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SUMMARY OF THE RESEARCH PROGRESS MEETING OF JUNE 12, 1952

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Berkeley, California
I The Use of Electron Track Plates in Mass Spectroscopy. F. L. Reynolds

The simple photographic transfer process of collecting radioactive mass spectra on a plate sensitive to positive ions and then before developing this plate, placing emulsion to emulsion a plate to detect the radioactive deposits relative to the inactive lines on the original plate, has been known for several years. Owing to the smallness of the sample, the usual lack of efficiency of the ion source and the geometry of the machine, the amount of material collected on the initial receiver plate is so small that counting technique is lacking in sufficient sensitivity to locate the active spectra lines. Mass assignments of active deposits that are alpha particle emitters may be detected as individual events by transfer plates which record alpha tracks. By suitable transfer time periods a suitable number of tracks over background tracks offers a sensitive method of detecting very small quantities of activity associated with the collected mass spectra. By this technique it has been possible to make mass assignments of some rare earth alpha emitters formed from cyclotron bombardments and to get half life information on some of the heavy elements. The same technique could be used on electron track sensitive plates, but the problem of electron track background existing and being constantly augmented makes electron track plate work a more formidable problem. The purpose here is to relate some of the problems connected with the possible use of electron track plates as transfer plate detectors, and to relate some of
the techniques of eradication of existing tracks and possible other methods of by-passing the need of the eradication step.

**Eradication.** Several track eradication experiments were tried. The usual technique employed by most workers has plates that are rack supported and kept level in a light tight sealed container. Excess water is added to a sponge supported above or below the plate rack level and the unit placed in a temperature controlled oven or water bath. At $35^\circ$ C it requires about 72 hours for eradication. Even with very careful temperature control trouble was often experienced from water collecting as drops on the emulsion with subsequent transport of the gelatin. To prevent condensation troubles, controlled humidity conditions were next tried, and the degree of eradication ascertained with changing the parameters of relative humidity, temperature and time. It is possible to eradicate at room temperature and 100 percent relative humidity, but the practicality of 30 day eradication is open to question. Another attempt to circumvent the drippage problem was used, where just sufficient water is added to swell the gelatin.

To summarize the eradication experiments, it has been ascertained that in a majority of runs there is a loss in sensitivity to minimum ionization electron tracks after submitting the plate to any method involving high humidity, temperature, and a mild oxidizing agent. This has been shown by the drop in grain count per 100 microns, by the track length, and by visible line intensity compared to an uneradicated plate taken from the same batch. The fading of tracks occurs very slowly below relative humidities less than 90 percent or at temperatures less than $25^\circ$ C with the relative humidity at 100 percent. Of the methods so far tried, eradicating at $50^\circ$ C, 100 percent R.H., and using only sufficient water to swell the gelatin seems to be the most reliable. The duration of eradication
is around 30 hours. Methods of by-passing the eradication process consists of pouring plates from bulk G-5 emulsion supplied by Ilford Ltd. Plates poured and dried at 80° F. for several hours seem to produce an emulsion with the same sensitivity as factory poured plates and are nearly free of electron tracks. The keeping qualities of the bulk emulsion is not too stable, and shipping conditions from England enhance the problem of emulsion stability. Continued experiment on this method could produce the best answer to the problem of nearly track free plates for the transfer plate requirements.

Room temperature eradication suggests one other possibility. Since plates will eradicate at 25° C and at R.H. of 100 percent, it is obvious that electron tracks do not record when the plate has a high water content. Ilford is willing to ship several test plates in sealed containers without attempting to dry the emulsion after the gelatin has set.

Plate Drying Methods. Three different drying methods were tried on the plates after eradication. Chemical drying agents, 80°F, circulating room air and drying under controlled humidity conditions in dessicators. It is concluded that the rate of drying does not affect the sensitivity, but does affect the distortion. No relationship was found between surface fog and drying rate. Surface fog is related more to eradication procedures and development.

Development Procedures. Several types of developers were tried. Amidol with boric acid buffer, and Elon-sodium sulfite with no buffer. General procedure was to cold soak at 5° C for 30 minutes, warm develop at 21° C for 45 minutes. For 100 micron plates the first three developers gave about equal results. The last named developer gave less surface fog, less random grains and the track grains were well developed.
Storage During Transfer. To date this has been the least studied step. Storage of plates during transfer periods in lead containers only, showed a marked increase in background tracks in three to five days. Stored in two inch thick iron containers surrounded by three inches of lead gave far less background tracks for the same period.

Low Energy Electrons (10 to 50 kv.). The regular emulsion to emulsion transfer technique outlined above cannot be employed to detect very low energy electron tracks. At the most these tracks are only a few grains in length and do not penetrate much below the surface fog of the electron sensitive plate. An alternate method is to collect the spectra on stacked foils, remove the activity by wet micro-chemical methods, and impregnate the solution into the emulsion.

With this last method, a collection of Cm isotopes was made on stacked foils, the Cm$^{242}$ separated from the foil by wet chemical methods. The solution was buffered to 3.5 pH and impregnated into a 100 micron G-5 emulsion. To ascertain the ratio of alpha tracks having associated electron tracks was the purpose of this experiment. This ratio was approximately 23 percent alphas with associated electron tracks, which was a lower figure from that obtained from our alpha particle energy spectrometer run, where the lower energy group measured 27 percent. Only about 1000 tracks were counted in the above experiment, but the results indicate that this method could be useful in many decay studies.

II. The Use of Annihilation of Positrons in Flight to Give a Peaked Gamma Ray Spectrum. Stirling A. Colgate

The theoretical behavior of the annihilation of positrons in flight with a negative electron at rest was derived by Dirac. The total cross section at high energy is qualitatively checked by Dirac's experiment, so
that the theoretical gamma ray spectrum can be relied upon. This spectrum is strongly peaked at the high and low energy ends. In one-half the annihilation events, one of the two gamma rays has an energy greater than

$$E = \frac{2(E-1)}{1}$$

where $E$ is the total energy of the positron. The spectrum of annihilation plus bremsstrahlung for positrons passing through low $Z$ materials is favorable from 10 Mev up to 200 Mev for threshold type experiments. 10 Mev positrons passing through $1/2$ cm of LiH will give an annihilation spectrum peak 10 percent (full width and 50 times the intensity of the upper 10 percent) of the bremsstrahlung spectrum. 200 Mev positrons passing through $1/100$ radiation lengths (20 cm) of liquid hydrogen give a peak 6 times the bremsstrahlung intensity and 3 percent wide.

The modern electron accelerator, betatrons and linacs, gives electron currents of the order of 1 microamp. For energies high compared to $mc^2$ these electrons can be converted to positrons, say of $1/2$ energy, 10 percent energy width by a factor $1/5000$ of the electron beam. A reasonable thickness of low $Z$ annihilator gives a gamma ray conversion of $1/200$, so that a net gamma ray flux in the upper 10 percent peak of the spectrum would have of the order of $10^7$ gammas/sec. This is ample for threshold type experiments.