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New Slit System for Stationary Crystal and Film X-Ray Topography Technique

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signal is then compared to a reference signal to give an error signal which is amplified and used to control the light source power supply. Use of the 814A dc power supply is particularly convenient for this purpose since not only can it be easily programmed by an external voltage but also its current limiting control can be set to prevent overdriving the lamp in case the light should be interrupted accidentally.

The performance of such a feedback system can be best demonstrated by comparing the thermocouple response with and without the feedback system connected. Since in the latter case the response is proportional to the light incident power and not to the number of incident photons, the feedback system needs to be connected, for a meaningful comparison, in such a way that constant incident power on the thermocouple is maintained. This condition can be achieved simply by disengaging the mechanical drive of the 10 turn potentiometer. The results obtained for our system are shown on Fig. 2. The maximum gain attainable in the feedback loop under stable operating conditions was found to be 10^4. Stable operating conditions were achieved with a time constant of 0.1 sec and a 6 dB/oct roll-off on the lockin amplifier. The particular time constant one should choose for a system designed around different feedback loop element would depend mostly on the characteristic of the light source. Under these conditions, as can be seen from Fig. 2, regulation of the light power output to better than 1% was achieved over a 0.3 eV energy range centered at 1.05 eV. A larger energy range can be obtained if lower light power level is acceptable.

The system described above has been used extensively in the study of the lowering of the barrier height of Schottky diodes. The diode load resistance is of low enough value that the ac voltage appearing across it is a true measure of the short circuit photocurrent under all bias conditions. This voltage is amplified and detected by a second lockin amplifier similar to the one used in the feedback loop. The physical properties of Schottky barriers that were observed have been reported elsewhere[6] and will not be discussed here.

The above described method results in an accuracy comparable to the one obtained by the extrapolation technique used by previous authors[1-3] to measure similar changes in barrier heights. The main advantage of our system is the very short experimental time needed to measure a given change in barrier height. The feedback light control system has proved to be quite adequate for a photon energy range between 0.90 and 1.20 eV. It can be extended further into the infrared by using a higher power lamp and a higher comparison amplifier gain or by reducing the output power level desired.

The present system is relatively easy to set up. The short time needed to complete a whole set of measurements

makes it worthwhile if one is planning to embark on a set of similar experiments.

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New Slit System for Stationary Crystal and Film X-Ray Topography Technique

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ONE of the most critical parts in the experimental set-up for the stationary crystal and film x-ray topography technique previously described[1] is the fine Soller slit. This slit system is difficult to produce with a sufficient degree of accuracy and has been replaced by the system shown in Fig. 1. The new slit system consists of six identical, relatively coarse, transmission gratings A, C, F, E, D, B mounted in a channel made of aluminum. The gratings are made of 1 mm thick brass sheets. The width of the slits is equal to the width of the brass strips separating them. The gratings are aligned and the spacings between them are arranged in a certain sequence as shown in Fig. 2. The distance between gratings is given by $x/2^n$, where x is the distance between the end gratings A and B, and n is an integer. By this arrangement one obtains that radiation from one slit in the first grating A passes the last grating B only through the corresponding slit in this grating. Considering radiation from, e.g., slit 1 in grating A (Fig. 2) we see that grating C prevents radiation from passing through slits of even number in grating B; grating D prevents radiation from passing through slits 3, 7, 11, $\cdots$; grating E prevents radiation from passing through slits 5, 13,
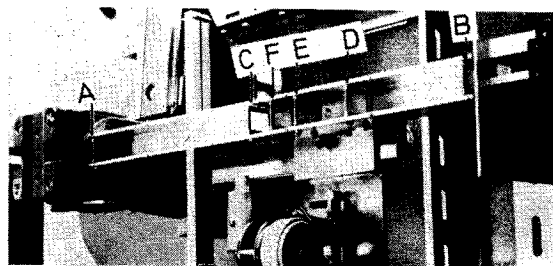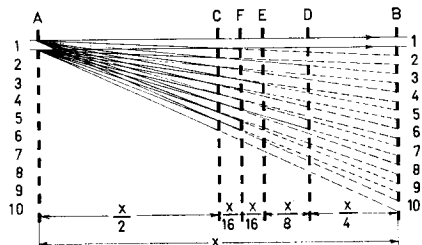

FIG. 1. Grating assembly A, C, F, E, D, B adapted to a Philips x-ray generator.

FIG. 2. Geometrical arrangement of the grating assembly. Radiation from one slit (e.g., slit No. 1) in the first grating A passes the last grating B only through the corresponding slit in this grating.

21, $\cdots$; etc. Thus, the grating assembly has the same effect as a Soller slit. For the equipment in use at this laboratory the width of the slits is 0.4 mm and the distance $x = 400$ mm resulting in a horizontal beam divergence of 2×10^{-3} rad. The grating assembly was found easier to fabricate than a corresponding Soller slit of similar accuracy. The replacement of the fine Soller slit in the experimental set-up[1] has resulted in a 50% reduction of the required exposure time and in a slight improvement of the resolution.

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Operation of a Germanium FET at Low Temperatures

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FOR more than a decade the need for active devices which will function at low temperatures has been recognized.[1] It is often desirable to amplify a weak signal generated at a low temperature, and match its impedance to a terminated cable as close to the point of generation as possible. The advantages to be gained by performing these operations at low temperatures are reduced thermal noise, improved frequency response, and reduced pickup of interfering signals.

In the search for active devices useful at low temperatures, the Texas Instruments TIXM12 germanium p-channel junction FET was studied. Typical characteristics at room temperature, measured on a lot of 100 units, were $g_m = 10\,000$ μmhos and $I_{dss} = 15$ mA. From 300 to 77°K these characteristics approximately doubled; from 77 to 4.2°K they increased only 10%; from 4.2 to about 1°K they increased less than 1%. This behavior suggests the possibility of testing circuits at liquid nitrogen temperatures with the assurance that they will perform similarly at liquid helium temperatures.

An experimental amplifier and an oscillator using TIXM12's were constructed. The amplifier circuit shown in Fig. 1(a) has a 50 Ω input impedance and is designed to operate into a terminated 50 Ω cable. At 77°K it has a voltage gain of about 6 and is 3 dB down at 250 kHz and 30 MHz. At 4.2°K the gain and bandwidth remained virtually the same as at 77°K.

The noise properties were measured at 77 and 4.2°K. The equivalent input thermal noise generated by R_1, R_2, and $1/g_m$ at 77°K is calculated to be 0.7 nV-Hz$^{-\frac{1}{2}}$. At that temperature the measured noise of the amplifier from 250 kHz to 40 MHz referred to the input was found to be substantially the value calculated. At 4.2°K the calculated thermal noise is 0.16 nV-Hz$^{-\frac{1}{2}}$, but the measured noise was found to be much greater. The equivalent input noise at 4.2°K as a function of frequency is shown in Fig. 2. The noise spectrum has a characteristic $1/f$ dependence which is not present at 77°K in the range of frequencies studied. It is apparent that below 30 MHz the noise will be increased upon cooling from 77 to 4.2°K by the appearance of $1/f$ noise. The level of thermal noise calculated at 4.2°K will not be reached until a frequency well beyond practical operation.

The circuit in Fig. 1(b) is a simple oscillator employing a TIXM12. At 77°K and below it will oscillate at supply voltages from 1 to 20 V. With proper choice of supply voltage, it exhibits a stability of ± 1 ppm at 1.3 MHz for periods of a few minutes.

The design of low temperature circuits using the TIXM12 presents few difficulties. The high value of g_m attained at low temperatures solves many problems. The
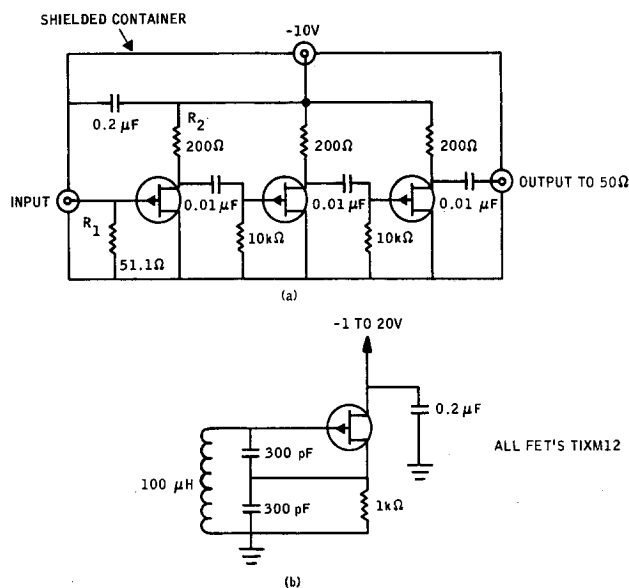

FIG. 1. (a) Schematic circuit of amplifier. (b) Oscillator.