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An Adaptive ac Null Detector

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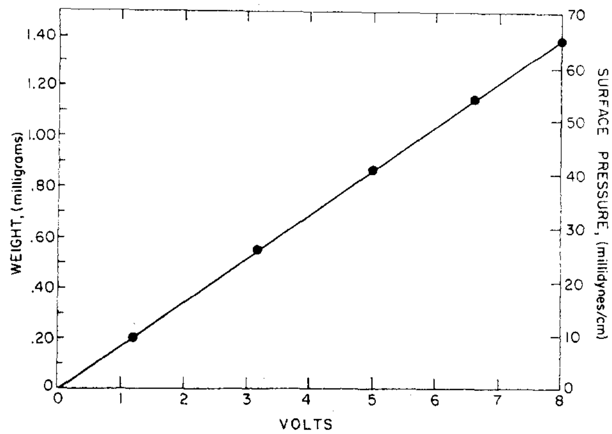

FIG. 3. Calibration curve for sensor. Diameter of torsion wire is 0.015 cm; float length is 10 cm.

dynes/cm are plotted as a function of the voltage output. The absolute error in reading the voltage output is of the order of $\pm 0.1\%$. Thus with this torsion wire, surface pressures as low as 1 millidyne/cm can be measured with an accuracy of ± 0.1 millidyne/cm. Increased sensitivity may be obtained by using a torsion wire of smaller diameter.

This level of sensitivity exceeds the practical requirements of most film balance experiments, where the precision is limited by other problems of the system (e.g., the error involved in depositing a precise amount of material in the surface). Our experience with gaseous monolayers indicates that the range of 0–200$\pm$1 millidynes/cm is routinely attainable.[10]

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An Adaptive ac Null Detector

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TWIN-T (narrow band) amplifiers are frequently used as null detectors in ac bridges in order to reduce the noise bandwidth. They are often followed by some form of compression circuit in order to give a useful indication far from balance. If a very narrow bandwidth (BW) is required for maximum sensitivity close to null, the response time of the amplifier will be long. While unavoidable close to balance, this adds unnecessarily to the balancing time when the bridge is far from a null. The difficulty may be avoided with the circuit shown in Fig. 1, in which tuning and compression are combined. The arrangement is quite simple, but does not appear to be generally known.

With the exception of the back-to-back diodes and voltage divider R_0, the circuit is a simple twin-T feedback amplifier[1] using an inexpensive operational amplifier[2] and commercial twin-T network.[3] Ignoring the diodes for the moment, the gain at the twin-T null frequency f_0 is given by

$$G = -R_2/R_1. \tag{1}$$

Using the notation of Fig. 2, the bandwidth and response time are given by[4]

$$BW = 2f_0(R/R_2)(2+K)^{\frac{1}{2}}\ \text{Hz}, \tag{2}$$

$$\tau = 1/\pi BW = R_2/[2\pi f_0 R(1+K)^{\frac{1}{2}}]\ \text{sec}. \tag{3}$$

For a suitable choice of diode and voltage divider ratio, to be discussed below, the amplifier will behave according to Eqs. (1)–(3) for sufficiently small input voltages, i.e., linear and sharply tuned. For larger voltages, the gain will be reduced and the response time will decrease because of the shunting of R_2 by the diodes. Thus, the amplifier gain and response time adapt to the available signal-to-noise ratio.

The instantaneous current through each diode is given by

$$I_d = I_0[\exp(\beta V/\Delta) - 1]. \tag{4}$$

Here, V is the *output* voltage of the amplifier, β the divider ratio, and it is assumed that the amplifier–divider combination is of sufficiently low impedance to drive the diodes. I_0 and Δ are the usual diode parameters, Δ being approximately $kT/e \approx 25$ mV. For sufficiently small signals, each diode behaves as a shunt across R_2 of apparent value

$$R_s = dV/dI_d|_{V=0} = \Delta/\beta I_0. \tag{5}$$

To obtain a linear response for small signals, R_s should be a few times R_2, the divider allowing considerable freedom

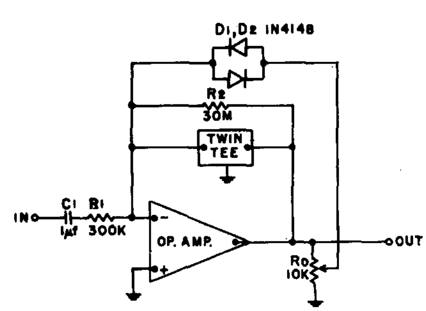

FIG. 1. Circuit diagram of tuned amplifier.

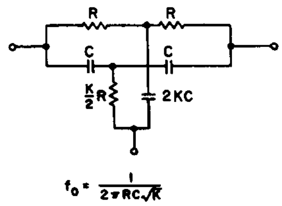

FIG. 2. Twin-T network.

in the choice of diode. The amplifier will then become nonlinear when $V \gtrsim \Delta$, eventually becoming logarithmic. By choosing a suitable preamplifier and/or ratio of R_2 to R_1, one can easily arrange for this crossover to occur for signals a few times the anticipated (or measured) noise level.

For the component values given in Fig. 1, the amplifier has a small signal gain of 100 at 15 Hz, a noise bandwidth of $\approx\frac{1}{3}$ Hz, and a small signal response time of ≈ 1 sec. It becomes nonlinear for inputs above a few millivolts and recovers from gross overloads (1000$\times$ noise) in ≈ 2 sec.

This amplifier has been used to drive an oscilloscope display in conjunction with a mutual inductance bridge and has proven to be convenient and trouble free in over a year of operation. If phase sensitive detection is required, a variable time constant filter using similar techniques should be possible.

[1] See, for example, *Applications Manual for Computing Amplifiers*, George A. Philbrick Researchers, Inc. (Nimrod Press, Boston, 1966), 2nd ed., p. 77.

[2] Philbrick P65AHU.

[3] White Instrument Laboratories type 542-15.

[4] For twin-T's of uncertain lineage, it is sufficient for design purposes to measure $2R$ with an ohmmeter and assume $K=1$ in Eqs. (2) and (3).

Simple Mylar Window Helium Cryostat for Mössbauer Measurements*

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THE advantages of resin coated Mylar as a vacuum window have been discussed in previous articles,[1] but its ease of application and excellent bonding properties, even to glass, should be more widely known.

For Mössbauer measurements it is frequently desirable to hold a γ-ray source at low temperatures for extended periods of time while the emitted radiation is used outside the Dewar. The problem of transmitting low energy radiation to the region outside the Dewar has usually been solved by using beryllium windows with epoxy or indium seals. Such seals may develop leaks, and the beryllium itself can be undesirable, e.g., in iron Mössbauer measurements, in which small amounts of iron impurities in the beryllium are easily detected. We have constructed a glass helium cryostat with Mylar windows which offers the simultaneous advantages of low cost, ease of construction, large solid angle, and high transmission.

The Dewar is a standard commercial design,[2] modified to accept a Mylar window at the bottom of the helium container. The normal arrangement of the cryostat was changed by extending the helium container past the N_2 jacket and outer vacuum shroud, as seen in Fig. 1. The helium container ends in a hole 3.8 cm diam, surrounded by a 1.0 cm glass flange.

To apply the Mylar window, the cryostat was inverted and a Mylar circle was positioned on the glass flange. The Mylar used (G.T. 300) was 0.013 cm thick with 0.0025 cm of thermosensitive polyester resin.[3] A smooth finish steel ring the same size as the flange was positioned over the Mylar and held in position with seven Ipko No. 2 paper clips.[4] The clips assured a uniform seal by exerting a pressure of about 1.4 kg/cm^2 during the bonding operation. A Variac controlled heating tape wrapped around the glass flange and spring clips was used to heat the assembly until the resin melted (180°C). After cooling, the springs and backing ring were removed and the seal was visually inspected.

Since the Mylar window supports 1 atm plus the column of liquid helium, the pressure of the steel ring was increased to about 20.0 kg/cm^2 to prevent the Mylar from peeling away from the glass. This was applied by a ridge 0.025 cm high by 0.215 cm wide near the inside diameter of the steel backing ring. The ring was again held with seven paper clips, whose handles could easily be removed

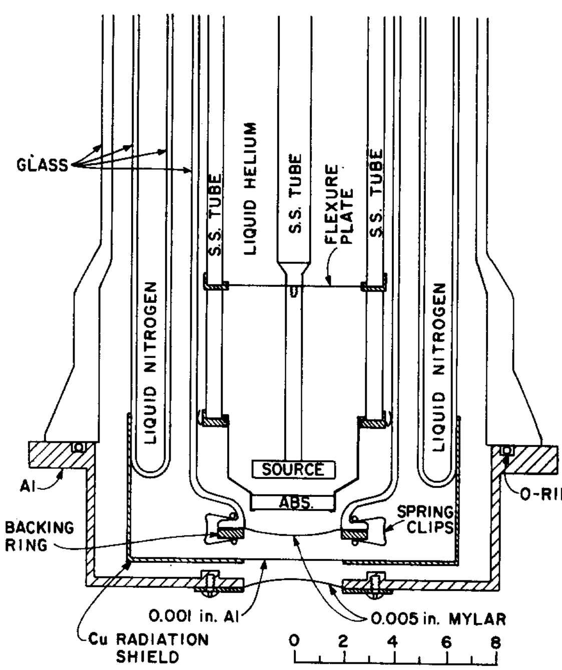

FIG. 1. Detail of the tail section of the cryostat.