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Operation

JANGLE

NEVADA PROVING GROUNDS
OCTOBER-NOVEMBER 1951

Project 6.1

EVALUATION OF MILITARY RADIAC EQUIPMENT

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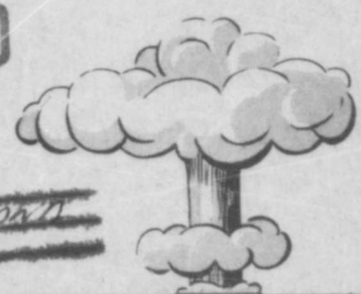

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OPERATION JANGLE

PROJECT 6.1

EVALUATION OF MILITARY RADIAC EQUIPMENT

by

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12 May 1952

U. S. ARMY SIGNAL CORPS

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PROJECT 6.1

PREFACE

Operation JANGLE provided an excellent opportunity for evaluation of military radiac equipment in use under field conditions. The intense and widespread radiological contamination following the surface and underground bursts provided realistic situations for determining adequacy of existing equipment for service-wide field use and needs for future development.

Four types of radiac survey instruments were field tested by actual usage of the equipment in area survey, health monitoring, and decontamination work of potential significance to a military command. Particular note was taken of ease of operation, ruggedness, and reliability. Two types (AN/PDR-18 and AN/PDR-32) received informative testing for engineering and technical guidance prior to being put into production. Several models of dose dose-rate meters were subjected to preliminary testing.

A rapid radiological survey of a highly contaminated ground area was performed in low flying aircraft to determine feasibility for tactical military application.

A possible solution to the need for mobile processing facilities to handle wet radiation dosage film was a developmental model of an automatic film processing unit operated and evaluated on this test.

Laboratory models of portable air monitoring equipment designed to determine the air loading of radioactive particles over a range of particle sizes were operated in the radiation field to determine feasibility of portable monitors and to obtain information for future development.

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CHAPTER 1

RADIAC METER EVALUATION

1.1 ABSTRACT

Consideration of the radiological effect produced by nuclear weapons detonated on the surface or underground made it evident that portable gamma radiac instruments for service-wide military use must have a maximum range of 500 r/hr. In addition, portable instruments should weigh considerably less than ten pounds (preferably less than five pounds). The instruments also must have a higher degree of ruggedness and dependability than that available in existing light weight type instruments. An indication of the adequacy of each type instrument as determined by the tests is presented in Table 1.1.

1.2 OBJECTIVE

It is necessary to test equipment and methods under field conditions to determine the true value of the equipment. It is only in this manner that unforeseen problems, both in operational performance and in techniques, are detected and the human element of the operator applied to the equipment.

Such a test was performed at Operation GREENHOUSE and its results indicated a need for additional tests of this type.

In the use of the equipment under field conditions problems are encountered which were not, or could not, be anticipated in the laboratory testing of the instruments. The laboratory tests merely determine whether a piece of equipment equals or exceeds the specifications set down for its design. The laboratory tests do not fully determine whether the specifications themselves are adequate.

This report covers tests designed to determine the adequacy of various types of radiac equipments for the following purposes:

a. Decontamination work.

b. Health Monitoring.

c. Military surveys for determining contaminated areas.

In determining the value of equipments for the uses listed above information was obtained on the following features:

TABLE 1.1

ADEQUACY OF RADIAC INSTRUMENTS

EQUIPMENT	RUGGEDNESS	DEPENDABILITY	MAXIMUM RANGE	WEIGHT	RECOMMENDED USE
Radiac Tng Set AN/PDR-T1B	Adequate	Adequate	Too Low	Excessive	Gamma area survey
Radiac Set AN/PDR-32	Not Determined	Inadequate	Adequate	Adequate	Gamma area survey
Radiac Set AN/PDR-18	I.N.A*	I.N.A*	Adequate	Excessive	Gamma area survey
Radiac Set AN/PDR-27( )	Adequate	Adequate	Too Low on beta	Excessive	Vehicular and Personnel
Radiac Set AN/PDR-10A	Inadequate	Adequate	Inadequate	Excessive though lighter than most	Alpha survey
Radiac Set AN/PDR-34	Inadequate	Adequate	Adequate for Alpha and Beta only	Excessive	Alpha and gamma Survey
Dose Dose-Rate Meter	I.N. A*	I.N.A.*	I.N.A.*	I.N.A.*	I.N.A.*

* I.N.A. - Insufficient numbers available for adequate test evaluation.

a. Ease of operation - includes ease of carrying, fatigue effects, necessity for repeated adjustments, ease of reading, stability and drift.

b. Ruggedness - ability to perform under conditions of field operation.

c. Consistency of readings with other equipments and accepted standards, especially when surveying the characteristic radiation spectra.

1.3 HISTORICAL AND THEORETICAL

1.3.1 General

In the Department of Defense, spheres of interest for radiac meters have been assigned to the Army and the Navy. The divisions of interest are:

U. S. Army	U. S. Navy
Radiac Meters	**Radiac Meters**
Ionization Chambers	Geiger Counters
	Scintillation Counters
	Proportional Counters
	Alpha Survey Counters

The U. S. Army Signal Corps is the responsible agency for the U. S. Army. A complete history of the Signal Corps contracting for the years 1948, 1949 and 1950 is available in the report, Project 5.1, Operation GREENHOUSE, "Evaluation of Ground Radiac Equipment".

The Bureau of Ships is the responsible agency for the U. S. Navy. In 1946, prior to the Bikini A Bombtest, the Bureau of Ships initiated a program for the development of military type radiac equipments. The stimulus for this program came from the ship decontamination problem. Available commercial equipments, purchased from the Atomic Energy Commission, were evaluated from the point of view of adequacy for military use. Tests showed that these equipments would not perform adequately under the rigorous conditions of military operation.

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Early in the program Research and Development contracts were initiated to investigate basic methods of radiation detection and measurement. The various techniques were reviewed and the development of equipment to cover requirements for low and high range survey requirements was initiated. Geiger-Muller tube techniques were selected for the low ranges, while both ionization chambers and scintillation counters were chosen for high ranges. At about this time the Panel on Radiological Instruments of the Armed Forces Special Weapons Project assigned areas of primary cognizance to the Bureau of Ships and to the Signal Corps. The former was assigned primary cognizance for G-M tube and scintillation counter equipment and the latter primary cognizance for ionization chambers.

In the low ranges, the Bureau of Ships emphasized the development of a low voltage G-M tube equipment. The halogen tube had been under development at the Naval Research Laboratory since early 1948. The first equipments developed, the AN/PDR-8 series, were quickly followed by the development of much lighter units which are now in production as the AN/PDR-27 series. These are beta-gamma survey equipments indicating the presence of beta and measuring gamma from 0.01 mr/hr to 500 mr/hr. The detectors are halogen filled G-M tubes.

Scintillation counter equipment has been developed which will measure intensities up to 500 r/hr. In its initial stages this development was hampered by difficulties in obtaining suitable crystals. These were overcome when improvements were made in techniques for growing calcium and cadmium tungstate crystals. The scintillation counter investigations culminated in the development of the AN/PDR-18( ) equipment. In the Radiac Set AN/PDR-18, radiation is absorbed by a phosphor composed of an anthracene crystal and a cadmium tungstate crystal. The re-emitted visible radiation is then measured with a 931A photo-multiplier tube. In the Radiac Set AN/PDR-18A, the phosphor is stilbene and a 1P 21 photo-multiplier is used. Intensities from 0.01 r/hr up to 500 r/hr are measured.

Functions of the AN/PDR-27 and of the AN/PDR-18 are combined in the miniaturized radiac set AN/PDR-32( ). This was developed on the basis of prior researches at the Naval Research Laboratory which disclosed that it was possible to design stable G-M counters having sufficient current to drive an indicating meter without electronic amplification. Subminiature G-M tubes developed for use in this radiac instrument have a sufficiently small dead time so that the instrument can cover the range from .005 to 500 r/hr. These tubes are also beta sensitive. Corrective gamma absorbers have been applied to the tubes in order to make the gamma response as near air equivalent as possible.

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Alpha detection and measurement were approached through the investigation of proportional counter and scintillation techniques. Basic investigations were carried on at the Naval Radiological Defense Laboratory, Naval Research Laboratory, and at commercial activities. A proportional air chamber alpha counter to meet the requirements of portable survey equipment was designed at the Naval Radiological Defense Laboratory. This design was developed by industry and is now in production as the Radiac Set AN/PDR-10A. The AN/PDR-10A has a background count of less than 3 cpm and covers the range from 0 to 10,000 cpm with a relative geometry of 15%. As a result of the scintillation counter investigation portable alpha scintillation equipment was designed and is now in process of engineering development.

1.3.2 Previous Tests

In the spring of 1951 at Eniwetok (Operation GREENHOUSE) representatives of the U. S. Army Signal Corps, Atomic Energy Commission, and the Federal Civilian Defense Agency jointly field-tested a group of military and AEC type survey instruments. The tests included ground area surveys, surveys of contaminated aircraft, and personnel decontamination operations. Complete maintenance records were compiled by the repair facility. Conclusions were reached and recommendations made regarding test methods, general design criteria, adequacy of Military Characteristics, and the adequacy of the instruments for field applications. For further information see "Report, Project 5.1, Operation GREENHOUSE, Evaluation of Ground Radiac Equipment."

1.4 INSTRUMENTATION

The following radiac meters were tested:

Radiac Training Set AN/PDR-T1B

Radiac Set AN/PDR-27( )*

Radiac Set AN/PDR-18

Radiac Set AN/PDR-32

---

* The symbol ( ) denotes the existence of several modifications of this instrument. Remarks referring to the AN/PDR-27( ) pertain to all the modifications.

[redacted]

Radiac Set AN/PDR-10A

Radiac Set AN/PDR-34

Dose Dose-Rate Meter

Calibration was performed by means of Co^{60}.

1.5 OPERATIONS

The radiac instruments to be field-tested were assigned to the Project and Rad-Safe personnel who operated the instruments and prepared operator evaluation reports based on their findings during the project monitoring, health physics, and decontamination monitoring. The instruments for informative testing were given to selected personnel who used the equipment in their specific operations and prepared operator evaluation reports on the results. All operator evaluation reports were filled out on a special form which is shown in Figure 1.1.

Maintenance work was performed in the electronics repair shop. Complete records were kept of all repair work performed on the field-tested instruments. A simple maintenance form was employed. See Figure 1.2.

The operator and maintenance forms were collected and evaluated by representatives of the Army and the Navy. From this it was possible to determine the usefulness of the field-tested instruments in the operation for which they were used.

1.6 RADIAC TRAINING SET AN/PDR-T1B

1.6.1 Results

The Radiac Training Set AN/PDR-T1B (Ion chamber, 0-50 r, gamma) (Figure 1.3) was used for area survey, project monitoring and cloud sampling. The set proved satisfactory as an interim gamma instrument for the above mentioned operations. As the standard Rad-Safe survey meter, the T1B received the widest use of any radiac instrument used on this operation. Thus it was possible to thoroughly field-test this set and arrive at specific recommendations which will improve the instrument.

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FIELD QUESTIONNAIRE FOR SURVEY INSTRUMENTS

(Note: The information in these questionnaires will be a valuable aid in improving instrument design. Please help by giving all your comments.)

1. Type of instrument ____________ 2. Serial No.__________

3. Operator's Name ____________ 4. Date __________

5. Condition of Instrument upon issue____________

6. No. hours used ________ 7. Place ____________

8. Types of radiation detected (check). ___Gamma ____Beta _____ Alpha

9. Highest gamma reading _____. 10. Highest total (from all radiation) reading ____________

11. How used (ground-survey, decontamination of personnel, monitoring of aircraft, etc.) ____________

12. Was it adequate for this use?____ Comment ____________

____

____

13. List any other instruments which you think are better for this use _____

____________ Comment ____________

____

14. Were the following satisfactory? Comment below:

a. Weight ____
b. Form ____
c. Shoulder strap ____
d. Resistance to weather ____
e. Ruggedness ____
f. Meter illumination ____
g. Controls ____
h. Range ____
i. Readability ____
j. Accuracy ____
k. Time constant (slow response or meter fluctuation ____
l. Beta detection capability______
m. Alpha detection capability (if used) ______

Comment:____________

____

____

15. Was zero drift excessive?_____ 16. Do switch changes affect the zero?____

17. Was instrument-directionality a problem? ____________

18. Remarks (Other criticisms, suggested improvements, etc.) ____________

____

____

____

____

____

Fig. 1.1 Field Questionnaire for Survey Instruments

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INSTRUMENT MAINTENANCE RECORD

Type: Serial No:

Date	Trouble	Corrective Action (Include Parts Used)	Initials

Fig. 1.2 Instrument Maintenance Record

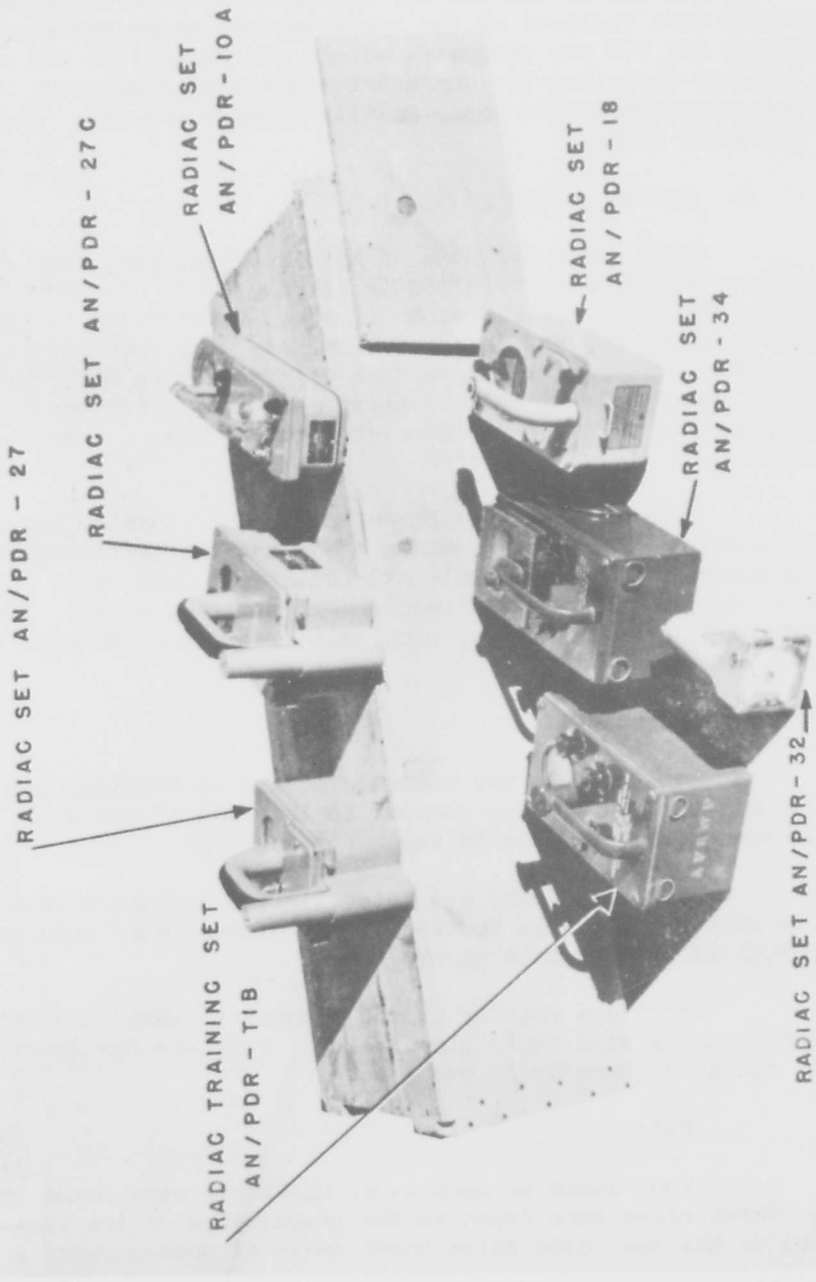

Fig. 1.3 Portable Radiac Survey Equipment

1.6.2 Discussion

In the use of the set for the previously mentioned operations, comments were received on the operation and maintenance of the unit. Although the T1B was adequate, within its range, for the assigned missions, certain objectionable characteristics were disclosed. Elimination of these characteristics would greatly improve the set. The factors are discussed below.

1. Switch Assembly

Over fifty per cent of the troubles, both from operator and repair evaluation, were directly attributed to the wafer and leaf switches. This one trouble alone is almost sufficient to make the set unsatisfactory on the most sensitive ranges. The trouble manifests itself by a wide variety of symptoms such as; failure to zero, erratic meter movement on one scale, erratic meter movement on all scales, full-scale reading on low scale, erratic meter movement when switch knob handled, etc.

The trouble attributed to the leaf type switch was usually corrected by such operations as adjusting the leaf contact, cleaning contacts, etc. The trouble attributable to the range change ceramic wafer switch (slamming of needle when changing ranges, long time constant when changing range, etc.) will require a redesign of the wafer switch.

2. Mechanical

Some trouble was encountered due to breaking off of the lucite studs holding the ion chamber to the rest of the unit. This made the instrument susceptible to shock and jarring.

The switch cams and meter linkage mechanism required adjusting in many cases. This resulted in erroneous meter readings and improper positions of the scale on the meter.

Operators wearing gloves frequently moved the zero control inadvertently with their gloved hand. This was the cause of much of the so-called zero drift problem.

3. Meter

Four cases of open meter movements were found on this operation. Three cases were found in the preparation of the instruments for shipment to the test site while three cases of open movements were found on Operation GREENHOUSE. In none of these cases was there any sign of an overload.

4. Form Factor

The set was found to be excessive in weight and too bulky in size for all operations except cloud sampling.

5. Miscellaneous

Excessive zero drift was found on a few instruments. This became highly objectionable in the cloud sampling when the set was placed directly on the floor of the B-29. In this position the bottom of the set was subjected to a cold temperature resulting in excessive zero drift. This made the equipment useless until placed on a warmer surface.

Difficulty was encountered in calibration. The set must be removed from the case when calibrating, but since the instrument is photosensitive in bright sunlight, the calibration is difficult to do under certain conditions.

6. Range

Range of 50 r/hr found to be insufficient.

1.6.3 Conclusions

The Radiac Training Set AN/PDR-T1B is an adequate military instrument for area survey, project monitoring, and cloud sampling operations requiring a maximum range of 50 r/hr, gamma only. It would be a more satisfactory instrument if certain modifications were made to the set to eliminate the previously mentioned objectionable characteristics.

1.6.4 Recommendations

1. It is recommended that the following modifications be made on all existing and future models of the T1B:

a. Leaf-Switch

Modify to new type to correct existing difficulties.

b. Wafer Switch

Redesign wafer switch to eliminate switching transients.

2. It is recommended that the following modifications be made on all future T1B's:

a. Meter

Replace with better grade of meter or improve quality control on existing meter.

b. Mechanical

(1) Use more adequate studs to fasten ion chamber to brackets.

(2) Move zero control so it cannot be accidentally moved.

c. Calibration

Provide means of calibrating, while set is in case, to protect against light.

3. It is recommended that the following problems be corrected by future development:

a. Form Factor

Make set lighter and smaller.

b. Miscellaneous

Investigate zero drift and temperature dependence.

1.7 RADIAC SET AN/PDR-27( )

1.7.1 Results

The Radiac Set AN/PDR-27( ) (beta, gamma, 0-500 mr/hr G-M type) (Figure 1.3) was used for mobile monitoring, personnel monitoring and area survey. The set proved satisfactory for detecting beta and gamma on the above operations within its low maximum range. For area survey the 27 has a very limited usage due to this extremely low range.

1.7.2 Discussion

The PDR-27( ) was satisfactory as a personnel and vehicular monitoring instrument. The range is too low to make it adequate for area survey. Comments of the users suggested several modifications which would improve the equipment for personnel and vehicular monitoring. These are discussed below:

1. Range

Beta range too low; both tubes should have beta window.

2. Probe

Beta shield easily lost from end of probe; hard to operate shield.

3. Operation

Difference in location of two G-M tubes objectionable; leads to confusion in operation and calibration.

4. Switch

Components mounted on switch wafer required complete disassembly of switch unit to replace them. Connections easily broken in removing and replacing chassis into case.

5. Phone Jack

Collects dust and dirt

6. Form Factor

The unit was found to be excessive in weight for survey work.

7. Strap

The set was found to have an unsatisfactory carrying strap and an unsatisfactory method of attaching the strap to the case.

8. Phones

Ear phones too large; cannot be used under helmet.

9. Calibration

Calibration adjustments are too inaccessible.

10. Carrying case

Carrying Case has excessive number of parts, most of which are never used.

11. Batteries

No check on "B" batteries. Find this is required. "B" batteries on 27 too temperature dependent. "B" batteries on 27C are satisfactory.

12. Nameplate

Nameplate easily scratched off.

1.7.3 Conclusions

The Radiac Set AN/PDR-27( ) is an adequate interim military instrument for mobile monitoring, vehicular monitoring, personnel monitoring, and low-intensity area surveys. The set has insufficient range and is too heavy for general survey work. The 27( ) can be improved with certain modifications based on the comments received during the operation.

1.7.4 Recommendations

1. It is recommended that the following modifications be made on all future models of the 27( ) procured:

a. Calibration

Make calibration potentiometers more accessible.

b. Probe

Redesign beta shield, locate both tubes in probe.

c. Beta

Place beta windows in both tubes.

d. Switch

Relocate components mounted on switch to protect from striking case when removing or inserting chassis.

e. Phone Jack

Place cover over phone jack.

f. Carrying strap

Redesign and lengthen strap; provide more positive attachment to case.

g. Batteries

Place "B" battery-check position on switch. Change "B" battery complement of 27.

h. Nameplate

Require etched or engraved nameplate; decals or silk screen too easily removed in field.

i. Phones

Equip set with phones which can be worn under helmet.

j. Carrying case

Redesign carrying case so that it contains only the instrument.

2. It is recommended that, in future development, instrument weight be reduced.

1.8 RADIAC SET AN/PDR-32

1.8.1 Results

The Radiac Set AN/PDR-32 (beta-gamma G-M type, .005 to 500 r/hr) (Figure 1.3) was tested to obtain data on its operating characteristics. From this it was possible to determine what modifications are required prior to making a production run. Valuable data was obtained and furnished to the sponsoring agency for guidance.

1.8.2 Discussion

Eleven units of the Radiac Set AN/PDR-32 were used during this operation. These units were models produced under a service test type of contract.

The units were used on several types of operations. These included: cloud sampling, rapid aerial survey, area survey, project monitoring, and the troop maneuvers. During the above operations the sets were given to selected personnel for use. Reports were then received on the ability of the set to accomplish its assigned task. Recommendations were received which would increase the effectiveness of the instrument.

No maintenance other than calibration and battery changing was attempted at the site. No spare parts were available for repairs. Those sets requiring repairs were returned to the contractor.

The sets drew favorable comment with regard to size, weight and range.

Difficulty was encountered with the vibrators and voltage regulator tubes. This difficulty resulted in either erratic needle deflections or low readings. The vibrator contacts on several units sparked, because of poor contact alignment, producing erratic deflections of the meter needle. Gas either leaked or was absorbed in the voltage regulator tubes causing the operating voltage point to decrease. These tubes had to be replaced. This difficulty prevented the set from holding its calibration.

The following comments were obtained from users of these equipments:

1. Beta Shutter

Beta-shutter control button requires operator to place finger between the instrument and the beta source. This is objectionable.

2. Carrying Case

A simple carrying case would facilitate the transporting and stowage of the unit.

3. Belt Clip

Allows clip to slip off belt too easily.

4. Earphones

Have a tendency to either slide off or pull on ear. The plastic hearing-aid type of earphone attachment is preferred.

5. Shoulder Strap

Hard to adjust; length too short.

6. Probe

Certain groups expressed a desire for a probe on the equipment.

1.8.3 Conclusions

The 32 shows good promise as a light-weight wide-range gamma-beta survey meter. It should prove satisfactory to perform most of the tasks required for a survey meter of this type providing the voltage regulator, vibrator, and calibration problems are overcome.

1.8.4 Recommendations

It is recommended that the following modifications be made in the production run of the Radiac Set AN/PDR-32:

1. Beta-Shutter Control

Relocate on side of instrument so that operator's hand is away from source.

2. Carrying Case

Provide carrying case for instrument when not in use.

3. Belt Clip

Modify so that a more secure arrangement is provided.

4. Strap

Shoulder strap to be more easily adjusted, lengthen strap.

5. Earphones

Cable should be clipped to clothing so that it does not pull on ear.

6. Vibrator

Increase reliability of the vibrators.

7. Voltage Regulator Tubes

Correct the design so that the tube will not change operating point.

It is recommended that, when the foregoing modifications have been made, sufficient quantities be distributed to all military agencies for Service Testing.

1.9 RADIAC SET AN/PDR-18

1.9.1 Results

Two units of the Radiac Set AN/PDR-18 (gamma, 0-500 r/hr scintillation counter) (Figure 1.3) were given limited field use in area surveys during the operation. These units gave an adequate performance in this use.

1.9.2 Discussion

The use of this equipment was so limited that a true evaluation of this type of equipment cannot be made.

1.9.3 Conclusions

This equipment gave adequate performance for its limited use in area survey. The PDR-18 is too heavy for general area survey work.

1.9.4 Recommendations

It is recommended the set be further tested when available in numbers. It is also recommended that further development of this instrument be reviewed in light of the present status of the AN/PDR-32.

1.10 RADIAC SET AN/PDR-34

1.10.1 Results

The Radiac Set AN/PDR-34 (alpha, 0-50,000 K D/M; beta, indicating; gamma, 0-50 r/hr; ion chamber) (Figure 1.3) was used for area survey in areas contaminated with alpha particles. The set performed satisfactorily for the assigned mission as an alpha survey meter.

The PDR-34 is a modified T1A which is similar to the T1B; therefore, in general, characteristics of the T1B can be assumed to apply to the 34 as far as gamma detection is concerned. The 34 was not used as a beta instrument on this operation. For an evaluation of the AN/PDR-34 as a beta instrument, see the Report, Project 5.1, "Evaluation of Ground Radiac Equipment", Operation GREENHOUSE.

1.10.2 Discussion

Comments were received on the use of the PDR-34 as an alpha meter. The instrument was satisfactory as an alpha survey meter but the comments pointed out details which, if corrected, would make the instrument much more satisfactory. The comments are discussed below.

1. Zero Drift

Some difficulty was encountered with excessive zero drift on the more sensitive ranges. This proved objectionable.

2. Window

The windows were frequently damaged during operation. Although the sets continued to opeqrate until repaired, some additional protection should be afforded the window.

3. Form Factor

The device was found to be excessive in weight.

4. Probe

A probe would be desirable for use as an alpha instrument in personnel and vehicular monitoring.

5. Scale

Scale marking is confusing in differentiating between D/M and r/hr.

1.10.3 Conclusions

The AN/PDR-34 proved to be an adequate military instrument for area survey of alpha contaminated regions. As a personnel or vehicular monitoring instrument the set requires a probe. The 34 has the same gamma characteristics as the T1B. For usefulness as a gamma instrument refer to section on Radiac Training Set AN/PDR-T1B. See the report, Project 5.1, Operation GREENHOUSE, "Evaluation of Ground Radiac Equipment", for conclusions regarding the 34 as a beta instrument.

1.10.4 Recommendations

1. The AN/PDR-34 is a modified Radiac Training Set AN/PDR-T1A. It is felt that many of the objectionable characteristics encountered with the T1B may apply to the 34. Since the T1B has replaced the T1A, it is recommended that future versions of the instrument be modified T1B's and include all recommendations made in this report for that instrument.

2. It is further recommended that the following modifications be made on all future 34's procured:

a. Window

Some form of window protection should be devised consistent with technical requirements of the equipment.

b. Scale

Mark scale for gamma and alpha radiation units.

3. It is recommended that the following problems be corrected by future development:

a. Zero drift

Zero drift be investigated and reduced.

b. Probe

A probe should be provided for use as a personnel or vehicular monitoring instrument.

1.11 RADIAC SET AN/PDR-10A

1.11.1 Results

The Radiac Set AN/PDR-10A (Alpha, proportional counter type, 0-10,000 c/m) (Figure 1.3) was used for area survey, personnel monitoring, and vehicular monitoring to detect alpha contamination. The set performed satisfactorily on all three of the above type operations.

1.11.2 Discussion

The 10A was satisfactory as an alpha meter for area survey. It should be modified for use as a personnel or vehicular monitoring instrument. Comments were received suggesting this and other modifications which would improve the instrument considerably. The comments are discussed below:

1. Time constant

The time constant of the instrument was excessive, thus preventing a quick return of the meter needle with a drop in field intensity. During the time the needle was returning the change in field intensity could not be detected in the earphones.

2. Window

The windows were frequently damaged during operation. It was still possible to operate the equipment until repairs could be made.

3. Range

Contamination levels were encountered which were beyond the range of the instrument.

4. Probe

A probe is required for use as an alpha instrument in vehicular and personnel monitoring.

5. Operating Instructions

It was noted that most equipment operators failed to read the instruction book. To properly operate the 10A it is necessary that the operator follow a certain procedure which is not evident upon examination of the controls. Therefore it is desirable that simplifed operating instructions be printed on the case of the 10A.

6. Alpha Source

Inconvenient to use since it is mounted in carrying case.

1.11.3 Conclusions

The AN/PDR-10A proved to be an adequate military instrument for area survey of alpha contaminated areas within its range. If desired for use as a personnel or vehicular monitoring instrument the 10A shoul be provided with a probe.

1.11.4 Recommendations

1. It is recommended that all future models of the Radiac Set AN/PDR-10A be modified as follows:

a. Time constant

Time constant be lowered considerably.

b. Window

Some sort of window protection should be devised consistent with technical requirements of the equipment. Standoffs should be provided to allow the operator to set the instrument down without danger of puncturing the window or contaminating the base.

c. Range

Range be increased,

d. Operating Instructions

Print abbreviated operating instructions on plate attached to set.

e. Alpha Source

The alpha source should be mounted on the instrument case.

2. It is recommended that in future development an alpha probe be added.

1.12 DOSE DOSE-RATE METER

Several models of a self-indicating dosimeter attachment for a dose dose-rate meter were present on the operation.

A device of this type is convenient when the personnel are in a high field (1 r/hr or more) and wish to have a quick continuous means of determining total dosage.

It is recommended that further work be done on a small, simple, integrating dosimeter to be used with a survey meter.

1.13 GENERAL CONCLUSIONS

In general the T1B and 27( ) serve as an adequate interim military set of instruments. The sets can be made more satisfactory if certain changes are made in the existing models. The T1B to be used for area survey, operations monitoring, and cloud sampling, while the 27( ) to be used for vehicular monitoring, personnel monitoring, mobile survey, and low-range area survey.

In the field of alpha instruments, the 34 and 10 appear to be satisfactory from a military standpoint. The 34 is best used as an area survey instrument; the 10A, being lighter, is better for personnel and vehicular monitoring and is adequate for area survey. Both sets should have a probe for any required extensive use in personnel and vehicular monitoring.

1.14 GENERAL RECOMMENDATIONS

In general, the present instruments suitable for immediate use, the T1B and 27( ), should be subjected to certain modifications; with these changes the instruments would be entirely satisfactory, within their range, for military use until newer light-weight instruments are available. However, future designs of survey instruments should have a range of 500 r/hr.

It is recommended that the proposed changes in the T1B and 27 ( ) be instituted on all future models procured. It is additionally recommended that the modifications suggested for existing models be made immediately.

In the field of alpha instruments it is recommended that the existing units (AN/PDR-10A and AN/PDR-34) be modified as indicated and, in view of the slight demand, be retained as the standard alpha instruments.

[redacted]

PROJECT 6.1

It is recommended that maximum effort in the field of radiac instrumentation be applied to the development of light-weight instruments, both ionization chambers and G. M. types.

1.15 NEED FOR FUTURE TESTS

It is felt that tests of the type performed at the Nevada Proving Grounds are valuable in the development of better radiac instruments. It is recommended that the tests be continued at future operations. These tests should include new models of instruments as well as those tested on this program. There is no need, however, to retest the present instruments until the recommended changes have been made in a sufficient number of units to permit evaluation of the changes.

1.16 IMPROVEMENT OF TEST METHODS

On future tests it is recommended that the Radiac Instrument Evaluation Project be more fully integrated into the instrumentation program of the entire operation. In addition, it is recommended that personnel carrying evaluation instruments be assigned as partners to Rad-Safe personnel to accompany them on all operations to permit varied use of equipment. A central instrument repair facility should be provided and staffed by personnel who are normally responsible for this type of operation in the service.

It is further recommended that, it addition to production run equipment, experimental and developmental types be tested at future operations. This would furnish valuable information to the developing laboratory.

Varied uses of standard instruments were noted on the operation. It is recommended that future tests include the investigation of uses of standard meters other than for routine survey work and monitoring. This could include such applications as the use of survey instruments to determine half-lives.

[redacted]

TABLE 1.2
SUMMARY OF RADIAC METER EVALUATION

TYPE	PRIMARY USES	RADIATION DETECTED	FULL SCALE RANGE	DETECTOR STAGE	PROBE	CARRYING WEIGHT (lbs)
AN/PDR-T1B	Area Survey (gamma)	gamma	0-50r/hr	Ionization Chamber	No	10
AN/PDR-27 AN/PDR-27C	Vehicle and personnel monitoring	beta gamma	0-500mr/hr gamma 0-5mr/hr beta	GM Tube	Yes	9.4-27 14---27C
AN/PDR-32	Area Survey (gamma)	beta gamma	.005 - 500 r/hr	GM Tube	No	2.5
AN/PDR-18	Area Survey (gamma)	gamma	0-500r/hr	Scintillation	No	8.5
AN/PDR-34	Area Survey (alpha, gamma)	alpha, beta, gamma	alpha: $0\text{-}5\times10^{7}$ D/M; beta-gamma 0-50rep/hr	Ionization Chamber	No	10
AN/PDR-10A	Area Survey (alpha)	alpha	0-10,000 CPM	Proportional Counter	No	7.6

[redacted]

TABLE 1.3
SUMMARY OF RADIAC METER EVALUATION

TYPE	QTY	DIMENSIONS (ins.)	BATTERY LIFE (hrs.)	MOST FREQUENT CASUALTY	MOST FREQUENT OPERATOR'S CRITICISMS
AN/PDR-T1B	180	7.5x6x10	600 fil 2000 plate	Leaf switch defective	1. Excessive size & weight 2. Switching transients on low range 3. Range too low
AN/PDR-27 AN/PDR-27C	87 52	8x5¼x10--27 8x6x12--27C	40 40	Non Jan Batteries defective in 27	1. Excessive size & weight 2. GM tubes not at same location 3. Range too low
AN/PDR-32	11	3¼x3x6½	20	Vibrators & voltage regulator tubes defective	1. Failed to remain in calibration 2. Beta-shutter control button location objectionable
AN/PDR-18	2	8x5¼x10 5/8	40	(insufficient no. tested)	1. Excessive size & weight
AN/PDR-34	16	7x5x6x10	600 fil 2000 plate	Windows frequently damaged during operation	1. Excessive size & weight 2. Excessive zero drift 3. Lack of probe 4. Poor scale marking
AN/PDR-10A	20	6¼x4¼x13	40	Windows frequently damaged during operation	1. Excessive time constant 2. Low range 3. Lack of probe

[redacted]

CHAPTER 2

RAPID SURVEY

2.1 ABSTRACT

By means of suitable techniques, without special or non-standard equipment, it was found practical to conduct a rapid aerial survey of a highly contaminated ground area as a military tactical operation in support of ground forces following a contaminating burst of an atomic bomb.

2.2 OBJECTIVE

The need for a method of rapid survey of a contaminated area is evident. It had been proposed that a low-flying aircraft equipped with standard field radiation instruments might be able to obtain this information. The test involved an application of this idea to analyze the possibilities for military use.

2.3 HISTORICAL AND THEORETICAL

Rapid surveys have been attempted on previous operations with various types of equipment. As far as is known this was the first attempt made for tactical applications.

2.4 INSTRUMENTATION

A Radiac Training Set AN/PDR-T1B connected to a d.c. linear amplifier and Esterline-Angus recorder was placed in a standard C-45 type aircraft. The recorder and amplifier were not required for the obtaining of data but were added merely to aid in a cross check of the techniques with other measurements. Actual field surveys would be done without the amplifier and recorder, which are military non-standard pieces of equipment. See figures 2.1, 2.2, 2.3 and 2.4. The field strength encountered by the aircraft appeared on the T1B meter scale and was recorded on the recorder chart. When properly calibrated the recorder charts indicated the dose of the radiac set.

The entire unit was placed inside the plane without any modification of the aircraft. All components were battery operated.

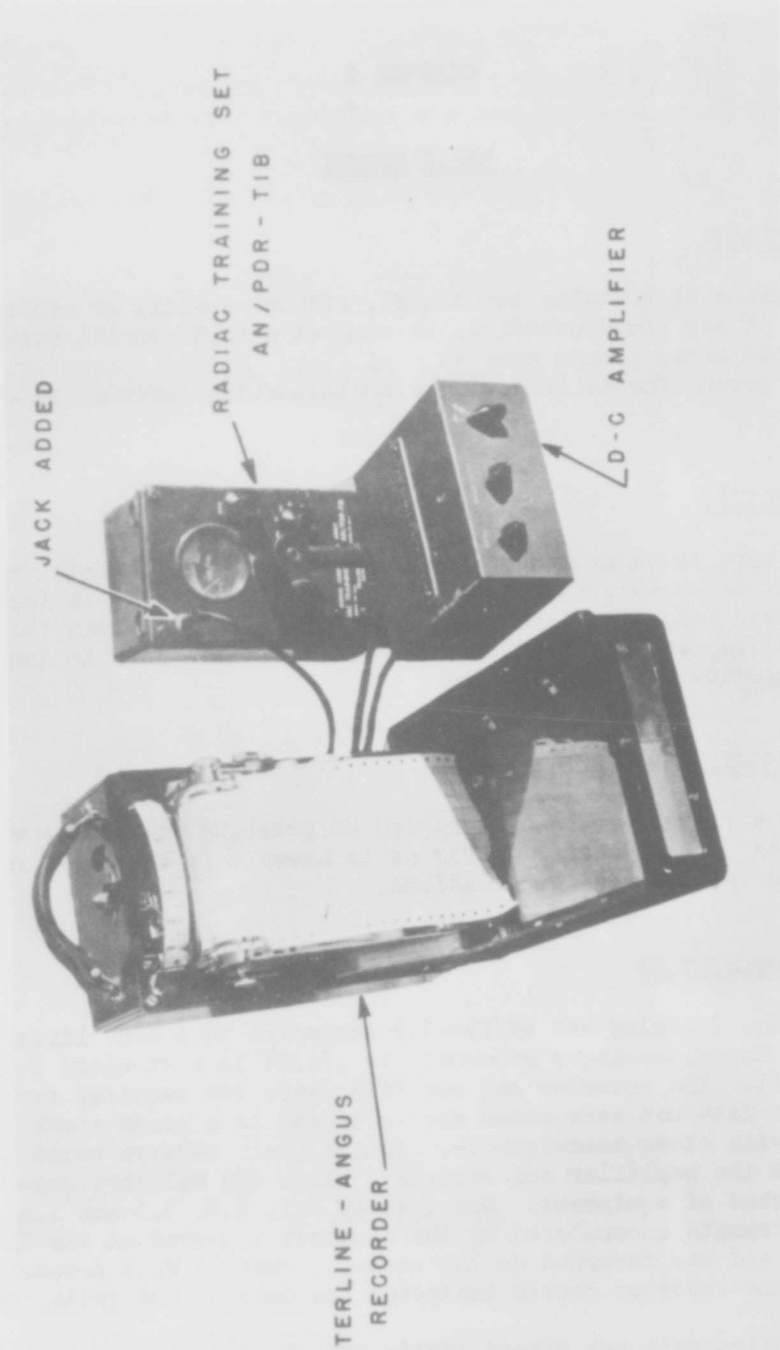

Fig. 2.1 Rapid Aerial Survey Equipment

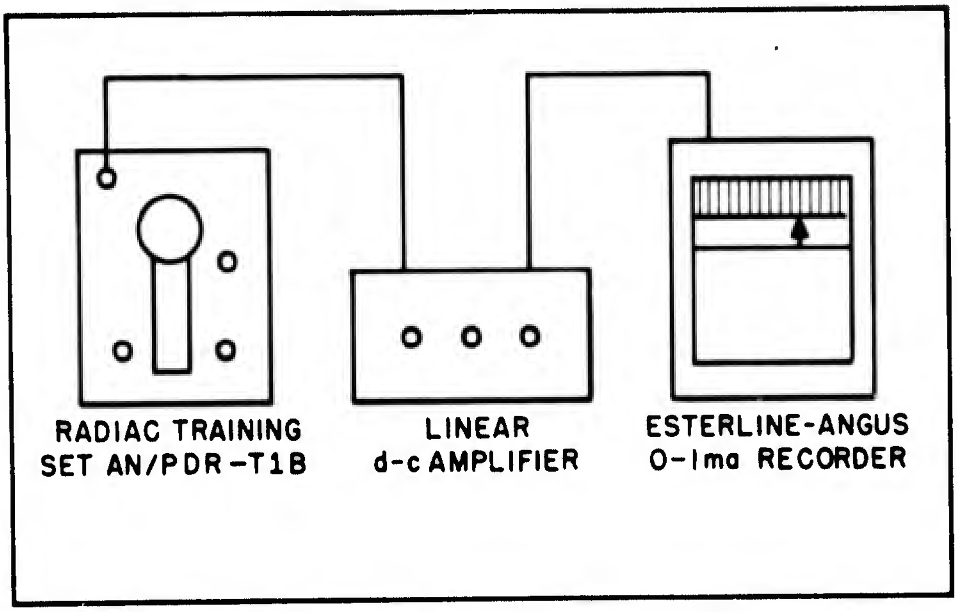

Fig. 2.2 Block Diagram of System

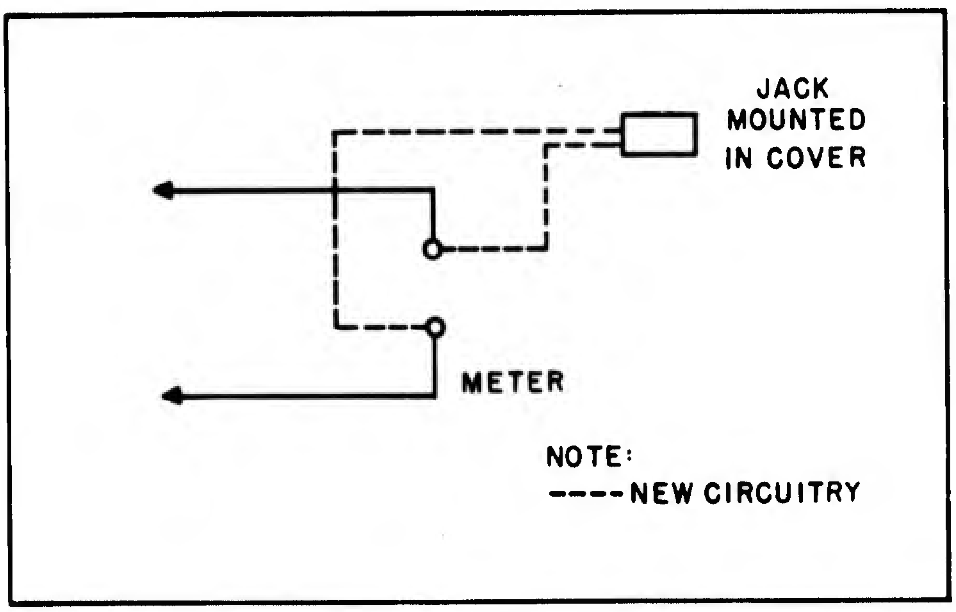

Fig. 2.3 Circuit Diagram, Modification of AN/PDR-T1B

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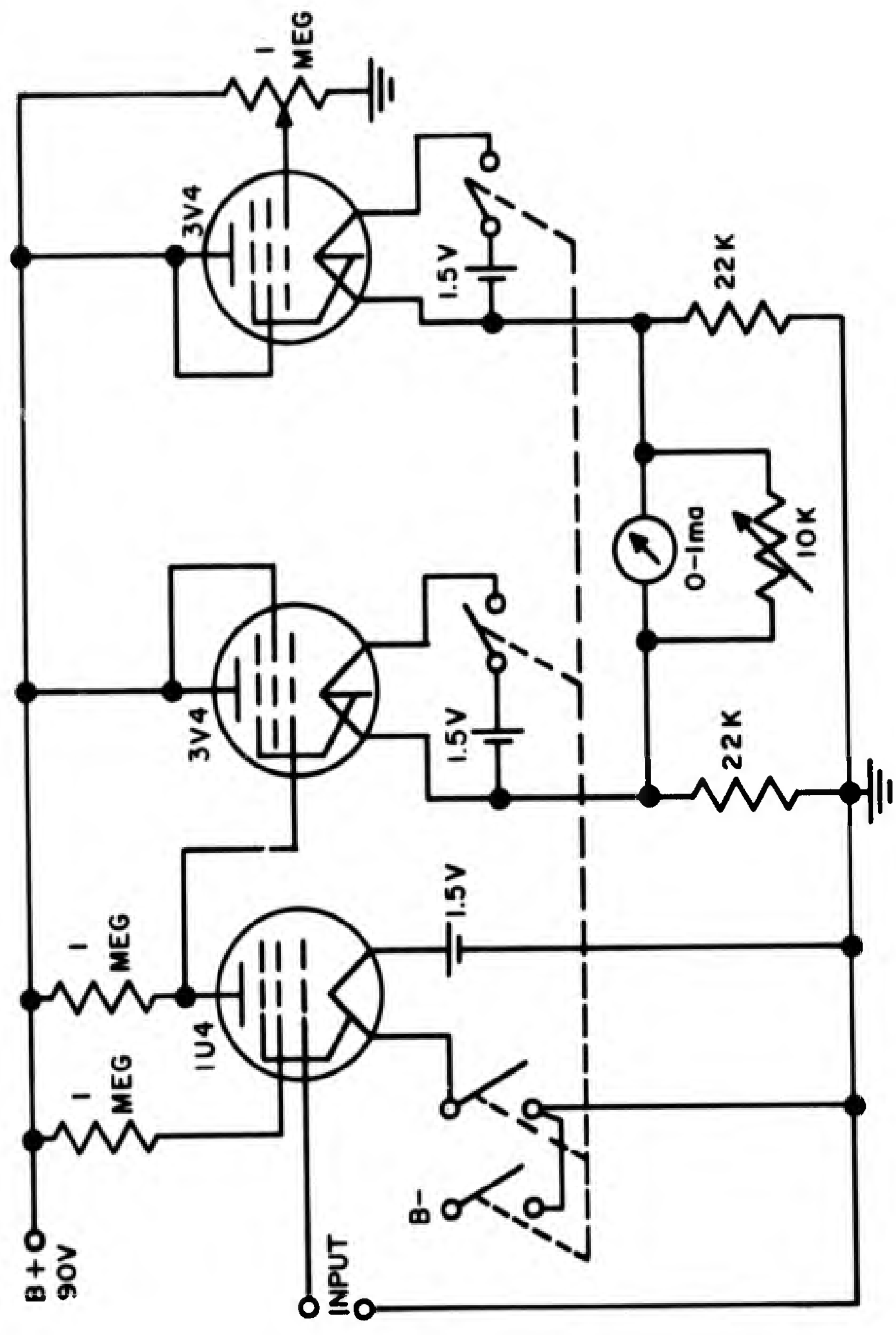

Fig. 2.4 Circuit Diagram, d-c Linear Amplifier

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2.5 OPERATIONS

The rapid survey equipment was placed in a standard C-45 aircraft which flew low over the contaminated area. The pilot was briefed on a flight pattern and the recorder charts were referenced in accordance with this pattern. The charts were then evaluated with respect to altitude, speed of aircraft, etc., thus providing a plot of the residual radiation field.

2.6 RESULTS

A rapid aerial survey of a highly contaminated area was attempted and proved to be very successful. It was possible to plot, from the air, both the center of the contamination and the area of highest fall-out intensity.

2.7 DISCUSSION

Two types of rapid aerial survey were made on this operation; survey of center of contamination; and determination of high-intensity fall-out pattern.

2.7.1 Survey of Center of Contamination

The plane carrying the survey equipment was assigned a flight pattern over the suspected center of contamination. This flight pattern was repeated at several altitudes, the plane descending five hundred feet each time, until levels were reached which exceeded the maximum range of the equipment. The recorded data was then examined. From this it was possible to determine an approximation of the intensity of the contamination. The results obtained are shown plotted in Figures 2.5 and 2.6. These show the use of the data to obtain the extrapolated intensity, at the ground, in the contaminated area.

2.7.2 Determination of Fall-out Pattern

The plane was assigned a flight plan consisting of a series of circles around the determined center of contamination. Examination of the data from each circle located the fall-out between two azimuths. The flight pattern was then changed so that the plane flew a series of radials over the suspected fall-out area. The flights were made at a low enough altitude so that significant data was obtained. From the recorded data it was then possible to make an approx-

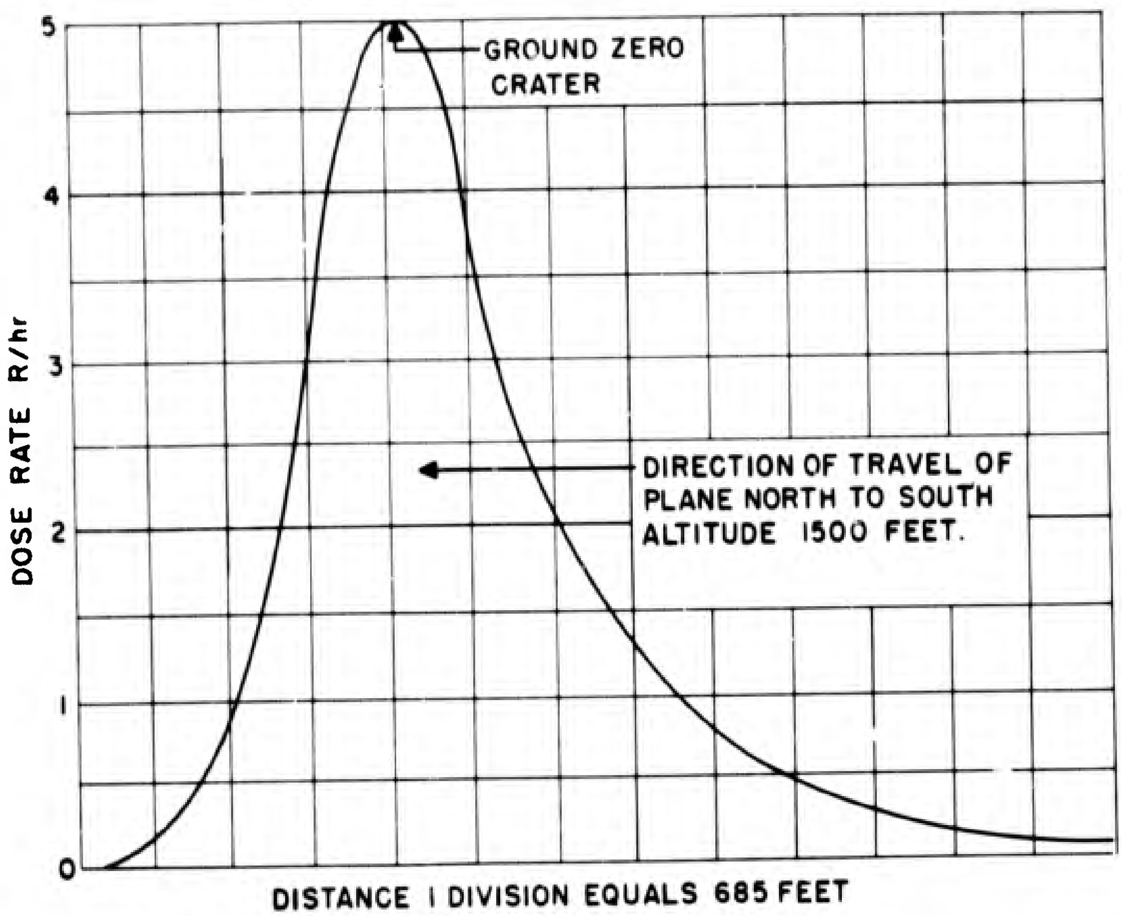

Fig. 2.5 Location of Center of Contamination

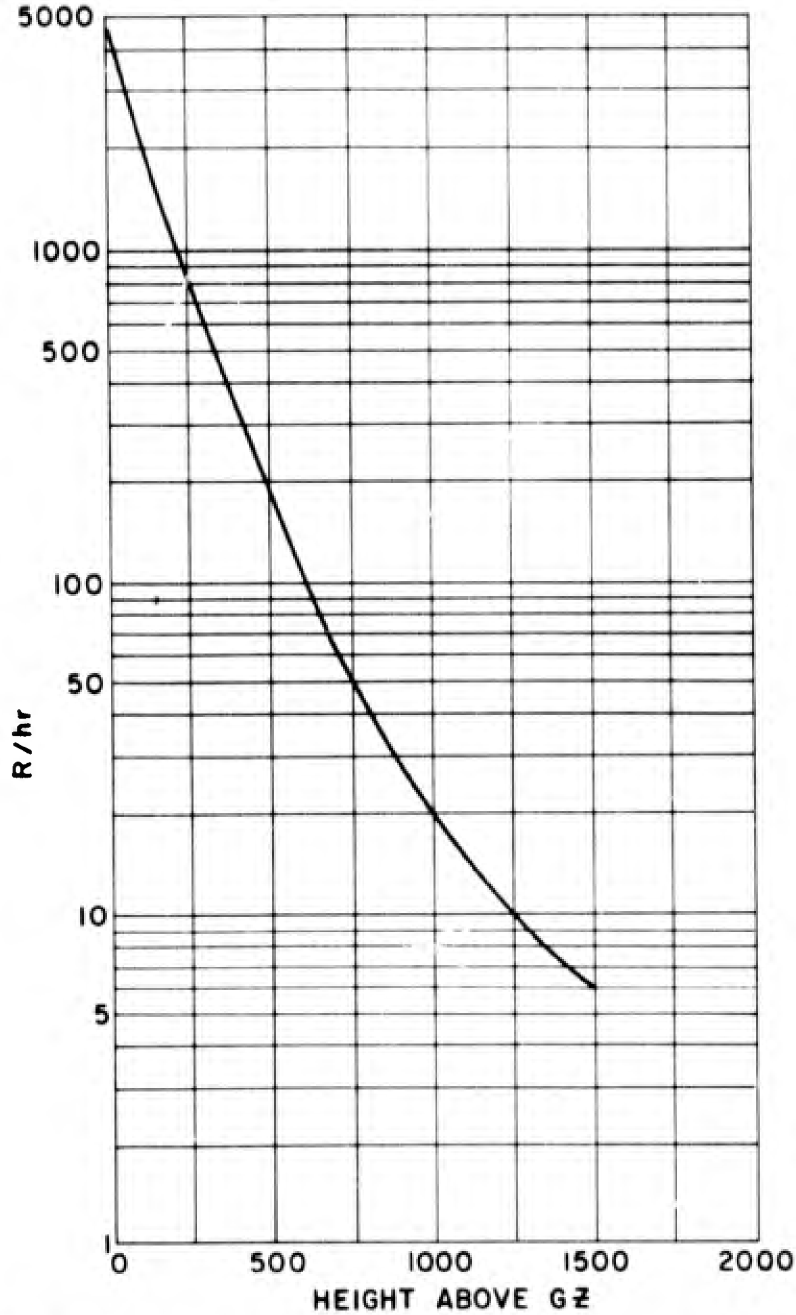

Fig. 2.6 Dose Rate Extrapolated to Crater, Surface Shot

imate plot of the fall-out pattern. By repeating this process at several different altitudes it would have been possible to extrapolate the curves and obtain an indication of the level of ground contamination. The type of results obtained for a pattern are shown in Figure 2.7.

2.8 CONCLUSIONS

This operation has shown that it is entirely feasible to make a rapid survey, from the air, of a highly contaminated area in a short time compared to that required for a mobile survey. No attempt was made to survey weak fields from the air.

Although the survey was made using a recorder, it is felt that the system could be applied to a survey meter without any auxiliary equipment. A very rough approximation could be obtained by merely recording the readings by hand and correlating them with the position of the plane.

2.9 RECOMMENDATIONS

It is recommended that this method of area survey be subjected to further development. On future tests a team should be formed and assigned a mission of plotting all high level contamination fields. This would provide additional information on the usefulness of the method and, at the same time, provide training for a military area survey team.

It is recommended that this method be given serious consideration as a military tactical survey plan.

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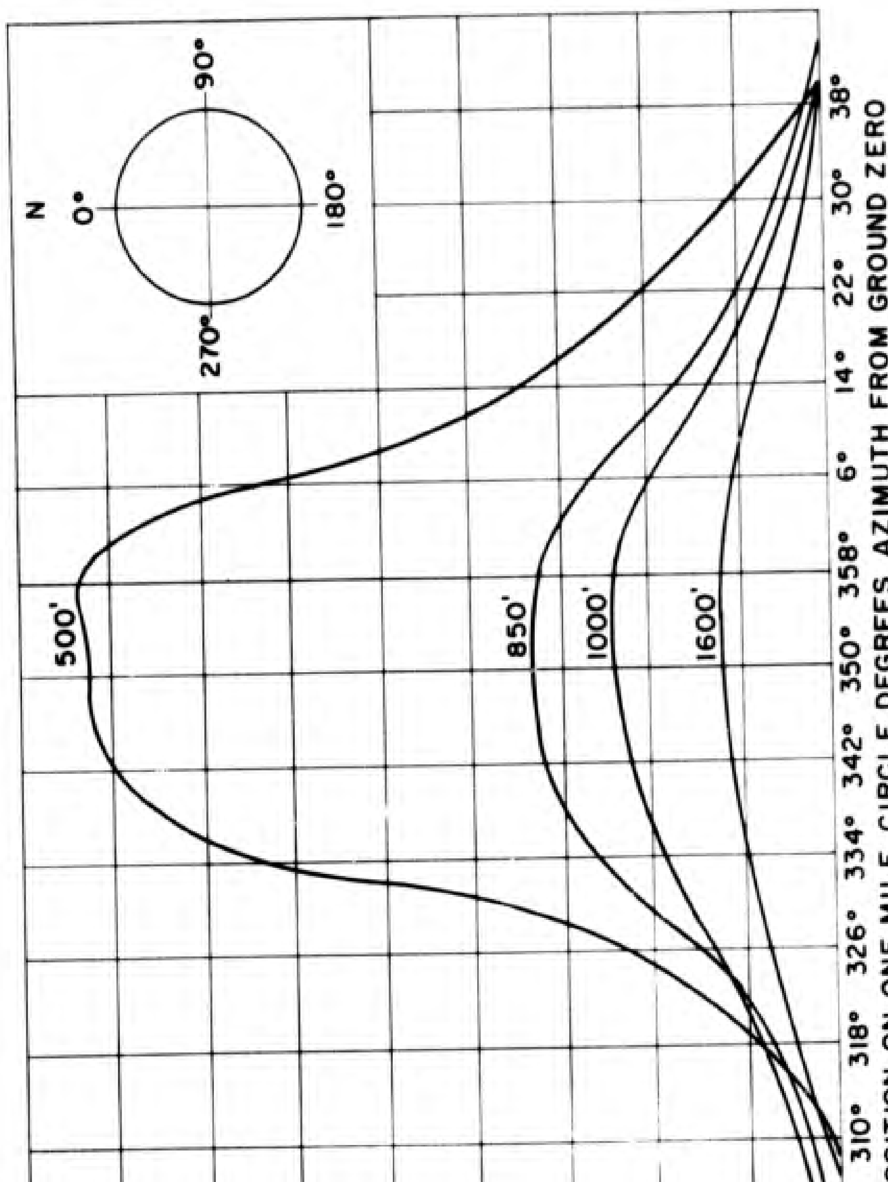

Fig. 2.7 Dose Rate as Function of Azimuth for Circle of One Mile Radius Around Center of Contamination

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CHAPTER 3

AUTOMATIC FILM-PROCESSING UNIT

3.1 ABSTRACT

The present automatic processing unit was tested and found impractical for the development of film records of radiation dosage under field conditions.

3.2 OBJECTIVE

There exists a need for a portable or mobile means of processing dosimeter film badges. Up to the present test this was actually carried out manually in fixed installations. The requirement for processing facilities has been a serious drawback to the use of photographic dosimeters. During this series of tests an automatic film-processing machine, mounted on a 2½ ton truck, was tested under various operating conditions.

3.3 HISTORICAL AND THEORETICAL

No specially designed automatic film-processing units have been previously field tested.

3.4 INSTRUMENTATION

A specially designed film-processing unit, viz, the Radiological Film Processing Set AN/TSQ-2(XM-1), was placed in a K-53, 2½ ton 6x6 truck.

The processing unit was designed to process standard film badges on a continuing basis. The unit carries its own water supply and continually purifies the water by means of ion-exchange columns. An automatic metering system replenishes the chemicals in each processing tank at a predetermined rate. The unit has heaters and coolers to maintain a constant temperature in all tanks.

The apparatus was designed with the aim of obtaining reproducibility of results, thus allowing comparison of film put through at different times without elaborate cross-calibration.

3.5 OPERATIONS

The automatic film-processing unit was tested as to its ability to process film during the operation. Tests were made on the effectiveness of the various components of the set.

3.6 RESULTS

The AN/TSQ-2(XM-1) was unsatisfactory as a film-processing unit on this operation. It was not possible to properly develop film on runs longer than approximately twenty minutes.

3.7 DISCUSSION

Short batches of films, such as calibration films, were developed satisfactorily if the total running time was considerably less than twenty minutes. Longer batches of films were improperly developed. Examination showed that the successful short batches were completed while the developer was still fresh, while the longer batches, even though in fresh developer, failed to develop properly because the developer oxidized excessively. The machine was so designed that an automatic metering device constantly replenished the chemicals and thus attempted to maintain a state of uniform freshness. In developing long batches of films it was found that the desired state of freshness was not maintained in the developer. This proved to be a serious defect in the machine since it prevented uniform developing for periods exceeding twenty minutes.

Additional difficulties in the machine involved the numbering punch, loading techniques, and accessibility of components with regards to maintenance. The number punch failed to operate properly and was poorly located. The loading of film into the machine was a difficult and laborious task. The operator encountered considerable fatigue in this step of the operation. It was necessary to do a certain amount of repair work on the pumps in the machine. This involved a major teardown of the entire unit. Examination of the machine disclosed that considerable difficulty would be encountered in any repair work.

3.8 CONCLUSIONS

The film processing unit requires additional engineering development before it will be ready for full field use. The feasibility of the device is proven in the ability to process short runs of film satisfactorily under proper conditions of developer freshness. The unit fails in that this condition cannot be maintained for periods of time exceeding twenty minutes. This makes the machine of little value in its present condition.

On this operation, the film that was to have been machine-developed was actually developed by hand. It was noted that the loading, developing, washing, and drying time, was not the limiting factor in the overall rate of film handling and processing. The time-consuming operations were those involving removal of the film from the packets, reading of the film on the densitometer, recording of results, and various other handling details. Thus the automatic processing machine does not tend to alleviate the most time-consuming problem involved in the film processing and handling. Actually it was possible, on this operation, for one man operating in the Film Processing Unit AN/TFQ-7 (XM-1) to develop, by hand, more film per hour than the automatic machine can process at its theoretical maximum speed of 600 badges per hour. Thus the question arises as to the value of such an automatic film-processing unit.

3.9 RECOMMENDATIONS

If a need for such a unit exists, it is recommended that the processing unit be returned to the laboratories for further engineering development. A detailed report of the difficulties has been furnished the responsible laboratory.

It is further recommended that the necessity for such a unit be reevaluated. Operations on this test indicated a need for a unit containing space for film handling, sorting, densitometric work, bookkeeping, and processing. The processing, from a time standpoint, can readily be handled by manual means and still maintain the production level of the rest of the operations. This point was very markedly evidenced on the subject test. It is recommended that future development work on field film badge processing units be centered around a film badge handling center with relatively simple equipment.

[redacted]

CHAPTER 4

AIR MONITORING

4.1 ABSTRACT

Laboratory models of air samplers were tested and good results obtained. The work on these devices is still in the development stage and the question of military need or adequacy could not be determined from these tests.

4.2 OBJECTIVE

Portable monitoring equipment to determine the air loading of radioactive particles over a range of particle sizes would be valuable in determining the radiation hazard in an area. Laboratory models of such equipment were tested to determine the feasibility of portable monitors and to obtain information for future development.

4.3 HISTORICAL AND THEORETICAL

A number of large, fixed installations for air monitoring have been designed and are in use. Mobile equipment has also been developed and used with some success. However, portable equipment is not available at the present time.

Air monitoring is accomplished by drawing the air through a suitable filter paper and measuring the activity of the material thus collected with a beta-sensitive counter. The counter gives a continuous current indication proportional to the activity of the sample.

4.4 INSTRUMENTATION

The primary components were a blower, a collection device, and a counting system. See Figures 4.1, and 4.2. The counter used a vacuum-tube voltmeter type indicator and differential chambers. The output of the counting system was automatically recorded. The slope of the counting rate curve was proportional to the air loading.

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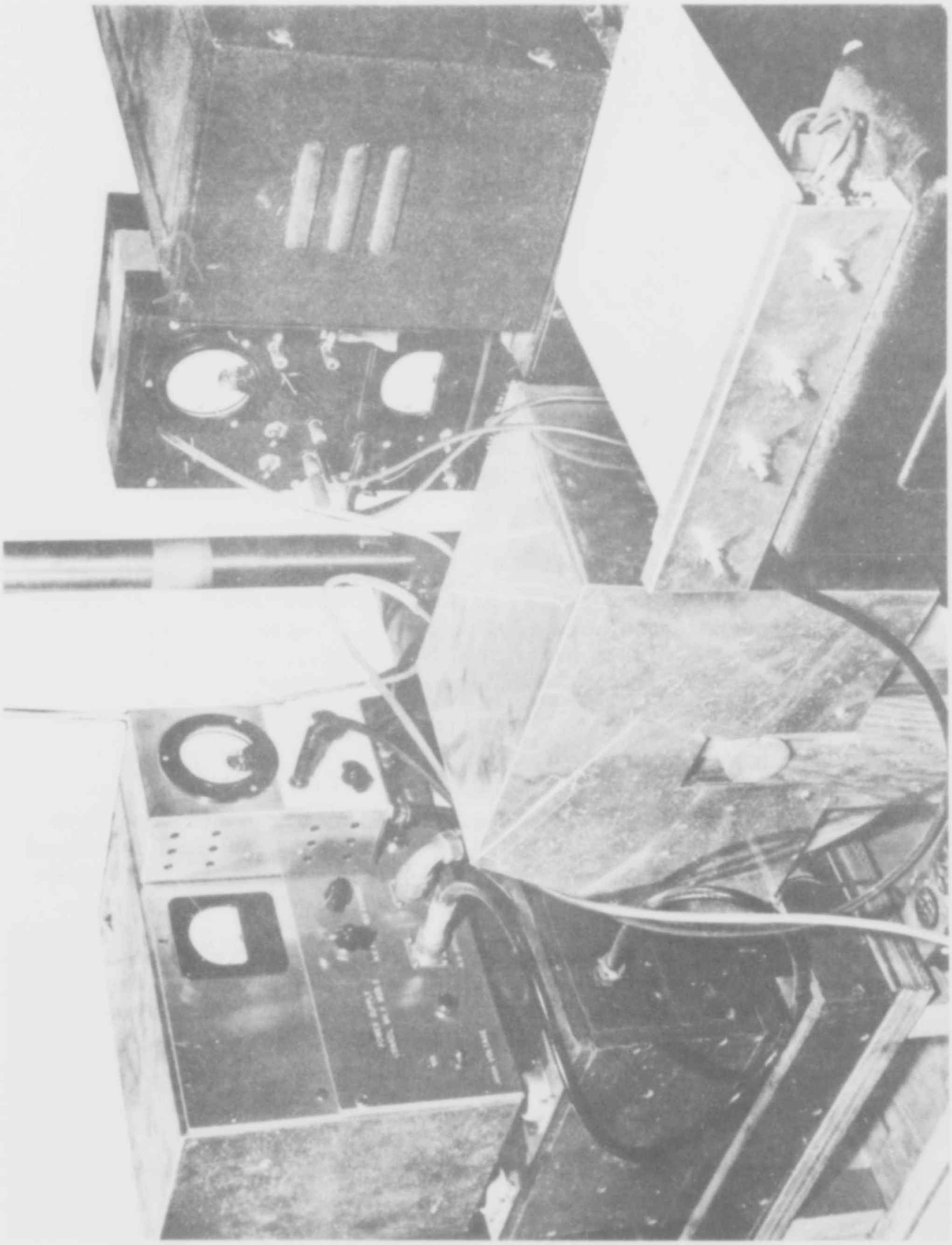

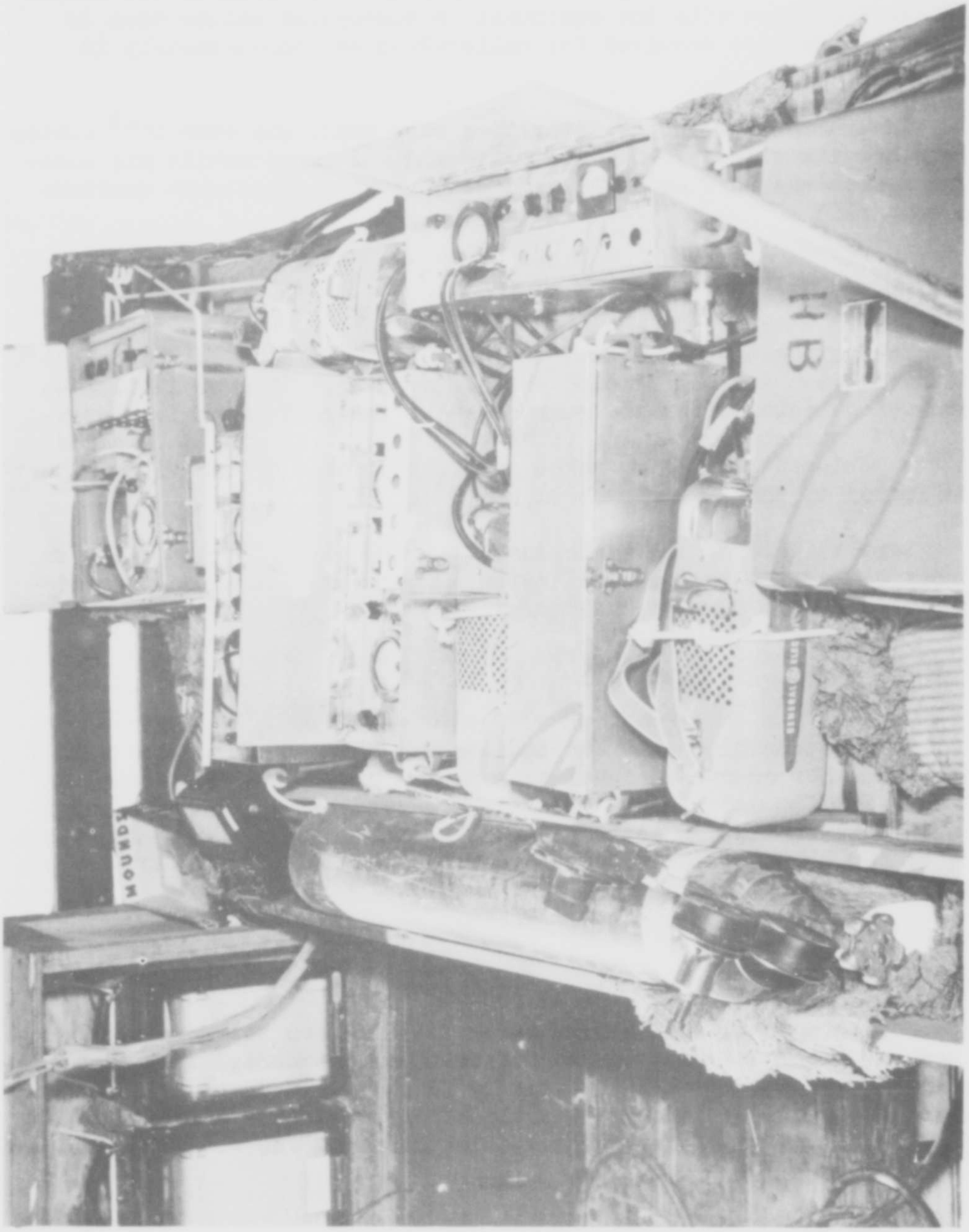

Fig. 4.2 Air Monitor Equipment

The filter paper was mounted in filter packs enabling the operator to replace the filters in the apparatus in approximately 10 seconds. Standard beta samples, which had the same form as the filter packs, were carried with the equipment to accomplish calibration in the field. The time required for calibration was approximately 10 seconds.

Instruments of two sensitivities were used; one with 10^{-3} curies $/m^3/min$ and six with 5×10^{-2} curies$/m^3/min$. A large mobile air monitoring system was used as a standard with which the portable monitors were compared.

4.5 OPERATION

The equipment was taken into the radiation field subsequent to both the surface and underground shots. However, since no inhalation hazard was detected after the surface shot, the most extensive operations were conducted after the underground shot. It should be noted that the equipment was never taken into any portion of the visible dust cloud formed at the time of the blast.

Samples were collected beginning 55 minutes after the blast on shot day and on the two days following. They were collected in radiation fields from 200 mr/hr to 10 r/hr.

4.6 RESULTS

It was possible, with the equipment tested, to determine within ¼ minute whether or not an inhalation hazard existed in the area. On shot day, for the underground explosion, hazards of the order of 2000 times the AEC inhalation tolerance were found. On D + 1 hazards of the order of 500 - 1000 times tolerance were detected and on D + 2 approximately 300 times tolerance.

4.7 DISCUSSION

During operation in a high gamma field it was not possible to balance out the gamma flux in the differential chambers. This resulted from the large numbers of low energy gamma rays entering the lower chamber. However, by lowering the collecting voltage and recalibrating the field, it was possible to operate in the gamma field.

4.8 CONCLUSIONS

Portable air-monitoring equipment can be developed to detect radiological inhalation hazards. The equipment tested during this operation, though satisfactory for laboratory measurements, is not ready for any military use. Valuable information was obtained to aid in the further development of this equipment.

4.9 RECOMMENDATIONS

It is recommended that portable air monitoring equipment be further developed and then given additional field tests.

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