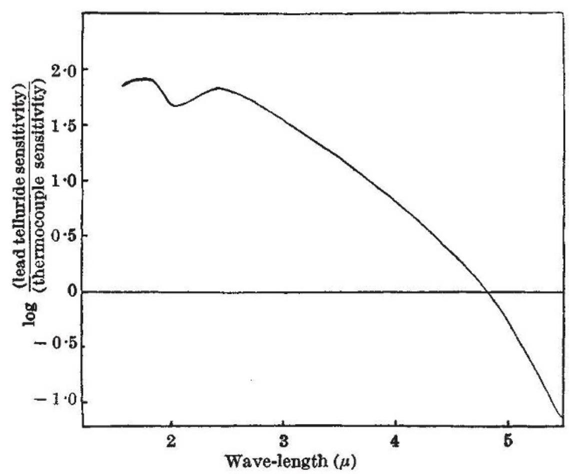
Lead Telluride Cells for Infra-Red Spectroscopy

FOLLOWING the successful development[1,2] of lead selenide photoconductive cells for the detection of infra-red radiation, we have now extended this work to lead telluride. It was known from very incomplete information that experimental cells of this material were made in Germany during the War[3] and showed some response as far as 5·8 μ, that is, considerably farther than lead selenide. However, no information was available to us on the method of preparation, nor on their performance, and it may be presumed that the absolute sensitivity was poor, in view of the widespread use in Germany of the lead sulphide cell in spite of its restriction to wave-lengths shorter than 3 μ.

As the evaporation method was used, one of the main problems was to find a window material for the base of the cell which would transmit radiation to at least 6 μ. After experimenting with various alternatives, including evaporation from small heating coils, an extremely simple solution has been found, namely, to make use of thin bubble windows similar to those used in certain ultra-violet work. It has been found that flat windows of glass approximately 20 μ thick transmit more than 90 per cent of any radiation between the visible and 8 μ, and that 'hemispherical' windows can be made which are sufficiently strong to withstand atmospheric pressure, and transmit freely to beyond 6 μ. Although some distortion of the beam occurs in passing through such a window, our results show that the effect of this on the performance of the cell is negligible.



The lead telluride cells show no photosensitivity at ordinary temperatures, and so far all the observations have been made at the temperature of liquid air. The response curve of one telluride cell to various wave-lengths is shown in the accompanying graph, in which the ordinate represents the logarithm of the ratio of the cell response to that of a Hilger–Schwarz vacuum thermocouple, the comparison being made in the same manner as for lead selenide[2]. It should be noted that at its maximum the sensitivity of the lead telluride cell is about a hundred times that of the thermocouple, that is, much the same as for the best lead sulphide cells[4]. Although the maximum of sensitivity shown by this cell lies between 2 and 3 μ, it is superior to a thermocouple up to 4·6 μ and some sensitivity is exhibited so far as 5·5 μ. As experience is gained with these cells, it may well be possible to control the position of maximum response and cause it to move to between 4 and 5 μ, as reported in the German work[3]. The time of response of these lead telluride cells is of the order of 10^{-4} sec., which is about the same as lead sulphide. It is important to note that the selenide cells which were much more rapid in response (about 10^{-5} sec.) were much less sensitive. It seems probable that there is a reciprocal relation between time of response and sensitivity for detectors of this class.

This note is primarily intended to indicate the potentialities of cells of this type for spectroscopic work, where they are clearly far superior to sulphide and selenide; full details of the method of preparation and of the properties of these cells will be published shortly.

It may be added, however, that an independent measurement of the sensitivity at 2·2 μ of a cell similar to the one used for the above tests gave a figure of 2×10^{-14} watt as the equivalent noise input (signal/R.M.S. noise) for a band width of 1 c./s. The area of the receiving surface was approximately 1 mm.^{2} and the time of response $1·5 \times 10^{-4}$ sec.

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[3] Elliott, A., in "Electronics" (Edited by Lovell. Pilot Press, 1947).
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High-Frequency Characteristics of Lead Sulphide and Lead Selenide Layers

RECENT work on the photoconductive effect in lead sulphide layers has suggested that the origin of both the high resistance and the photoconductive effect is in the intercrystalline barriers existing in such layers[1,5].

Impedance measurements have been made on lead sulphide and lead selenide photoconductive cells at frequencies high enough to ensure the substantial short-circuiting of these barriers. In all cases so far investigated, it has been found that as the frequency of measurement is increased the shunt resistance component of the cell impedance decreases until at about 60 Mc./s. a steady value is reached equal to a fraction of the D.C. value at room temperature. If the cell is cooled to the temperature of solid carbon dioxide (194·5° K.) or liquid oxygen (90° K.), the D.C. resistance increases exponentially in the usual manner found for semi-conductors, while the high-frequency resistance is only slightly affected. Either a small positive or a small negative temperature coefficient of high-frequency resistance is obtained, and the high-frequency behaviour is essentially semi-metallic.

For all the layers studied, the photoconductive effect decreased with increasing frequency, finally disappearing at frequencies high enough for the cell resistance to have reached a constant value.

These effects are illustrated in Figs. 1 and 2 for a lead sulphide cell which had been manufactured by a vacuum evaporation process.

Fig. 1 illustrates the variation of cell resistance with frequency at two temperatures, measurements being made with the cell illuminated and unilluminated.