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on a surface. The essential part of the vacuum microbalance is a quartz spiral supporting a bucket, on the lower surface of which the vapor particles impinge and condense. By interrupting the vapor beam with a shutter the elevation of the bucket produced by the beam can be measured with a micrometer-microscope. Calculations are based on kinetic theory:

$$p = \frac{2 \pi F}{dS \ d\omega}$$

where p is vapor pressure, F is force of impact, dS is area of effusion orifice, and dω is the solid angle subtended by dS to the liquid surface. Vapor pressure of bismuth obtained in a preliminary experiment by this method is in fairly good agreement with the values obtained by other experimenters.

OBSERVATIONS ON THE ESCAPE OF RADON FROM VASELIN*

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Vaselin in which radon has been dissolved is occasionally used as a therapeutic agent for treating lesions of the skin. The effects produced by these treatments are generally considered to be due to alpha and beta irradiation of the tissue. A layer of vaselin from 1 to 5 mm. thick containing from 20 to 100 microcuries of radon in each cubic centimeter of vaselin is spread over the area to be treated. The area is then covered with rubber or some plastic material, the edges of which are sealed to the skin with adhesive tape, to prevent the escape of radon. The observation that some vaselin containing radon, which had been poured into a cup and left in a ventilated hood, still fluoresced after being exposed to the air for several days, suggested that the escape of the radon was slow. Additional tests and observations indicated that while radon near the surface escaped quickly it diffused through the vaselin at a slow rate when at or near room temperature.

A layer of radon-vaselin a few millimeters thick will fluoresce for several weeks when left in a well-ventilated place at room temperature. The intensity of the fluorescence gradually decreases, as would

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be expected from the decay of the radon. No actual measurements were made of the intensity of the fluorescent radiation, and of course its apparent intensity varies with the degree of dark adaptation of the observer's eyes. An approximate estimation of the intensity can be made by comparing the fluorescence with that of a watch dial or an old radon tube. Heating the radon-vaselin to its boiling point and immediately allowing it to cool causes a decrease in the intensity of fluorescence. In order to get rid of all of the radon (and fluorescence) it is necessary to agitate the vaselin for several minutes while it is at or near its boiling point.

Several experiments have been conducted in which the escape of radon from radon-vaselin has been determined by measuring the intensity of the gamma radiation emitted from it. In the first experiment a dish 4 mm. deep was filled with radon-vaselin and the cover was sealed on until after the radon content had been determined. The cover was then removed and the dish was left in a well-ventilated hood at a temperature of 26° C. At the end of eight hours the cover was sealed on again. It was found that the radon content had decreased 22 per cent, which is an average rate of 3.1 per cent each hour. After being sealed for thirty-six hours the cover was removed again for eight hours with the dish setting in a water bath kept at 41° C. Seventeen per cent of the radon escaped during this second period, or an average rate of 2.3 per cent each hour. Some of the radon-vaselin stuck to the cover; hence, removing and replacing the cover caused some mixing of the vaselin and also there were two surfaces from which the radon could escape. Still the rate of escape was less during the second period even though the temperature was higher.

In the second experiment a piece of glass tubing of 13 mm. internal diameter, 3.6 cm. long, closed at one end, was filled to a depth of 1.8 cm. with the vaselin ointment. The open end was closed with a rubber stopper on three occasions while the tube was taken to the measuring room; the remaining time the tube was open in a well-ventilated hood at a temperature of about 25° C. During the first three days the radon content decreased 20 per cent, and during the next four days it decreased an additional 2 per cent. It seems probable that most of the loss occurred during the first day.

In the third experiment the radon vaselin had been sealed in an ointment tube for several days. It was then squeezed out into a paper cup so that it was in the form of a cylinder of about 4 mm. diameter. This cylinder touched the cup in places and also crossed over itself several times, but most of its surface was exposed to air. Immediately after the vaselin was put in the cup it was covered and taken to the measurement room, then taken back to the hood where it was left uncovered, the temperature being about 23° C. Later measurements showed that there was a loss of 21.5 per cent of the radon during the first five hours, 36 per cent during the following twenty hours, 58 per cent during the next forty-eight hours, 27 per cent during the next twenty hours and 28.5 per cent during the next twenty-four hours. This corresponds to an average rate of loss of radon during each of the periods of 4.8, 2.2, 1.7, 1.6 and 1.4 per cent each hour.

The rate of escape of radon was approximately 1.5 times as fast for the 4 mm. diameter cylinder (experiment 3, first five hours) as it was for the 4 mm. layer (experiment 1, first eight hours). This ratio is a little less than would be expected from the ratios of surface to volume for the two shapes. However, for the 4 mm. layer there actually were two surfaces since a small amount of vaselin stuck to the cover when it was removed.

In a fourth experiment a study was made of the rate of diffusion of radon in vaselin. A test tube 10 cm. long and having a diameter of 5 mm. was filled to a depth of 8 cm. with vaselin and the end of the tube was connected to one arm of a three-way stopcock. Radon was introduced into the space above the vaselin and the region of fluorescence was observed daily. The room temperature was about 23° C. The rate of advance of the fluorescence was 3 to 4 mm. each day. The results do not give the true rate of diffusion because the intensity of fluorescence was also decreasing as the radon decayed, and the vaselin appeared to pull away gradually from the glass wall of the tube. However, the results do indicate that the rate of diffusion of radon through vaselin is slow.

The purpose of these experiments was to try to determine whether or not it was necessary to seal radon ointment during a treatment; the purpose was not to determine accurately the rate at which radon escapes from and diffuses through vaselin. The accurate determination of these values would necessitate the building of some special apparatus and would require more time than has been available for such work. Visual observations of fluorescence are not satisfactory for quantitative work. Measurements of the emitted gamma radiation are an indication of the amounts of radium B and radium C present and not of the amount of radon present unless a period of four hours has elapsed since there was any change in the amount of radon, for it takes about four hours for equilibrium to be established between radon and radium B and radium C. One must also remember that radon and its disintegration products are dangerous materials to handle, and proper precautions must be taken to prevent breathing radon, undue exposure to the beta and gamma radiations, and contamination of rooms and equipment due to escape of radon.

These experiments do show that while the rate of escape of radon from vaselin is rapid, most of the radon which escapes comes from near the surface. Since diffusion of radon through vaselin is slow the concentration of radon in deeper layers of the vaselin probably changes very slowly. This would suggest that the ointment need not be sealed during treatment if the biologic effect is primarily due to alpha irradiation. For unless an alpha ray is produced practically in contact with the tissue it can have no effect, since its range in tissue or vaselin is of the order of 0.1 mm., hence loss of radon from the outer layers of vaselin would not affect the alpha irradiation of tissue. If beta irradiation is also of importance, then the escape of radon from layers a few millimeters from the tissue would be of importance, since beta rays have a range of approximately 1 cm. in tissue or vaselin. There is also the probability that radon escapes from the vaselin into the tissue, but this process should not be significantly affected by changes in the concentration of the radon in vaselin more than 1 or 2 mm. from the skin.

At the present time our conclusion from these experiments is that as far as the therapeutic effects are concerned it is not necessary to seal the ointment during treatment, but if it is not sealed there is some danger of contaminating rooms in which the patient stays. Also it is desirable to use a covering which will prevent rubbing off the ointment. However, the use of this ointment is still in the experimental stage. Problems of dosage and what produces the biologic effect must be at least partially solved before the question of the necessity of sealing the ointment can be answered. On the other hand, a comparison of the results of a series of treatments given with the ointment sealed with those of a series given with the ointment not sealed might suggest some answers to some of the other problems.

THE DESIGN OF A LARGE APERTURE GRATING MONOCHROMATOR FOR USE IN PHOTOSYNTHESIS INVESTIGATION*

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ABSTRACT

An instrument has been constructed that will give monochromatic light of sufficient intensity for the measurement of photosynthesis in red light with reasonably narrow spectral band width. The apparatus uses a 4 x 6″ replica grating and large condenser lenses of 17¾ inch focal length. It covers the spectral range of 350 to 1000 mu. The dispersion is 3.55 mu/mm in the second order and 7.1 mu/mm in the first order. The entrance and exit slits are fixed on axes at 90° to each other and the wavelength of the emergent beam is controlled by the rotation of a mirror and one lens. The per cent

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