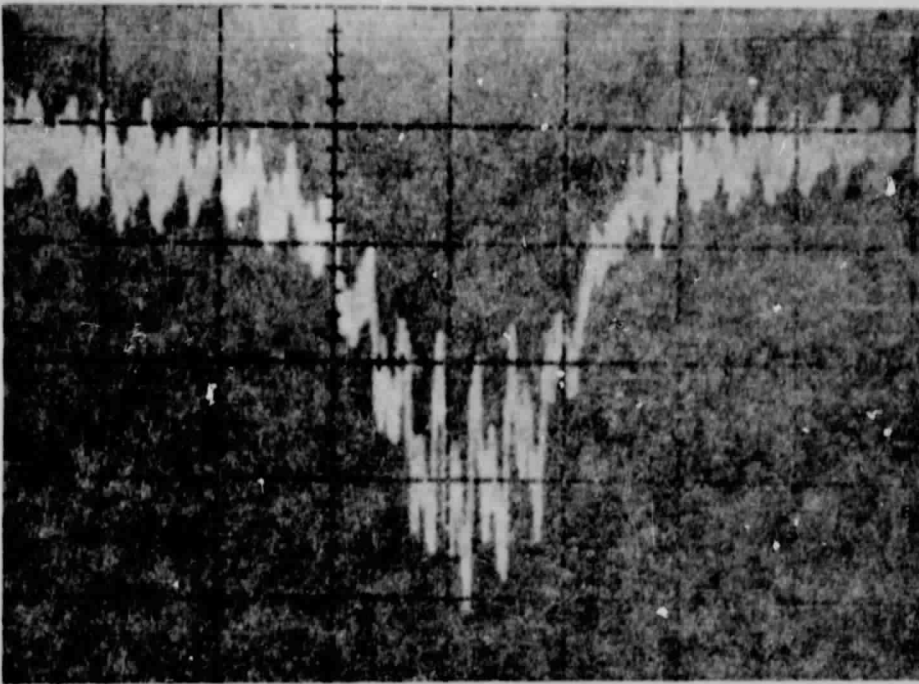


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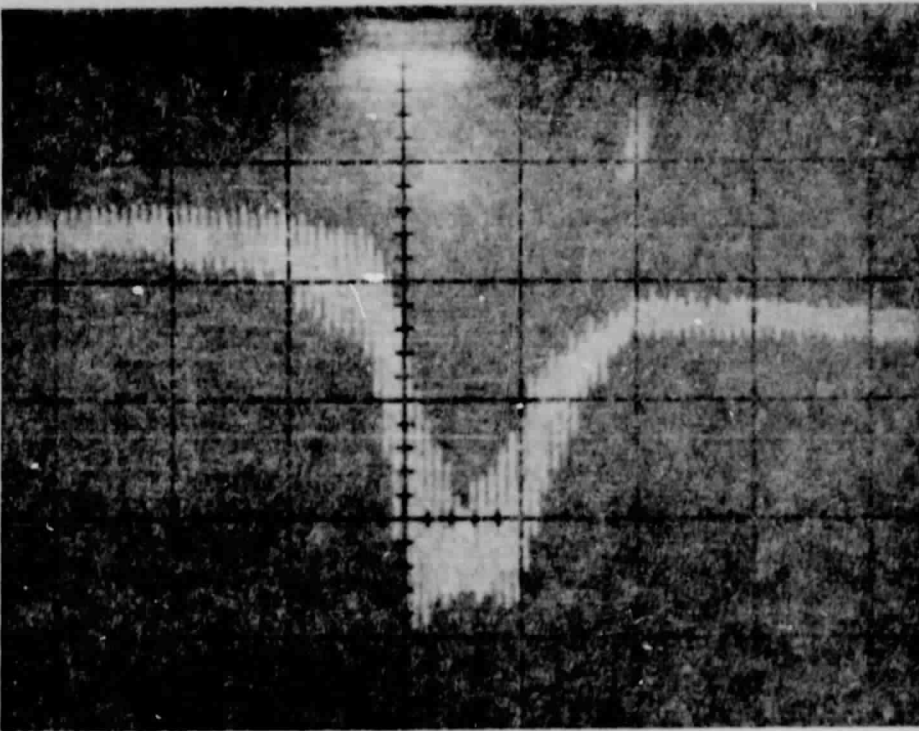
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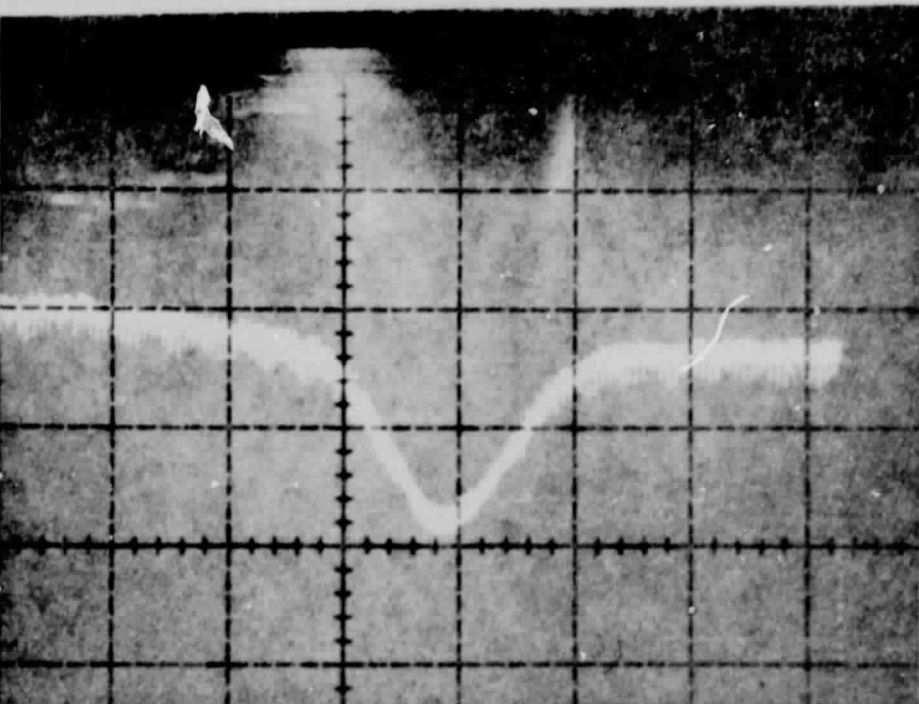
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(a)



(b)



(c)