February 1, 2, and 6, it is evident that the activities in the snow must have come from the blasts of January 27 and/or January 28.

Subsequent snowfalls in Ann Arbor until February 11 were also checked for activity. Rare earth fractions from the snowfalls of February 6 showed very little activity, a maximum of about 1 dis/min/ml—approaching the limit of detection of our counting equipment. The activity of one other snowfall sample—that of February 4—was too near background to give evidence of isotopes in the rare earth region.

Many eastern localities have also reported the presence of radioactivity in their snows after the Las Vegas explosions. Although the activities reported in Ann Arbor in no way approach dangerous levels from a health standpoint, they could possibly become the source of contamination problems in such work as film packaging (*4*) or low-background radioactivity experiments.

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Electromigration in a Cation Exchange Resin[1]

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The exploration of the electrical conductance of ion exchange resins (*1–3*) and its dependence on the nature of the adsorbed ions suggest the study of electromigration in synthetic ion exchangers and the use of these resins for the separation of ions of different mobility. Electrical fields have been used to improve chromatographic separations (*4, 5*) on cotton and siliceous materials and to effect separations on paper (*6, 7*). Owing to the high capacity and great versatility of synthetic ion exchange resins, electromigration in these media is of special interest.

We followed the movement of ions in a resin column by use of the radiotracer technique. The experiments prove that the adsorbed cations carry the current. Thus, although solid in the physical sense, from the point of view of electrical conductivity the wet resins act similarly to solutions of electrolytes, confirming the hypothesis advanced to explain equilibrium experiments (*8*) that the resin phase is equivalent to an ionized salt solution.

An electric potential was applied to a resin column containing a layer of radioactive ions, and the movement of this layer along the column was observed. A Plexiglass electrolysis cell with perforated platinum electrodes was filled with Dowex-50[3] in the sodium form. A thin layer of active resin containing radiosodium was embedded in the resin column 3 cm from the anode. The activity at the beginning of the experiment and after passage of a constant current for a given time was measured by inserting the cell in a slide propelled by a screw under a Geiger-Mueller tube. This was mounted on a lead brick 9 cm high, covered with aluminum sheet to absorb most of the γ-radiation except for a narrow beam passing through the 3-mm slit cut in the brick under the tube. As different parts of the cell were exposed, the radiation emanating from each was recorded. The position of the tube could be read to an accuracy of 1/32 in. Voltage and current were measured at regular intervals, and a fast stream of deionized water (sp res, 10^6 ohm-cm) passed through the resin from anode to cathode in order to keep the resin temperature constant and to remove the sodium hydroxide formed at the cathode and the gases formed at both electrodes.

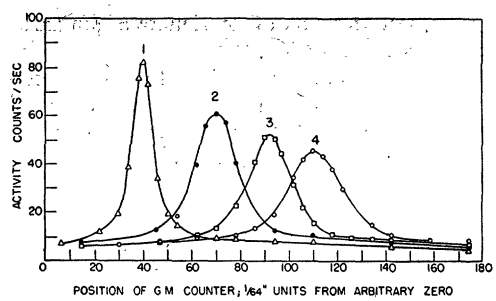

FIG. 1. Electrolysis of Dowex-50 in the sodium form traced with Na^{22}. Cell length, 9.8 cm; diam, 1.6 cm; resin mesh size, 80–100 (dry basis); current, 50 ma; tagged layer initially 3 cm from anode.
Curve 1, before applying the potential
" 2, after an electrolysis period of 3 hr
" 3, " " " " " 6 "
" 4, " " " " " 9 "

It had been verified that within a period equal to the length of the experiment only slight spreading of radioactive material occurs unless an electric potential is applied.

In different experiments, current and resin grain size were varied. The results of a typical experiment are given in Fig. 1, which shows a plot of the activity from a lamina of 2.6y Na^{22} tracer in the NaR, measured along the column at different times during the electrolysis.

The following electrode reactions were shown to occur:

Anode:

$$4R^- + 2H_2O = 4HR + O_2(g) + 4e^- \quad (1)$$

Cathode:

$$4e^- + 4NaR + 4H_2O = 4Na^+ + 4R^- + 4OH^- + 2H_2(g) \quad (2)$$

where R represents the resin radical.

As electrolysis proceeds, the hydrogen ions formed at the anode penetrate the whole sodium layer and

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[3] Furnished through the generosity of the Dow Chemical Company, Midland, Mich.

slow down its movement by virtue of competition by their higher mobility. They eventually reach the cathode. At this point the following reaction competes with reaction (2):

$$4e^- + 4HR = 4R^- + 2H_2(g) \qquad (3)$$

In the HR electrolysis reactions (1) and (3) there is no net production of the hydrogen form of the resin. Thus the yield of HR at the end of the electrolysis measures the extent to which the current is carried by sodium ions. For a total current of 252 and 1,140 mah (milliampere-hours) the yields varied between 100 and 67%, respectively, of the value to be expected if only reaction (2) occurred at the cathode.

At the beginning of the electrolysis the movement of the activity maximum is proportional to the current. The spread was found to increase with the particle size of the resin. In electrolyses where the slower ions follow the faster, sharp boundaries may be obtained. Thus when the system $Pt|NaR|ZnR_2|Zn$ is electrolyzed with the zinc and platinum electrodes as anode and cathode, respectively, metallic zinc dissolves in the resin and the boundary between the zinc and sodium resin remains sharp while moving toward the cathode, as shown by the results of an experiment in which the boundary was traced with 250d Zn^{65} (Fig. 2). In this case the displacement of the boundary from its original position is proportional to the electric charge passed, and practically only the following reaction occurs at the cathode:

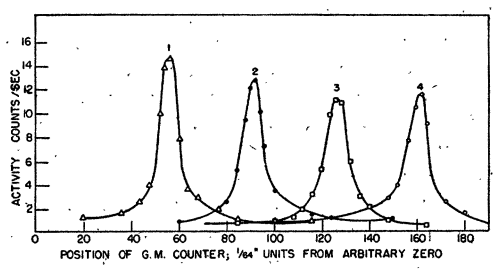

FIG. 2. Electrolysis of Na Dowex-50 and Zn Dowex-50 between platinum and zinc electrodes, respectively. Boundary between NaR and ZnR_2 traced with Zn^{65}. Cell, resin mesh size, and current as in Fig. 1. Traced layer initially 4.8 cm from anode. Activity corrected for room background. Designation of curves and time intervals as in Fig. 1.

$$2R^- + Zn = ZnR_2 + 2e^- \qquad (4)$$

The observed small flattening of the curves is probably due to the effects of diffusion, inhomogeneous packing of the column, temperature gradients, and in the case of the sodium resin also to the penetration of hydrogen ions.

The aspects of separations by resin electrolysis are different from those of regular chromatography, as both adsorption affinity and frictional resistance to ionic movement determine the movement of a band in an electric field, whereas in regular chromatography the mobility of the band is determined by the distribution of the adsorbate between solid and solution. In resin electrolysis there is no solution in the conventional sense unless the extensive ionic double-layer be considered as such. It is thus possible to induce band movement in the adsorbent column without its coming in contact with solution.

Apart from its possible application as a separation method, resin electrolysis may find use as a method for regenerating resins without using regenerant solutions; for instance, the conversion of the sodium into the hydrogen or zinc forms as shown in these experiments. Further studies are in progress.

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A New Electronic Apparatus for the Measurement of the Fusion Frequency of Flicker

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After introduction of the fusion frequency of flicker (fff) for the study of fatigue (*1*), anoxia (*2*), and various types of pathology (*3–6*), a rather large number of papers has appeared, and it is likely that this method will find rather general application in applied physiology and clinical medicine.

In the past the method has been applied in one standardized condition, which unfortunately differed in the investigations of various authors. It is highly desirable to provide for the variability of the brightness level, the visual angle, and the light: dark ratio, in order to test the effect of these fundamental variables on the response in physiological stress situations and to reproduce the testing conditions of other authors.

The classical experiments on the fff have been performed with rotating disks or cylinders with openings cutting a beam of light. An electronically produced and regulated flicker would have the advantage of freedom from vibration and noise and of a perfect square wave form of the light stimulus with a transition time not exceeding 1% of the cycle length.

The construction of the new apparatus was made possible by the recent development of a "glow modulator tube" (R1131A) by the Sylvania Electric Company for facsimile transmission (*7*). This tube emits, at maximum current flow, from a circular area of 3-mm diameter, a bright light of mixed white char-

[1] Now with Engineering Research Associates, Inc., St. Paul, Minn.

[2] Published with the approval of the chief medical director. The statement and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or the policy of the Veterans Administration.