Multiple Scattering of Fast Electrons: A Correction

In a letter to the editor of *The Physical Review*[1] which we published recently concerning the multiple scattering of electrons in carbon and lead, an error was made in giving the weight of the carbon scatterer used. The correct value is 0.57 g/cm^2, instead of the value of 0.75 g/cm^2 which was given previously. In Table I are given the

TABLE I. *Experimental and theoretical average values of* $H\rho\theta$.

	EXP. $\langle H\rho\theta\rangle_{Av}$ GAUSS CM DEG.	THEOR. $\langle H\rho\theta\rangle_{Av}$ GAUSS CM DEG.
C, 0.57 g/cm^2	1.60×10^5	1.87×10^5
Pb, 0.072 g/cm^2	1.56×10^5	2.38×10^5

numerical values of the average $H\rho\theta$ (measured in projection), which may be of convenience, and which were not given explicitly in our previous letter. The averages given include all the tracks observed; no attempt was made in this case to distinguish between the Gaussian part of the distribution and the single or plural scattering tail. The theoretical values given are those calculated by means of the formula of E. J. Williams.[2] The formula which he designates as (37) in his text is the particular one which we have used. According to our understanding this formula takes into account the contribution due to the single scattering tail, and is therefore the appropriate one to use in comparison with our experimental values.

N. L. OLESON
K. T. CHAO
J. HALPERN
H. R. CRANE

University of Michigan,
Ann Arbor, Michigan,
November 10, 1939.

[1] N. L. Oleson, K. T. Chao, J. Halpern and H. R. Crane, Phys. Rev. **56**, 482 (1939).
[2] E. J. Williams, Proc. Roy. Soc. **A169**, 531 (1939).

A Report on the Development of the Electron Supermicroscope at Toronto

In a previous paper,[1] the construction of a magnetic electron microscope of high resolving power was described and some of the preliminary photographs were reproduced. From these a resolving limit of 200A was inferred. During the past year, the apparatus has undergone considerable refinement in an attempt to increase the facility of operation and to obtain an estimate of the practical limit of the resolving power for various types of specimens.

A vacuum camera has been constructed which enables the plate to be introduced into the recording chamber through an "air-lock" without breaking the vacuum in the whole system. The time required to change plates has been reduced from 35 minutes to 5 minutes by this arrangement. This camera effects a further saving of time in that it enables the operator to record a number of images on a single large plate. The number of photographs per plate may be varied from 3 to 34 (3 in.×2 in. to $\frac{1}{4}$ in.×2 in.) according to the requirements of the type of work in progress.

The technique of preparing specimen-holders and mounting specimens has been refined to ensure that any preparation less than 3000A in thickness will be unaffected by the electron bombardment. The time required for the preparation is approximately the same as the time required to carry out the corresponding technique in light microscopy. During the past month the authors have prepared more than 300 specimens of a variety of types, and have taken over 500 electron microphotographs of approximately 60 specimens selected from those prepared. The results of this work will be published in the near future in the periodicals devoted to the particular types of problems involved.

The magnetic lens, which was described in the paper referred to above, has been fitted with a new type of pole-piece assembly which ensures a more precise axial symmetry in the magnetic field produced. The images which have been obtained with this new lens show considerable improvement over those obtained with the previous type.

As a result of a thorough investigation into the method of alignment, it has been established that the proper control of the illuminating system is the most important factor in the production of images of high quality. An illuminating pencil of large angular aperture with correspondingly high intensity and small depth of focus has been found most suitable for visual observation of the images, while an illuminating pencil of small angular aperture and correspondingly low intensity, but large depth of focus, has been found most suitable for the successful photographic recording of the images.

The resolving limit of the instrument is now estimated to be better than 60A. This limit appears to be imposed,

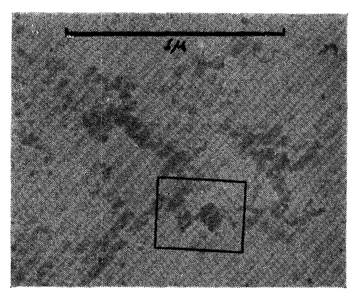


FIG. 1. Electron microphotograph of colloidal gold. Electron-optical magnification 12,700. Total magnification 45,000.

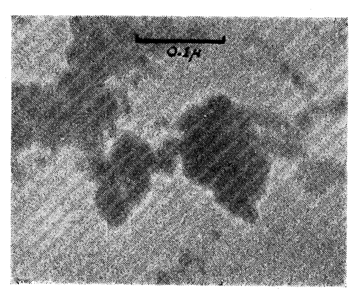


FIG. 2. Portion of Fig. 1. Total magnification 180,000.

to a great extent, by the nature of the specimens rather than by instrumental factors. Fig. 1 is an electron microphotograph of a test object consisting of colloidal gold deposited on a collodion membrane 200A in thickness. The electron-optical magnification was 12,700. In order to make visible to the eye all the details present on the negative and in order to overcome difficulties of reproduction, the photograph has been enlarged, by optical means, to a total magnification of 45,000. The indicated part of this photograph has been enlarged to a total magnification of 180,000 and is shown in Fig. 2. The separations of the smaller particles and the sharpness of the edges of the larger particles allows a resolving power of better than 60A to be inferred.

E. F. Burton
J. Hillier
A. Prebus

Department of Physics,
University of Toronto,
Toronto, Canada,
November 13, 1939.

[1] A. Prebus and J. Hillier, Can. J. Research **A17**, 49–63 (1939).

Lecture Demonstration of Resonance Radiation of Sodium

The phenomenon of resonance radiation is of such fundamental importance in connection with the theory of atomic spectra that some method of demonstrating it to a large audience is much to be desired. The earlier methods which I have employed—small glass bulbs containing the vapor of sodium, illuminated by a sodium flame, are not well suited for the lecture table, as the images of the flame seen reflected from the spherical surface of the bulb are so bright that one sees the fainter cone of resonance radiation with difficulty, except from certain rather restricted directions.

The recent development of the sodium arc as a commercial lamp, and the invention of a glass capable of resisting the action of sodium vapor at a high temperature, have made it possible to demonstrate the resonance radiation of the vapor to a large audience. Small sodium arc lamps are coming into use for spectroscopic purposes in most laboratories, and the large cylindrical bulbs which are employed for the street lamps make ideal resonance bulbs. With the cylindrical container and a properly directed light beam, none of the rays reflected from the glass reach the audience, and the resonance phenomena can be seen from all directions.

Through the courtesy of Mr. L. J. Buttolph, of the General Electric Vapor Lamp Company, I was furnished with a highly exhausted cylindrical bulb of sodium resisting glass, charged with a suitable amount of metallic sodium. This bulb measures 6×24 cm and is mounted vertically above a chimney made of thick asbestos paper, heated from below by a ring gas burner of the type employed in gas stoves. The chimney is about 13 cm in diameter and 30 cm in length. The glass cylinder should be supported from below by an iron ring furnished with three thin metal rods as shown in Fig. 1. This arrangement is made to give a minimum obstruction to the upward flow of hot air along

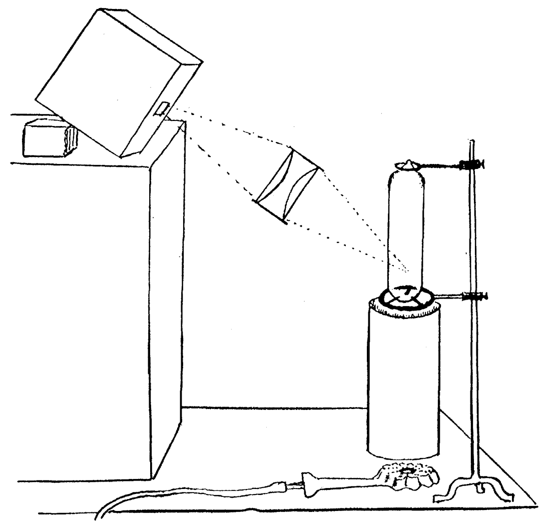
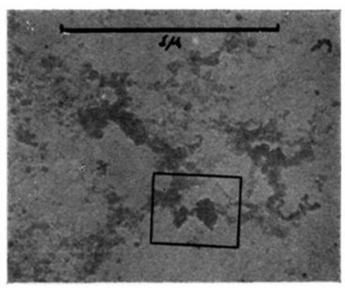


Fig. 1. Arrangement of apparatus to show resonance radiation of sodium.

the side of the bulb. The sodium "lab-arc," as furnished by the Vapor Lamp Company is housed, together with the transformer, in a small metal box, with a sliding panel on one side perforated by a wide slit. This can be removed and a panel of asbestos paper perforated by a 2-cm square hole put in its place. The lamp is mounted in an inclined position as shown in Fig. 1. Its rays shoot down from the square window at an angle of about 30° and fall on a large short focus condensing lens which focuses the rays on the cylinder as shown. It is obvious that the reflected rays are thrown down upon the table by this arrangement instead of going off at all angles as is the case with a spherical bulb.

The gas burner is now lighted, the numerous small flames being turned down low at the start. When first trying the experiment it is well to check the temperature of the hot air stream flowing over the bulb with a thermometer. It is best not to let it rise above 350° C which is about the maximum temperature that can be measured with a mercury thermometer. If sodium condenses on the walls in the region where the resonance phenomena are to appear, the deposit can be wiped out by brushing the wall of the tube with the flame of a Bunsen burner. When the temperature reaches 130° the path of the rays through the vapor is marked by a faint yellow luminosity which increases rapidly in brightness as the temperature rises. The region outside of the luminous cone of light will now be observed to glow with a fainter yellow light. This is the secondary resonance radiation, excited by the primary radiation from the illuminated cone of vapor. At the same time the luminous cone retreats towards the front wall of the tube, the vapor becoming so dense at 300° that the radiations capable of exciting resonance are all absorbed and re-emitted laterally within a short distance from the point of entry. An image of the rectangular aperture is now seen on the wall of the tube where the radiations from the lamp enter and at 350° this image is as sharply



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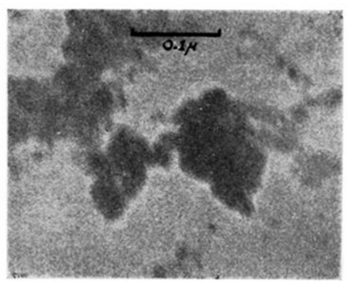

FIG. 2. Portion of Fig. 1. Total magnification 180,000.