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Y-12 CENTRAL FILES
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AIR SAMPLING FOR THE CONTROL OF INTERNAL EXPOSURE FROM ENRICHED URANIUM AT Y-12

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Plant Declassification Representative RCP

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September, 1958

ABSTRACT

This paper describes very briefly the program for determining the concentration of uranium in the air being breathed by persons working in the enriched uranium processing areas of the Y-12 Plant of Union Carbide Nuclear Company at Oak Ridge, Tennessee. The aim of the program, ways to accomplish this aim, and the methods used to process the data accumulated are mentioned. The Y-12 Plant limit for permissible concentration of air-borne uranium and its origin or derivation are given.

The sampling program and techniques are rather standard, but mention is made of three unique features; the use of a cardboard planchet to simplify handling of samples, the use of automation to expedite sample counting, and the use of several twin head sample collectors and statistical analysis to determine over-all program precision and optimum sampling frequency.

Figures illustrate air sampling and counting equipment and graphs show uranium concentrations determined by the program.

The program for monitoring the atmosphere in the enriched uranium processing areas of the Y-12 Plant of Union Carbide Nuclear Company is not unique. We use the rather standard procedure of drawing the air through a filter to collect the suspended particulate contamination and then counting the disintegrations from the radioactive material collected on the filter in a suitable counting instrument. The general philosophy or aim of the air monitoring program at Y-12 is to see that the average concentration of radioactive contaminants in the air remains within reasonable limits and is not hazardous to employees. To accomplish this aim, one must collect many samples representative of the air being breathed by the majority of the persons, but one also must monitor many individual operations which may result in localized high concentrations of air-borne uranium. It follows then that our air samples are classified as either general air, breathing zone, or operational samples. These descriptive classifications indicate that the samples were collected to determine either the average concentration of air-borne uranium in an area, the concentration in the air being breathed by a particular operator, or the amount being released to the atmosphere by a particular operation.

Figure 1 shows a typical sample head used for both portable units and permanent systems. Shown are the two-piece quick-opening paper holder, the rubber gasket, wire "spider" to support the paper, and

the 1-1/4 inch diameter sample disc of Hollingsworth and Vose No. 70 filter paper. Each of these sample heads is connected to its source of vacuum through a rotometer and valve to permit adjustment of the air flow rate.

Figure 2 shows the basic sampling equipment used in most locations at Y-12. The majority of our air samples are collected by means of permanently installed systems of several sample collection units connected by pipe manifolds to a special vacuum pump or perhaps, the house vacuum system. The primary consideration in determining the locations for these sample collection units is that the samples be representative of the average atmosphere breathed by the majority of persons in the area. Thus, they must not be biased or unduly influenced by high concentrations localized at any one operation. It can be seen that one very high activity sample averaged in with the results from many very low samples may suggest that the atmosphere being breathed by the majority of persons in a given work area is highly contaminated when such definitely is not the case. On the other hand, close scrutiny of the levels of activity shown by these individual samplers is necessary for the control of both local and average contamination levels.

Portable units similar to the one shown in Figure 2 are used for collecting breathing zone or operational samples to locate sources of air

contamination, or to evaluate new operations or the effects of operator technique, changes in equipment or ventilation, etc., on the levels of air contamination. Each unit has its own vacuum pump and air flow adjustment with the collection head mounted on a telescoping boom for versatility. These units also may be used to collect general air samples in temporary situations or where permanent systems have not been installed.

Equipment, such as the Hi-Vol sampler shown in Figure 2, is used for collecting special samples which require a large air volume in a short collection time. Several different types of filter collectors and an adaptor to permit use of an annular impactor are available to be used with this device.

One rather unique feature of our sample handling technique is the doughnut shaped cardboard planchet on which our samples are mounted for handling and counting. The planchets of 1/8 inch thick cardboard are approximately 2-5/8 inches in diameter with a 1-3/8 inch diameter hole in the center. Masking tape stuck onto one side of the planchet leaves a gummed surface exposed in the hole. The health physicist' collecting air samples carries a supply of the planchets in a special dispensing container similar to a bus driver's coin changer. Using forceps he removes the paper disc from the sampler head and places it in the planchet so that it adheres to the masking tape. Pertinent sampling and identification data can be recorded on the planchet itself.

Another unique feature of our air sampling program is the use of statistical analysis of past experience to determine the frequency with which one must sample to provide the desired reliability of results. In two areas we have installed a pair of twin sampling heads side by side. The results of the samples collected simultaneously during a quarter year by these twin heads are compared statistically to obtain a per cent limit of error for the mean concentration. Our statisticians examine the data from samples collected over an extended period and apply the limit of error suggested by the twin sample data to determine the minimum number of samples which should be collected in a given area in order that the average shown by the data may have the desired reliability.

Air samples together with printed data forms are sent to a central counting laboratory. To permit the decay of the short-lived alpha emitting daughters of radium and thorium and be sure the activity counted is that from the long-lived uranium, samples are not counted until at least 16 hours after the end of the sampling period.

Routine general air samples are counted in an automatic alpha scintillation counter. (See Figure 3.) The counter has twin scintillation detectors which permits each sample to be given two four-minute counts. The two counts and an identification number for each sample are printed on a tape. The counter usually is loaded with 125-130

samples (about an 8 hour supply). It often is loaded in the afternoon and left to count overnight. In the morning the counted samples are found stacked in the tube on the right and sample counts have been printed on the paper tape. Upwards of three hundred samples can be loaded into the sample tubes, but the weight of that many samples sometimes causes the mechanism to jam. Breathing zone, operational or other special samples are counted in Nuclear Measurements Corporation gas proportional counters.

Considerable use is made of machine computers in the calculation and tabulation of data from the large numbers of air samples collected during a week. However, the completed data cards are first sent from the counting laboratory to the Health Physics Department central office where they are screened to check any high count samples before being sent on to the tabulating machines. The concentration of uranium in d/m per cubic meter of air is calculated by hand for these high count samples and the results are reported to the health physicists and operating supervisors in the areas affected. The weekly machine tabulation lists the contamination level indicated by every sample during the week; and for the routine general air samples gives a summary which shows the average concentration for the week for each area, the number of samples included, and the per cent of the samples which indicated levels in excess of the maximum permissible concentration.

At this point let us discuss briefly the matter of maximum permissible concentration. Some years ago the limit we use for the permissible concentration of enriched uranium in air was "derived" from the preliminary limits suggested by Morgan [1] and Neuman[2] for insoluble normal uranium. By converting the suggested limit of 50 $\mu g/M^3$ $d/m/M^3$ and adjusting this for the greater energy per disintegration of the enriched uranium we arrived at a maximum permissible limit of 70 $d/m/M^3$ air. When in 1953 the National Bureau of Standards published its Handbook 52[3] suggesting a more lenient permissible limit for natural uranium, we were hesitant to adopt it or revise our limit for enriched uranium. There were several factors contributing to this hesitancy, but the main reason we did not revise our limit was the fact that at that time many of our people were working 56 hours a week rather than the usual 40. We still use the old limit, but we do not take any stringent action unless a given location consistently exceeds the MPC or the average for a whole area is too frequently close to or in excess of the MPC. When the revised version of Handbook 52 is published in the near future, we will change our plant limits to conform to the ones recommended therein. Prepublication information suggests that there will be no really drastic change from the Handbook 52 MPC for uranium in air; thus, the new limit likely will be more lenient than the one we presently use. If this is the case, we undoubtedly will have to revise our present policy and take more positive action when either localized or general concentrations approach the permissible limit.

Figures 4 through 10 illustrate some of the atmospheric uranium concentrations determined by our air sampling program.

Figure 4 shows for each of the first 11 months of fiscal 1957, the average of the concentrations indicated by some 1,950 samples per month in the entire enriched uranium processing facility. For the most part, the average concentration shown is less than our plant maximum permissible, however, the peak concentration shown for September, 1956, is less than forty per cent (40%) of the limit which may be suggested in the new Handbook 52.

Figure 5 shows the per cent of the same 1,950 samples per month which exceeded our plant maximum permissible level. This illustrates that a relatively few high samples can cause average concentrations to be rather high and suggest a possibly biased or untrue average.

Figure 6 shows the average concentration for several, but not all, of the enriched uranium processing areas during the last nine months of fiscal 1958. The graph lines near the abscissa indicate the per cent of the more or less 250 persons breathing this air whose urinalyses suggested an internal dose in excess of the maximum permissible limit. The broken line indicates the per cent of those exposed whose urinalyses exceeded our action point calling for restricting their exposure to uranium. As one might suspect, the urinalysis peaks do not quite coincide with the air peaks.

However, in Figure 7 we can see by shifting the time scale of the urinalysis curves that the urinalysis peaks really do follow the air peaks, but there is a lag of about two months before changes in average air concentration are reflected in the average internal dose picture of a large group. The main reason the urinalysis curves do not follow the air curves more completely is that these urinalysis points include the results of urine samples submitted during the previous three months and the air points are the average picture for only one month. Factors not reflected in air sampling, such as occasional use of respirators or area evacuation during high air activity releases, also tend to flatten the peaks of the urine curves and prevent their correlation with air data curves.

Figure 8 shows the monthly average air concentration in an enriched uranium machine shop. The high concentration shown for July was the result of a chip fire which caused extremely high air activity on only one day. If the results for this one day are ignored the average for July would have been only 40 disintegrations/minute/cubic meter. Even including this one day, the July average is not greatly above that which may be the new Handbook 52 limit. For the sake of comparison, the small insert graph is the urine picture for the approximately 33 persons working in the machine shop. In this case, the urine points are the monthly average as are the points on the air

curve. It can be seen that the internal dose suggested by urinalyses follows the trends of the average air activity curve quite faithfully, but the two months lag is still evident.

Figure 9 shows how the level of air activity in the same machine shop will fluctuate from day to day. The average for this month of February, 1958, was shown in Figure 8 to be 140 disintegrations/minute/cubic meter. Individual day averages vary from 24 to 419 disintegrations/minute/cubic meter. Figure 9 also illustrates the effectiveness of an active air sampling program in getting unsatisfactory conditions corrected. The peaks during the early part of the month reflect heavy work load days in a uranium rod sawing operation which was inadequately ventilated. Note that after more efficient ventilation was provided the average level for the whole shop was much more reasonable and less subject to large fluctuations.

Figure 10 compares the monthly average air activity levels in four different types of processing operations. Note that dry chemistry, reduction and casting operations seem to generate higher average concentrations of air-borne contamination than do machining and salvage or uranium recovery operations.

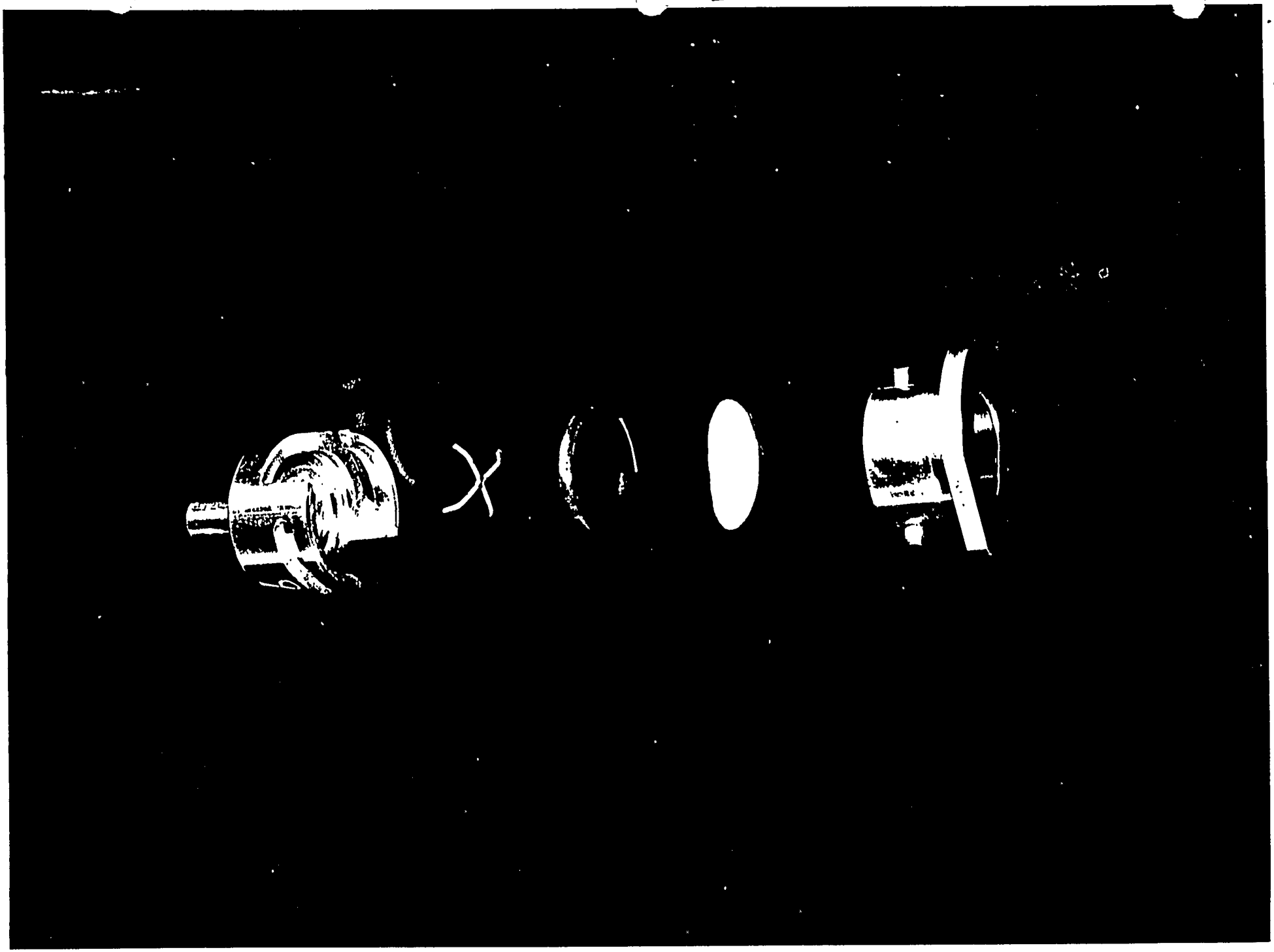
In closing, it is felt that any program short of having a full time breathing zone sampler for each employee is incomplete; however, an active, well-planned air sampling program is an invaluable tool in the control of hazards to persons working with uranium.

References

(1). K. Z. Morgan, "Tolerance Concentrations of Radioactive Substances", Journal of Physical and Colloid Chemistry", Vol. 51, No. 4, July, 1947.

(2) W. F. Neuman, in Voegtlin & Hodge, "Pharmacology & Toxicology of Uranium", Part IV, pp. 2409, McGraw-Hill Publishing Co., New York, 1951.

(3) National Bureau of Standards, Handbook 52, "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water", 1953.



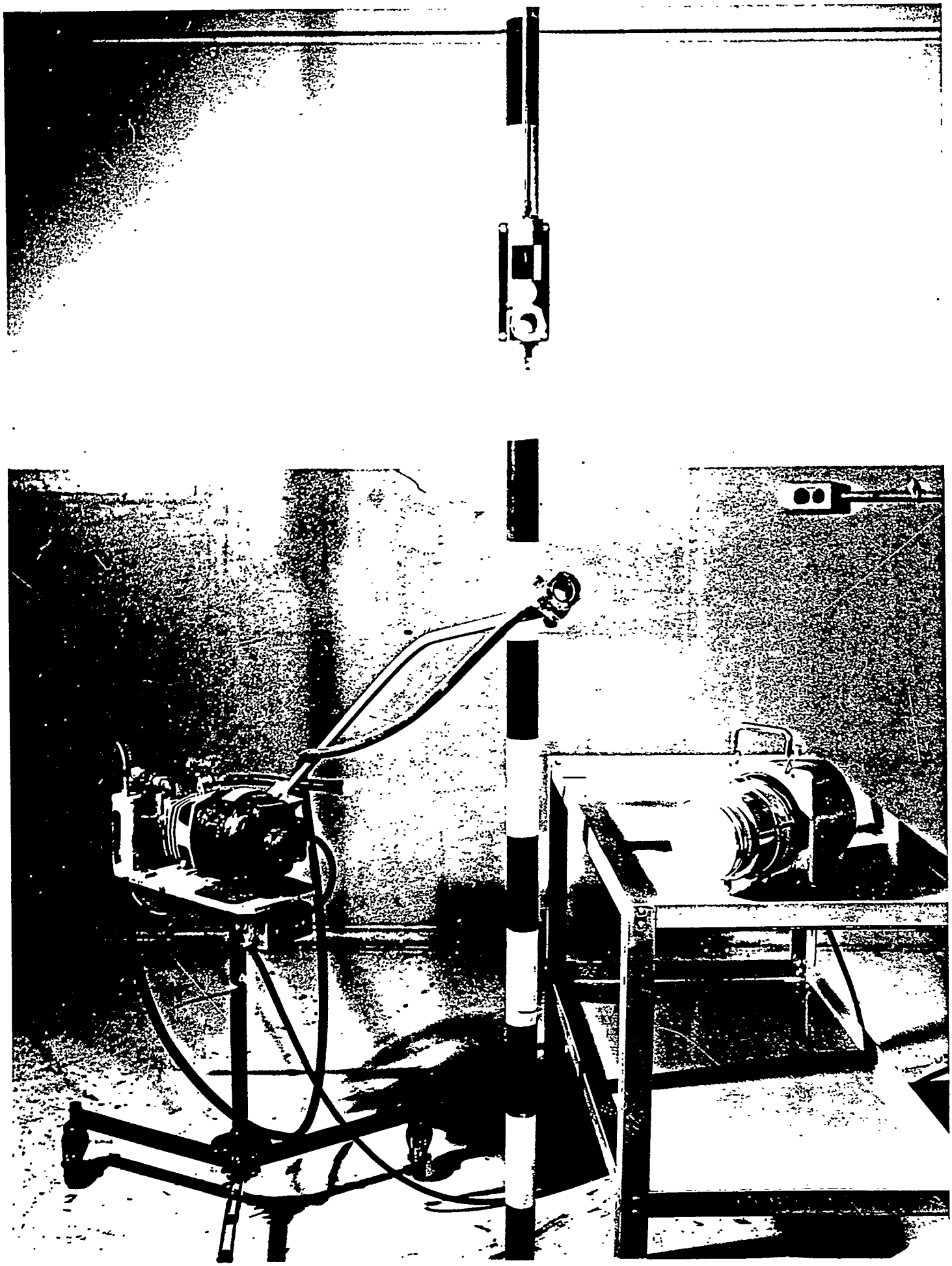


Figure 2
Air Sampling Equipment

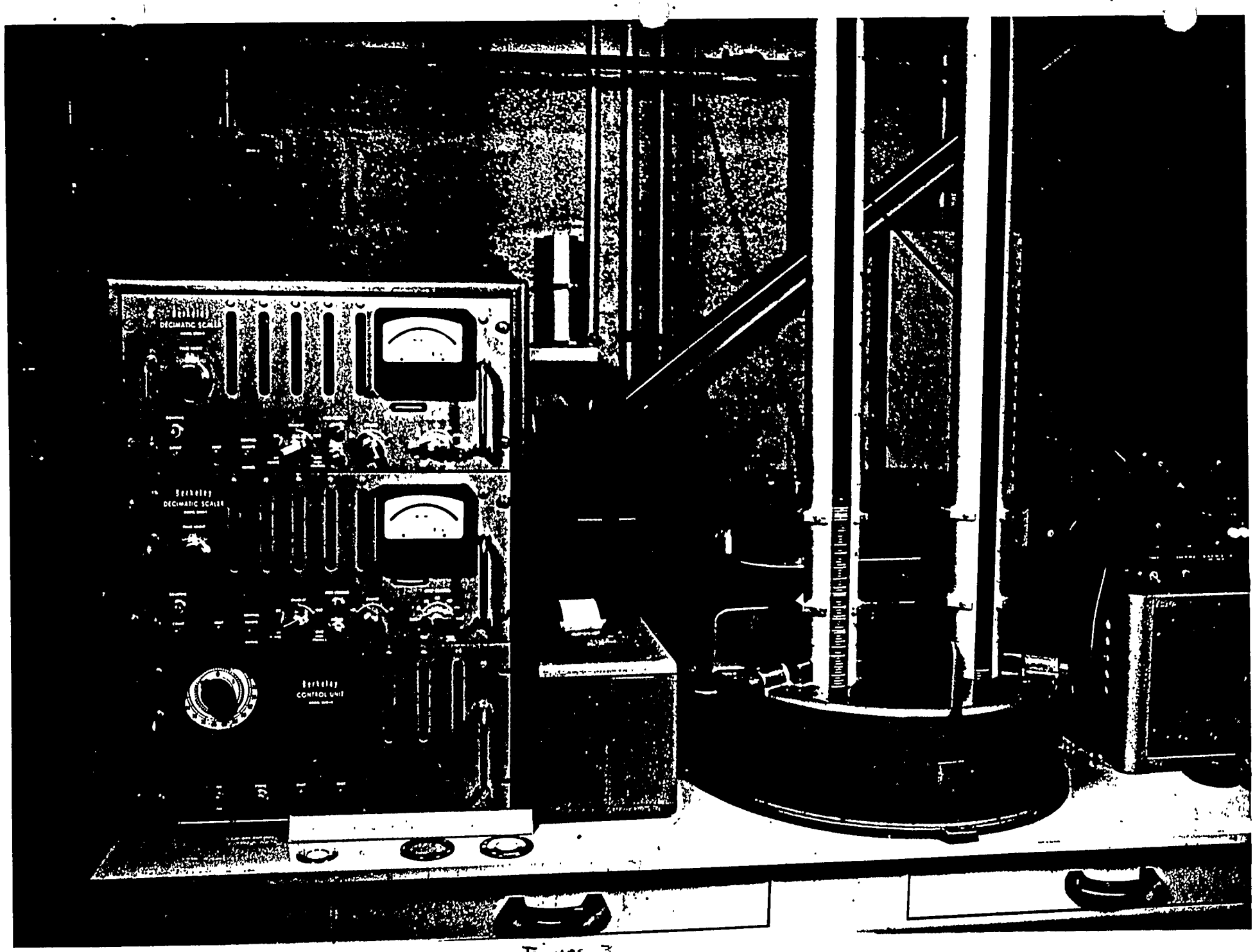


Figure 3
Automatic Air sample Scintillation Counter

GENERAL AIR SAMPLES — AVERAGE CONCENTRATION

~ 1950 SAMPLES / MONTH

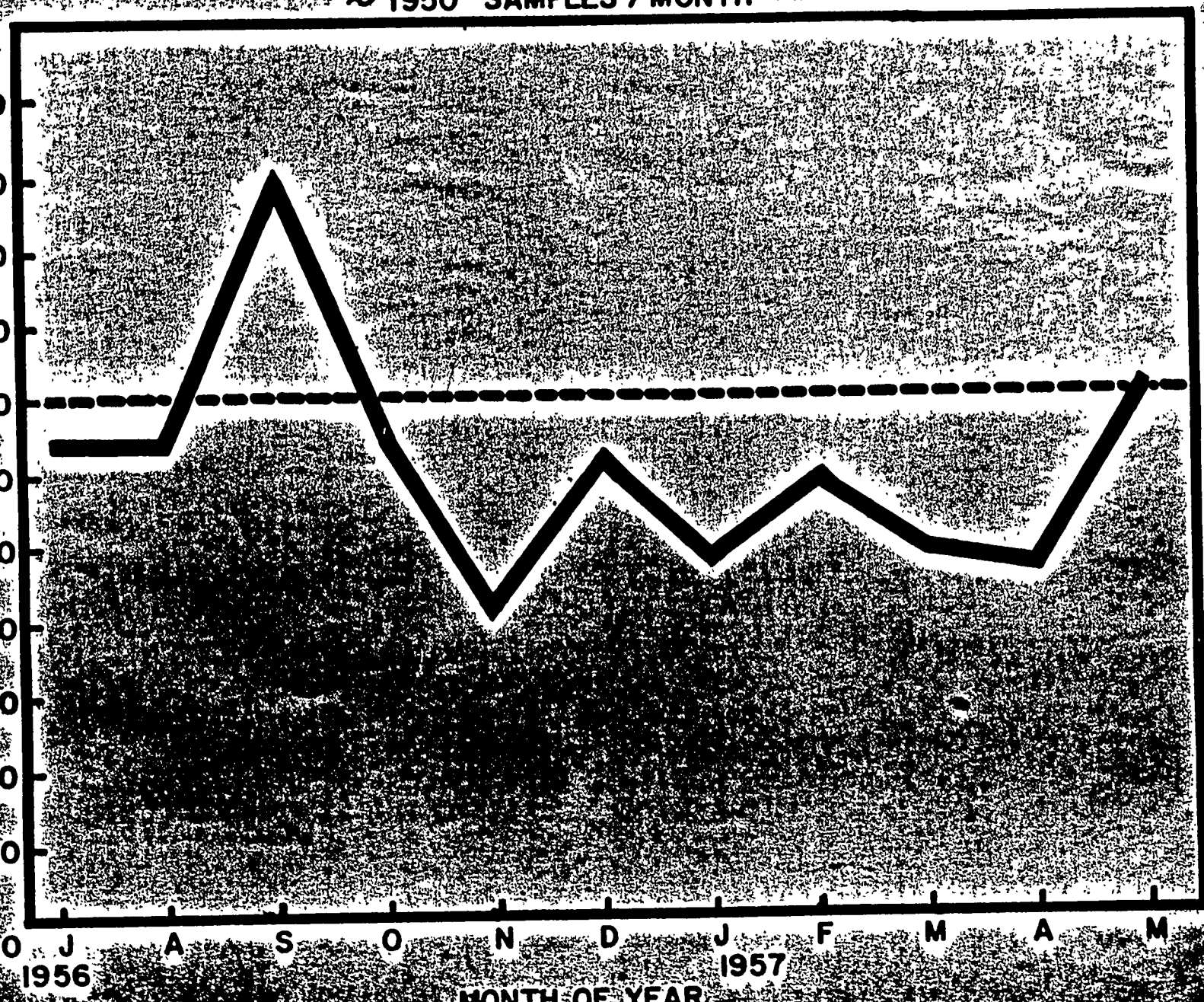


Figure 4

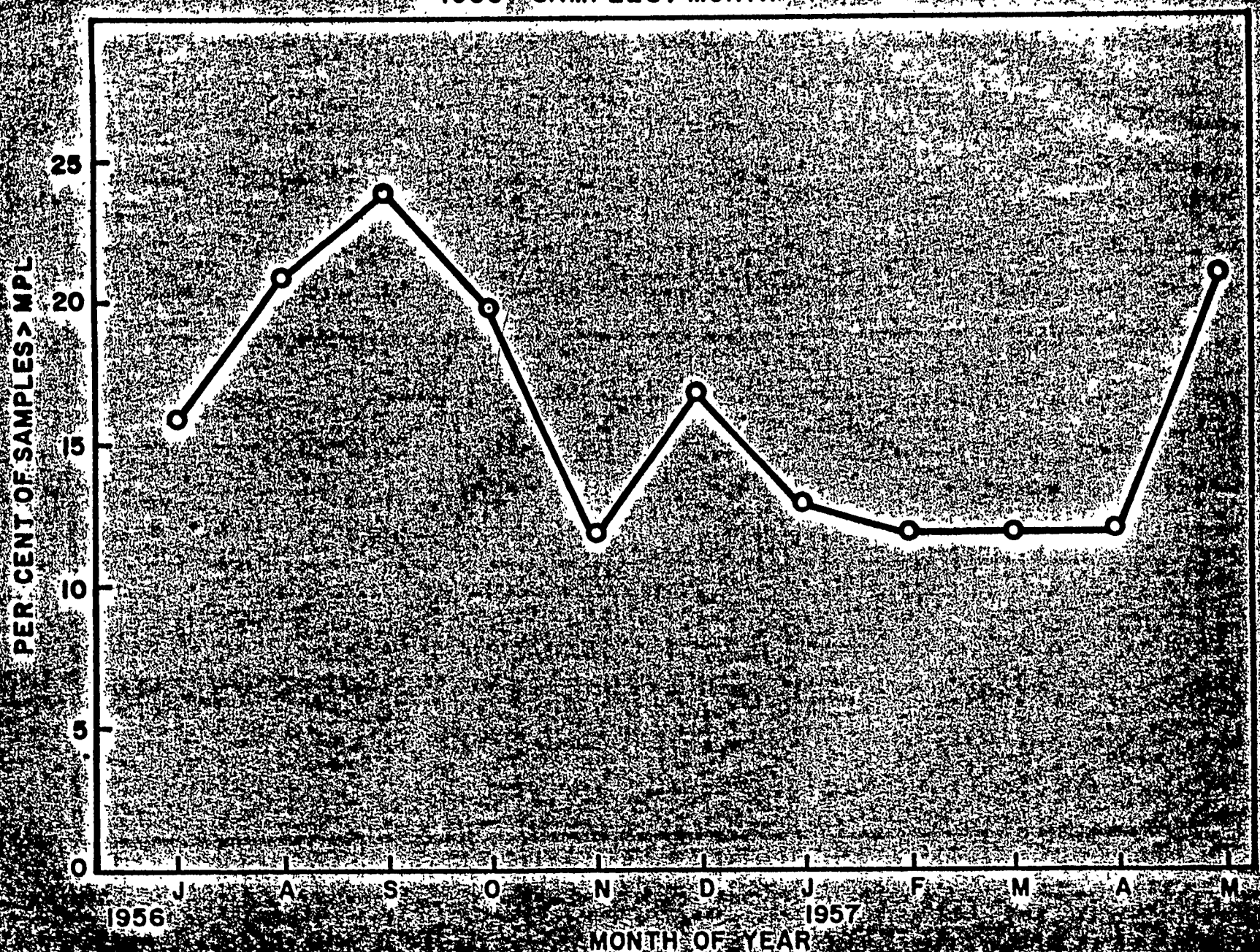

GENERAL AIR SAMPLES ~ PER CENT IN EXCESS OF THE MPL
~1950 SAMPLES / MONTH
PER CENT OF SAMPLES > MPL
25
20
15
10
5
0
J
A
S
O
N
D
J
F
M
A
M
1956
1957
MONTH OF YEAR

Figure 5

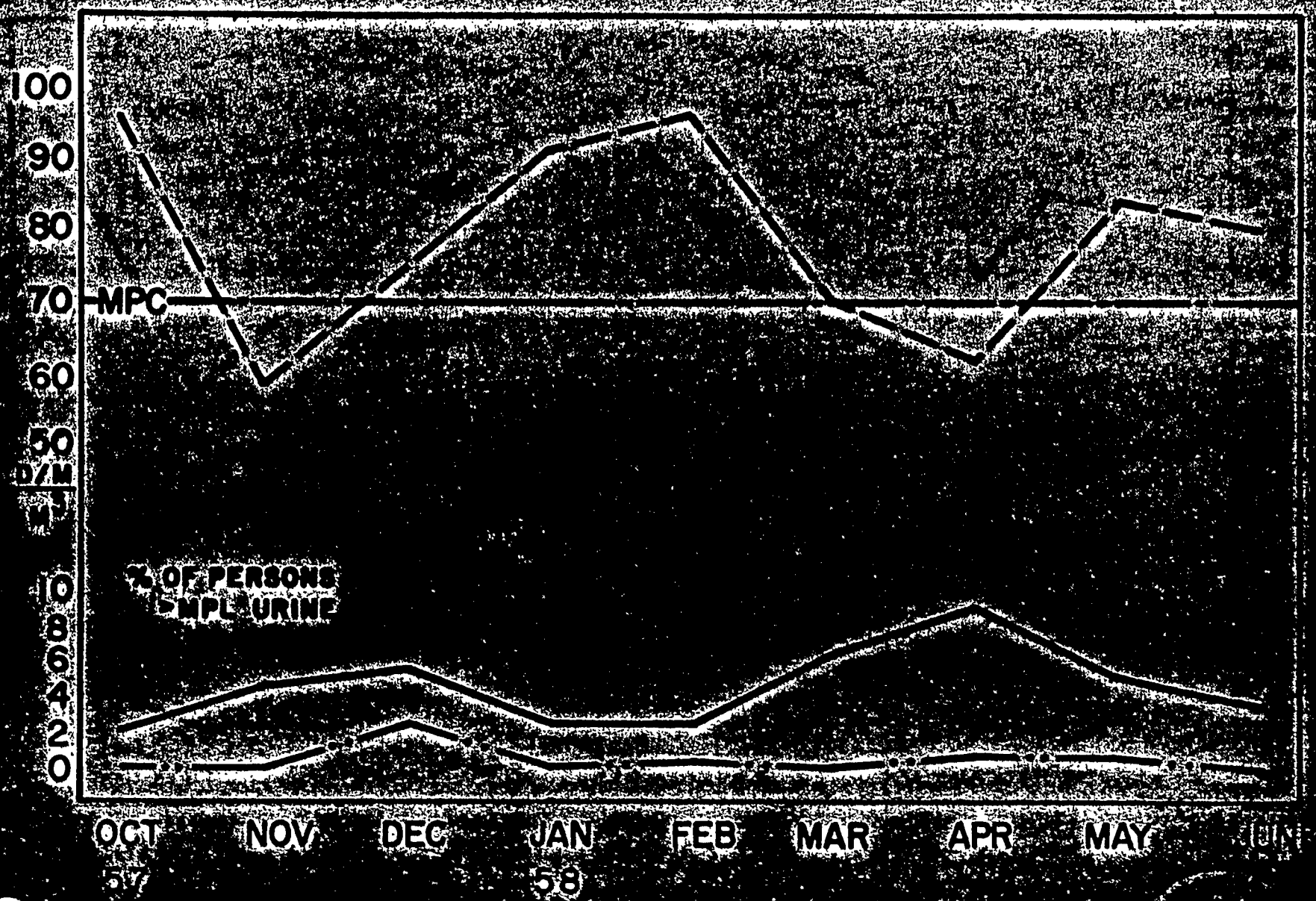

COMPARISON
AVERAGE URANIUM IN AIR
TO % PERSONS >MPL URINE
100
90
80
70
MPC
60
50
D/M
10
8
6
4
2
0
% OF PERSONS
>MPL URINE
OCT
57
NOV
DEC
JAN
58
FEB
MAR
APR
MAY
JUN

Figure 6

COMPARISON
AVERAGE URANIUM IN AIR
TO % PERSONS > MPL URINE

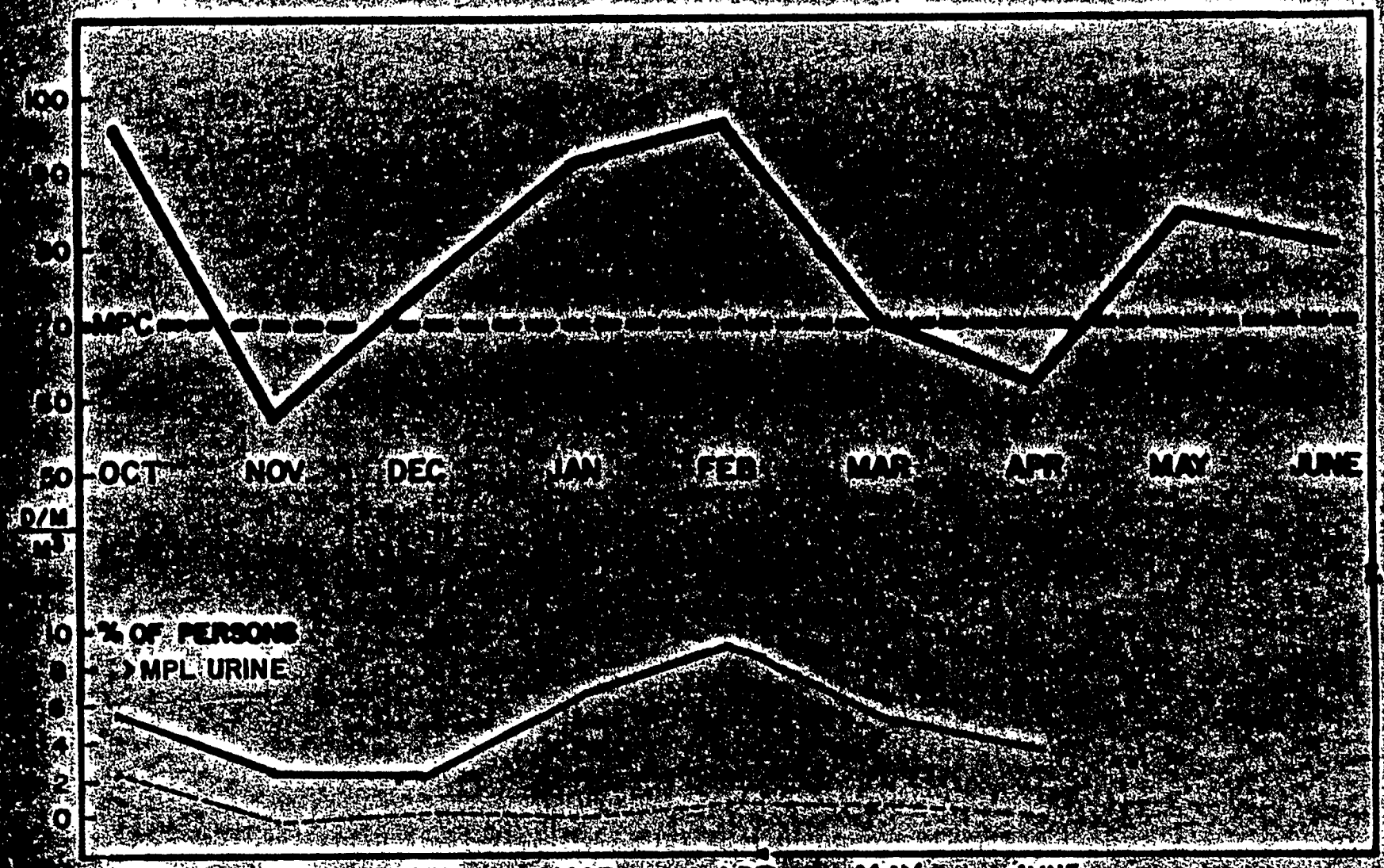


Figure 7

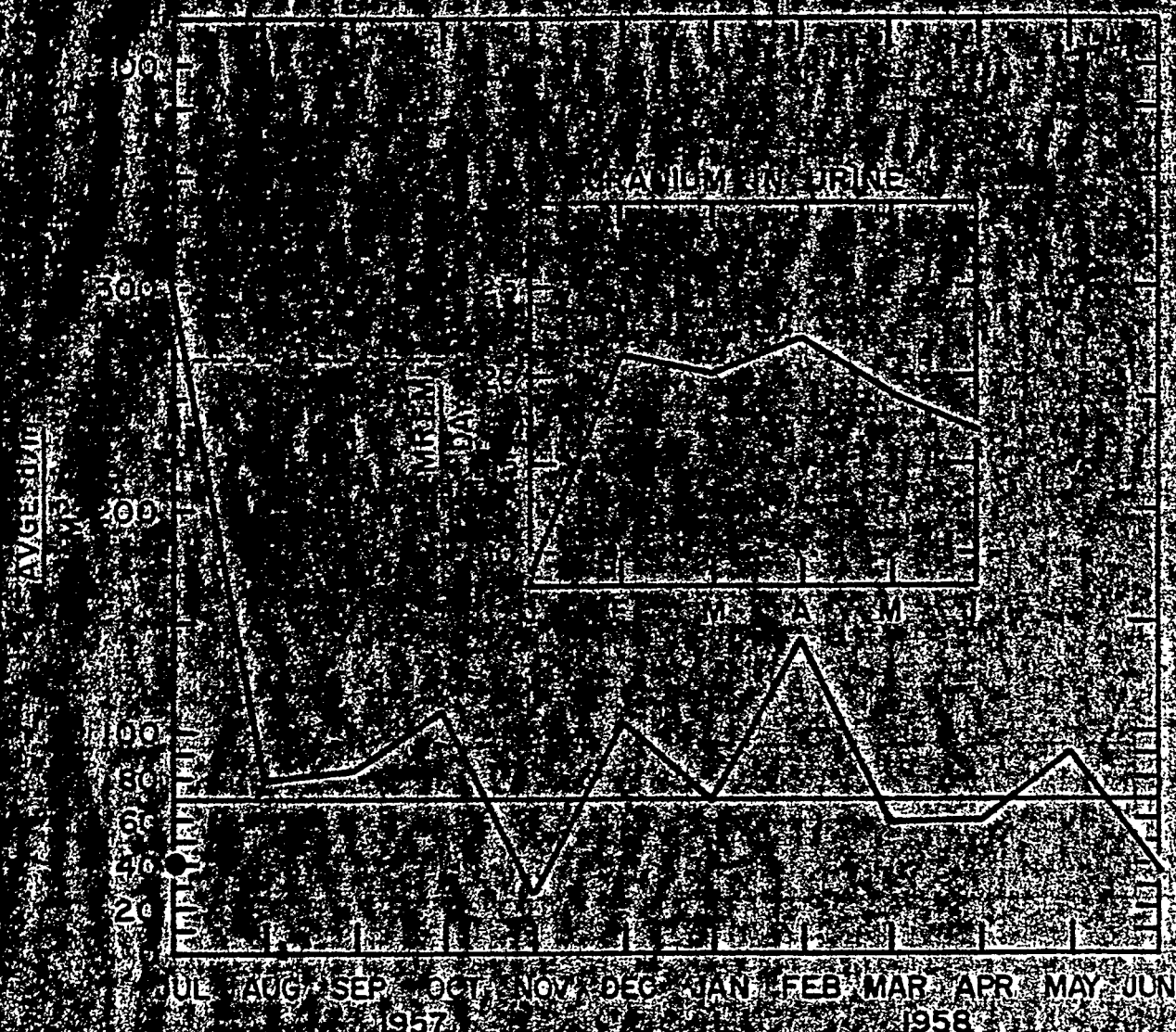


FIGURE 8 URANIUM IN AIR (MACHINE SHOP)

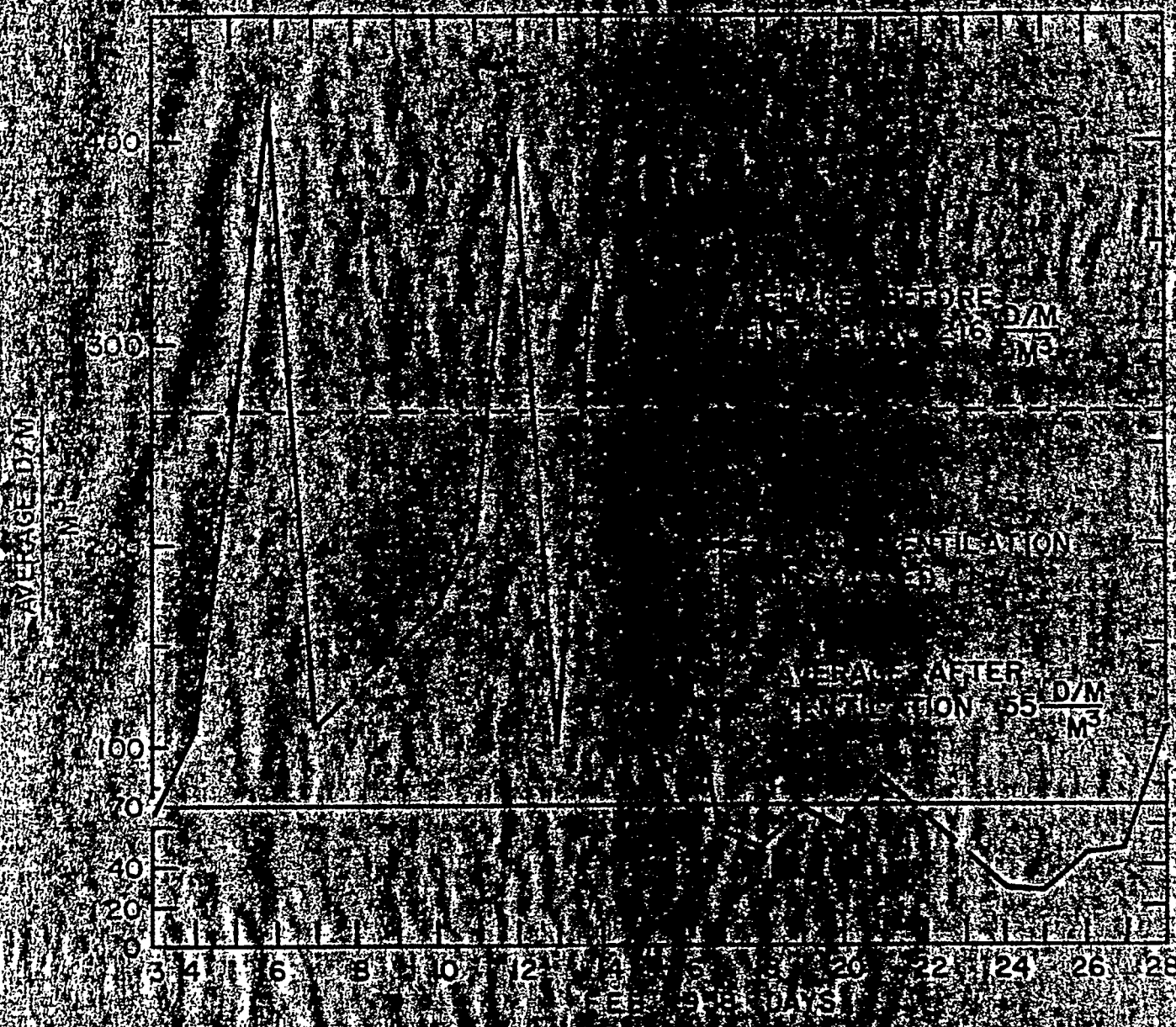


FIGURE 9. DAILY AVERAGE OF URANIUM IN AIR—MACHINE

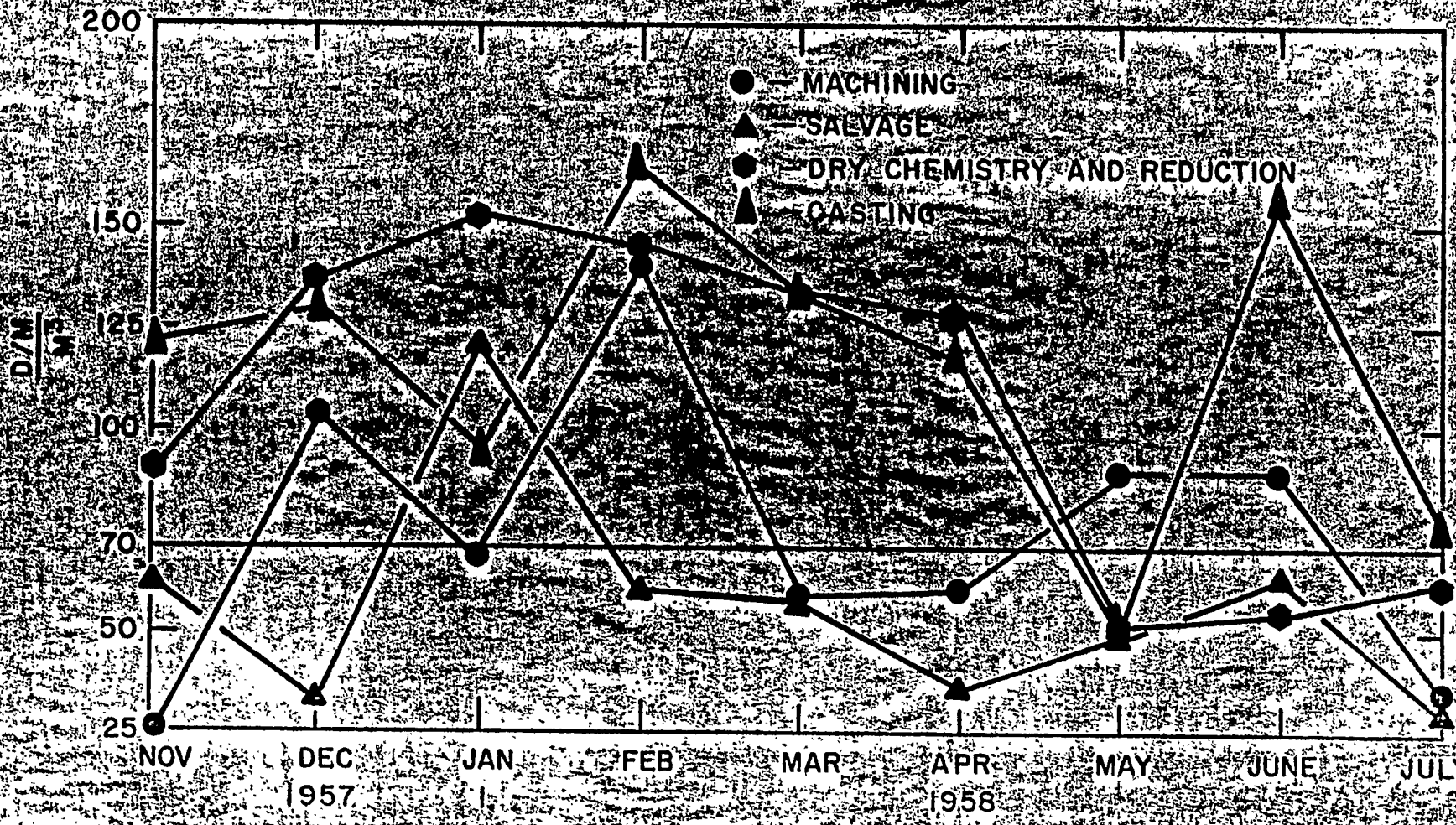

200
150
125
100
70
50
25
D/M
MACHINING
SALVAGE
DRY CHEMISTRY AND REDUCTION
CASTING
NOV
DEC
1957
JAN
FEB
MAR
APR
1958
MAY
JUNE
JULY

FIGURE 10