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SUBJECT: Use of Light Aircraft for Surveying for
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ABSTRACT

The recent Windscale incident has emphasized the need for available light aircraft and proper instrumentation for aerial surveys following a release of large quantities of airborne radioactive materials. Early Tests, 1951 and 1955, are reviewed and the program now in effect at the Laboratory is presented.

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Use of Light Aircraft for Surveying for Radioactive Ground Contamination

Introduction

Tests to determine the practicability of using light aircraft (< 100 HP engine) and commercially available radiation detection equipment for rapid ground surveys were first made at the Laboratory in 1951. The basis for these tests was the possibility that large ground areas might become contaminated with radioactivity resulting from radiological warfare, atomic bombings, sabotage, or accidents in nuclear facilities. The recent accident at Windscale verified the feasibility of the aerial survey technique and reports of this incident have suggested some measures that should be taken to improve this type survey.

Results of 1951 Tests*

The radiation detector used in the 1951 tests was of the GM type, Figure 1. The GM type instrument was selected on the basis of ruggedness, sensitivity, mobility, simplicity, relative economy, and availability. Although it was realized at that time, 1951, that the scintillation counter survey meter offered certain advantages, it was not considered because of its high cost and lack of commercial availability.

*"Aerial Surveying for Radioactive Ground Contamination", Davis, Hart, Morgan, Nucleonics, November 1952, Vol. 10.

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Fig. 1 Recorder, Power Supply and G. M. Counter

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Table I indicates the types and quantities of sources which were used in the 1951 test.

TABLE I

<u>Type</u>	<u>Number of Sources</u>	<u>Total Curies</u>
Cobalt-60	6	37
Cesium-137	1	6.4
Sodium-24	1	0.87
Tantalum-182	18	720

Figures 2 and 3 indicate two arrangements of the cobalt sources and the results obtained. The tantalum sources were used primarily to check the response of ionization chamber type instruments, but results indicated that the response time of this type instrument was too slow for aerial survey work. Results for sodium and cesium are shown in Table II and III.

TABLE II

Experimental and calculated values with 0.87 curie Na^{24} source.

<u>Altitude (ft.)</u>	<u>Instrument reading (mr/hr)</u>	<u>Calculated Reading (mr/hr)</u>
400	0.15	0.19
300	0.30	0.30
200	0.70	0.46
100	1.90	2.00

FIGURE 2

FIGURE 3

TABLE III

Cs¹³⁷ Source of 6.4 Curies

<u>Altitude (ft.)</u>	<u>Maximum Instrument Reading (mr/hr)</u>	<u>Maximum Calculated Reading (mr/hr)</u>
500	0.03	0.022
200	0.30	0.35

Although there was reasonable agreement of experimental and theoretical data in the 1951 test, the experiments were intended to check the operation of commercially available radiation detection instruments and were not an attempt to check or develop the theory of radiation attenuation and scatter. As would be expected, in some cases there was considerable deviation of the experimental from the theoretical data. This, however, did not nullify this method of radiation survey as perhaps the most promising method of quickly surveying a contaminated area.

Joint Operation Between the Health Physicist of ORNL and Group IV,
Tennessee Wing, Civil Air Patrol

In 1955 a Group IV Training Mission was conducted as a joint operation between the Health Physicists of ORNL and Group IV, Tennessee Wing, Civil Air Patrol. The purpose of this mission was to acquaint CAP members with procedures developed by ORNL Health Physicists designed to locate significant amounts of radioactivity on the ground resulting from radioactive fallout or some similar incident.

The mission was planned in much the same manner as SARCAP or regular search mission. The base of operations was in the general vicinity of the hidden source of radiation and at an airport that could service the aircraft used in the mission. Radio and telephone facilities were available and operating during the mission.

The search area was defined as a square 24 miles on a side or a total of 576 square miles. The total area was further divided into 36 sectors with 4 miles on a side or 16 square miles each. Each sector was numbered for identification purposes as shown in Figure 4.

The flight pattern flown over the terrain was the "creeping line". Pilots were directed to maintain the pattern at distances of one thousand feet apart and at an altitude of five hundred feet maximum. When the complete sector was covered, the aircraft would have passed over the sector approximately twenty-one times and would have flown approximately ninety-four miles.

Sources for the mission were provided by the Isotope Production Division of ORNL. They consisted of 8 pellets of cobalt of approximately 8 curies each. The source array chosen was a central square formed by four sources and 400 feet on a side. Four additional sources were placed 500 feet from the sides of the square on a line perpendicular to their centers, Figure 5. The size and location of the array were chosen to insure a reasonable likelihood of finding it with standard GM type survey meters having a low

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A - BASE OF OPERATIONS
S - SOURCE LOCATION

FIG. 4 SEARCH AREA PATTERN

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FIG.5. SOURCE ARRAY

range full scale reading of 0.2 mr/hr. This was postulated on flying at 500 feet $\pm$ 200 feet elevation above the ground on a search pattern with 1000 feet $\pm$ 500 feet between successive passes. Under these conditions, transient observations of off-scale readings on the most sensitive scale or significant aural indication above background should have been, and were, observed.

Personnel taking part in the mission were CAP members of Group IV, CAP visitors from North Carolina, Virginia, and Georgia Wings. Twenty-two aircraft participated in the mission. Thirty-two Health Physicists from ORNL participated as observers, instructors, and in material-control assignments.

Figure 4 shows that the source was located at a point where sectors 14, 15, 20, and 21 join. This meant that four aircraft were in a position to locate the source area. Sources were located by all planes assigned to these areas with one exception. In this case the pilot maintained an altitude of more than 1000 feet.

Current Aerial Survey Program

Within the past few months, flights have been made in the vicinity of the Laboratory with a limited number of flight passes directly over the Laboratory Area. The purpose of these flights is threefold: (1) to provide a means of evaluating instrumentation for aerial survey purposes, (2) to determine the radiation profile over the Laboratory and for several miles on each side of the Laboratory in the direction of the prevailing winds, and (3) to provide an

opportunity to evaluate aerial survey procedures and train personnel in effective aerial survey methods.

The recent aerial surveys were made with an ORNL model Q 1105 scintillation survey meter. The instrument utilizes a 2" x 2" sodium iodide crystal and has been modified to drive an Esterline Angus Model A W Recorder. This meter has 4 ranges: 3K, 10K, 30K, and 100K. The full scale sensitivity for gamma radiation is 0.015, 0.05, 0.15, and 0.5 mr/hr, respectively. The time constant is of the order of one second or less and the meter reading is recorded on the Esterline Angus chart. Figure 6 is a picture of the scintillation counter and the Esterline Angus recorder.

Figure 7 is a typical chart of a recording of the background encountered on a flight over the Laboratory. It is of interest to note that there is a slight rise in activity as the Laboratory was approached from the east, with significant peaks in activity at the 7000 Area, X-10 proper, and the old burial ground. A steady background was encountered upon leaving the burial ground area until it was encountered again on the return trip. Again peaks in activity were encountered at the old burial ground, X-10 Area proper, and 7000 Area with a trailing off in activity upon leaving the 7000 Area.

The peaks at the 7000 Area had not been seen on previous flights and subsequent examination revealed the probable source of activity to be an operating X-ray machine used for materials testing in the 7000 Area. The generally higher activity encountered in an

Fig 6

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HEADING EAST

8

7000 AREA 11:03

MAINTENANCE
SHOPS

X-10 AREA 11:01

LABORATORY
AREA

OLD BURIAL GROUND 11:00

4

Fig. 7

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14

easterly direction from the plant may be postulated to be the result of stack emitted activity since there was a wind blowing in that direction with a velocity of approximately 6 miles per hour at the time of the flight. These findings give some indication of the sensitivity of this means of locating unknown sources of contamination on the ground.

Reports of the Windscale incident stated that the maximum permissible values used for human consumption of whole milk was 0.1 microcurie of I^{131} per liter of milk; and that the corresponding contamination tolerance levels of pasture land on which the cows grazed was 1.0 microcurie per square meter. In order to determine the adequacy of our technique and instrumentation for detection and measurement of I^{131} as an air-deposited contaminant on pasture grasses, a test simulating such deposition was conducted during May of this year (1958).

To simulate the contaminated condition, 320 millicuries of I^{131} in an aqueous solution of 72 ml. was obtained from the Isotopes Division at ORNL. The iodine solution was contained in 36 polyethylene bottles of one ounce capacity with 2 ml. of solution in each bottle, thus 8.85 μ c per bottle. The bottles were placed on the ground at 100 feet intervals on a 500' x 500' grid, Figure 7A. The grid area was located in grazing land of the University of Tennessee-AEC experimental station.

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Fig. 7A

Background flights were made prior to the placement of the sources. After the placement of the sources, flights were made at several altitudes to obtain the dose rates over the center of the source array. Results are shown in Table IV.

TABLE IV

Experimental and Calculated Values for 320 mc I^{131} .

<u>Altitude (ft.)</u>	<u>Experimental Readings (mr/hr)</u>	<u>Calculated Readings (mr/hr)</u>
50	.03	.026
150	.005	.013
350	.002	.004

The experimental values are for sources arranged as shown in Figure 7A. The calculated values are not corrected for air attenuation, build-up, and scatter. Also, the 50 foot altitude was estimated rather than measured.

In order to detect lower levels of contamination by the aerial survey technique, the Instrument and Control Division at the Laboratory is currently designing an improved instrument which will include shielding of the detector unit to reduce the background reading of the instrument.

Proposed Program

It is proposed that the aerial surveys, including flights over the Laboratory, be continued at a frequency of about one per month on a pattern as indicated in Figure 8. These flights will be made in cooperation with Group IV, Tennessee Wing, Civil Air Patrol.

The instruments will be supplied and maintained by the Laboratory and the CAP will furnish pilots, planes, and a technician to observe readings and adjust instruments as required.

In addition to determining the background in the vicinity of the Laboratory, the CAP flights will permit operational checks of instruments currently in use and provide a means of testing new instruments. Also, it will provide a means for CAP Group IV personnel to become familiar with aerial survey techniques. In case of emergency, it has been determined that CAP will be able to place planes in the air within 2 hours, or less, from time of notification.

U. S. Geological Survey Aircraft

In addition to surveys with light aircraft, it has been proposed that routine surveys be made over the major AEC installations using the equipment developed by Davis and Reinhardt* for the U. S. Geological Survey Aircraft, a DC-3. Figure 9 is a block diagram of this equipment.

There are several advantages of the Geological Survey type equipment and the larger aircraft, the DC-3, over the light aircraft for the rapid survey of large areas. One major advantage is the altitude compensating feature which is illustrated by Figure 10. In Figure 10 are shown records obtained from a portion of a flight line flown February 2, 1955, from St. Louis, Missouri, to Moline, Illinois. The records run from right to left. The top record is the altitude

*"Instrumentation in Aircraft for Radiation Measurements," Davis and Reinhardt, Nuclear Sciences and Engineering 2, pp. 713-727 (1957).

Fig. 9 Block diagram of airborne radiation survey equipment

Fig. 10. Record of Radiation Measurement from St. Louis,
Missouri to Moline, Illinois.

in feet above ground, the second is the radiation reading without altitude correction, and the third is the radiation reading corrected for altitude. The third record also has the soft cosmic radiation component subtracted. The light aircraft is not able to carry this type of equipment.

Conclusion

In conclusion, it is evident that aerial surveying is one of the best methods of determining the magnitude and spread of contamination during an accidental release of large quantities of radioactive materials. To be of maximum value, adequate instrumentation and background data are required. To meet this need, the Laboratory is currently fabricating improved types of scintillation counters and is making routine background surveys over the Laboratory area.

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