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CIVIL EFFECTS STUDY



FORT McCLELLAN RADIOLOGICAL
INSTRUCTION AREA (ARMS-11)

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FORT McCLELLAN RADIOLOGICAL INSTRUCTION AREA (ARMS-II)

By

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ABSTRACT

An Aerial Radiological Measuring Survey (ARMS) of the U. S. Army Chemical Corps School, Radiological Instruction Area, Fort McClellan, Ala., was made for the Civil Effects Test Operations, Division of Biology and Medicine, U. S. Atomic Energy Commission, on Jan. 15, 1962, by Edgerton, Germeshausen & Grier, Inc., (EG&G). The primary purpose of the survey was to test and evaluate the operation of the ARMS-II system over a high-intensity radiation field of small area. The radiation area is about 1000 yards long and less than 300 yards wide. The sources (Co^{60}) produce a dose rate of about 300 mr/hr along the center line.

Data from an areal survey of the range were contoured to show the distribution of the gamma-ray flux at 500 ft above the ground. The count rate over the center of the range was greater than 15,000 counts/sec on the low-sensitivity detector.

Data on the air attenuation of gamma rays were collected from flights along the center line of the range at altitudes ranging from 100 to 3500 ft above the ground. Maximum count rates on low sensitivity ranged from more than 50,000 counts/sec at 100 ft to 1300 counts/sec at 1300 ft. Maximum count rates on high sensitivity ranged from more than 50,000 counts/sec at 1500 ft to about 2000 counts/sec at 3500 ft above the ground.

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FORT McCLELLAN RADIOLOGICAL INSTRUCTION AREA (ARMS-II)

1 INTRODUCTION

An Aerial Radiological Measuring Survey of the U. S. Army Chemical Corps School, Radiological Instruction Area, Fort McClellan, Ala., was made for the Civil Effects Test Operations, Division of Biology and Medicine, U. S. Atomic Energy Commission, by Edgerton, Germeshausen & Grier, Inc. (EG&G), on Jan. 15, 1962. The area surveyed, which is approximately 1 mile square, is about 11 miles northwest of Anniston, Ala. (Fig. 1).

The primary purpose of the survey was to test and evaluate the operation of the ARMS-II system over a high-intensity radiation field of small area. This detailed survey was a severe test of the ARMS-II aircraft space-positioning subsystem because the development of the system was predicated on the rapid acquisition and reduction of radiation data for areas as large as 10,000 square miles. It was also the first operational test of the low-sensitivity detector that was included in the ARMS-II system to provide a capability for surveying the high-intensity radiation fields resulting from radiation accidents.

Data obtained over the Fort McClellan radiation range will permit an informal correlation between the ARMS-II system and several other detecting systems being developed by the U. S. Army.

Measurements of the gamma-ray flux at different altitudes above the source range furnish data that will be used to develop an increased understanding of the attenuation of gamma rays in air.

The radiation range at Fort McClellan was constructed about 1955. It originally consisted of a systematic arrangement of Co^{60} sources ranging in strength from 5 to 14 curies. Two 30-curie sources were located in the center of the range. The original nonuniform distribution of radiation intensities has been compounded by the removal of many sources and by the deterioration of the range. The sources have decayed to about one-half their original strength, and the present dose rate along the center line is about 300 mr/hr.

The range at present is about 1000 yards long; its maximum width is less than 300 yards. The center line is oriented approximately northeast-southwest. The maximum difference in elevation within the range is about 20 ft. A low ridge (about 100 ft high) parallels the center line about 600 yards on the northwest. Cane Creek is about 200 to 400 yards from the center line on the southeast and southwest.

Several tanks were placed randomly in the range, and the area is crossed by numerous roads and trails.

2 INSTRUMENTATION

The EG&G ARMS-II instrumentation is installed in a Beechcraft, model 50 twin Bonanza, N702B. The apparatus consists of three subsystems (Fig. 2): (1) the radiation-detection and

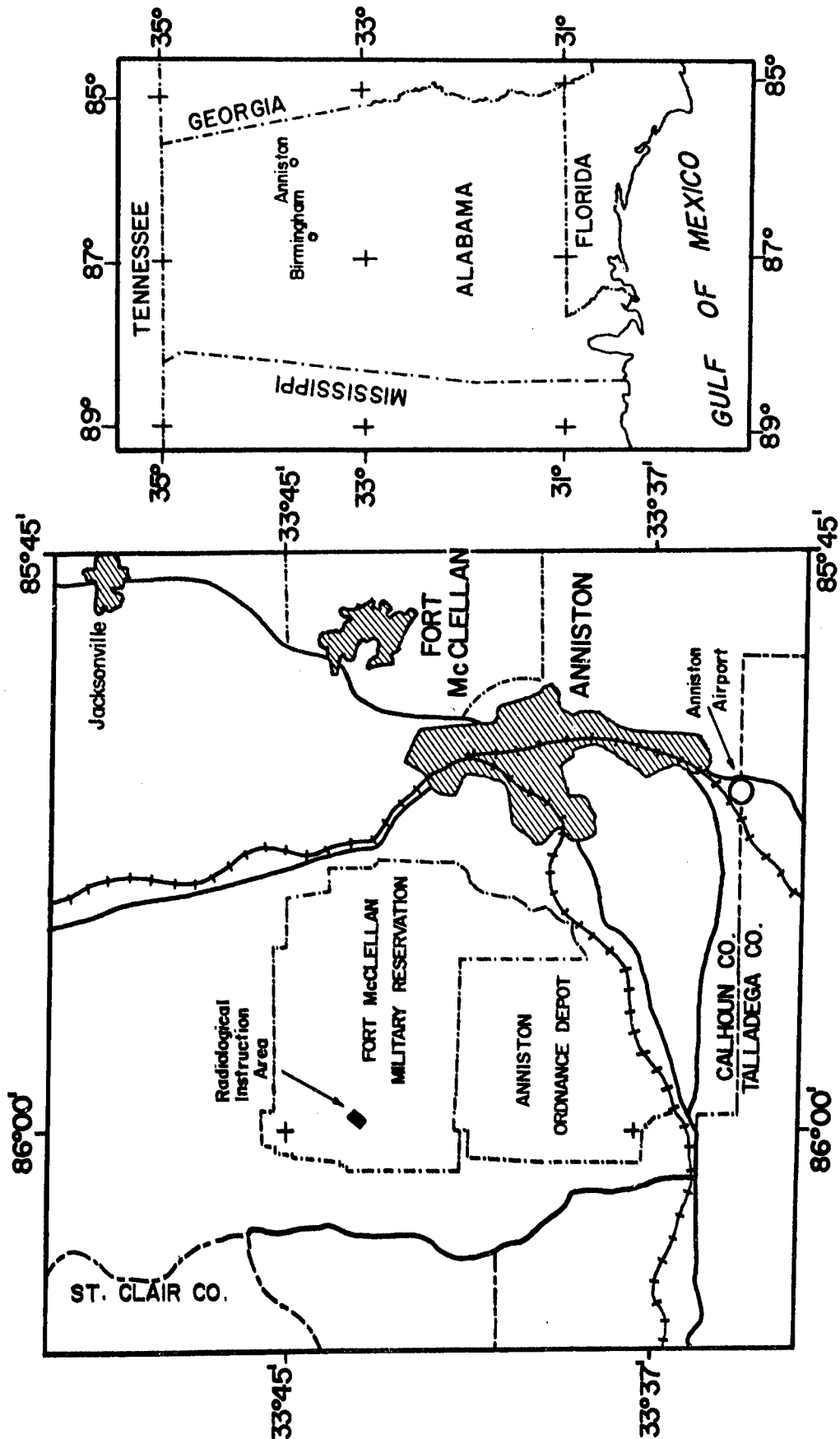


Fig. 1 - Location of Fort McClellan Radiological Instruction Area.

radiation-measurement subsystem, (2) the aircraft space-positioning subsystem, and (3) the information printout subsystem. The functions of these subsystems and their components are described in detail in Ref. 1.

The high-sensitivity detecting unit utilizes a 9-in.-diameter 3-in.-thick thallium-activated sodium iodide crystal and a 12-in. photomultiplier tube. The low-sensitivity detector, which was used over the high-intensity radiation field below 1300 ft, has a $\frac{3}{4}$ - by $\frac{3}{4}$ -in. thallium-activated sodium iodide crystal. The radiation amplifier unit consists of a voltage amplifier, a pulse shaper, and an energy discriminator. The discriminator is set to reject pulses caused by gamma rays with energies below 50 kev for routine surveying and 662 kev for calibration. The arithmetic computer performs the cosmic-background correction, the compensation of the data for deviations from the nominal surveying altitude, and the classification of count rate into channels and gives print command signals to the information printout subsystem. The correction for cosmic and other undesirable background consists of subtracting from the gross count at 500 ft above the ground a count rate equal to the undesirable background; this gives the net count. This background is normally measured at 3000 ft above the ground. Compensation of the data for deviations from the nominal surveying altitude is accomplished through control of the sampling period by introducing a signal from the radar altimeter. The normal sampling period is 1 sec. The sampling period is less than 1 sec when the aircraft is below 500 ft and greater than 1 sec when the aircraft is more than 500 ft above the ground in the 300- to 900-ft range above the ground. The arithmetic computer classifies the count rate into digital channels of predetermined width. In the range of most natural materials, between 0 and 2000 counts/sec, the channel width is narrow. Above 2000 counts/sec a progressively wider channel is used.

The aircraft position is determined by a modified General Precision Laboratories Doppler navigation system. The J-4 compass system establishes a reference line against which the actual path of the aircraft is compared, the heading information being held by either a driven gyro or a magnetically slaved gyro. The RADAN 500 Doppler radar unit determines the ground speed and drift angle of the aircraft relative to the J-4 reference line. Signals from the J-4 compass and the RADAN 500 go to the TNC-50 (track navigation computer), where the along-track and the across-track distances relative to an initial ground point are computed. The along-track and the across-track distance signals then go to the analog-to-digital converter. Upon receipt of a print command from the radiation computer, these outputs go to the printer and are recorded.

The information printout subsystem consists of two data recorders: (1) a decimal printer and (2) a binary tape punch. The data recorded are: survey leg number, radiation channel, along-track distance, across-track distance and direction, and detector sensitivity.

3 FLIGHT PROCEDURE

The ARMS-II aircraft N702B left Galveston, Tex., and arrived at Anniston, Ala., on Jan. 14, 1962.

The survey mission was discussed with the Operations Officer, Reilly Field, Fort McClellan, on the morning of January 15 to coordinate the ARMS-II flights with possibly hazardous ground activities and other aircraft operations in the Fort McClellan restricted area. Arrangements were made to land at Reilly Field after the survey to demonstrate the ARMS-II system to interested persons from the Chemical Corps School and the Signal Corps.

A 1-hr and 50-min mission, from takeoff at Anniston at 11:25 a.m. to landing at Reilly Field at 1:15 p.m., was flown to make the survey. About 1 hr was spent over the source range. The ARMS-II crew consisted of E. K. Raschke, pilot; R. B. Guillou, navigator; and J. B. Gilliland, observer. Visibility was excellent, wind was about 15 mph north, and air temperature was about 50°. The ground in the area was wet because of recently melted snow.

The flight time included equipment-stabilization time and in-flight calibration of the radiation-detection system. As soon as the aircraft was airborne, the equipment was turned on and was allowed to reach temperature equilibrium. After thermal stabilization of the circuitry had been reached, the radiation apparatus was calibrated with a Cs¹³⁷ source. Meas-

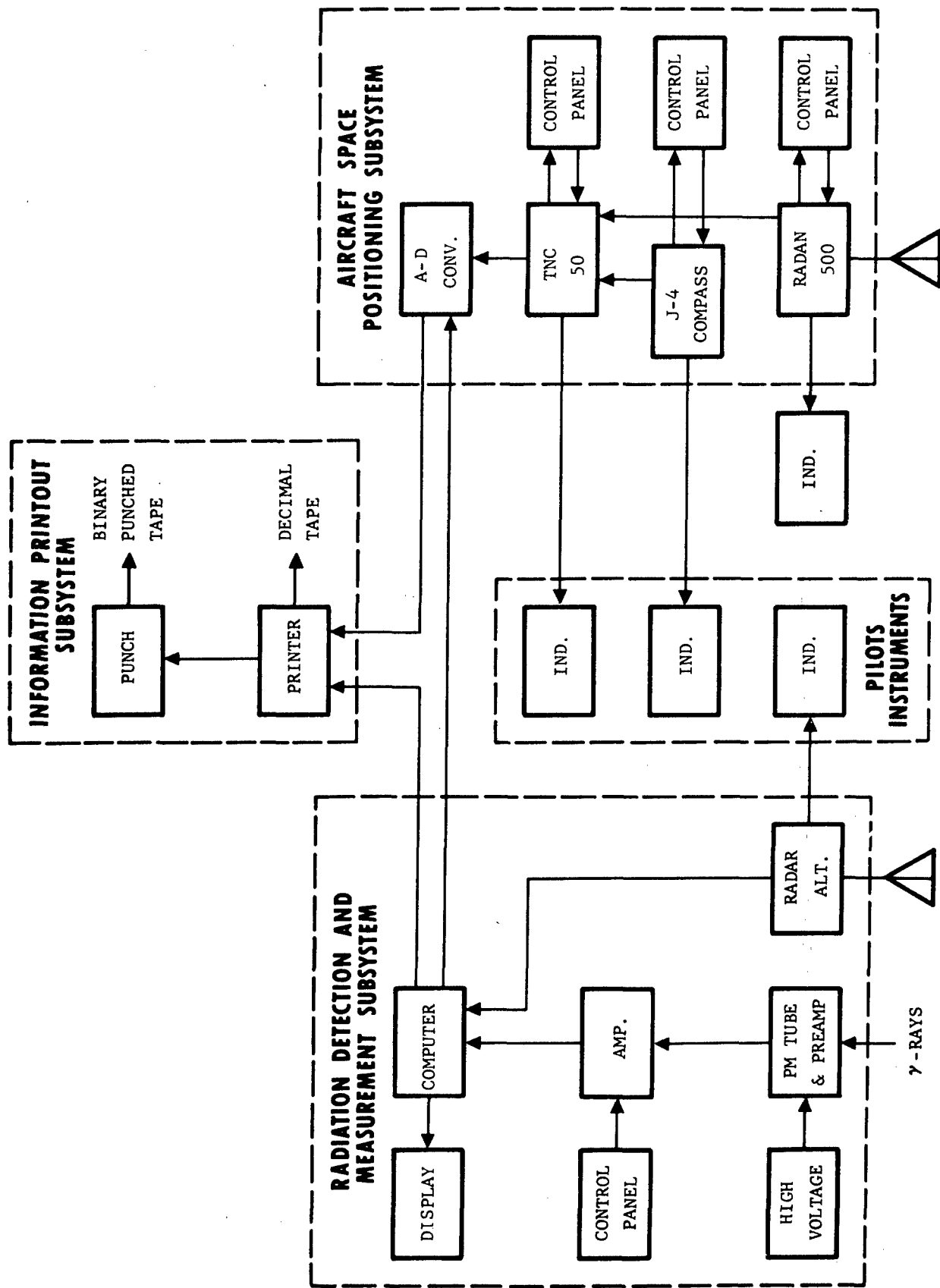


Fig. 2—EG&G ARMS-II instrumentation.

urements of airborne, cosmic, and extraneous radiation were then taken at 3000 ft above terrain. Upon arrival at the survey area, the aircraft descended to the 500-ft survey altitude, and the value of the undesirable radiation, as measured at 3000 ft, was set into the radiation computer. The radiation data recorded during the survey represented net terrestrial gamma radiation.

The Fort McClellan radiation range was surveyed in two ways: (1) an areal survey of the range made at right angles to the center line and (2) flights along the center line at different altitudes.

The areal survey was flown at a nominal 500 ft above the terrain. The low-sensitivity detector ($\frac{3}{4}$ -in. crystal) was used. The data were automatically compensated for deviations from the nominal surveying altitude. Data printout occurred when preselected levels of radiation intensity were crossed. In addition to level data, the visual display was monitored, and the maximum count rate on each line was recorded. Because of the expected rapid changes in radiation level, the binary tape punch was not used. This decreased the minimum time for successive data printouts to less than 1 sec. Anomalous radioactivity was detected on seven flights across, or adjacent to, the radiation range. Three of these flights were over the area of sources. Each flight line started or ended at prominent road junctions. One road junction was 2 miles northwest and the other $1\frac{1}{2}$ miles southeast of the center line. The spacing of the flight lines was irregular to permit flying directly over recognizable ground features.

The center line of the radiation range was flown at altitudes ranging from 100 to 3500 ft above the ground. The data were not compensated for altitude variations, and the Doppler radar was not used below 500 ft. The decimal tape was manually advanced one space to indicate each end of the center line. Scattered low clouds precluded flying higher than 3500 ft above the ground although radiation from the source range probably would have been discernible as high as 5000 ft.

Upon completion of the survey, the aircraft landed at Reilly Field, and the ARMS-II system was demonstrated to persons from the Chemical Corps School and the Signal Corps. The aircraft returned to Anniston after the demonstration.

On January 16 the ARMS-II aircraft and crew departed from Anniston for Galveston.

4 AERORADIOACTIVITY DATA

4.1 Areal Survey

The data from the areal survey of the radiation range were compiled on Army Map Service topographic maps, scale 1:25,000, or $2\frac{1}{2}$ in. equals 1 mile. The area appears on parts of the Francis Mill and Eulaton sheets.

Five distinct steps were used in the compilation:

1. The data points were plotted on tracing paper at map scale (1:25,000). The recorded Doppler distances were used to plot the flight lines.
2. The flight lines were corrected for instrumental error, and data points were converted from radiation channels to count rate and then plotted on the compilation map. The correction consisted of graphical proportioning of the error between the map locations of the end points. For the areal survey of the Fort McClellan radiation range, this procedure is considered to have corrected the along-track position of the data points and to have indicated the flight path in the center of the area within 100 yards.
3. The flight lines were then shifted in the across-track direction until they were directly over the map positions of the points flown over in the center of the area. The maximum across-track shift was less than 100 yards. The accuracy of this correction depends on the accuracy of determining the map position of features appearing on a photomosaic of the radiation range and on the ability of the pilot to fly directly over the feature.
4. The radiation data points were then moved 225 ft back along the flight path to correct for the 1-sec instrumental lag in printing radiation data.

5. In the final step of compilation, the data were contoured. Data obtained on the 500-ft-altitude center line traverse were used as guides for contouring in places where the areal survey data did not give sufficient control.

Figure 3 is an aeroradioactivity map of the Fort McClellan radiation range. The contour lines show the intensity of the gamma flux at 500 ft above the ground, expressed as hundreds of counts per second. Dashed lines are used where the data do not give sufficient control for contouring.

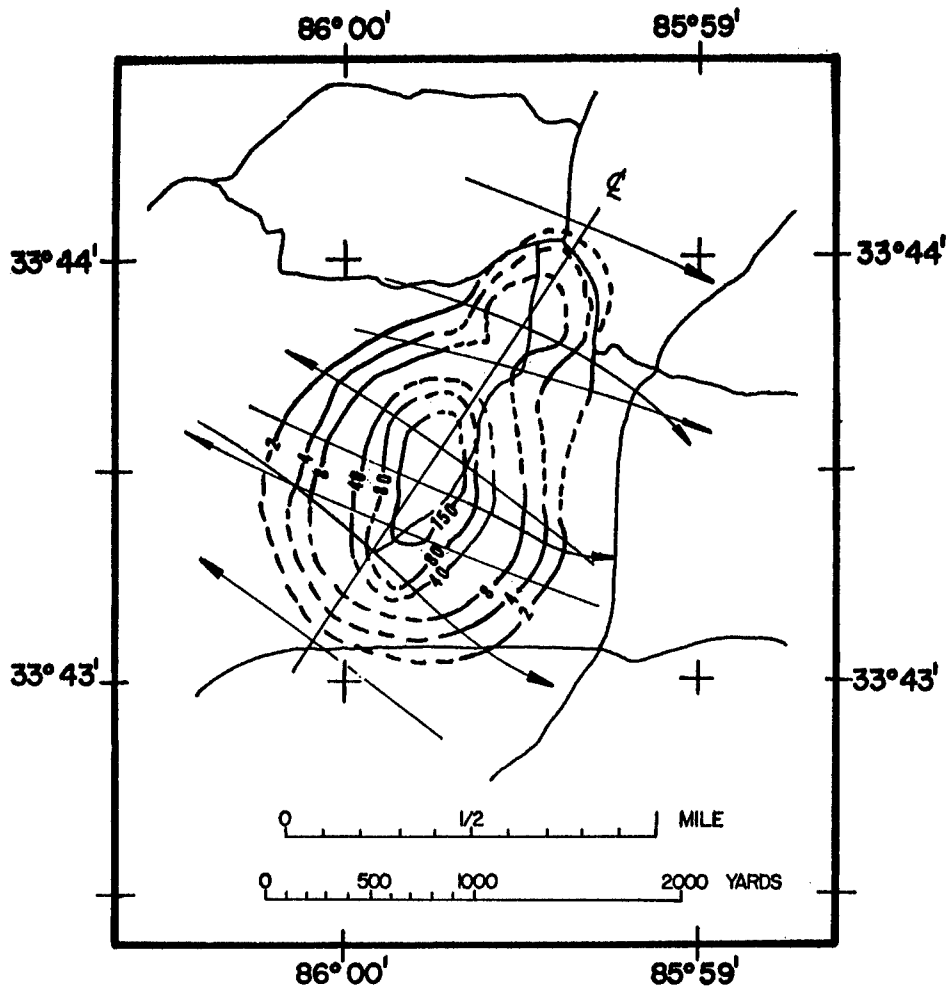


Fig. 3—Aeroradioactivity map of the Fort McClellan Radiological Instruction Area. Radioactivity levels are in hundreds of counts per second measured at 500 ft above the ground. Surveyed by EG&G Jan. 15, 1962, with the ARMS-II low-sensitivity detector.

4.2 Center Line Traverses

The data recorded on flights at different altitudes along the center line of the radiation range were compiled as profiles. Doppler distances were used to construct each profile, and the radiation channels were converted to count rates. The profiles obtained with the low-sensitivity detector ($\frac{3}{4}$ -in. crystal) are shown in Fig. 4. Only maximum and minimum values over the radiation range are shown for the 100- and 300-ft traverses because the Doppler system does not operate this close to the ground.

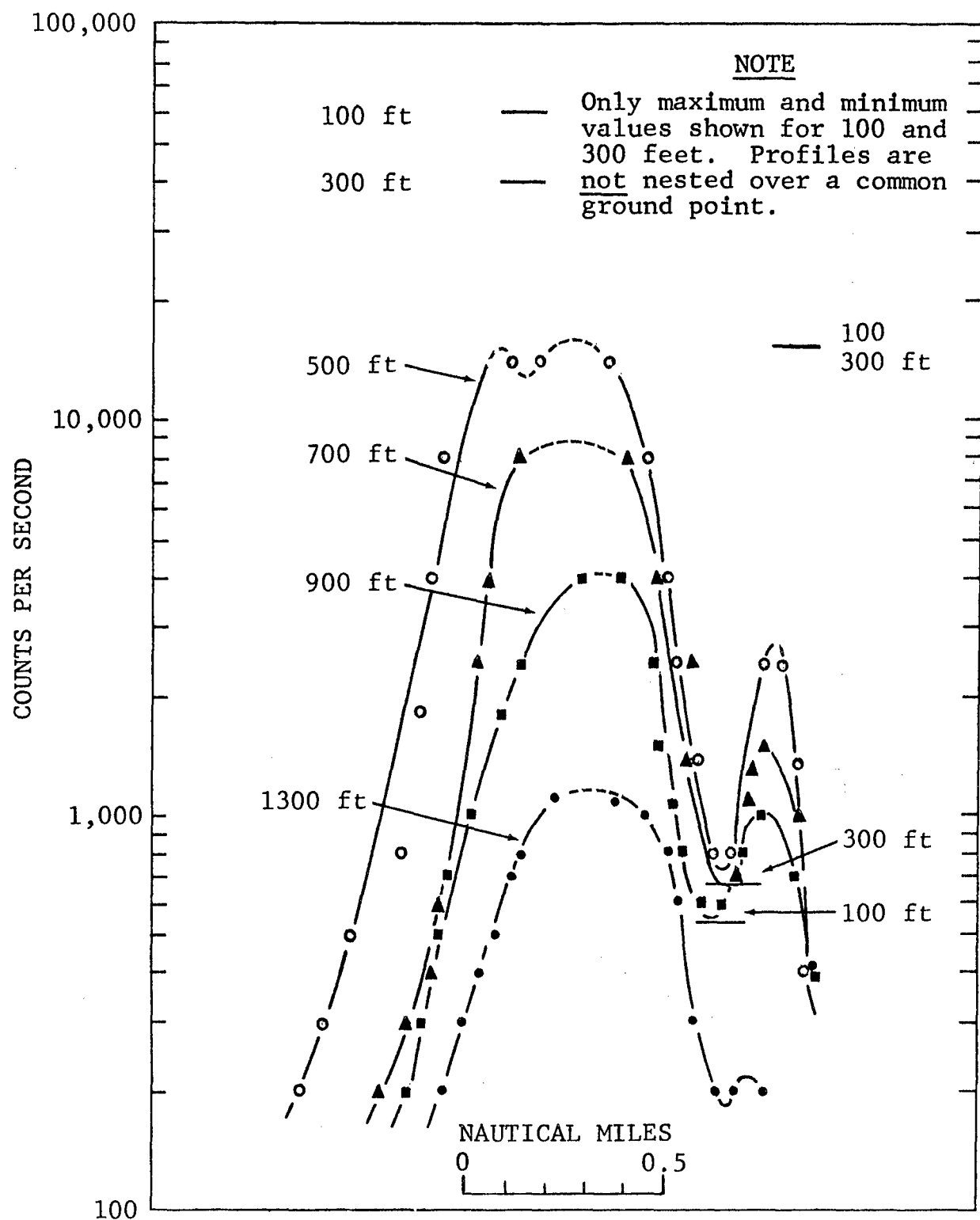


Fig. 4 — Radioactivity profiles over center line of radiation range (low-sensitivity detector).

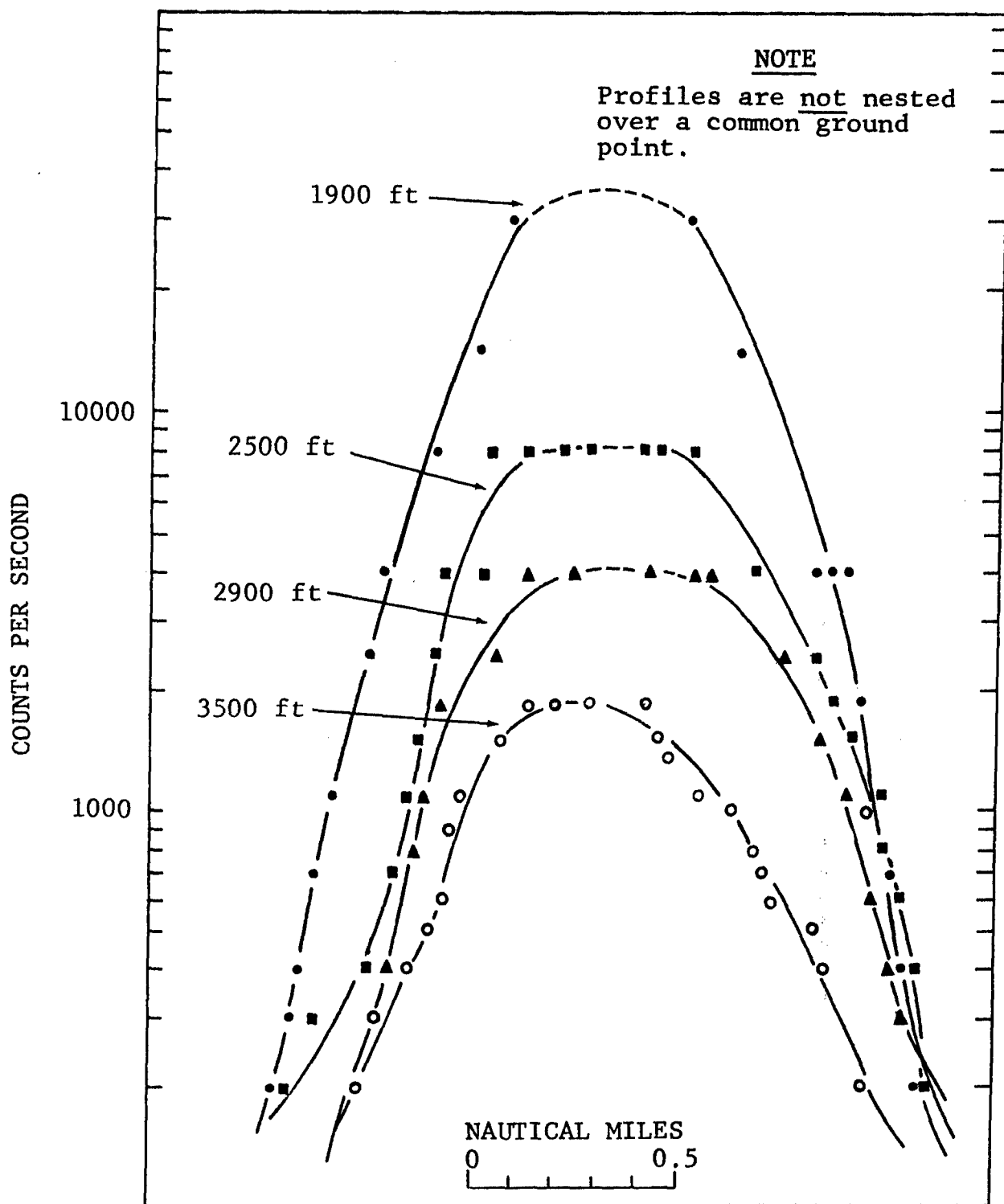


Fig. 5—Radioactivity profiles over center line of radiation range (high-sensitivity detector).

The profiles obtained with the high-sensitivity detector (9-in. crystal) are shown in Fig. 5. On the traverses at 1500 and 1700 ft above the ground, the high-sensitivity detector was saturated, and meaningless data were recorded above 10,000 counts/sec.

5 DISCUSSION

5.1 Conversion of Count Rate to Dose Rate

The EG&G ARMS-II instrumentation was designed to give data compatible with the data of the existing USGS ARMS-I equipment. Both units were flown over the Extended Source Calibration Area at the Nevada Test Site for cross-calibration purposes. The calibration range consisted of 400 equal-valued sources spaced on 100-ft centers to form a square that was 2000 ft on each side. The results of the flight have been reported by F. J. Davis, Oak Ridge National Laboratory.²

The gamma dose rate 3 ft above terrain in the center of the area was measured by R. M. Johnson of Oak Ridge National Laboratory. His measurements, combined with the EG&G ARMS-II data taken at 500 ft above terrain, give the following conversion factors:

Co⁶⁰ (high sensitivity): 22 counts/sec at 500 ft = 1 μ r/hr at 3 ft

Co⁶⁰ (low sensitivity): 115 counts/sec at 500 ft = 1 mr/hr at 3 ft

These conversion factors should not be used with the Fort McClellan data because

1. The source range is heterogeneous and does not produce a uniformly distributed gamma field.
2. The source range (maximum dimensions 1000 by 300 yards) is not a broad source.
3. The conversion factor was determined by using a ground dose of about 0.2 mr/hr, whereas the ground dose at the Fort McClellan source range is greater than 300 mr/hr.

6 CONCLUSIONS

The Fort McClellan survey proved the versatility of the ARMS-II system. The system was designed primarily to measure the low-background environmental radiation in large areas on flight lines spaced 1 mile apart and to acquire data efficiently which could be compiled rapidly. In this test consistent data were obtained over a high-intensity source of small area on closely spaced flight lines. Data in the form of peak intensities over the source range were available as soon as the aircraft landed and could have been radioed to the ground as soon as they were recorded. A plot of the areal survey data, accurate to 0.1 mile, can be prepared within hours after a survey mission is completed. If suitable large-scale maps or photographs of the area of interest are available, more refined compilation of the data can be accomplished.

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