II. THE RELATIVE OPTICAL REFLECTIVITIES OF SOLID AND LIQUID MERCURY

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As an aid in the interpretation of photoelectric experiments made by one of us,[4] and because of its theoretical value, an investigation has been made of the relative optical reflectivities of solid and liquid mercury in the region of wave-lengths 4358A to 2537A. In a study of a similar nature, Haak and Sissingh[5] found no change in the optical constants of the metal either on freezing or on subsequent cooling to −80° C. Unfortunately, the mercury surfaces which they employed were contaminated with adsorbed gases.

The monochromatic reflectivity of a surface, symbol R(λ), may be defined by the equation:

$$R(\lambda)=\frac{i}{I}, \qquad (1)$$

where I is the incident radiant energy of wave-length λ and i is the reflected portion of this energy. Let $R^1(\lambda)$ denote the monochromatic reflectivity of liquid mercury and i_1, the energy in the beam of wave-length

[4] D. Roller, Phys. Rev. 36, 738 (1930).
[5] K. Akd. Amsterdam, 21, 678 (1919).

λ reflected from the liquid; and let $R_2(\lambda)$ and i_2 denote these qualities for the case of the solid. Then, if I be the same for both states of aggregation, we have by equation (1):

$$\frac{R_1(\lambda)}{R_2(\lambda)}=\frac{i_1}{i_2}. \qquad (2)$$

In the present work the energy of the incident beam, I, was kept constant and i_1 and i_2 were measured by means of photometer. The photometer consisted of a bismuth-bismuth tin vacuum thermocouple of the compensated type and a Leeds and Northup high-sensitivity galvanometer. A Cooper-Hewitt quartz mercury arc lamp of the horizontal type was employed as the source of radiation; the lamp was enclosed in a box made of asbestos board and was operated at 3.25 to 3.50 amperes, 78 to 80 volts, and an ambient temperature of 180°. Monochromatic radiation was obtained by means of a Leiss quartz monochromator.

The mercury under investigation was placed in a specially designed container (Fig. 1). This consisted of a 50 mm. Pyrex flask to which were sealed two Pyrex tubes, each 6 c. m. long and 1.2 c. m. in diameter, the angle between them being approximately 40°. Quartz windows were fastened to the ends of these tubes with sealing wax. The flask was evacuated through a third tube which was sealed to the pumps. During evacuation the mercury and Pyrex were out-gassed by heating the walls of the container with a Bunsen flame. After about two hours of pumping, with a vacuum better than 0.1 micron, the flask was sealed off from the pumps.

The radiation from the arc lamp and monochromator was first passed through a quartz collimating lens, and then through one of the quartz windows of the mercury container (Fig. 1) onto the surface of the mercury. After reflection, it passed out through the other quartz window of the container and was focussed on one of the receiving surfaces of the thermocouple by means of a second quartz lens. The position of this lens was adjusted by two micrometer screws whose motions were at right angles to each other. Very accurate focusing was possible.

To make an intensity measurement, the monochromator was set on the desired wave-length, and the focusing lens was adjusted until the galvanometer showed a maximum deflection. The radiation entering the monochromator was then shut off by means of a camera shutter, thus permitting the galvanometer to return to its closed-circuit zero. When the radiation from the arc was readmitted to the monochromator, the galvanometer would deflect to its original maximum. The difference between this maximum and the closed-circuit zero was the net effect due to the reflected light for this setting. A group of from 10 to 20 such settings were made in the neighborhood of each of the five lines 4358, 3680, 3125, and 2537A, and the maximum net deflection obtained in each group of settings was taken as the intensity of the line in question.

In the first attempt to make measurements of reflected radiation from the liquid surface, considerable difficulty was experienced because the vibration of the building made the mercury surface tremble. This difficulty was partly overcome by suspending the mercury container in water by means of rubber bands. Due to its viscosity, the water damped the vibrations of the mercury and the reflected radiation could be focused on the thermocouple receiver and held there fairly steadily.

To obtain solid mercury, the container (Fig. 1) was suspended in a Dewar flask containing liquid air. The liquid air did not touch the container, but was about 5 c. m. below it. Natural evaporation of the air froze the mercury in from 10 to 15 minutes. A solid surface formed in this way appeared to be specular and a good reflector, but it was very uneven. To make it into a plane mirror, the container was removed from the Dewar flask, its walls were warmed with the hand until some of the mercury melted and flowed over the solid surface, and then the freezing process was repeated. The resulting solid surface formed images that apparently were quite sharp and undistorted.

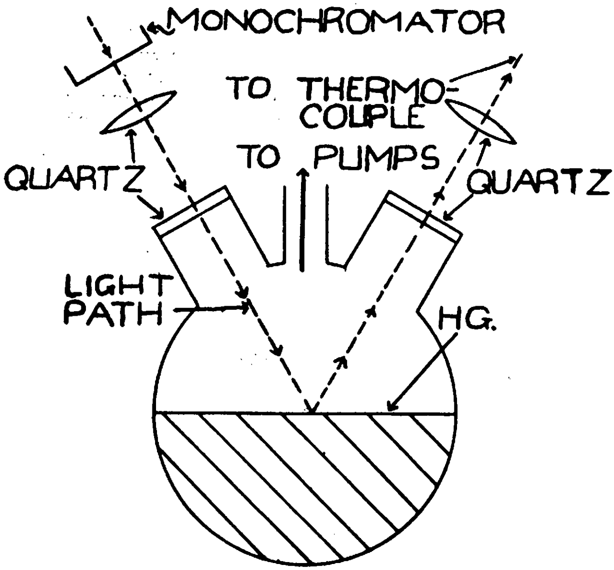
In Table I are given the average values of the galvanometer deflections due to the radiation reflected from the liquid and from the solid surfaces.

TABLE I.—Energies of Reflected Beams from Liquid and Solid Mercury for the Same Incident Beam.

λ	i_1	i_2
4358	26	26
3680	36	36
3125	20	20
2967	13	12
2537	8	6

Each value is the average of four trials. The absolute value of the largest variation of any individual reading from the average given in the table is 2 mm., this being for the line 3125A; other individual readings did not vary more than 1 mm. from the average.

Figure I.—Mercury Container.



Legend for Figure to Accompany Webb-Roller Relative Optional Reflectivity of Solid and Liquid Mercury.

In view of equation 2, the data of Table I point to the conclusion that, within the limits of accuracy of this work, the monochromatic reflectivity of mercury is the same for both the liquid and solid states in the region of wave-lengths 4358A to 2967A. No conclusion can be drawn from the apparent difference in the case of wave-length 2537A because of the smallness of the galvanometer deflections.

Since information regarding the relative reflectivities of liquid and solid mercury in the region 2800A to 2400A is needed for the photoelectric work mentioned at the beginning of this paper, it will be necessary to continue the present work with refined apparatus and a more sensitive photometer. It is also desirable that a higher vacuum be employed, and that the mercury and mercury container be more thoroughly out-gassed.