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Summary of the Research Progress Meeting

November 18, 1948

Henry P. Kramer

Berkeley, California

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Standard Distribution	Copy Nos.
Argonne National Laboratory	1-8
Armed Forces Special Weapons Project	9
Atomic Energy Commission, Washington	10-11
Battelle Memorial Institute	12
Brookhaven National Laboratory	13-20
Carbide and Carbon Chemicals Corp. (K-25 Plant)	21-24
Carbide and Carbon Chemicals Corp. (Y-12 Plant)	25-28
Columbia University (Dunning)	29
General Electric Company, Richland	30-33
Hanford Operations Office	34
Iowa State College	35
Knolls Atomic Power Laboratory	36-39
Los Alamos	40-42
Mound Laboratory	43-44
National Bureau of Standards	45-46
Naval Radiological Defense Laboratory	47
NEPA Project	48
New York Operations Office	49-50
North American Aviation, Inc.	51
Oak Ridge National Laboratory	52-59
Patent Advisor, Washington	60
Sandia Base	61-62
Technical Information Division, OROO	63-77
UCLA Medical Research Laboratory, (Warren)	78
University of California Radiation Laboratory	79-83
University of Rochester	84-85
Bureau of Ships	86
Total	86

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Summary of the Research Progress Meeting

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Henry P. Kramer

Developments at Columbia University. I. Rabi.

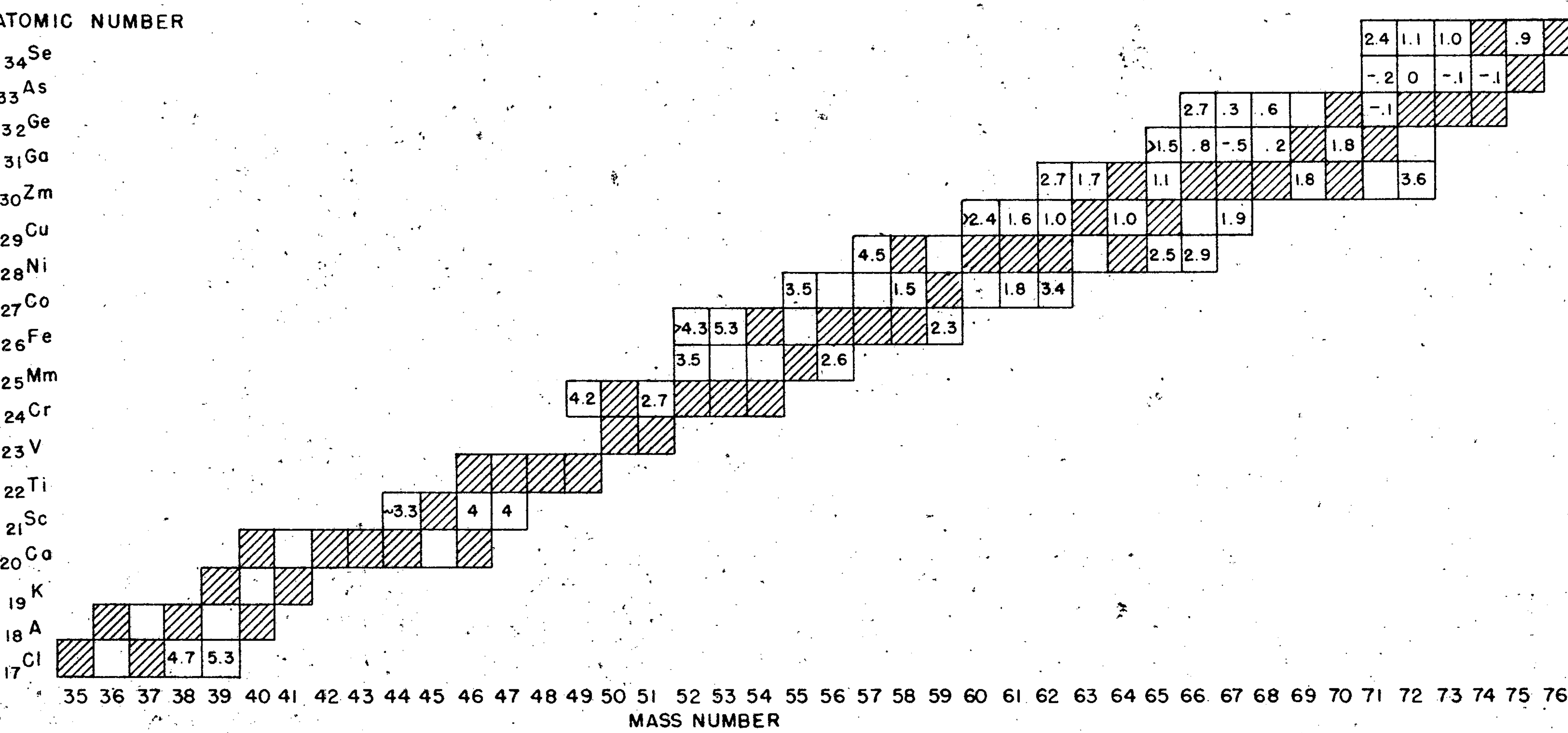
Professor Rabi visited the Laboratory and made some brief remarks at the meeting regarding the state of development of the Columbia cyclotron. It is expected that the apparatus will be in operation early during 1949. It is designed to produce 386 Mev protons. The cast magnet is now completed. Investigations are being carried out on the hyperfine structure of tritium, the mesonic structure of the proton, and electron neutron interaction.

Spallation Products of $_{33}As^{75}$ with 190 Mev Deuterons. H. Hopkins, Jr.

The investigation of the yield and activity of the products which result from the bombardment of $_{33}As^{75}$ has been carried on continuously since the beginning of the operation of the 184" cyclotron. It is part of a larger program of determining the spallation products of nuclear reactions with high energy deuterons.

The samples of arsenic which are used contain the following impurities: Al - .0005 percent, Ca - .0001 percent, Cu - .0002 percent. These impurities are not sufficient to affect the yield results in any significant manner. Bombardments extend from 1/2 to 10 hours and are made on foils of 1 mm thickness. After the bombardment, the fractions are separated and counted. Absorption measurements are also taken. Table I shows the isotopes which are formed. The abscissa is the mass number, the ordinate is the atomic number. The numbers which are entered in the squares corresponding to the isotopes, represent the negative logarithm of the ratio $\frac{\text{yield of isotope}}{\text{yield of } _{33}As^{72}}$, so that the smaller numbers correspond to greater yields and negative numbers indicate that the yield is larger than that of $_{33}As^{72}$.

It is seen from the table that the spallation products cover a range of atomic numbers from 34 for Se to 17 for Cl and a range of mass numbers from 75 to 38. The



YIELDS OF ISOTOPES FROM ARSENIC + DEUTERONS (190 MEV)

NEGATIVE LOGARITHMS RELATIVE TO $As^{72} = 1$

TABLE I

solid squares of the table represent stable isotopes. It is seen that the yield decreases as one goes from a stable isotope either in the direction of changing mass number or atomic number.

The results indicate that the isobars are formed directly rather than intermediately from positron emitters. The formation of the isotopes is brought about by the boiling off of charged particles and neutrons. In order to obtain the isotopes in the lower part of the table, charged particles other than protons must be emitted.

Finally, it is of interest that for pairs of isobars, those of odd atomic number possess the greater yield.

A more detailed account of the activities which were identified will be found in the Chemistry Division's Quarterly Report, October 1, 1948, UCRL-172.

<u>Kinetics Studies in Photosynthesis. J. Weigl.</u>

The basic reaction of the synthesis of inorganic compounds to organic matter is:

$$6H_2O + 6CO_2 + (100 \text{ kg-cal. per mole of } CO_2) = C_6H_{12}O_6 + 6O_2$$

When this reaction goes toward the right, and the energy which is required is furnished by light from the visible spectrum, the process is known as photosynthesis. When the reaction is reversed, that is, when energy is given off, it is known as respiration. Thus photosynthesis is the means by which plants are able to capture the sun's radiant energy and preserve it as the binding energy of glucose or grape sugar. When heat is needed to carry on the functions of life, the glucose is burned in the plant, that is, the above reaction is reversed. It is a remarkable fact that photosynthesis and respiration occur simultaneously in the same plant and in some cases even in the same cell. The present investigation has for its aim the quantitative determination of the rates of synthesis and respiration both when the plant is exposed to light and when it functions in the dark.

This measurement of the rate of photosynthesis was carried out by placing barley leaves in a closed system which was initially filled with an atmosphere of CO_2 containing some radioactive carbon C^{14}. Thus, the loss of free C^*O_2 in unit time is equal to the relative amount of C^*O_2 which is absorbed in photosynthesis. The increase in the amount of free CO_2 is equal to the difference between the amount given off in respiration and the amount absorbed in photosynthesis. From the reaction equation it can be seen that the rate at which CO_2 is absorbed in photosynthesis, is equal to the rate at which oxygen gas is given off. In a very simple analysis then, the following equations describe the process:

$$\frac{d}{dt}(CO_2) = R - PS = -\frac{d}{dt}(O_2)$$

$$\frac{d}{dt}(C^*O_2) = -PS\left(\frac{C^*O_2}{CO_2}\right)$$

Respiration of labeled C^*O_2 is not taken into account because it is negligible in the time interval during which the experiment is run.

Fig. 1 shows a schematic diagram of the apparatus. A is the container for the barley leaves. B is a pump which delivers 500 cc/min. by periodically squeezing the rubber tubing which transports the gas. C is a CO_2 analyzer which utilizes the fact that the absorption of light in a gas is a function of the concentration. D is a conventional ionization chamber which measures the concentration of C^*O_2 as a function of the radiation which is counted. E is an instrument which determines the concentration of O_2 by making use of the paramagnetic properties of the gas.

Since C and E are novel pieces of apparatus they will be described more in detail. Fig. 2 illustrates the functioning of the CO_2 analyzer. Light from 1. is interrupted with great frequency by the rotating shutter wheel 2. and then passes through tubes 3. and 5. into tubes 4. and 6. 3. is connected to the flow of gas whose concentration of CO_2 is to be measured. The absorption of light in 3. varies with and is therefore a measure of the concentration of CO_2. The periodicity of the light which enters the closed tube 4. results in a periodic expansion and contraction of the gas contained in it. The amplitudes of these sound waves vary with the intensity of the light which enters the tube and this in turn varies with the concentration of CO_2 in tube 3. The sound waves produced in 4. are picked up by a microphone which transmits the signals for suitable recording. Tube 5. contains a known concentration of CO_2. The function of 5 and 6 is to provide a zero point for the measurement.

The O_2 analyzer is shown in Fig. 3. A pair of dumbbells is suspended on a quartz fiber. A magnetic field is applied with the result that the dumbbells rotate, and exert a couple on the fiber. The beam of light which is reflected by a little mirror attached to the fiber is deflected until the torsion in the fiber balances the couple produced by the magnetic field. Since O_2 is a paramagnetic substance, the magnetic field strength varies with the concentration of O_2, and therefore the deflection of the beam of light varies with the concentration.

The experiment was started with the lights turned off. After about twenty minutes, the lights were turned on. After photosynthesis had proceeded for about thirty minutes, the lights were again shut off. The results are set down in Fig. 4 in terms of the time-wise variation of the partial pressure of the total amount of CO_2 in mm of Hg, the time-wise variation of radioactivity, and the specific activity which is a measure of the fraction of radioactive C^*O_2.

During the initial period of darkness, it is seen that the amount of CO_2 increases because of respiration. However, the radioactivity remains constant since the barley leaves contain no radioactive carbon and therefore do not respire any. This fact is demonstrated clearly by the decrease during this time in the specific activity. When the lights are turned on at twenty minutes, after the plants have adjusted themselves to the new condition, photosynthesis takes place. There is a violent decrease in both the total amount of CO_2 as well as in the amount of radioactive C^*O_2. This result was of course expected. The behavior, however, of the specific activity curve is remarkable. During the period of photosynthesis, the specific activity increases sharply, that is, the relative amount of free C^*O_2 increases. The interpretation of this phenomenon is that the plants are able to distinguish between light and heavy carbon and that they exercise a preference for ordinary CO_2. The mechanism by which the plants reject heavy carbon is at present unknown.

After photosynthesis has gone on for about twenty minutes, a steady state is reached in which the rate of synthesis equals the rate of respiration. After this state had been established, the lights were again turned off.

It is seen that the plants respire ordinary CO_2 at a greater rate than radioactive C^*O_2. The specific activity decreases somewhat. At intervals, the lights are turned on and off. The curves show a uniform repetition.

The details of the selective synthesis of light CO_2 in preference to tracer C^*O_2 are presented in An Isotope Effect in Photosynthesis, UCRL 228, by J. W. Weigl and M. Calvin.

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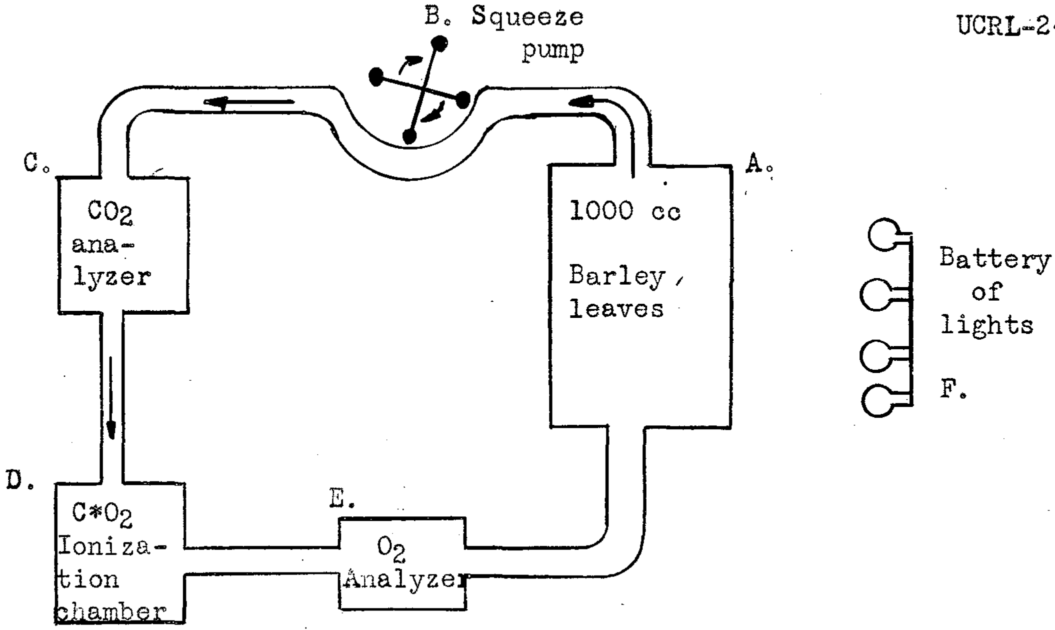

Fig. 1

Apparatus for Kinetics Studies in Photosynthesis

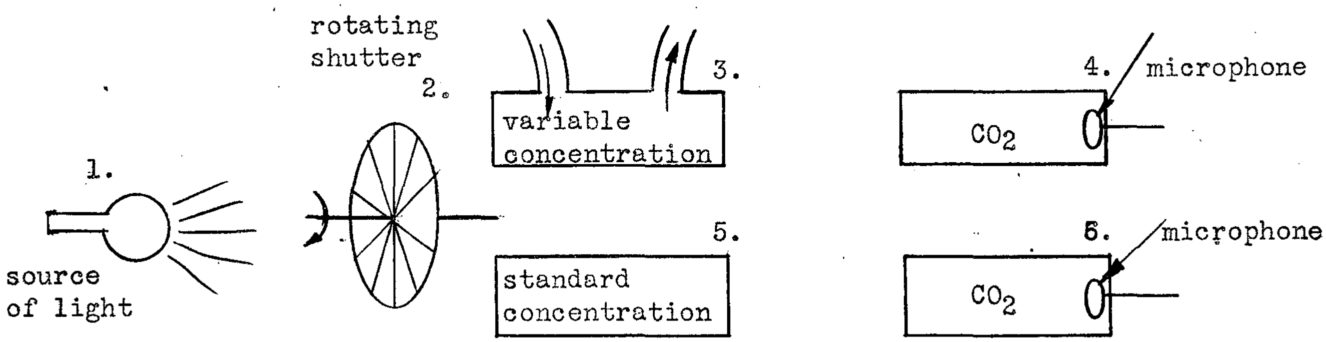

Fig. 2

The CO_2 Analyzer

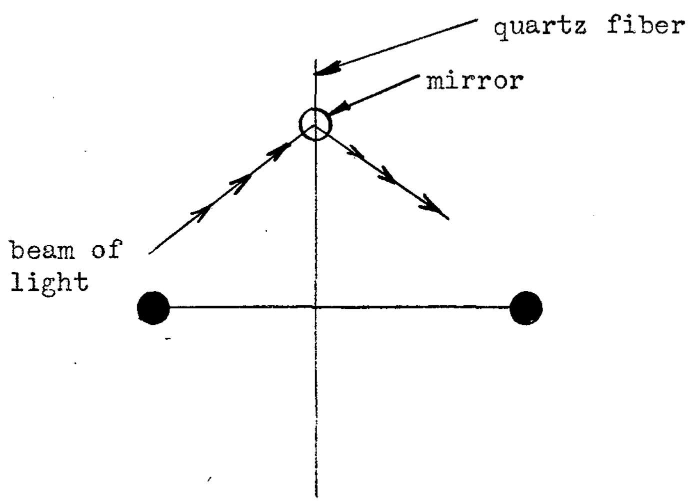

Fig. 3

The Magnetic O_2 Analyzer

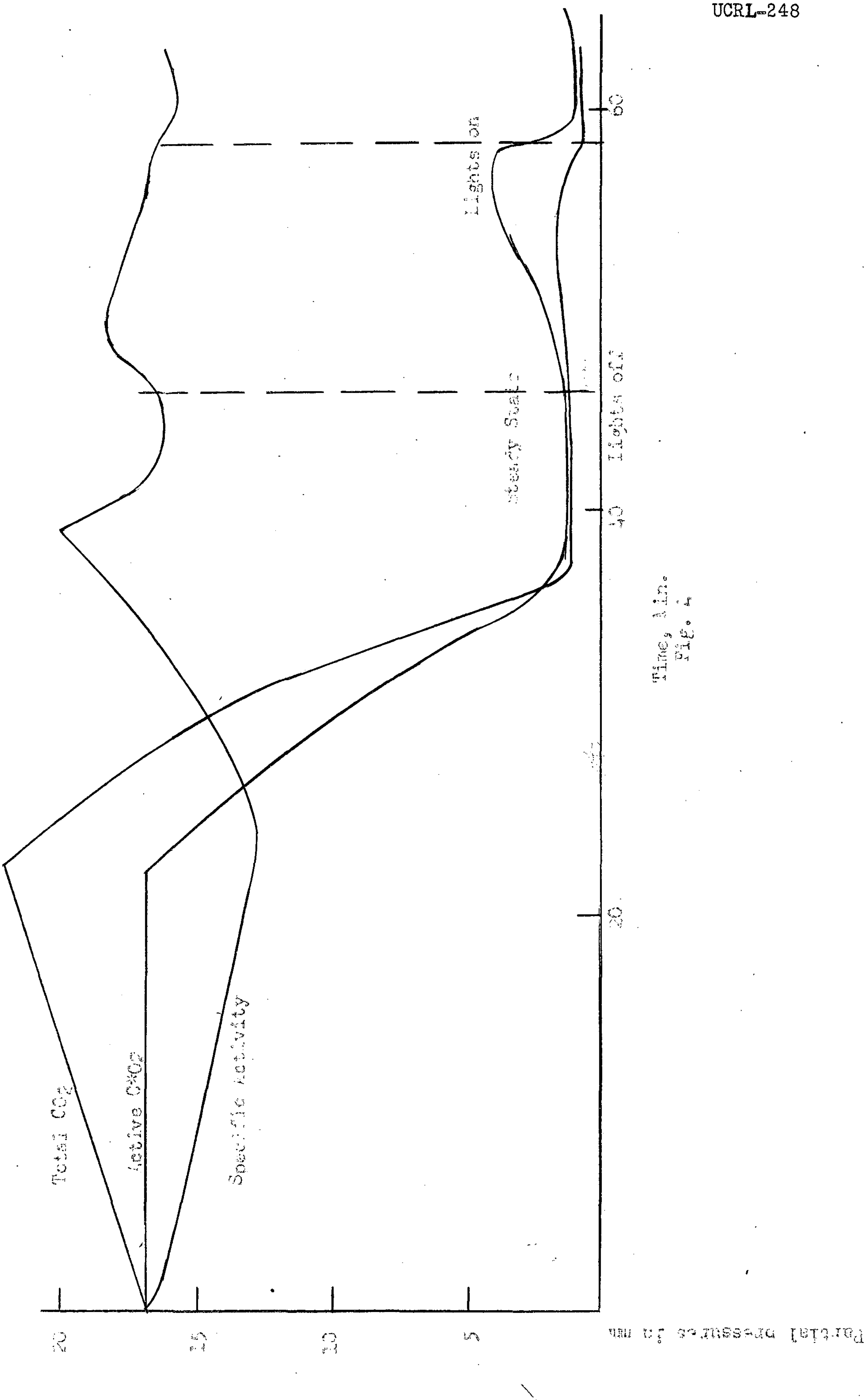
Total CO2
Active CO2
Specific Activity
Steady State
Lights off
Lights on
20
40
60
Time, Min.
Partial pressure in mm
20
15
10
5

Fig. 4

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