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DETECTION OF NUCLEAR-EXPLOSION DUST IN THE ATMOSPHERE

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ABSTRACT

An attempt was made to collect dust from the atomic-bomb explosions at Trinity and Hiroshima by using a filter carried at high altitudes in an airplane. The presence of the fission products was detected by measuring their activity with a Geiger counter. In accordance with the meteorological predictions, some activity was found on flights made along the Pacific coast August 10 and 11; while the flights of August 12, 13, and 15 collected no activity.

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DETECTION OF NUCLEAR-EXPLOSION DUST IN THE ATMOSPHERE

It was suggested by J. Magee and A. Turkevitch that radioactive fission products from the July 16 nuclear explosion at Trinity might be detectible after having been blown around the world by the prevailing west-to-east high-altitude winds. By the time the test to be described was carried out the active dust from the Trinity shot was expected between Bakersfield and Prince Rupert, British Columbia, 24 to 30 days after the shot. After August 10 the fission product activity detected should have been due to the bomb dropped on Hiroshima. We were advised by J. Hubbard that the dust from the bomb dropped on Nagasaki was dispersed because of local weather conditions and that it probably would not be brought over the North American continent.

The counting rate due to fission products from the atomic bomb in a Geiger counter simply immersed in air would be far too small to observe after the active air had crossed the ocean unless the cloud from the shot held together much more than was expected. The technique suggested was to filter large volumes of the upper atmosphere and count the activity in the filter. The atoms of active material remaining at high altitudes after crossing the Pacific Ocean should have collected on dust particles of the order of ten microns in diameter so that the air intake filter of an airplane might pick up some of the activity. A more convenient filter, particularly in view of the time and facilities required for extracting and concentrating the activity from a standard airplane filter, was designed by C. Runyan and K.T. Bainbridge. This filter had been tested previously, was easy to install and remove, and any activity collected could be counted soon after a flight so that whether active air had been traversed could be determined before the next flight.

This filter consisted of a piece of soft paper tissue* wrapped around the inside of a cylinder of perforated sheet iron 24 inches long and 24 inches in

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diameter. To hold the paper in place it was placed between two layers of copper screen wire before being fitted into the iron cylinder. The ends of the cylinder had brass disks clamped over them. This device was supported by two wooden cross bars in the forward bomb-bay of a B-29 airplane. The air to be filtered came in through a scoop mounted above the bomb-bay and was led down to the filter through a section of six-inch-diameter pipe. This terminated at the center of one of the brass end-disks of the filter. The installation and flight facilities were provided by the 2nd Air Force, U.S. Army.

After a flight the paper was removed from the cylinder, folded several times, and wrapped around a tube the same size as a standard thin-walled aluminum Geiger counter. From this tube the paper could easily be slipped onto the Geiger counter tube within the usual lead shield.

After each of the flights a large part of the activity died out with an initial half-life short compared with the time since the Hiroshima shot. An initial half-life of about 30 minutes was observed in the one case when the filter was taken out and counted as quickly as possible; i.e., 25 minutes after landing. This suggests that this activity was due to the radon disintegration products RaB (beta of 0.65 Mev, 26.8 minutes) and its daughter RaC (beta of 3.15 Mev, 19.7 minutes). Though the sensitivity of the counting arrangement is much greater for RaC, the half-life observed 25 minutes after an effectively infinite exposure (five hours) would be dominated by the 26.8-minute period. The initial counting rate was 450 counts per minute in the case mentioned above. That all the observed counts were due to beta activity was checked by placing a lead tube 1/32 inch thick between the paper and the Geiger counter. This cut

* This type of tissue, called "All-Mat," is manufactured by the American Air Filter Co. It is used in the intake air filters at [redacted]

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the counting rate to the normal background rate of the counter. A piece of the filter paper which had not been in the filter showed no activity at all.

An order of magnitude estimate of the solid angle subtended by the counter when the paper was in counting position and of the self-absorption of the paper indicates that the observed counting rates should be multiplied by 100 to get the total activity in the paper. Using this factor and expecting the radon activity in the air to be 10^{-17} curies per cubic centimeter, the efficiency of the filter for radon products appears to be around 20%. This was estimated for a flight at 250 miles per hour and a scoop of ten square inches cross section. This is a lower limit based on the assumption that all the volume swept out by the cross-section of the scoop passes through the filter; i.e., that the impedance of scoop, pipe, and filter is negligible. That the efficiency of this filter was fairly high was shown experimentally by placing a second layer of filter paper outside of the first for one flight and finding that this outer layer had only about one-third the activity of the inner layer of paper.

In addition to this short half-life activity there was some long half-life activity on the filters from the early flights. Below is a table of the times of the flights and the residual long half-life activity in the filter papers.

No.	Time of Flight	Route	Altitude	Residual counting rate 16 days after Hiroshima bomb, in counts per minute
1.	Aug. 10	W47 to Bakersfield	30,000 ft.	55
2.	Aug. 11	W47 to Bakersfield to Seattle	30,000 ft.	35
3.	Aug. 12	Seattle to Alaska and return	15,000 and 25,000 ft.	9
4.	Aug. 13	Seattle to Alaska and return	15,000 and 25,000 ft.	5
5.	Aug. 15	Seattle to W47	15,000 ft.	7

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The counting rates are arbitrarily given at 16 days after the Hiroshima bomb so that the short half-life activity mentioned above would have had time to decay from the last flight. The low counting rates from the last three flights are probably not significant since they are so small compared with the natural background of the Geiger counter (50 to 60 counts per minute).

It is considered unlikely that anything except 8-day iodine and 5-day xenon could come from Hanford, and the observed half-life is approximately 40 days or more. In addition there was no correlation between where the flights were made with respect to Hanford and the activity on the filter papers. This is shown on the map.

If we assume the same efficiency of filtering for the fission products as was computed above for radon disintegration products and take the observed long half-life activity to have been uniformly collected over the flights on which it was obtained, the fission products from one bomb, when uniformly distributed at this concentration, would occupy over 10^{19} cubic feet; for example, a volume 2,000 miles square by 4 miles deep.

In addition to the tests made on the filter paper mentioned above, several efforts were made to detect the activity both on the paper filter and on the regular airplane engine filters with a portable Geiger counter (model T) developed by Richard Watts. Although the minimum detectible ionization with this instrument was roughly equivalent to 100 counts per minute there was never any indication of activity on the filters. This was probably due to the poor solid angle subtended by the counter because of the large dimensions of the filters and to the absorption of the beta particles in the material of the filters. The use of this portable meter does not seem to be practical for these low intensities, but we did find that it would easily detect the beta activity which we found to come from the concrete and gravel at Boeing Field in Seattle.

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It seems reasonable that the activity observed is due to the fission products from Hiroshima. It was predicted from meteorological considerations that this active material produced on the evening of August 5 (our time) would reach the west coast about August 9, and would have passed inland after August 11. This test was not started soon enough to record the first arrival of the active material, but the fact that we did not find much long half-life material on the flights of August 12, 13, and 15 seems to agree with the latter part of the prediction. It is possible that the activity remained longer in the region south of Seattle since the flights of August 12 and 13 were made to the north, but at that time Hubbard thought that the greatest concentration of material would be to the north.

From the apparent efficiency with which this type of air filter operated it would seem to be a practical means of detecting an atomic bomb explosion almost anywhere with proper meteorological conditions. If future tests of the Trinity type are to be made, much more information could be obtained concerning the type of material picked up by operating closer to the shot than was possible in this case.

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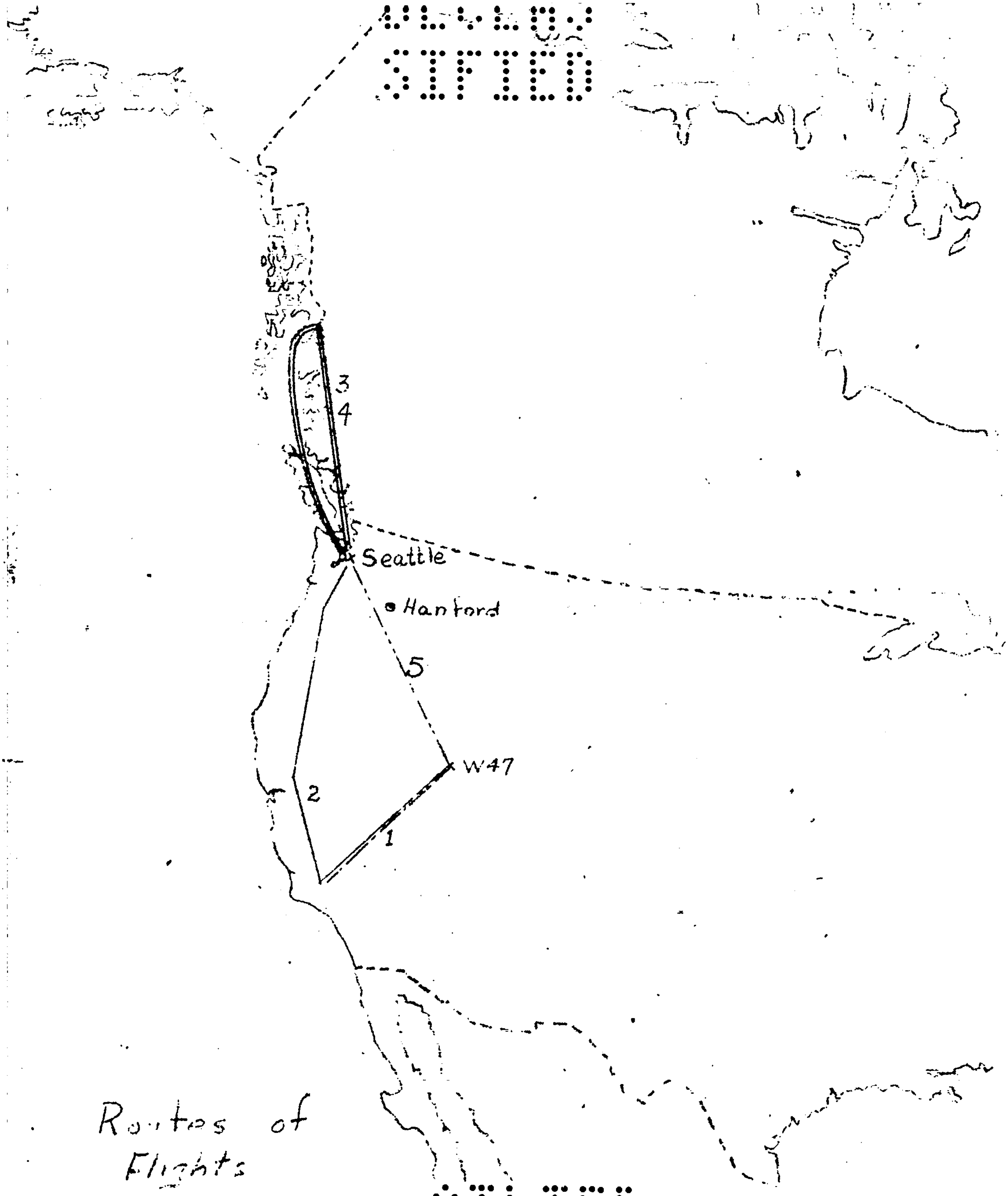

Routes of Flights

Numbers correspond to the numbers in the table