compound nucleus [10] have been calculated. The transmission coefficients used in the calculation have been extrapolated for mass 12 from neutron penetrabilities tabulated by MANI et al. [11]. In computing the transmission coefficients these authors used the optical potential comprising a real SAXON–WOOD term, a GAUSSIAN imaginary part and a spin-orbit term of the THOMAS form. The theoretical curves are shown in Fig. 2 (solid curves). In adding the theoretical angular distribution of neutrons scattered to the 10.1 MeV level to the distribution of neutrons scattered to the 9.64 MeV level (Fig. 2 a – dashed curve) the shape of the distribution was slightly altered though no appreciable change could be noticed, especially if compared to the experimental points with large errors. However, for the 9.64 MeV level a fairly good agreement between theory and experiment has been obtained.

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High Sensitivity Bolometer Detector for Molecular Beams

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It is shown how a high sensitivity infra-red detector can be used as molecular beam detector.

The max sensitivity achieved is $2 \cdot 10^8$ molecules sec^{-1}.

Furthermore the advantages of using this kind of detector in scattering experiments are pointed out.

It is well known that in molecular beam experiments, severe intensity problems are posed by the constantly increasing demand in angular and energy resolution. Therefore in many laboratories workers are striving to find a simple, sensitive, stable and, if possible, small neutral molecule detector suitable for all kinds of molecules.

Up to now the effort to find a universal detector has mostly been taken in the direction of the so called electron bombardment detector, where the neutrals are ionized by a transverse electron beam and then measured by electrical means [1–3]. The most sophisticated versions of electron bombardment detectors can reach quite high degrees of stability and a sensitivity in the thermal energy range, as high as 10^6 molecules sec^{-1} on the detector surface, which, in most cases, is of the order of 1 mm^2. Therefore one needs:

a) Ultra high vacuum techniques to reach 10^{-9} mm Hg in the ionization volume to reduce concurrent ionization of the background.

b) Quite accurate electron and ion optics to improve the ion collection efficiency.

c) High transmission mass selection to further reduce the background.

d) Chopped operation of the beam with some kind of integration processing of the final signal. Usually one employs either a lock-in amplifier or a particle multiplier associated with a counting system.

It follows that such a kind of detector can be sensitive and stable but is far from being simple and usually is not shorter than 30 cm.

The purpose of this paper is to show the possibility of using a commercially available low temperature infrared bolometer [4] for detecting neutrals of energies down to the thermal range with a performance comparable to that of more complicated and bulky electron bombardment devices.

Fig. 1 shows the detector assembly. Through the 1 mm diameter channel C a chopped molecular beam impinges on the surface of a very thin doped germanium single crystal B originating periodic changes of its temperature. The crystal is electrically insulated but is in thermal contact with the high purity copper substrate A, which is kept at liq. He temperatures. The temperature oscillations of the crystal generate periodic variations of its resistance, which are the origin of an electrical signal. This is amplified by a low noise, low frequency amplifier and finally integrated by normal lock-in technique. For calibration purposes a beam was produced in the classical way by effusion from a hole in a very thin wall at room temperature and its

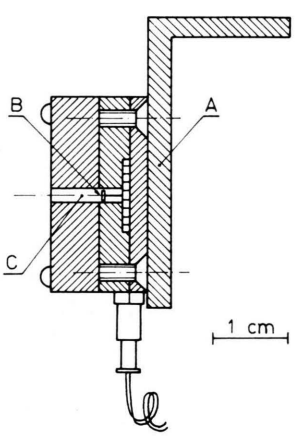

Fig. 1. Details of the bolometer assembly.

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intensity calculated from the geometry of the apparatus. The chopping frequency was 30 cps. Operation at 4.2 °K and 2.3 °K showed that the minimum detectable signal corresponds to a beam intensity of $4 \cdot 10^8$ and $2 \cdot 10^8$ molecules sec^{-1} respectively. In both cases the RC of the lock-in was 1 sec.

The noise equivalent power declared by the manufacturer for our bolometer operating at 2 °K is $5 \cdot 10^{-13}$ watt [5]. The order of magnitude of the energy brought to the bolometer surface in one second by the beam molecules corresponding to our minimum detectable signal being the same, we have not endeavoured to study the origin of small discrepancies between the two quantities.

To check the stability we have applied the same beam intensity at different times of the same run. The measurements agreed within 2%. Between two of these measurements the bolometer was exposed for two hours to an average flux of 10^{10} molecules per second. This means that the accomodation coefficient of the surface was virtually not changed by the deposition of a few layers of gas molecules. This is not surprising because the detector surface cannot be considered clean, being covered by a black paint to reduce its reflectivity.

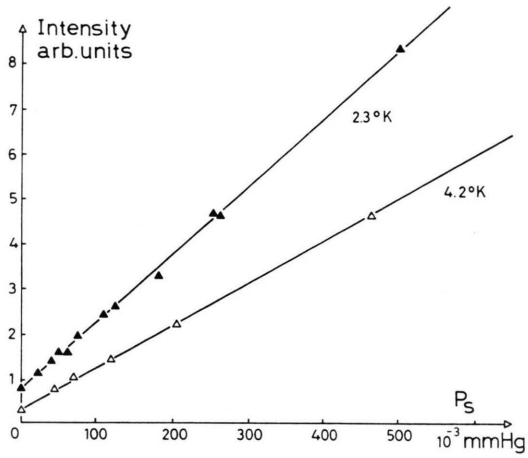

Fig. 2. Linearity of the detector output as a function of the pressure in the source.

Fig. 2 shows the linearity of the bolometer output as a function of pressure in the source. The flow being molecular, this pressure is proportional to the intensity of the beam. A signal is present also at zero beam intensity due to chopped background radiation. No special effort has been taken to reduce this signal although this can be accomplished improving the homogeneity in emissivity of the surfaces in the region of the chopper. We should like to conclude this note by pointing out some special features that make the bolometer particularly useful in scattering experiments. First its smallness greatly reduces the demands on the volume to be evacuated and on the mechanism used to move the detector. In the second place, the use of liquid He and the absence of hot elements in the detector volume makes it comparably easy to reach and maintain very low pressures. The background is thus strongly reduced without use of mass spectrometry. Finally we must remember that the sensitivity of the electron bombardment detector decreases with increasing velocity of the beam particles while the contrary is true for the bolometer. This is of some importance since several interesting scattering experiments can be done in the energy range from 0.1 eV to 10 eV.

[5] It is perhaps worthwhile noting that, recently, a Ge bolometer was reported in the literature, F. J. Low, Proc. IEEE **54**, 477 [1966], which reached a sensitivity of a few 10^{-14} watt.

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