UCRL-1391
C.2
UNCLASSIFIED

UNIVERSITY OF CALIFORNIA — BERKELEY

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

RADIATION LABORATORY

UCRL-1391
C.2

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UCRL-1391
Unclassified Instrumentation

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

INVESTIGATIONS WITH A DEVICE FOR THE PROMPT DETECTION OF RADIOACTIVE AEROSOLS

C. T. Rainey

June 8, 1951

Berkeley, California

INVESTIGATIONS WITH A DEVICE FOR THE PROMPT DETECTION OF RADIOACTIVE AEROSOLS

C. T. Rainey

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

June 8, 1951

ABSTRACT

A device for the prompt detection of radioactive aerosols is described. It consists of two detectors -- one measuring the activity of suspect air, the other measuring air known to contain no activity other than that due to naturally occurring airborne radioisotopes. The difference between the two channels is recorded as a measure of contamination. Alpha emitters were used in the investigation but the equipment may be converted to measure beta. The fact that contamination may be expected to occur in bursts makes possible the detection of levels below the average concentration considered permissible. The equipment lends itself to the investigation of probable sources of contamination in laboratory procedures.

INVESTIGATIONS WITH A DEVICE FOR THE PROMPT DETECTION OF RADIOACTIVE AEROSOLS

C. T. Rainey

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

June 8, 1951

INTRODUCTION

The presence of short-lived alpha emitters in the air in concentrations that are many times the maximum permissible level for long-lived alpha emitters makes the problem of detecting the long-lived emitters difficult. In the past, the only workable system has been to collect air samples for long periods of time and then allow for the decay of short-lived emitters. This system has three serious drawbacks. First, the presence of any contamination is not known for at least one day. Second, the time of occurrence is not known. Third, it is not known whether the contamination was a burst of high concentration or a long lasting condition of low concentration. These three factors make this system ineffectual as a means of preventing further contamination.

At the University of California Radiation Laboratory all active work is done in gloved boxes, as shown in Figure 1. The box is maintained at slightly negative pressure. The incoming air is filtered by a PF105 glass filter and all air leaving the box is filtered by a train of high efficiency filters. In many cases the level of activity handled is above 10^{10} counts per minute of alpha. If the filter system fails or if a sample is spilled when being removed from the box a serious hazard will exist. The number of times that such a level of activity is routinely handled in this manner makes the need for a prompt air contamination detector urgent (Figure 2).

If we assume that the level of activity due to natural emitters is of

the same magnitude throughout a laboratory, and that a rise in activity due to contamination might be expected to occur in bursts of high concentration following particular operations, the following solution to the detection problem is suggested. Sample the air from two locations, one known to be uncontaminated (incoming ventilation system), the other suspected of being contaminated (the active work area), and count each sample. The difference in count rate will be a measure of the contamination. The obvious limitation is that to have a significant difference, the contamination would have to be of great magnitude. However, if our assumptions are correct, this limitation would be minimized. The experiments described below demonstrate the validity of our assumptions and have led to the development of a means of rapidly detecting air contamination.

EXPERIMENTAL BACKGROUND

1. Two cylindrical air proportional alpha counters were installed in the cave room at the University of California Radiation Laboratory. The walls of the cylinders were heated which caused air to be drawn through each counter. The following observations were made:

A. The activity measured by each counter was of the same order of magnitude in various parts of the room.

B. When one probe was placed immediately in front of the cave wall and the other was placed in the stream of incoming room air, a rise in activity was detected near the cave. Investigation with a smoke gun revealed a small eddy current sweeping over the chemistry area in the cave and back into the room. When this ventilation defect was corrected, the activity detected became the same on each channel.

C. Inherent noise in an air proportional counter raised the background to a point where only extremely high levels were detectable.

D. The sampler did not collect a sample but only counted the air passing through the chamber. Therefore, when a rise was detected, there was no way to recount the sample at a later time. Therefore, it was not possible to discriminate between noise and activity.

Because of the above difficulties, the equipment was discarded in favor of a low background scintillation counter and a moving filter paper.

2. Routine air monitoring procedures had revealed that contamination of the room air had occurred following the sparking of alpha emitters in the spectrographic laboratory. By means of a moving filter paper and a low background scintillation counter the room air was sampled during the operation. The results are shown in Figure 3. Before further work was accomplished, the arc-spark chamber gloved box was replaced by a new assembly. Investigations after the new box was installed revealed no further contamination of the room air.

EQUIPMENT

An experimental unit of the two-channel system described above has been constructed. It consisted of a paper drive assembly pulling a strip of Hollingsworth and Vose #H-70 paper across two air streams and then under two #5819 photomultiplier tubes coated with silver-activated zinc sulfide. The photomultipliers drive two scalers as well as an Esterline Angus chart recorder indicating individual pulses. Thus we have an integrated reading as well as an indication of the time occurrence of activity. The air mover

is a Filter Queen vacuum cleaner with a rheostat for controlling the air flow. The paper moves continuously over two 1-1/4 in. x 1-1/4 in. collection areas at a speed of 1/8 in. per minute. The counting area is of the same dimensions and is situated as close as possible to the collection area (approximately 1-1/4 in.). This yields a collection time and a counting time of ten minutes with about a ten minute delay before detection. The paper may be rerun through the counter if a decay plot of the filter paper is desired.

Consideration of the system yields the following observations:

1. If the activity collected by each channel is of the same order of magnitude, the counts detected will vary according to a random distribution curve.

2. If the suspect air contains contamination in addition to natural activity, the difference between the activities will indicate the magnitude of contamination. In order to be significant, this difference must be greater than the variation that might be suspected from random fluctuations.

3. To be significant, any difference in activity must be indicated by the chart recorder for at least twenty minutes which is the time required for the sample to move across the counting area.

4. A burst of activity will be indicated by the activity rising to a maximum and falling to background in twenty minutes.

5. A long lasting uniform contamination will be indicated by a flattened peak on the count rate versus time curve.

6. For bursts, the maximum count rate is a direct indication of the concentration of contamination.

7. If the activity collected is on a single particle, the count rate will be high for 10 minutes with a very sharp rise and fall.

8. The sample may be recounted if a reading is questioned or if a decay curve is desired.

9. The ultimate sensitivity will depend upon the level of activity on each channel due to radon and thoron daughters.

EXPERIMENTS

The sequence of the following experiments was designed to provide a semi-quantitative evaluation of the two-channel system. A more extensive investigation will be undertaken following the assembly of improved equipment.

Procedure Using the two-channel system, air was sampled from various locations within a glove box enclosure and in the room. Operations in the box were logged and were correlated to the chart recording of activity. The sourse of radioactive aerosol was contamination of the inside of the box as well as an aerosol generated by sparking microgram quantities of plutonium. The complete operation of the spark-arc gloved box is described in UCRL-1138. During all experiments the air in the laboratory was sampled by routine air monitoring procedures. In no case was contamination of room air detectable.

Experiment 1: The immediate detection of air contamination within a box. (Figure 4)

	Sample 1	Sample 2
Location:	Box air	Room air
Flow Rate:	3000 cc/minute	3700 cc/minute. Difference due to negative pressure of box.
Aerosol:	Three Pu samples: 70, 100, and 120 micrograms plus blank.	
Operations:	Introduce samples, evaporate on electrodes. Open chamber, spark sample.	
Results:	1. Peak due to manipulations and evaporation. Maximum of 170 c/m detected 20 minutes after starting operations. Activity was high for 25 minutes with uniform rise and fall. Flat-topped for five minutes. 2. Activity between 1 and 2 counts/minute for 3-1/2 hours between operations. 3. Peak due to sparking. Maximum of 14 c/m detected. 24 minutes wide.	Activity remained between 2 and 4 c/m throughout period.

Experiment 2: (Figure 5) Difference in activity in the two units of gloved box installation. Closer identification of peaks. Activity due to chemistry procedures.

	Sample 1	Sample 2
Location:	Spark chamber box	Chemistry box directly over sample preparation area. Through sampling funnel.
Flow Rate:	3700 cc/minute	3000 cc/minute
Aerosol:	Four Pu Samples: 90.0, 92.5, 125, 15 micrograms plus blank	Same.
Operations:	Opening chamber Sparking Glove manipulations	Pipetting Evaporating Glove manipulations
Results:	1. Peak 18 minutes after starting to work in box. Max. 100 c/m detected. Dropped to background of approximately 2 c/m after 35 minutes. Was working in box about 12 minutes.	1. Peak of 125 c/m at same time. Dropped to background of about 1.5 c/m.
	2. Remained at approximately 2 c/m while #2 went through peaks.	2. Peaks following pipetting and evaporating. Each peak was of the order of from 6 to 15 c/m detected, and was well defined on chart.
	3. Opened chamber, cleaned windows and sparked samples. Activity rose and was too high for pen recorder. Average count rate was 30 c/m for 18 minutes	3. Removed funnel and sampled spark chamber box Same peak as Sample 1. Average count rate was 60 c/m.

Experiment 3: (Figure 6) Difference in activity in the two units of gloved box installations. Sparking operations.

	Sample 1	Sample 2
Location:	Spark Chamber Box	Chemistry box
Flow Rate:	7000 cc/minute	7000 cc/minute
Aerosol:	Four samples of Pu: approximately 100 micrograms plus blank	Same
Operations:	Sparking of samples. Flushing chamber for varying lengths of time. Glove manipulations	Same
Results:	1. Peak due to setting up equipment. Approximately 150 c/m max.	1. Peak due to setting up equipment. Approximately 40 c/m max.
	2. Peaks after opening chamber and sparking. Flushing chamber after sparking lowered the peak by factor of 30.	2. Peaks detected at same time were always consistently lower.
	3. No peak detected after sparking without opening chamber.	3. Same
	4. Glove manipulations for one minute gave large peak.	4. Same but lower.

Experiment 4: (Figure 7) Comparison between moving system and standard air monitoring procedure. Immediate counting, then recounting after decay period.

	Sample 1	Sample 2	Filter Queen 1	Filter Queen 2
Location:	Box	Room	Box	Room
Flow Rate:	3500 cc/min	3500 cc/min	3500 cc/min	4 CFM (Normal air monitoring procedure)
Aerosol:	Box contamination	Same	Same	
Operation:	Glove manipulations	Same	Same	
Results:				
1. Immediate Count	Peak of 11 c/m 20 min wide. Background approx. 1.5 c/m	No Peak. Background approx. 1.5 c/m	151 c/m	188 c/m
2. After Decay	Peak 9 c/m 20 min wide. Background approx. 0.25 c/m	No Peak. Background approx. 0.25 c/m	73 c/m	17 c/m

See graph of Experiment 4 for greater details.

NOTE: The discrepancy between counting yield of each system may be accounted for by considering the lack of a representative sample as well as difficulties in regulating air flow.

Experiment 5: To determine the degree of airborne contamination due to the air stream in the box lifting active dust off of contaminated surfaces.

Air in the box was samples by standard air monitoring procedures and the following counting results obtained:

Flow Rate:	3500 cc/minute
Total Sample:	1.26×10^6 cc
Operation:	no operations within box
Time of Run:	6 hours
Filter Paper:	H-70, 4 in. x 9 in.
Counter:	Argon filled ion chamber

Results:

	counts/minute above background
1st Count	171 c/m
16 hr. decay	16 c/m
48 hr. decay	3 c/m
64 hr. decay	0 c/m

OBSERVATIONS

In all cases, a rise of activity was readily detectable following operations in the box. This rise was detectable over the background due to radon and thoron.

It was observed that the background in the box was consistently lower than in the room. The box air is prefiltered by PF105 glass wool. Further investigations as to the effect of prefiltering air supplies might be worthwhile.

In all cases, the level of activity in the box dropped rapidly to background indicating that, even in a highly contaminated area, air contamination may be expected to occur in bursts.

It is realized that the air passing through the box will sweep away a cloud of contamination in short order. However, the flow rate (10 CFM through a box volume of 14 cubic feet) is not far different than the rate the air is changed in the vicinity of a standard hood drawing 1000 CFM. The resolving time of the moving paper system was too slow to determine fall out time of a burst of activity.

It should be noted that we did not detect any air contamination due to the air stream lifting activity off the surfaces of the box.

CONCLUSION

Preliminary experiments show that bursts of contamination of a few times background are readily detectable. Though this level is many times the maximum permissible concentrations of long-lived alpha emitters, the following point should be noted. The tolerance level is an average concentration arrived at by sampling the air for long periods of time and averaging the amount collected over the total time. Results indicate that, even in a highly contaminated area, air contamination may be the result of bursts of activity

caused by particular operations. Such bursts are detectable by this system. This puts a preventive aspect to the system and would enable one to take immediate steps to prevent further contamination. Though the work described above is with alpha contaminants, the system is adaptable to beta emitters by means of replacing the zinc sulfide screen with a suitable phosphor.

The two-channel system is not intended to be a replacement for present air monitoring practices. The large volume of air sampled by present equipment makes them indispensible for detection of low concentrations.

APPENDIX

Calculation of concentration of contamination:

$$\text{curies/cc} = \frac{\text{counts/minute}}{\text{flow rate x time x filter yield x geometry x } 2.2 \times 10^{12}}$$

Filter yield is that activity level detectable from a filtered sample. It includes filter efficiency and absorption of alpha particles. We assume a value of 75 percent. Geometry is about 25 percent.

In the case of the ion chamber used for counting 4 in. x 9 in. papers, the geometry is near 50 percent.

The expected count yield is measured at 3500 cc/minute sample rate.

Peak Count Rate	Concentration averaged over 10 minutes
0.135 c/m	1×10^{-17} curies/cc
1.35 c/m	1×10^{-16} curies/cc
13.5 c/m	1×10^{-15} curies/cc

ACKNOWLEDGMENTS

The author wishes to thank John G. Conway for his interest in the problem and for providing the use of his spectrographic arc-spark gloved box for the generation of aerosols.

BIBLIOGRAPHY

1. Carmichael and Tunnicliffe, CRTec-326, "Measurement of Alpha Active Dust in the Atmosphere".

2. "California State Industrial Safety Orders", 1949.

3. Conway, J. G. and Moore, M. F., UCRL-1138, "The Spectrographic Analysis of Radioactive Materials".

Information Division
7/17/51 nw

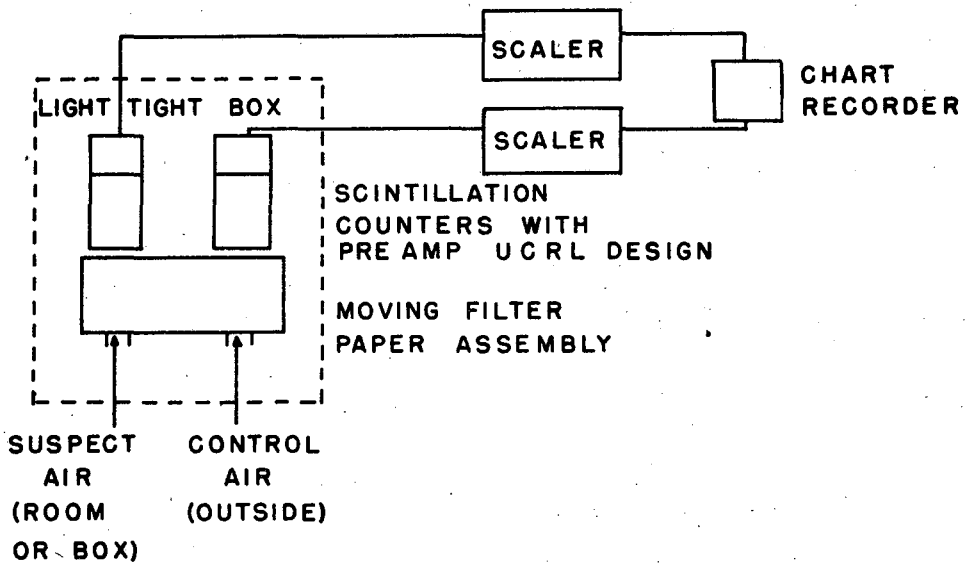

FIG. 1 AIR CONTAMINATION DETECTOR

MU 2168

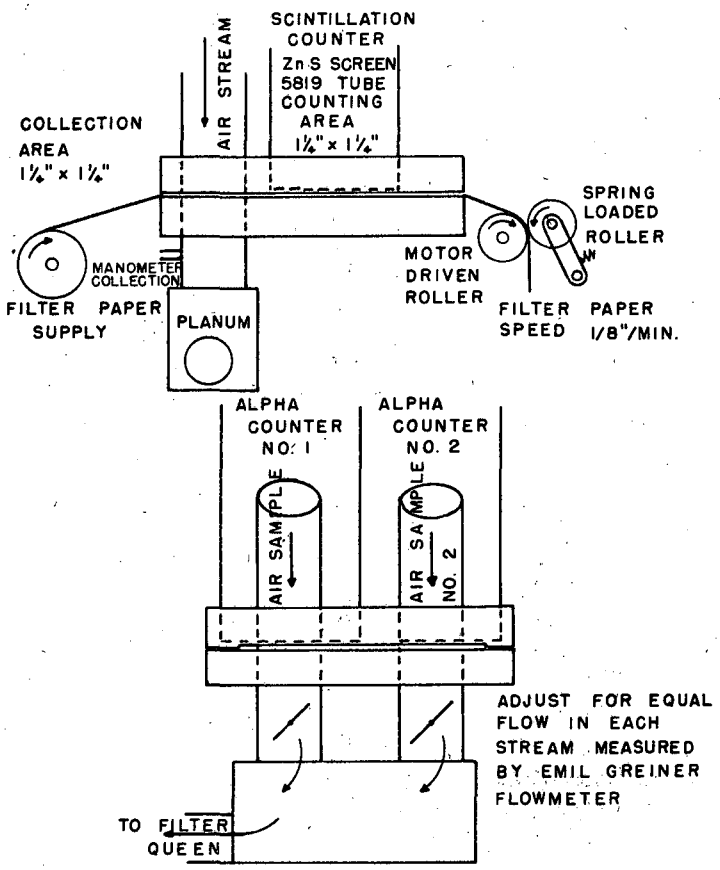

FIG. 2 ALPHA AIR CONTAMINATION DETECTOR

MU 2169

179231

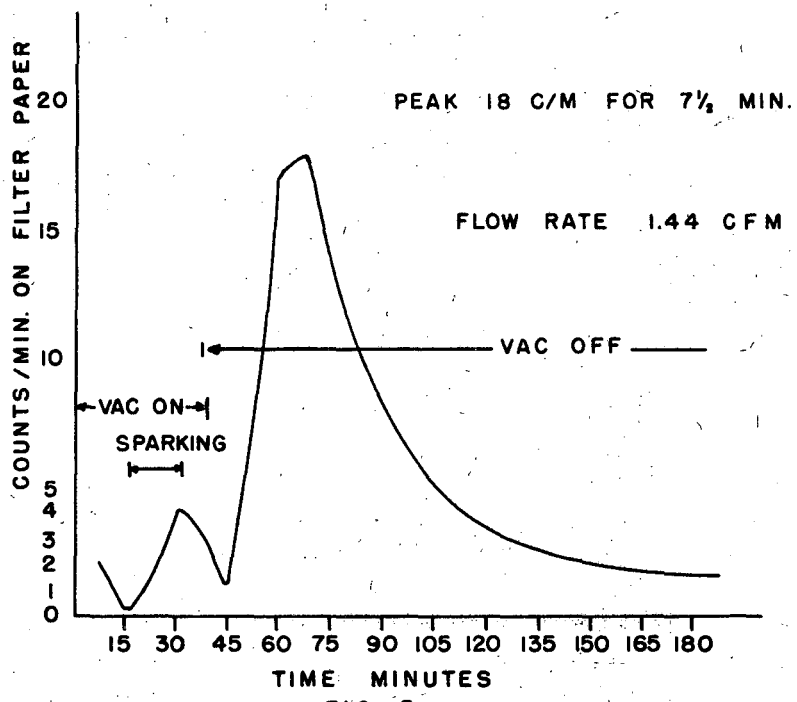
COUNTS/MIN. ON FILTER PAPER
20
15
10
5
4
3
2
1
0
PEAK 18 C/M FOR 7½ MIN.
FLOW RATE 1.44 CFM
VAC OFF
VAC ON
SPARKING
15 30 45 60 75 90 105 120 135 150 165 180
TIME MINUTES

FIG. 3

MU 2170

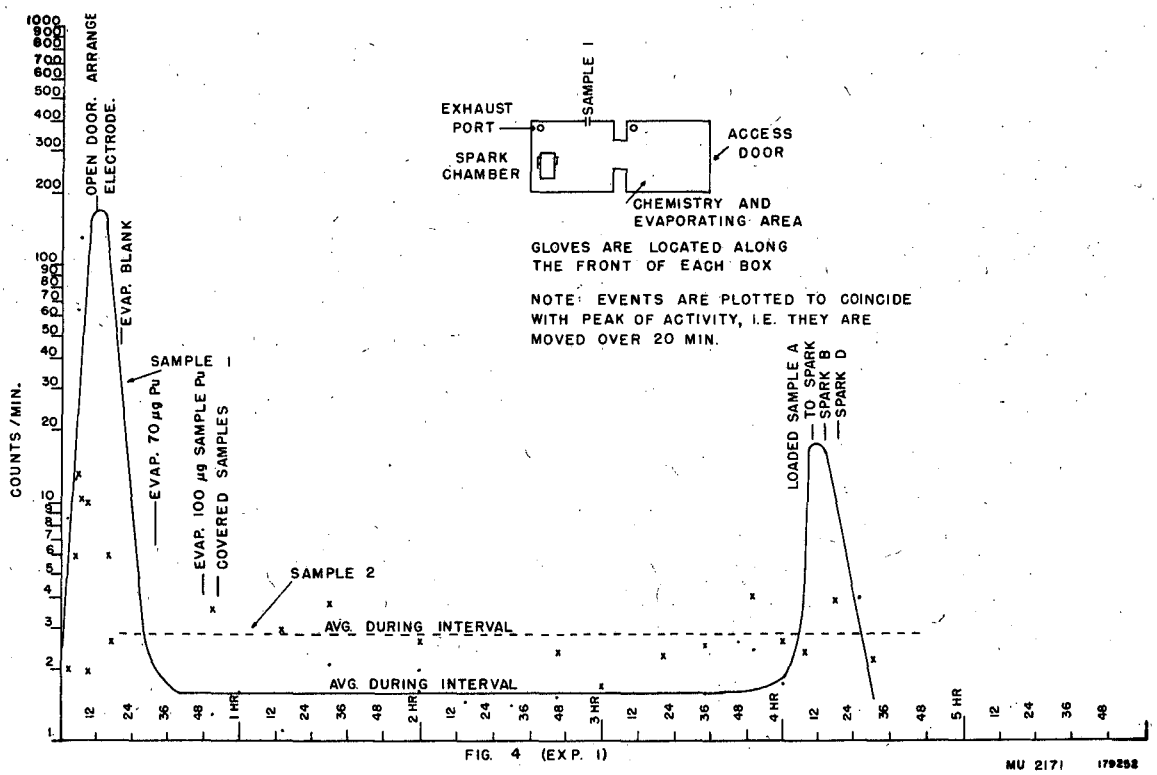

FIG. 4 (EXP. 1)

MU 2171 179258

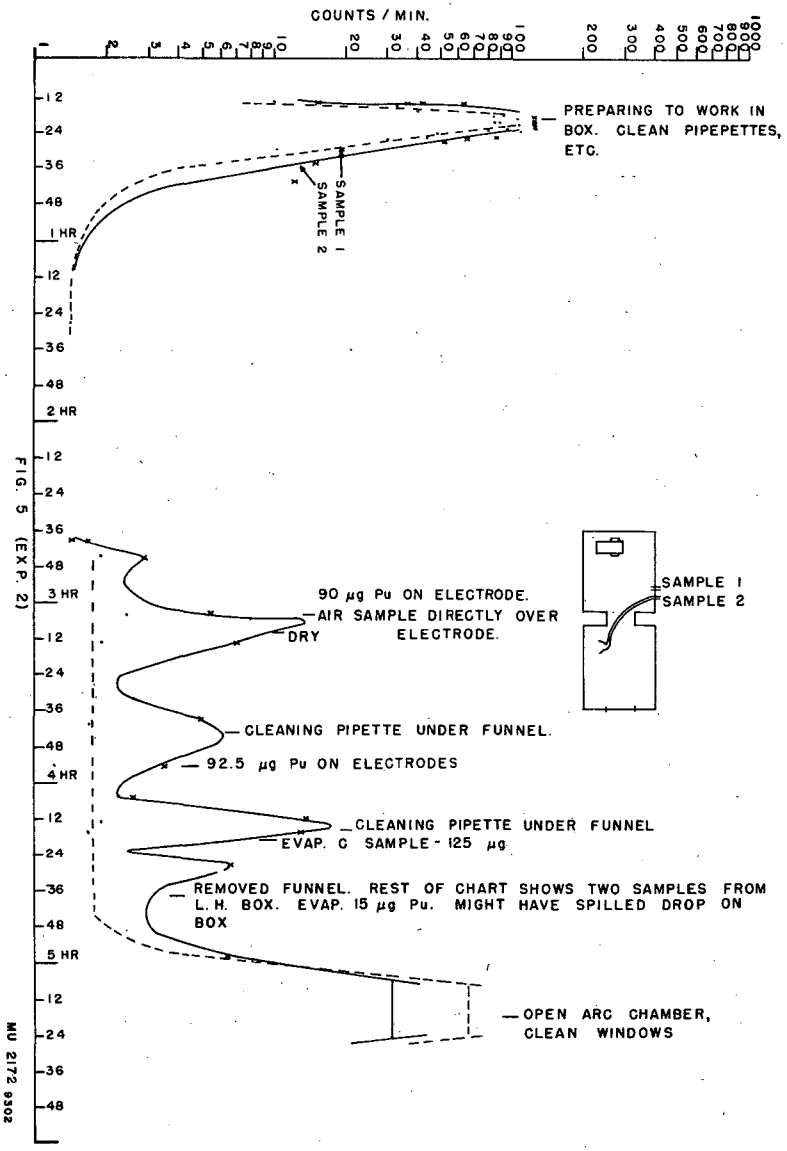

FIG. 5 (EXP. 2)

MU 2172 9302

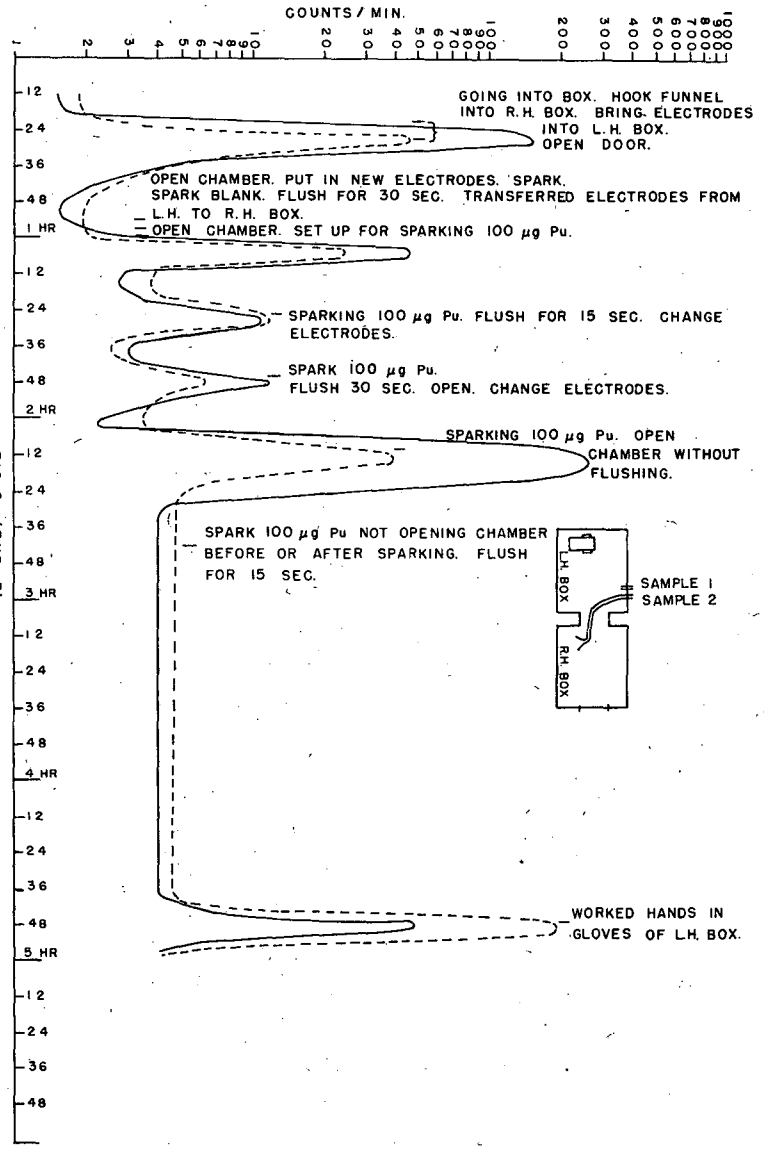

FIG. 6 (EXP. 3)

MU 2173 19312

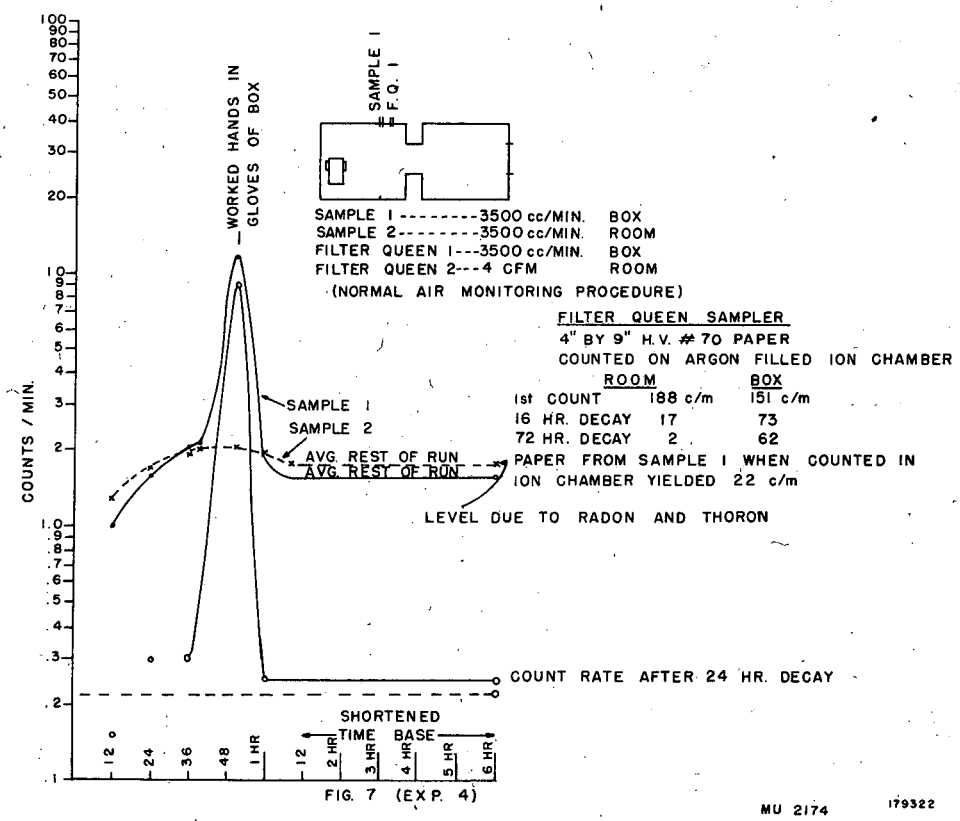

FIG. 7 (EXP. 4)

MU 2174 179322