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Summary of the Research Progress Meeting

February 10, 1949

Henry P. Kramer

...al Review of Declassified Reports
Au...d by USDOE JK Bratton
Unclassified ... May 79

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Radiation Laboratory
University of California
Berkeley, California

Summary of the Research Progress Meeting

February 10, 1949

Henry P. Kramer

Radiation Laboratory, University of California
Berkeley, California

The Decay of Circulating Ions in the Cyclotron. E. Lofgren.

At the Research Progress Meeting of January 27, 1949 L. Alvarez sparked interest in the matter of charge neutralization of the ions in the circulating beam of the bevatron whose design is in the stages of final development. He mentioned the possibility that charge neutralization may be the cause of loss of the entire beam of charged particles since the ions traverse an extremely long path in the bevatron and the probability of electron capture is therefore very high. Furthermore, the charge neutralization is particularly pronounced at small energies and velocities, so that this effect may be extremely serious in the quarter-scale, low energy model of the bevatron which is now nearing completion. A good quantitative knowledge of the extent of charge neutralization is therefore of great importance at this time so that appropriate devices to alleviate the effect may be incorporated in the design. Higher injection energies and lower vacuum are two means by which loss of the beam by charge neutralization may be diminished.

In order to gain a quantitative knowledge of the loss of beam due to charge neutralization, a number of experiments with the 184" cyclotron have been suggested by L. Alvarez and E. McMillan. Some of these have been performed by E. Lofgren and H. Bradner and others will be completed shortly.

The experiments may be classified as to whether the oscillatory system which drives the cyclotron was turned on or off during the course of the measurements. With the cyclotron in operation measurements were made by photographic exposure and with the rf system shut off after an initial acceleration, the decay of the

beam from scattering and charge neutralization was counted with anthracene counters.

a) Measurements with a photographic plate. The apparatus is sketched in Figure 1. It consists of a copper box with walls 1 inch in thickness in which a photographic plate was mounted. A slit in the front of the box allowed particles to enter. The box was placed on the end of the probe rod and exposed inside the cyclotron chamber, in such a way that no portion of the beam of ionized particles could enter the slit. However, if any neutral particles are ejected at a tangent from the circulating beam they are caught in the slit and recorded on the photographic plate. By covering the slit with a thin foil it is possible to strip the captured electron from the neutral particle and then from the curvature of the track to compute the $H\rho$ and thus gain knowledge of the energy of the particle. These measurements were made with the cyclotron operating both with deuterons and with protons. Figure 2 shows tracks made by neutral hydrogen atoms originating from protons which lost their charge by electron capture. The two sets of tracks are due to two slits in the photoplate holder. In each set one sees a heavy line and next to it a very faint line. Judging from the angle between the two lines, it is thought that the faint line is made by particles which leave tangentially from the negative beam as shown in the sketch of Figure 3. The heavy band points to a circular orbit with radius 2.6"-6.5" and the light band points to a circle with radius 4.5"-11". When a foil is placed in front of the slit, the particles are again charged and the curved track which is shown in Figure 4 results. Assuming that these tracks are caused by particles of mass 1, the energy interval computed from $H\rho$ measurements is 1.2-3.4 Mev. One knows the energy which these particles must have in the cyclotron since one knows the radius at which they cease being accelerated by the cyclotron oscillation. Computed from the radii the energy of the particles coming from the positive direction lies between .5-3 Mev. This interval is in fair agreement with the values, 1.2-3.4 Mev obtained from $H\rho$ evidence.

An additional way of determining the energy of the particles is from the range

energy curves in the emulsion for protons. When the tracks are examined under a microscope, it is seen that they fall into two distinct groups. There are tracks whose energy is .8 Mev and others whose energy is 2-3 Mev. These two classes of tracks have quite distinct energy levels although they are not separated in space.

Figure 5 shows the bands made by neutralized deuterons. Three distinct lines are seen to emerge from the slit. As yet no measurements have been made of the $H\rho$ and the range in the emulsion. The results of the measurements with photographic plates on the proton and deuteron beams are summarized in Table 1.

Protons

Radius (inches)		Energy (Mev)		
pos. direction	neg. direction	from radius	from $H\rho$	from range
2.6-6.5		.5-3	1.2-3.4	.8 and 2-3
	4.5-11	1.5-8.5		
	Deuterons			
5-10		.9-3.5		
	3.5-9	.5-3		
	16-21	9-14.5		

Table 1

b) Measurements with Anthracene Counters. A telescope of anthracene counters (Figure 6) was set up outside the neutron port of the 184" cyclotron. Ions were accelerated to the instantaneous circle at 12" and the oscillator of the cyclotron was turned off. The anthracene counters then measured the time-wise decay of the constant velocity beam from scattering and charge neutralization. Since the telescope can be rotated, it is possible also to see radii of 12" $\pm$ 12". A graph of the change of counting rate with time is presented in Figure 7. It is seen that the decay is approximately exponential with a half time of about .36 sec. The total duration of the measurement was 1.6 secs. and 1660 counts were recorded during this time. The maximum initial counting rate was 3200 counts/sec. Meas-

urements for other radii will be made and the results will be analyzed. It probably will not be possible to obtain results at the 6" radius because of the difficulty of shutting off the drive so soon after it has started.

A Study of Aluminum Oxide Gaseous Species above 2000° K. A. Searcy.

The ultimate aim of this research is to reconcile the fact that hydrogen has remained in the atmosphere of the earth with the high temperatures which are supposed to have reigned at the birth of the earth. One possible resolution of this difficulty is the hypothesis that the hydrogen was bound in hydroxides during the initial period of high temperatures on the earth. In order to test this hypothesis it is necessary to know which oxides and therefore which hydroxides can exist at high temperatures. In order to study the possibility of existence of aluminum oxides one must first determine the vapor pressure at temperatures in excess of 2000° K.

The vapor pressures are determined by the Knudsen diffusion method. The material which is to be tested is enclosed in a chamber which is equipped with a small vent. As the material is heated and vapor pressure develops, a portion of the matter is forced out of the vent and condensed on a plate placed immediately in the stream emanating from the hole. By weighing the matter which is collected on the plate, determining the dimensions of the hole, and applying gas dynamical theory, it is possible to calculate the vapor pressure in the tank. A practical difficulty in performing this experiment with Al_2O_3 consists in finding a suitable material for the container. Tungsten and tantalum were attacked, but molybdenum was found to be satisfactory. Measurements showed that the vapor pressure at 2300° K is 10^{-6} atmospheres.

Once the vapor pressure had been determined, the next step in our general line of research was to make use of the result in hypothecating the state in which the original substance Al_2O_3 exists at the high temperature of the experiment.

The possibility that the reaction $Al_2O_3 = 2Al + 3O$ takes place must be

rejected because the vapor pressure which was found is too high for the coexistence of aluminum vapor and oxygen. Even though the reported value for the vapor pressure of aluminum may be in error, a more accurate measurement would yield a lower value, so that it may be stated with fair assurance that the above reaction does not describe the state of aluminum oxide at 2300° K.

It is reasonable to think that AlO may somehow be formed as a product of the decomposition of Al_2O_3, since it is seen in stars. The reaction $Al_2O_3 = 2AlO + O$ is, however, not likely, since on the basis of the vapor pressure it is calculated that the stability of AlO would have to be about 6 volts, whereas the D_o line of the compound indicates a stability of 1-4 volts. However, if Al is added to Al_2O_3, no increase in the vapor pressure within the experimental error is seen, and thus it is likely that $Al + Al_2O_3 = 3AlO$ describes what happens at high temperatures.

A first essay to introduce H_2 into the system at extremely low pressure yielded an equilibrium constant $K = 10^4$. This is an encouraging preliminary result, but it will be necessary to work with H_2 at pressures of about 1 atmosphere. Since the diffusion method does not function at high pressures, it is contemplated that the flow or spectrographic methods will be used instead.

Separations of Macro Quantities of Rare Earth Elements. D. Stewart.

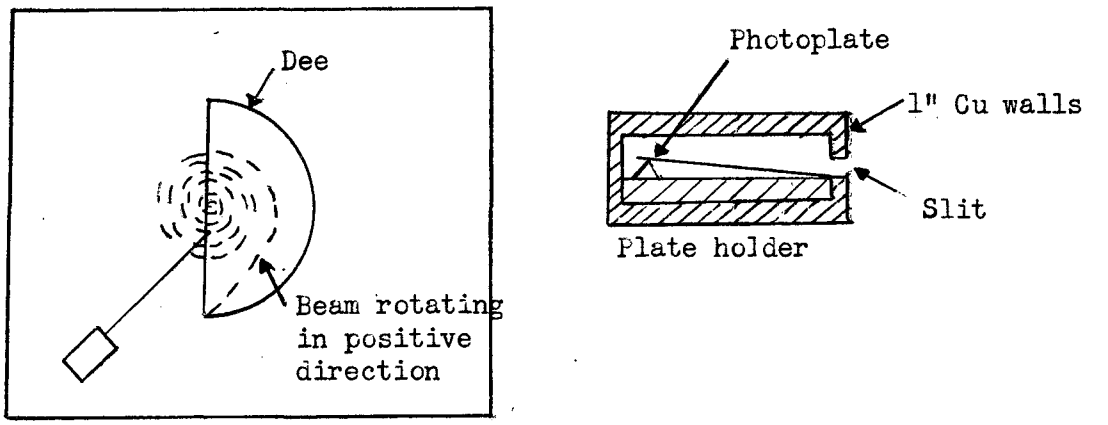
Work in the separation of rare earths by ion exchange columns at this Laboratory has generally been so successful that one of the largest stocks of pure samples of rare earths in existence has been built up.

The exchange columns are charged with zeolite resins, rare earth solutions are placed on the column and the elements are eluted at different rates by a 5 percent citrate elutriant of pH 3.

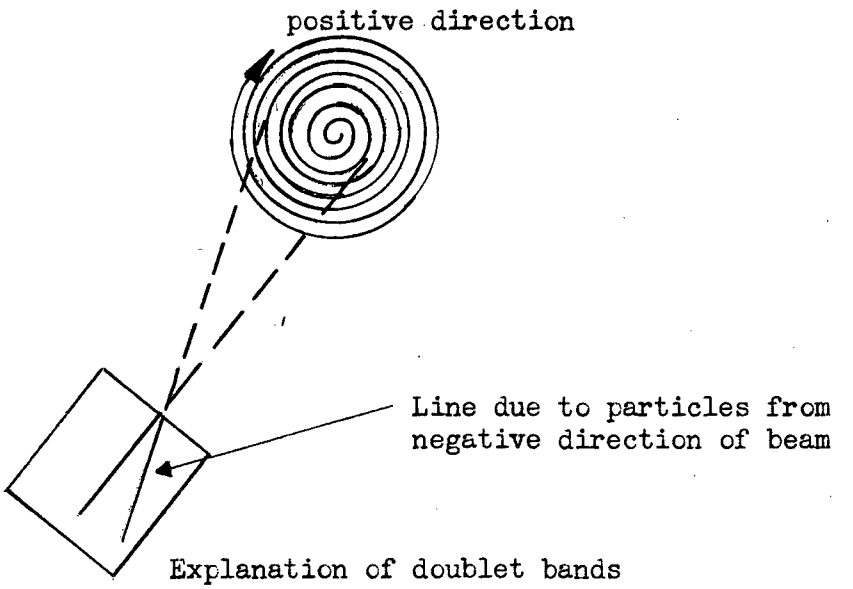
Difficulty has been experienced in the separation of Sm and Eu and Tb and Dy, since these elements come off the column in pairs. A possible way of overcoming this trouble is to work at increased temperatures. However, gas formation may

make the entire process inoperative if the temperature is increased.

There is an interesting variation in the sharpness of the peaks at which the rare earths are eluted. Beginning with La of lowest atomic number the sharpness of the separation increases as one passes to higher atomic numbers.



Photoplate Experiment
Figure 1



Explanation of doublet bands
Figure 3

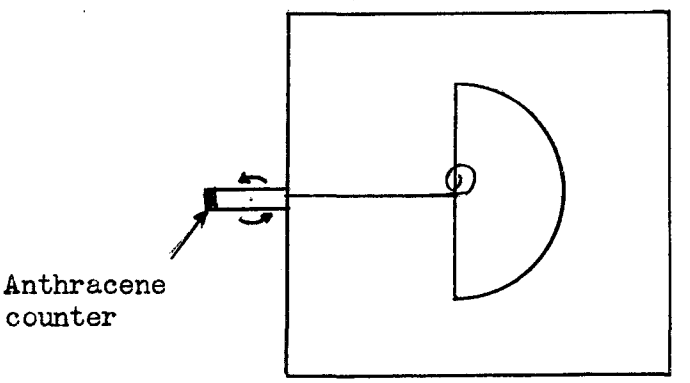


Figure 6

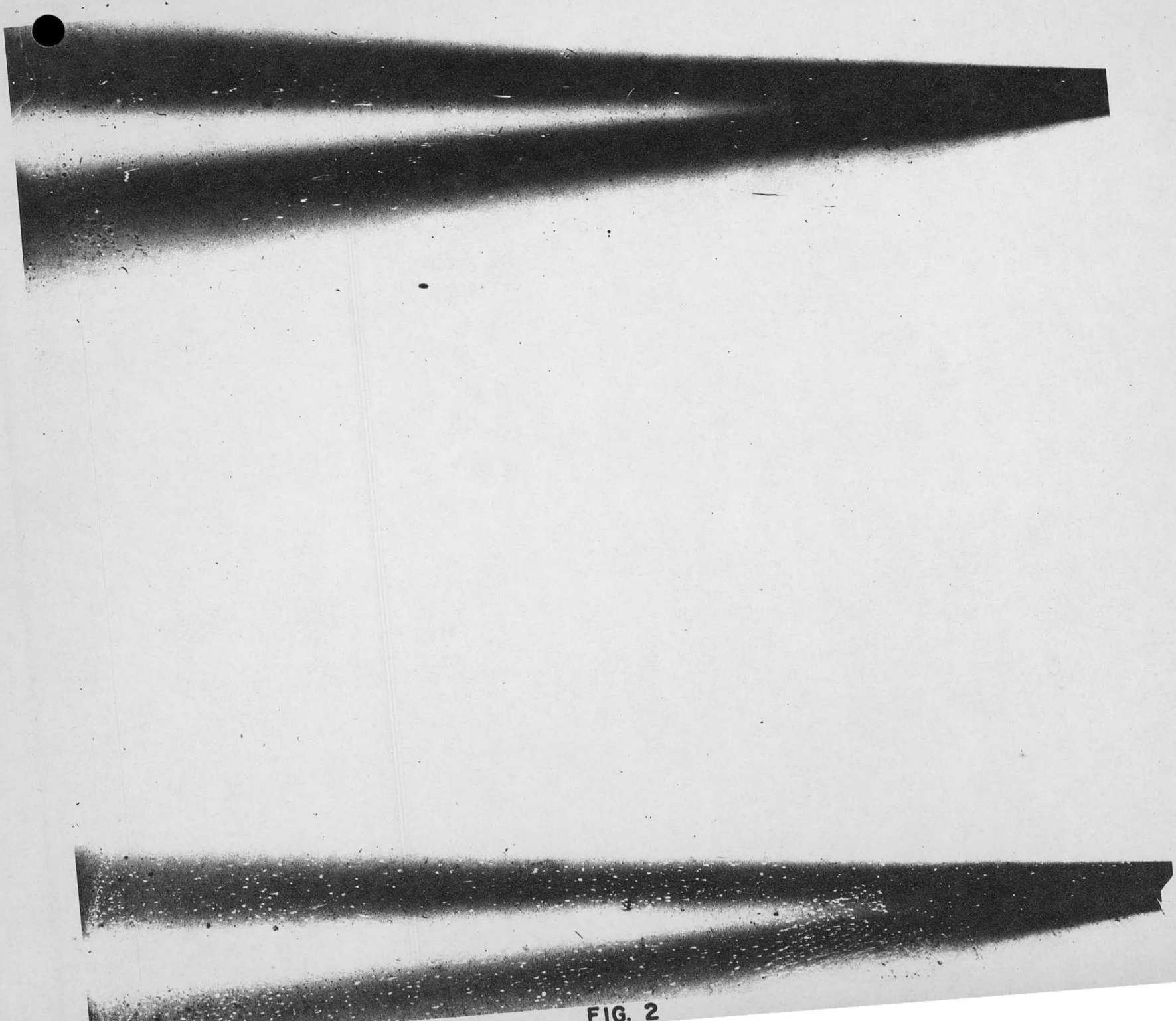
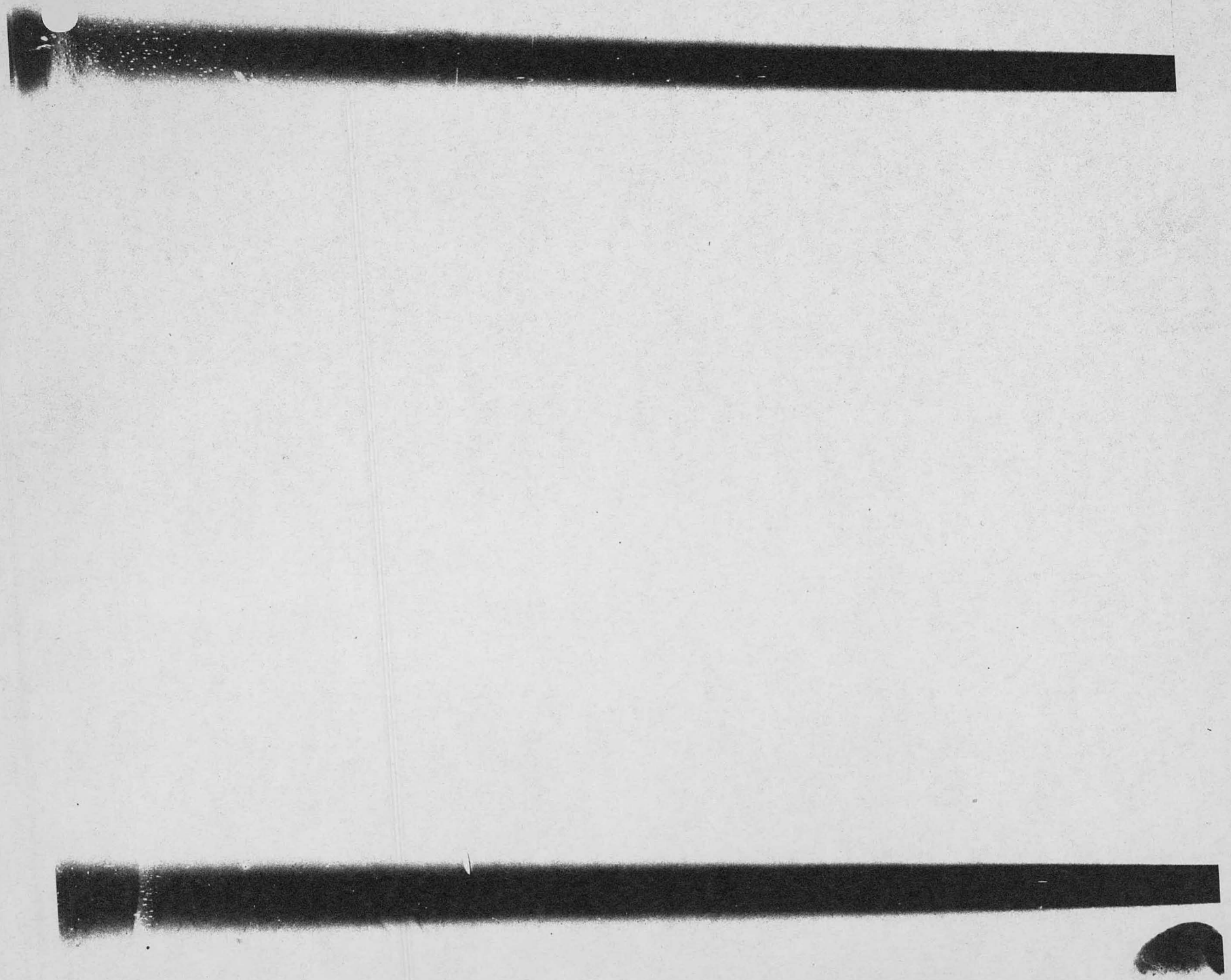


FIG. 2

OZ 349

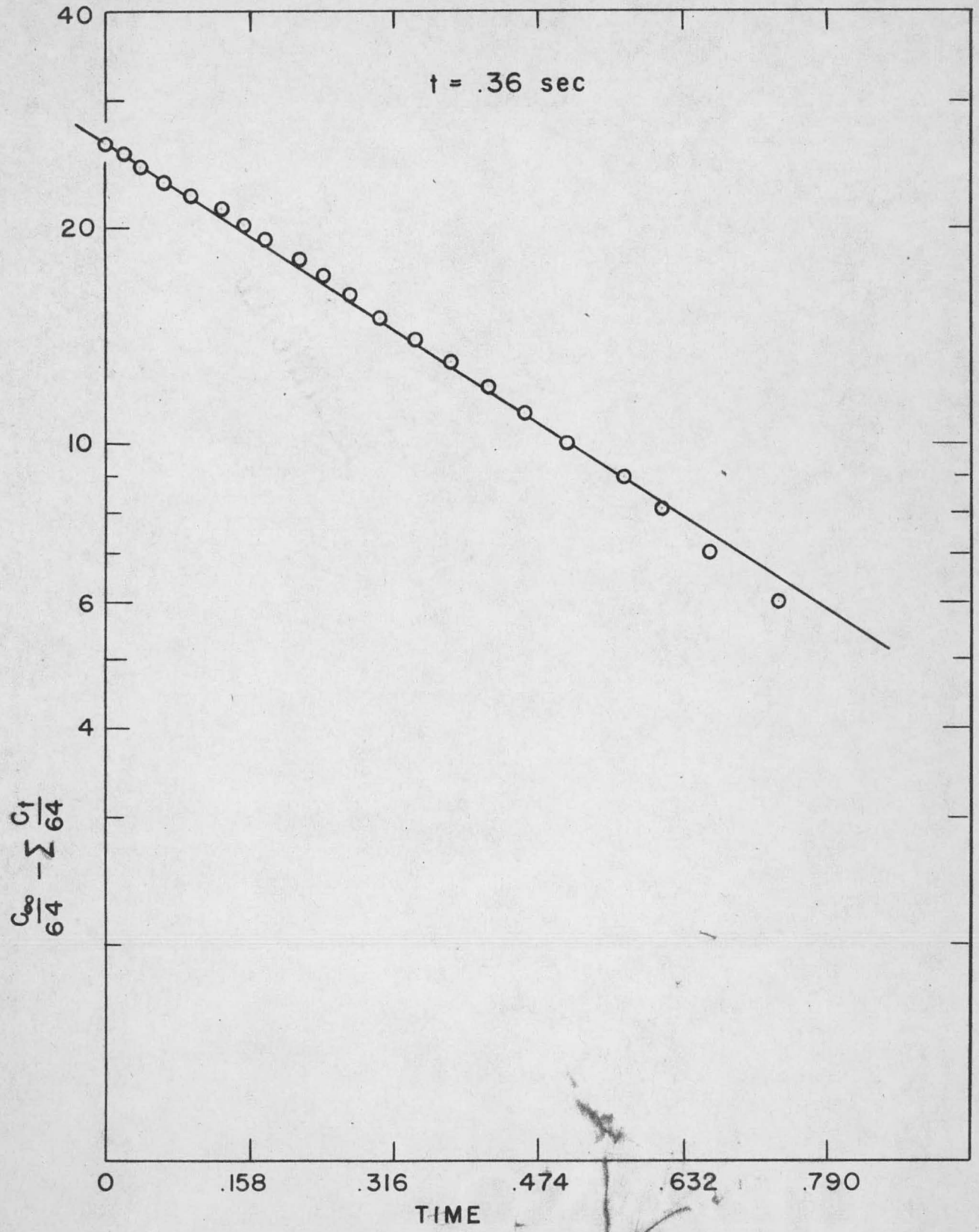
FIG. 4

07 348



OZ 358

FIG. 5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40
20
10
6
4
$\frac{C_\infty}{64} - \sum \frac{C_t}{64}$
0
.158
.316
.474
.632
.790
TIME

FIG. 7

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