2

DNA-TR-85-13-AP-H

INTEGRATED BATTLEFIELD EFFECTS RESEARCH FOR THE NATIONAL TRAINING CENTER

Appendix H—Designs of Nuclear and Chemical Field Simulators for the National Training Center

Science Applications International Corporation
P. O. Box 2351
La Jolla, CA 92038-2351

31 December 1984

Technical Report

CONTRACT No. DNA 001-81-C-0273

THIS WORK WAS SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODE S400082466 V99QAXNL00125 H2590D.

DTIC
ELECTE
APR 10 1986
B

Prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, DC 20305-1000

DISTRIBUTION LIST UPDATE

This mailer is provided to enable DNA to maintain current distribution lists for reports. We would appreciate your providing the requested information.

☐ Add the individual listed to your distribution list.

☐ Delete the cited organization/individual.

☐ Change of address.

NAME: ______________________________

ORGANIZATION: ______________________________

OLD ADDRESS	CURRENT ADDRESS
______________	______________
______________	______________
______________	______________

TELEPHONE NUMBER: (   ) ______________________________

SUBJECT AREA(s) OF INTEREST:

______________	______________
______________	______________
______________	______________

DNA OR OTHER GOVERNMENT CONTRACT NUMBER: ______________________________

CERTIFICATION OF NEED-TO-KNOW BY GOVERNMENT SPONSOR (if other than DNA):

SPONSORING ORGANIZATION: ______________________________

CONTRACTING OFFICER OR REPRESENTATIVE: ______________________________

SIGNATURE: ______________________________

[illegible]

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b RESTRICTIVE MARKINGS:

2a SECURITY CLASSIFICATION AUTHORITY: N/A since Unclassified

2b DECLASSIFICATION / DOWNGRADING SCHEDULE: N/A since Unclassified

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.

4 PERFORMING ORGANIZATION REPORT NUMBER(S): R:LJF-84-019

5 MONITORING ORGANIZATION REPORT NUMBER(S): DNA-TR-85-13-AP-H

6a NAME OF PERFORMING ORGANIZATION: Science Applications International Corporation

6b OFFICE SYMBOL *(If applicable)*:

7a NAME OF MONITORING ORGANIZATION: Director Defense Nuclear Agency

6c ADDRESS *(City, State, and ZIP Code)*:
P.O. Box 2351
La Jolla, CA 92038-2351

7b ADDRESS *(City, State, and ZIP Code)*:
Washington, DC 20305-1000

8a NAME OF FUNDING / SPONSORING ORGANIZATION:

8b OFFICE SYMBOL *(If applicable)*:

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: DNA 001-81-C-0273

8c ADDRESS *(City, State, and ZIP Code)*:

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
62715H	V99QAXN	L	DH065313

11 TITLE *(Include Security Classification)*: INTEGRATED BATTLEFIELD EFFECTS RESEARCH FOR THE NATIONAL TRAINING CENTER
Appendix H—Designs of Nuclear and Chemical Field Simulators for the National Training

12 PERSONAL AUTHOR(S): Erickson, D.; Ickler, J.; McKeown, P.; Metzger, L.; Plock, R.; Packard, B.; and Birney, J.

13a TYPE OF REPORT: Technical

13b TIME COVERED: FROM 830613 TO 841230

14 DATE OF REPORT *(Year, Month, Day)*: 841231

15 PAGE COUNT: 84

16 SUPPLEMENTARY NOTATION: This work was sponsored by the Defense Nuclear Agency under RDT&E RMSS Code S400082466 V99QAXNL00125 H2590D.

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
15	7	
5	9	

18 SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*:
Training
Integrated Battlefield
Military Strategy
Military Doctrine

19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Research performed to evaluate and develop enhancements for integrated battlefield training at the U.S. Army National Training Center is described. These enhancements had been identified and concepts developed for their application in earlier phases of this research. The report consists of the basic volume summarizing the research tasks, approach, results, conclusions, and recommendations; plus twelve appendices which provide details on the nine major tasks into which the research was divided. Research performed and the associated appendices are as follows:

Development of nuclear and chemical environmental and effects software:

Analysis of nuclear algorithms	Appendix A
Requirements specification for nuclear and chemical model algorithms at the NTC	Appendix B
Chemical model algorithm description	Appendix C

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a NAME OF RESPONSIBLE INDIVIDUAL: Betty L. Fox

22b TELEPHONE *(Include Area Code)*: (202) 325-7042

22c OFFICE SYMBOL: DNA/STTI

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

11. TITLE (Continued)

Center

19. ABSTRACT (Continued)

Demonstration of the system for combining live and notional battalions for training higher level staffs in integrated battlefield (IB) command and control:

Functional requirements analysis for IB command and control simulation	Appendix D
Report on the demonstration	Appendix E

Analysis and design of field simulators for nuclear and chemical warfare:

Technical and operational impacts of field simulators	Appendix F
Capability of off-the-shelf paging system to communicate at Ft. Irwin	Appendix G
Designs of field simulators	Appendix H

Adaptation of nuclear and chemical software to other Army training models:

Feasibility of transferring ARTBASS Code from Perkin-Elmer to VAX	Appendix I
Division/Corps training simulation functional analysis	Appendix J
ARTBASS conversion to VAX	Appendix K
Requirements specification for adding nuclear and chemical models to ARTBASS	Appendix L

This research provided the following products:

Software which models nuclear and chemical environment and effects with appropriate fidelity and timing for training and which is ready for installation on NTC computers.

A demonstrated capability for combining actions of real battalions with computer simulated notional battalions for training brigade/division commanders and staffs.

An analysis of the impacts of using field simulators at the NTC for nuclear and chemical warfare training, and the designs of the selected simulators (i.e., common control system, radiacmeters, dosimeters, chemical detectors).

Analysis of the application of nuclear and chemical models to other Army battalion training models; conversion of the ARTBASS model to operate on the VAX 11/780; incorporation of the nuclear and chemical models into ARTBASS; and demonstration of the nuclear and chemical models using ARTBASS.

CONVERSION FACTORS FOR U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

To Convert From	To	Multiply By
angstrom	Meters (m)	1.000 000 x E -10
atmosphere (normal)	Kilo pascal (kPa)	1.013 25 X E +2
bar	kilo pascal (kPa)	1.000 000 X E +2
barn	meter^2 (m^2)	1.000 000 X E -28
British thermal unit (thermochemical)	joule (J)	1.054 350 X E +3
cal (thermochemical)/cm^2	meca joule/m^2 (MJ/m^2)	4.184 000 X E -2
calorie (thermochemical)	joule (J)	4.184 000
calorie (thermochemical)/g	joule per kilogram (J/kg)*	4.184 000 X E +3
curie	giga becquerel (Gbq) †	3.700 000 X E +1
degree Celsius	degree kelvin (K)	$t_K = t°_C + 273.15$
degree (angle)	radian (rad)	1.745 329 X E -2
degree Farenheit	degree kelvin (K)	$t_K = (t°_F + 459.67)/1.8$
electron volt	joule (J)	1.602 19 X E -19
erg	joule (J)	1.000 000 X E -7
erg/second	watt (W)	1.000 000 X E -7
foot	meter (m)	3.048 000 X E -1
foot-pound-force	joule (J)	1.355 818
gallon (U.S. liquid)	meter^3 (m^3)	3.785 412 X E -3
inch	meter (m)	2.540 000 X E -2
jerk	joule (J)	1.000 000 X E +9
joule kilogram (J/kg) (radiation dose absorbed)	gray (Gy)*	1.000 000
kilotons	terajoules	4.183
kip (1000 lbf)	newton (N)	4.448 222 X E +3
kip/inch^2 (ksi)	kilo pascal (kPa)	6.894 757 X E +3
ktap	newton-second/m^2 (N-s/m^2)	1.000 000 X E +2
micron	meter (m)	1.000 000 X E -6
mil	meter (m)	2.540 000 X E -5
mile (international)	meter (m)	1.609 344 X E +3
ounce	kilogram (kg)	2.834 952 X E -2
pound-force (lbf avoirdupois)	newton (N)	4.448 222
pound-force inch	newton-meter (N·m)	1.129 848 X E -1
pound-force/inch	newton/meter (N/m)	1.751 268 X E +2
pound-force/foot^2	kilo pascal (kPa)	4.788 026 X E -2
pound-force/inch^2 (psi)	kilo pascal (kPa)	6.894 757
pound-mass (lbm avoirdupois)	kilogram (kg)	4.535 924 X E -1
pound-mass-foot^2 (moment of inertia)	kilogram-meter^2 (kg·m^2)	4.214 011 X E -2
pound-mass/foot^3	kilogram-meter^3 (kg/m^3)	1.601 846 X E +1
rad (radiation dose absorbed	gray (Gy)*	1.000 000 X E -2
roentgen	coulomb/kilogram (C/kg)	2.579 760 X E -4
shake	second (s)	1.000 000 X E -8
slug	kilogram (kg)	1.459 390 X E +1
torr (mm Hg, 0° C)	kilo pascal (kPa)	1.333 22 X E -1

*The gray (Gy) is the accepted SI unit equivalent to the energy imparted by ionizing radiation to a mass and corresponds to one joule/kilogram.

†The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

Section Page

LIST OF ILLUSTRATIONS

Figure Page

LIST OF TABLES

SECTION 1
INTRODUCTION

1.1 PURPOSE

This report documents work done under Subtask 12.1 in the DNA sponsored program for "Integrated Battlefield Effects Research for the National Training Center."

1.2 SCOPE OF WORK

Task 12 consisted of Subtask 12.1, analyzing the technical and operational impacts on the NTC of using nuclear and chemical measurement simulators and effects simulators; and Subtask 12.2, designing the three measurement simulators with the greatest initial implementation potential.

The Statement of Work (SOW) for Task 12 is as follows:

"Previous work provided a preliminary design of a nuclear burst cue simulator and concept definitions for a number of other measurement and effects field simulators. In this task this work will be completed by providing designs for key field simulators needed to support the overall NTC Integrated Battlefield training concept."

The SOW for Subtask 12.1 is as follows:

"Perform all work needed to identify and analyze technical and operational issues associated with integrating IB field simulators into the NTC field instrumentation and using these simulators in training exercises. Specifically, perform the following subtasks:

- Identify interfaces of simulators with each other and with the NTC Core Instrumentation Subsystem (CIS), Range Data Measurement Subsystem (RDMS), Range Monitor and Control Subsystem (RMCS), and with operational and control communications. Analyze the compatibility of these interfaces, identify potential problems, and recommend changes to simulators or to current NTC field instrumentation to assure interface compatability,

- Estimate the number of simulators of each type required for operation of the NTC, including spares, replacements, and/or maintenance float. Determine requirements for maintenance and logistic support and estimate resources for O&M,

- Address technical and operational issues associated with introducing and operating the proposed field simulators. Technical issues shall include commonality between simulator types, range limitations, area coverage, probability of false alarms and errors. Operational issues will include requirements for issuing and initializing simulators, monitoring simulator operability and outputs, changes in CIS controller and OC capabilities and work-loads, limitations on training scenarios, and effects of simulator failures or errors on training credibility, and

- Document results and recommend changes to simulator design concepts based on the results of the foregoing technical and operational analyses."

Subtask 12.1 was documented in an earlier report, "Technial and Operational Impacts of Field Simulators on the National Training Center," SAI Draft Report 1 February 1984. The report has been updated by changing cost estimates where appropriate. The updated report is included as Appendix F to the overall Phase 3 Report.

The SOW for Subtask 12.2 is as follows:

"Perform all work needed to develop designs of key IB field simulators. Only those measurement and effects field simulator concepts which pass the technical and operational filters applied in Task 12.1 will be carried forward in this task. Candidate field simulators t be addressed in this task include:

- Measurement Simulators
  - Radiacmeter
  - Chemical Alarm
  - Dosimeter

- Effects Simulators
  - Chemical Masking Casualties
  - EMP effects on Electronic Equipment
  - Nuclear/Chemical Contamination"

1.3 ORGANIZATION OF THE REPORT

Brief background information is provided. A review of the concept of employment of field simulators for enhancement of nuclear and chemical warfare training at the NTC is provided first. This is followed by a description of the systems engineering process used in the development of the designs. Section 2 provides results of the design process with a section for each of the following field simulator designs:

- Common Control System
- Chemical Detector Simulator
- Radiacmeter Simulator
- Dosimeter Simulator

These three type of simulators were recommended by DNA and the U.S. Army TRADOC representatives for further development at this time based on findings in the report delivered in Subtask 12.1.

For each field simulator its function is first described, followed by design requirements, a discussion of design evolution and trade-offs, details of the selected design, conclusions, and recommendations.

1.4 REVIEW OF SYSTEM CONCEPT FOR EMPLOYMENT OF FIELD SIMULATORS

This brief description of the concept provides a frame of reference for the analysis of the technical and operational impact on the NTC of nuclear/chemical field simulators and design of the selected simulators. More detailed information is provided in the following reports:

> "Integrated Battlefield Research for National Training Center, Volume 1, Executive Summary" Science Applications, Incorporated, August 1983 (Draft)
>
> "Integrated Battlefield Research for the National Training Center, Volume 4, Field Simulators, Science Applications, Incorporated 30, June 1983 (Draft).

The overall concept for the use of field simulators is shown in Figure 1.

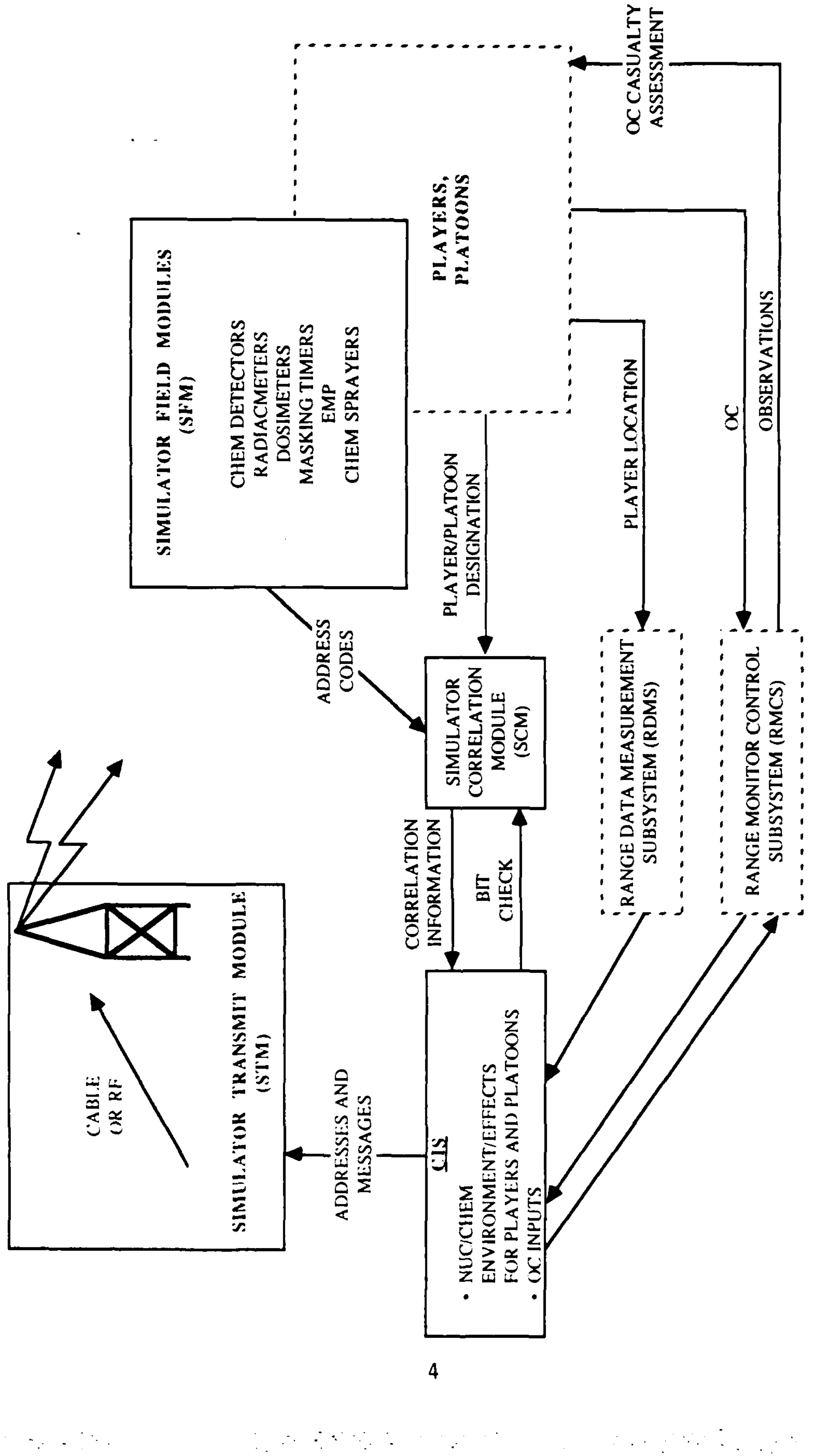


Figure 1. Overview of field simulator concept.

Once the software, which has been developed under Task 10 of the SOW for this phase of contract, has been installed at the NTC, the simulated nuclear and chemical environments, and their effects on personnel and equipment, will be computed and stored in the Computational Component (CC) of the Core Instrumentation Subsystem (CIS). The simulated radiation rate and chemical environment throughout the exercise areas will be computed at least every two minutes. In addition, accumulated dose levels, contamination and degradation of players and platoon-sized units will be available computed and stored in the CC.

Using the field simulator control software (which remains to be developed) the CC will also store the correlation of units with field simulators and the field simulators' address codes. Nuclear and chemical environments and effects information will be filtered to identify information which relates to units having field simulators. Each unit designation can be used to determine the address codes of the field simulators for that unit. The field simulator control messages will be formatted to describe the address and environment or effects. Each message, consisting of a field simulator address and indicator/value, will be passed from the CC to the Simulator Transmission Module (STM).

The STM consists of a telephone compatible cable or RF link to good relay locations, (e.g., Tieford Mountain, LFA 1, and Goat Mountain) and from there via a radio frequency link to all simulators within the engagement simulation and live fire manuever areas. The STM link is one-way from CIS Computational Component (CC) to the Simulator Field Modules (SFM). Each message is sequentially sent by each of the RF stations to provide the best transmission to the field simulators for all locations. The design assumes that the STM is government furnished equipment. These cables now exist and are maintained by AMEX Systems.

Research conducted in Phase 2 identified the following types of simulators to provide the needed nuclear and chemical warfare training:

- Radiacmeter
- Dosimeter
- Chemical Alarm
- Masking Timer/Casualty Indicator
- EMP Radio Interrupter

- Chemical Contaminant Simulant Sprayer

On the basis of results of Subtask 12.1, the types of field simulators to be developed initially were reduced from six to three. The last three field simulators (masking timer/casualty indicators, EMP radio interrupters, and chemical contaminant sprayers) were judged to be too expensive at present for the training enhancement provided. The higher cost of these simulators was caused by the quantities required (one per man or one per player). The simulators which were selected, provide realistic cues for environments and effects to satisfy current Army training objectives. The messages received via the STM will cause the SFMs to indicate the following environment and effects which will have been computed and stored in the CC and updated at least every two minutes:

- Radiation rate at the location of the unit to which the radiacmeter simulator is assigned.
- Total radiation accumulated dose (since the dosimeter was last zeroed) for the unit to which the dosimeter simulator is assigned.
- Activation of the alarm signal at the chemical agent detector if the detector is in an area of chemical contamination.

Correlation of unit/player identification and SFM address codes will be accomplished by field controllers before exercises begin. Initially this will be done manually, as is currently done with "B" units. If higher quantity type simulators become operational this will be done using the Simulator Correlation Module (SCM). The SCM consists of a noncontact bar code reader, a keyboard input, a data storage device, and an RF transmitter/receiver. For each company-sized unit, a field controller will enter the unit designation via the keyboard or bar code scanner. He then will scan the type and address code of each field simulator assigned to the unit by use of the bar code reader. (Each field simulator will have a bar code attached). The information will be transmitted to the CIS, via the SCM RF link, and entered into the CC computer. A backup copy will be made on tape.

Functions which are part of the current system which will assist in the nuclear and chemical training are shown with dotted boxes in Figure 1. Player location for instrumented players will be tracked by the range data measurement system (RDMS). The RDMS will not be modified to implement the IB functions. The tracking data for the IB system will use the

RDMS data in the CC computer. This will provide the location of field simulators by providing the location of the players whose unit designations and field simulator addresses will have been correlated manually or by using the SCM. Field controllers will observe players and provide information on their posture (e.g., inside or outside APC's) to the controllers within the CIS. Casualty recommendations for nuclear and chemical effects follow the same path in reverse, from the CC via CIS controllers to field controllers, who assess the casualties.

1.5 SYSTEMS ENGINEERING APPROACH

A systems engineering design process was used. Based on the overall nuclear and chemical warfare training concepts and the specific functions to be satisfied by each simulator, required and desired characteristics were identified. Both operational and logistic efforts were considered in identifying the characteristics.

Next designs were developed. At each point in the evaluation of the design, where there was more than one viable alternative, bases for selection of the best alternative were identified. The best approach was selected by analysis which considered both training value, including reliability, and operating, acquisition, and development costs. These alternatives were documented for each field simulator, along with the reason for selection, to provide a design trail for each field simulators.

As the design developed, design risks were identified and, where feasible were resolved by limited special purpose testing. Requirements for further tests were also identified.

SECTION 2
RESULTS OF THE DESIGN PROCESS

2.1 COMMON CONTROL COMPONENT

2.1.1 Function of the Common Control Component

The function of the common control component is to transmit control messages from the CIS computer to the element within the simulator which causes its activation. The common control components elements are: (1) data links from the CIS computer to the RF transmitters, (2) RF transmitters which cover the operational areas of Fort Irwin, and (3) receiver/decoders within the individual simulators.

Since the control component is partially external to the individual field simulators, and the RF receiver/decoder would more likely be common to all types of receiver/decoders, a universal common control component was designed.

2.1.2 Characteristics of the Common Control System

Required and desired characteristics of the common control component are shown in Table 1.

Table 1. Required and desired characteristics of a common control component.

CHARACTERISTIC	REQUIRED OR DESIRED
With a high degree of reliability transmit to all areas of operational interest in the engagement simulation and live fire areas of Fort Irwin.	Required
Provide discrete addresses for each pager or group of pagers in the field simulator system.	Required
Provide the capabilities for binary on/off information and ten digits of information per message.	Required
Not exceed RF power levels allowed at at Fort Irwin (approximately 25 watts).	Required
Operate on an RF frequency available at Fort Irwin.	Required
Demonstrate requisite RF frequency and power stability for approval to operate at Fort Irwin.	Required
Provide no emissions which are unacceptable at Fort Irwin.	Required
Not require an operator physically present at the RF transmission sites except for periodic maintenance.	Required
Operate reliably in the RF environment present during training exercises.	Required

Table 1. Required and desired characteristics of a common control component (concluded).

Operate with less than thirty hours per month maintenance, except for individual simulator receiver/decoders.	Desired
Individual simulator receiver/decoders operate with less than five hours per year maintenance, except for changing batteries.	Desired

2.1.3 Alternatives and Trade-Offs in the Common Control Component Design

The first design trade-off had the objective of selecting a transmitter/ receiver combination which could cover the Fort Irwin operational area. Two alternatives were considered:

1. A commercial, off-the-shelf, GSA approved paging system as the transmitter/receiver/decoder.

2. A specially designed transmitter/receiver/decoder.

The first alternative had the advantages of lower cost (including a one year warranty on the pagers), ease of maintenance, and proven capability to assist in obtaining permission to operate. The second alternative appeared to offer better transmission capability. Tests were made throughout the Fort Irwin area which measured RF path loss in two frequencies of interest (Appendix F). These tests were inconclusive due to conflicting information as to the sensitivity of the off-the-shelf pagers. The path losses measured were too great for the low estimates of sensitivity, but acceptable for the high estimates of receiver/decoder sensitivities.

Therefore a test was conducted using the transmitter and pagers which had been selected for the off-the-shelf approach. (Results of the test are documented in Appendix G). The test showed that operating at a transmitter input to the antenna of 25 watts from three sites (Goat Mountain, LFA1, and Mount Tiefort) complete coverage of the operational areas of interest could be obtained. This resulted in the selection of the commercial system.

The performance of the commercial Motorola system in the tests eliminated most of the other design choices, since the Motorola family of equipment provided logical and compatible selections without the need for further analysis of alternatives. The transmitter selected provides the required power at relatively low cost. A commercial modem is used to encode messages into the pager format.

A special transmitter antenna was configured to focus signals in the area of interest, and direct them away from potential areas, where interference could be caused. Two types of pagers were selected, one of which provides on/off signals and one of which provides a ten-digit output.

2.1.4 Recommended Design of the Common Control Component

The recommended design of the Common Control Component of the Field Simulator Subsystem is shown in Figure 2. The

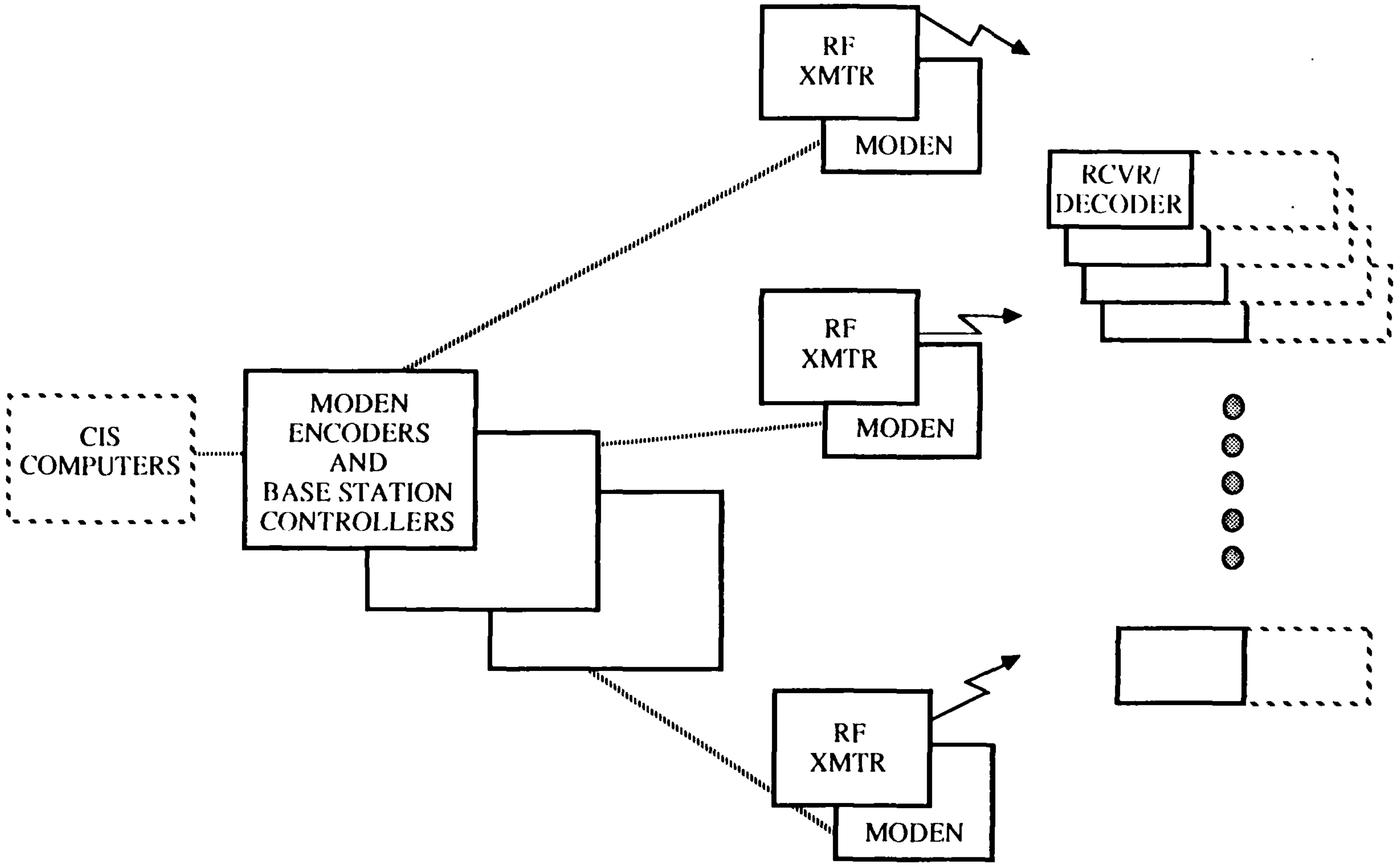


Figure 2. Common control component of the field simulator subsystem.

Common Control Component will consist of four types of major elements.

- Encoder and Base Station Controller
- Transmitter
- Antenna
- Receiver/Decoder

All of the above items except the antenna base, masts and guys will be commercial, off-the-shelf items.

It is assumed that the following will be provided by the government:

- Conditioned telephone lines transmission lines from the CIS to Goat Mountain, LFA 1, and Mount Tiefort. 1200 Baud. (These lines now exist and are serviced by AMEX Systems Inc.).
- Electrical power at the above locations (Power is currently available and is serviced by AMEX Systems, Inc., although the Goat Mountain site may require auxiliary power.)

2.1.4.1 Encoder and Base Station Controller

The encoder and base station controller converts the output of the computer consisting of field simulator address codes and associated data messages into code for transmission over telephone line to the RF transmission sites. At each transmission site a second modem converts the messages into the Golay code format used in the RF control of the receiver/decoders. Each base station controller remotely controls the operation of an RF base station transmitter located at one of the three transmission sites. The encoding, base station control, and modem functions are provided by a combined element, the Motorola MODEN Plus Microprocessor Controlled Paging Encoder, Model EOPLS200-T with full alphanumeric expansion. Interface with the CC computer is via an RS 232 terminal line. Details of the Motorola MODEN are provided in Figure 3.

2.1.4.2 Transmitter

Each of the three transmitters is a standard off-the-shelf Motorola PURC Radio Paging Station, Model Series C73JZB, operable at 132-174 MHz with 50 to 100 watts of output. The transmitter will be operated at minimum power, with the

MODEN Plus Paging Encoder

Performance Specifications

Model:	E08PLS 2000 ___ T
Number Capacity:	2 000 User codes with up to 4 addresses each
Page Code/Types:	2-Tone 5 6-Tone Golay Sequential Code (GSC)
Paging Tones Output:	Adjustable to - 5 dBm maximum @ - 3% distortion ± 3 dBm @ 300-3 000 Hz reference 1 000 Hz into a 600 ohm load. 6 dB per octave de-emphasis or flat response
Stability/Accuracy:	- 0 15% 0°C to - 50°C (25°C reference)
Channel Monitor Audio:	1W @ 5% distortion Volume control settable
Dimensions:	4 x15 x10 (102x381x254 mm) (Height x Width x Depth)
Operating Temperature Range:	0°C to - 50°C Ambient 25°C reference
Weight:	10 lbs (4 54 kg)
Supply Voltage:	117 VAC 50 60 Hz: 12 VDC. 230VAC Field Settable
Power Consumption:	50W
Transmitter Control:	Remote Tone or PURC (Paging Universal Remote Control) binary remote control, one or two transmitters Local One transmitter (PURC local not available)
Alarm Page:	Two remote closure activated pages Alert codes settable to any two addresses Separate audible siren tones transmitted for each
Group Call:	Random Maximum of 5 groups with up to 15 random addresses Radio Motorola "Tone B" and GSC group call
Memory:	Up to 20 tone-alert or display pages of 24 characters each. Longer messages take up more than one memory location.
Automatic Station Identifier:	Up to 10 characters per channel with settable transmit interval time
Voice Page:	Manual push-to-talk, pre-timed (settable), or voice operated transmit
Display Page:	Basic unit provides the following alphabetic characters, in addition to the numeric, for transmission to OPTRX Display Pagers: A. B. C. D. E. F. G. H. I. J. L. N. O. P. S & U

Full Alphanumeric Expansion

Ports:	Two
Data:	RS-232C Signalling, 7 bit ASCII with start, stop bit, odd parity
Rate:	150, 300 600, 1200, 2400, 4800, 9600 Baud rates, selectable
Connection, VDU:	Hard wire local: 4 wires, 50 feet max Remote: Bell 103 modem or equivalent, 300 baud rate Bell 212A or equivalent, 1200 baud rate
Input Device(s):	VDT or computer emulating VDT per Motorola defined format*

* For full details refer to the MODEN Plus System Planner 68P81026C35-A

USED WITH PERMISSION OF
MOTOROLA, INC.

Figure 3. MODEN plus paging encoder.

MOTOROLA
1301 East Algonquin Rd , Schaumburg, Illinois 60196
(312) 397-1000

Specifications subject to change without notice antenna lead line attenuating the power to 25 watts. Details of the transmitter are shown in Figure 4, which is from a Motorola brochure. It will be housed in a weatherproof shelter which can be opened for service. The equipment will be connected to a protected ground using bonding straps. The transmitter will normally operate remotely controlled and unattended.

2.1.4.3 Antenna

The directional antenna consists of a commercial off-the-shelf electrical element combined with a specially designed reflector, mast, guys, and base. The electrical element is a Decibel Products Incorporated, Broad Band Directional Gain Antenna, DB-224 E, using the DB-224 side mount kit. The antenna lead for the transmitter is a Type "N". Details of the DB-224E are provided in Figure 5, which is from a Decible Products brochure. The reflector, steel mast and legs are modifications of the portable antenna used in the tests at the NTC on 17-20 September 1984. The reflectors are in two sections, each fourteen inches wide and ten feet high, with the sides bent back at 30 degrees. The mount will be configured as it was for the test, which facilitates delivering the antenna to the site and lowering it for repairs. In the permanent mounting, each leg will be strapped to a concrete cube which is two feet on a side. Guy wires will be connected from the top of the mast to each of the feet at each concrete cube and tightend by turnbuckles. The entire antenna assembly will be at earth ground. Further lightning protection will be provided by an in line lightning protector. The antenna will be installed in accordance with the intent of MIL-B-5087, Bonding, Electrical and Lightning Protection for Aerospace Systems. The mast will be grounded to ground rods or surface radials depending upon the terrain. The top of the antenna assembly will be mounted two or more feet below the top of the support mast. This, with the guy wires, will provide a sixty degree cone of protection for the mast.

PURC Radio Paging Stations

Performance Specifications*

General

Model Series:	C73JZB
Frequency (MHz):	132-174
Watts:	50-100 variable
Cabinet Height:	46"
AC Power Input:	120 VAC 60 Hz
Control:	tone remote simulcast control
No. of Frequencies:	1
120 VAC AC Current:	Standby: 0.63 Δ Transmit: 5.46 Δ
Weight (one receiver):	46" Indoor cabinet 180 lb. (80 kg) 46" Outdoor cabinet 180 lb. (80 kg) 75" Outdoor cabinet 400 lb. (108 kg)
Dimensions:	46" Outdoor 46"H x 22"W x 20"D(115 x 55 x 50 cm)
Metering options:	COMPA STATION radio-internal mounted meter used to measure all essential circuits for tuning and checking. Indoor upright-two panel mounted meters with associated selector switches, provide resonant indication of exciter, power amplifier and circuits essential to tuning and checking.

Transmitter

RF Power: output:	50-100W variable
Output Impedance:	50 Ohms
Spurious and harmonics emissions:	more than 85 dB below carrier
Transmitter sideband noise:	-90 dB @ ±30 kHz -105 dB @ ± 1 MHz
Frequency stability:	± .0002 from -30°C to 60°C ambient (+ 25°C ref.)
All Bands Simulcast Models:	± 0.002 PPM from -30°C to +60°C ±0.1 PPM per year aging

* Extracted from Specifications Brochure, Motorola Communications and Electronics, Inc

Figure 4. Transmitter characteristics.

Audio sensitivity: . . . . .0.18µV ± 3 dB for 60% maximum deviation at 1000 Hz

Remote telephone line: . . . .-20 dBm for 60% maximum deviation at 1000 Hz

Audio response: . . . . +1 - 3 dB from 6 dB/octave pre-emphasis. 300-3000 Hz ref. 1000 Hz

Fiat audio response: . . . . +1, -3 dB 250-3000 Hz, ref 1000 Hz*

Audio distortion: . . . . 2% at 1000 Hz 60% deviation

Modulation: . . . . 15F2, 16F3, 16F9Y ± 5 kHz for 100 at 1000 Hz

FCC Information:
Authorized Emission. 15F2, 16F3, 16F9Y
Applicable Parts of the Rules 22, 90

Model: C73JZB; C73JZB

Frequency Range (MHz): 150.8-174

Power Output (Watts): 50-100

Stability: . . . . .0.0002%; HSS*

Type Acceptance Number: ABZ89FC3636; ABZ89FC3637

<u>Monitor Receiver:</u>

Channel Spacing: . . . . .30 kHz (25 KHz)

Frequency stability: . . . .± .0005% (±.0002% opt) from -30° C to +60° C ambient (+25°C ref.)

Sensitivity: (20 dB quieting) . . . . .5 V

EIA SINAD: . . . . .35 V

Selectivity EIA SINAD: . . . . -100 dB at ± 30 kHz*

* Without 2175 Hz Notch

* HSS: ±0.002 PPM from -30° C to +6-° C
± .01 PPM per year

Figure 4. Transmitter characteristics (continued).

Intermodulation EIA SINAD: . . . .-80 dB

Squeich sensitivity Carrier squelch (adj.): . . . . .20 µV or less at threshold

EIA modulation acceptance: . . . .± 7 kHz

Spurious & image rejection: . . . . 100 dB minimum

Aduto distortion: . . . . 3% at 1000 Hz (Line)

Audio response: . . . . +1, -3 dB from 6 dB/octave
de-emphasis 300-3000 Hz

Hum & noise: . . . .-55 dB (Line)

Audio output: . . . . + 11 dBm at 600 Ohms

Local Speaker: . . . . .5 watts at 8 Ohms

Distortion: . . . . 5% at 1000 Hz (Loc. Spkr)

Hum & noise: . . . . .50 dB (Loc. Spkr)

Figure 4. Transmitter characteristics (concluded).

6 dB or
9 dB GAIN

DB-224
118-174 MHz

BROAD BAND GAIN ANTENNA

USED WITH PERMISSION
OF DECIBEL PRODUCTS, INC.

MODEL DB-224 is a high gain, light weight, high strength antenna for use in the 118-174 MHz band. It is factory adjusted and checked for minimum VSWR over a wide band of frequencies. Clamps for top mounting are supplied with the antenna but an additional side mount kit (Model DB-5001) must be ordered when side mounting the antenna.

OPTIONAL RADIATION PATTERN. The radiation pattern of the DB-224 can be easily changed from a 6 dB gain omni-directional pattern to a 9 dB maximum gain offset pattern, or from an offset to an omni-directional pattern. When the four dipole elements are positioned evenly every 90 degrees around the mast, a circular radiation pattern results. When all four dipoles are in line (collinear) along one side of the mast the antenna has a directional characteristic.

BANDWIDTH. Through the use of folded dipole elements and binary cable harness, the DB-224 has an exceptionally broad bandwidth. Performance characteristics (gain, VSWR) are essentially constant over a frequency range of 10 MHz or more. This permits the DB-224 to provide optimum performance when used in either single or *multi-frequency* systems.

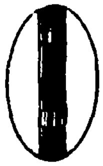
TWO PIECE MAST. For ease of handling and to facilitate shipment, the mast is made in two sections. Assembly of the sections is quite simple and requires only the use of ordinary hand tools. The unique center splice assures proper alignment. (See illustration).

LIGHTNING PROTECTION. Superior protection against lightning damage is provided by the aluminum mast with pointed top cap which provides a positive low resistance discharge path to tower or ground system. The *radiators* are operated at DC ground to provide further protection against lightning *and static build-up.*

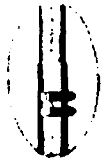
SPLIT VERSION. A split version of the DB-224 is available in both omni-directional and offset radiation patterns. Essentially it amounts to two 3 *dB gain omni-directional or* two 6 dB gain offset antennas on a single mast. Separate feed lines are provided to the two antennas.

DB-224E
(offset pattern)

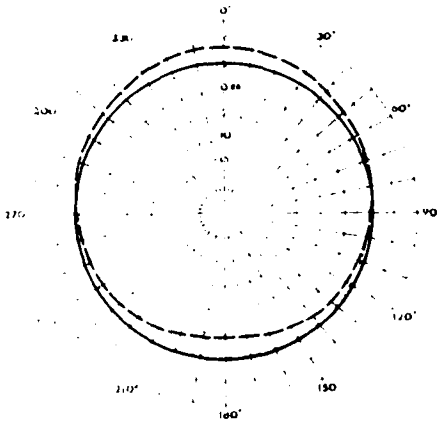
Simple but secure stainless steel banding clamp allows an easy change from circular to offset radiation pattern.



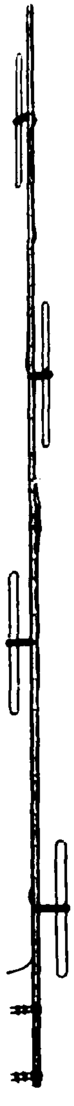
Molded connections for weatherproof operation.



Unique center splice prevents misalignment; two piece construction for easier handling before installation.



Horizontal patterns illustrate the maximum gain of the DB-224 (6dB) and DB-224E (9dB) with respect to a half wave dipole (0dB level).

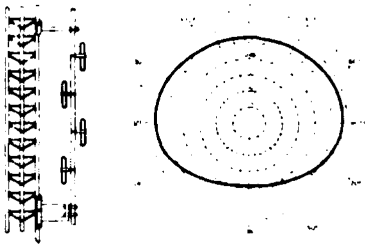


DB-224
(omni pattern)

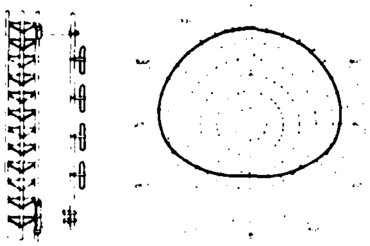
USED WITH PERMISSION
OF DECIBEL PRODUCTS INC.

SIDE MOUNTING

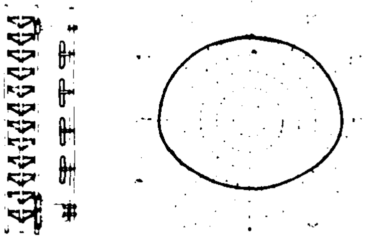
When the **DB-224** and **DB-224E** antennas are mounted to the side of a tower the horizontal radiation pattern necessarily becomes distorted. The patterns shown below indicate *the typical pattern shape of the antenna* side mounted on a tower with an 18" to 24" face using the DB-5001 Side Mount Kit.



DB-224 (omni) mounted on side of tower



DB-224E, elements pointed away from the tower



DB-224E, elements pointed toward the tower

The **DB-5001** Side Mount Kit positions the antenna approximately 18" from the tower and consists of an upper sway brace, lower bracket (both galvanized) and the necessary hardware for attaching the bracket to round tower members up to 3" OD, or angular members up to 2" on a side. Other size clamps can be supplied on special order.

ORDERING INFORMATION

Model	Frequency
DB-224 Antenna, circular pattern	Specify exact
***DB-224E Antenna**, offset pattern*	*frequency(s) or*
DB-224S Split Antenna, circular	frequency range
DB-224ES Split Antenna, offset	(and termination if
DB-5001 Side Mount Kit	non standard)

BANDWIDTH

In the frequency range 118-144 MHz the DB-224 is manufactured to order at the specified frequency. The bandwidth is approximately ± 2% of frequency for a VSWR less than 1.5:1.

In the frequency range 144 to 174 MHz the DB-224 is available in four frequency ranges from 144 to 150 MHz, 150 to 160 MHz, 155 to 165 MHz, or 164 to 174 MHz.

DB-224S, SPLIT VERSION

The DB-224S is a split version of the DB-224. It consists, *essentially, of two independent antennas on the same* mast, each with a separate feedline terminated at the bottom of the mast. Each antenna has 3 dB gain in an omni-directional pattern (DB-224S) or 6 dB gain in an offset pattern (DB-224ES). Each antenna may be used omni-directionally or directionally without regard to the other. Isolation between the two antennas is 35 dB or more.

ELECTRICAL DATA

Frequency Ranges:	
A Range	150-160 MHz
B Range	155-165 MHz
C Range	164-174 MHz
D Range	118-144 MHz*
E Range	144-150 MHz*
Bandwidth (150-174 MHz)	10 MHz
VSWR	1.5 to 1 or less
Nominal impedance	50 ohms
Gain (over half wave dipole)	
Omni pattern	6.0 dB
Offset pattern	9.0 dB
Maximum power input	500 watts
Vertical pattern beamwidth (half power points)	16°
Decoupling between antennas (split models)	35 dB minimum
Lightning protection	Direct ground

Standard Termination: Captive Type N male attached to end of flexible lead. Other fittings are available on special order.

**Gain and bandwidth are reduced in the 118-150 MHz band.* Contact factory for details.

MECHANICAL DATA

Materials:	
Mast — upper	6061-T6 Aluminum 1¾" OD with 1/16" to ⅛" wall
Mast — lower	6061-T6 Aluminum 2" OD with ⅛" to 3/16" wall
Radiating elements	6063-T832 Aluminum ½" OD with .058" wall
Mounting clamps	Galvanized steel
Maximum exposed area (flat plate equivalent)	3.17 sq. ft.
Lateral thrust at 100 mph (40 psf flat equivalent)	126 lbs.
Bending moment at top clamp at 100 mph (40 psf flat equivalent)	1020 ft. lbs.
Wind rating *	
Survival (w/o ice)	100 mph
Survival (½" radial ice)	74 mph
Overall length (150-174 MHz)	255 in.
Shipping length	148 in.
Net weight (w/clamps)	32 lbs.
Shipping weight (w/clamps)	48 lbs.

Mounting Clamps (DB-365) are supplied with the antenna and fit round tower members up to 2¾" OD, angle members up to 2½". Other size clamps can be furnished on special order.

*Top mounted antenna. Wind rating is greatly increased when antenna is side mounted with appropriate side mount kit.

NOTE: The mechanical specifications are degraded for the antenna covering the 118-150 MHz band.

Figure 5. Antenna elements (concluded)

2.1.4.4 Receiver/Decoder

Two types of commercial, off-the-shelf pagers are used as receiver/decoders. Readout will be disconnected and the pigtails connected directly to circuit boards which will convert the pager outputs to simulators activation. The output of the pagers constitutes the interface of the Common Control Component and the three simulator types discussed below.

A pager with a digital readout will be used in the radiacmeter simulator and in the dosimeter simulator. For this purpose the Motorola BPR 2000 Display Radio Pager (Model A03BGC4661) will be used. Details of the BPR 2000 Pager are provided in Figure 6 which is from a Motorola brochure.

The ENVOY Tone Pager (Model AO3GAC4668AA) will be used for the chemical alarm. Detailed information on this device is shown in Figure 7 which is from a Motorola brochure.

BPR 2000 Display Radio Pager

Performance Specifications [*]

Model Specifications:	A03BGC4661
Frequency:	138-174 MHz
Weight: (with alkaline battery)	4.7 ounces (134g) standard model
Dimensions:	3.10 x 2.30 x 0.84 inches (7.87cm x 4.84cm x 2.13cm) (6.0 cubic inches) (97.9 cubic cm)
Paging Sensitivity:	5μV per meter
Display:	12 characters .16 inches high with a with a temperature compensated LCD display
Memory:	Two 24 character messages
Sensitivity:	60 dB at 30 KHz
Spurious and Image Rejection:	55 dB
Audio Output - Alert Tone:	83 dB SPL 12
Frequency Stability:	.002% from $-10^{\circ}C$ to $+50^{\circ}C$
Power Supply:	One 1.5 Volt AA Alkaline Battery or One 1.5 Volt rechargeable Nickel-Cadmium Battery
Average Life of Alkaline Battery: [†]	Alkaline: With battery saver - 13 weeks Without battery saver - 6 weeks Nickel-Cadmium: With battery saver - 6 weeks Without battery saver - 2 weeks
Code Format:	2.3/12 Golay Sequential Code
Bit Rate:	300 Bits/sec address - 600 Bits/sec data
Code Capacity:	1,000,000 display pagers

[*] Extracted from Specifications Brochure, Motorola Communications and Electronics, Inc.

[†] Based on three 12 unit messages per 8 hour day, 5 days per week

Figure 6. BPR 2000 pager characteristics.

ENVOY Tone and Visual Alert Radio Pager

Performance Specifications *

Model Specifications:	A03GAC4668AA
Frequency:	138-174 MHz
Size: (without clip)	2.78" x 2.05" x 0.71" (7.06mm x 5.20mm x 1.80mm)
Weight: (without battery)	2.08 ounces (59 grams)
Battery Complement:	One 1.5 Volt AA Size Disposable (Alkaline)
Battery Life in weeks: (typical) (assuming 8 hours per day 40 hours per week, .15 call per user-hour (peak) full capacity battery)	About 19 weeks (6 weeks without battery saver)
Power Consumption:	7.2ma (1.6ma Standby)
System Call Time:	4.4 Calls per second
System Coding:	Golay Sequential
Maximum Address Capacity:	4,000,000 Unique Codes
Field Strength Sensitivity: (paging)	5μV per meter
Adjacent Channel Selectivity:	60 db at ± 30 KHz 65 dB at ± 25 KHz (Int'l)
Spurious and Image Rejection:	60 dB
Frequency Stability: -10°C to + 50°C, 25°C ref.	± 0.002%
Alert Tone Output:	84 dB minimum at 12"
Alert Tone Length:	10 sec ± 0.5 sec unless manually reset
Alert Tone Frequency:	3200 Hz

* Extracted from Specifications Brochure, Motorola Communications and Electronics, Inc.

Figure 7. Envoy pager.

2.2 CHEMICAL DETECTOR SIMULATOR

2.2.1 Function of the Chemical Detector Simulator

The chemical detector M-43 is used as part of the M-8 chemical alarm system. The detector is employed upwind of using units in a stationary environment or mounted on a truck or APC in a mobile environment. The M-43 is the principal device currently used for detection of the presence of chemical agents (except mustard gas). It has an internal alarm or may be connected by field wire to a distant remote alarm, M-42. The M-43 detector is a wet chemistry device which must be serviced and the filter changed after each exposure to an activating agent.

The field simulator will be used in training troops to properly employ the M-43 detector, and to stimulate troops to respond to an alarm activation. By using the NTC computer capability of dynamic tracking of the area where a chemical agent is present, coupled with the location of the using unit or vehicle with which the detector is associated, the Core Instrumentation Subsystem (CIS) computers of the NTC will determine when any chemical detector is in a simulated chemical environment. The CIS computer can then format a discretely addressed digital message, which will be transmitted via RF to the chemical detector field simulator. Upon receipt of this message, the detector will activate its internal alarm and/or a remotely activated M-42 alarm depending on the setting of the M-43 simulator. The field simulator should provide training in all of the operating characteristics of the actual M-43. Detector activation should be on command from a controller in the CIS or automatically done using a computer program, whenever the detector is within a simulated contaminated area of a toxic chemical of the requisite density and type.

2.2.2 Characteristics of the Chemical Detector Simulator

Required and desired characteristics of an M-43 detector field simulator are shown in Table 2. Training needs, logistic factors and costs were the main bases for selection of the characteristics.

Table 2. Required and desired characteristics of a chemical detector field simulator.

CHARACTERISTIC	REQUIRED OR DESIRED
The field simulator shall, on command, cause a signal to be transmitted which activates the internal alarm or an external alarm, M-42.	Required
Development, procurement, and operating cost shall be low.	Required
Maintenance requirements shall be low.	Required
Permanent modification of an operational detectors shall not be required.	Required
The field simulator shall operate in both the static and mobile mode.	Required
Reliability of operation shall be high.	Required
The field simulator shall remain operational throughout the operational environment associated with field maneuvers at Fort Irwin, California.	Required
The false alarm rate shall be similar to an actual M-43 chemical detector	Required
Operation of the field simulator shall not create a safety hazard.	Required
The external chacteristics of the field simulator shall approximate that of the M-43 chemical detector.	Required
All settings, connections, maintenance procedures, and operational procedures of the field simulator shall be the same as the M-43 chemical detector	Desired
Little or no special training shall be required to operate the field simulator.	Desired
The design shall use an off-the-shelf pager, which is common to all field simulators, as a receiver/decoder.	Desired

Table 2. Required and desired characteristics of a chemical detector field simulator (continued).

A readout shall be provided which shows when an activation signal has been received since the last emplacement.	Desired
Batteries installed in the field simulator shall last for a two week exercise rotation.	Desired

2.2.3 Alternatives & Trade-Offs on the Chemical Dectector Simulator Design

The design path for the chemical detector field simulator is shown in Figure 8. Each branch point represents alternative design choices which were considered. These choices and the rationale for the selection of each branch are described in this section.

The letters heading each of the following paragraphs refer to branch points in Figure 8.

A. Basic Operational Concept

Three basic operational concepts were identified.

1. Operate an actual detector by subjecting the sensor to a harmless chemical agent.
2. Use an existing detector but include additional circuitry which would cause a signal to be sent to the M-42 alarm. The signal would emulate that sent by the M-43 when a chemical agent is detected. This general approach is much like that currently used with the XM -81 Chemical Alarm Trainer.
3. Simulate the existing detector. This approch would build an electromechanical device which looks like the M-43 and which, upon receiving a proper input signal, will output a signal to selectively activate an M-42 alarm and/or the M-43 simulator internal alarm.

Initially, the first approach appeared to be the most cost-effective. This approach requires the using of troops to properly emplace the detector, as well as to properly maintain it, including changing the batteries every ten to twenty hours, and servicing it and changing the filter between each exposure to an activating chemical agent. It would also parallel the M-43 in generating false alarms.

The "operate" approach also left the troops with a fully functional detector, so if concentrations of simulated agents were used, they would also be picked up by the detector.

False alarm rates would probably be highest using the "operate" concept, but these false alarm rates would be realistic and would provide training in reacting to false alarms. The "operate" approach appeared to be the least expensive to develop, construct, and maintain. Two

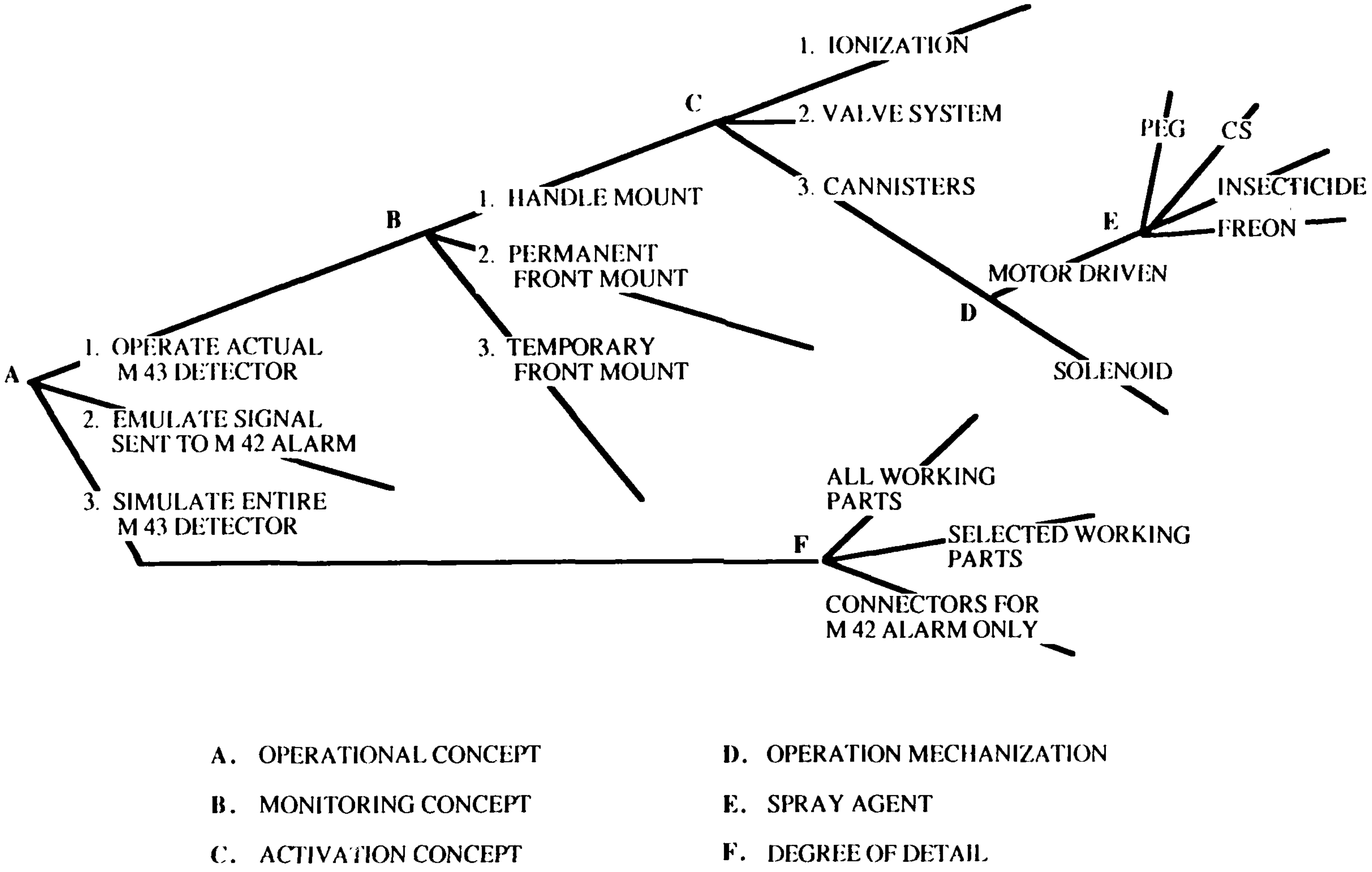


Figure 8. Path for the design of the chemical detector field simulator.

potential limitations or disadvantages have been identified for the "operate" approach. The first potential disadvantage is that battalions may not have their authorized quantities of M-43 alarms. The second disadvantage is that the relatively expensive, complex electromechanical chemical TO&E equipment would be subjected to the rigors of training use which will cause it to wear out faster, and be subjected to possible breakage. There is also a design risk in the reliability of stimulating the detector with a harmless agent.

Emulating the signal to the M-42 detector is similar to the XM-81 trainer, but with a remote control that provides more address codes and longer range. The design could be such that the modified detector will still be useable with real, but harmless agents. This approach will not require servicing the device after each operation for a simulated attack. This approach also has disadvantages of the first approach; i.e., battalions may not have their authorized quantities of the M-43; and using actual M-43s will subject them to wear and breakage.

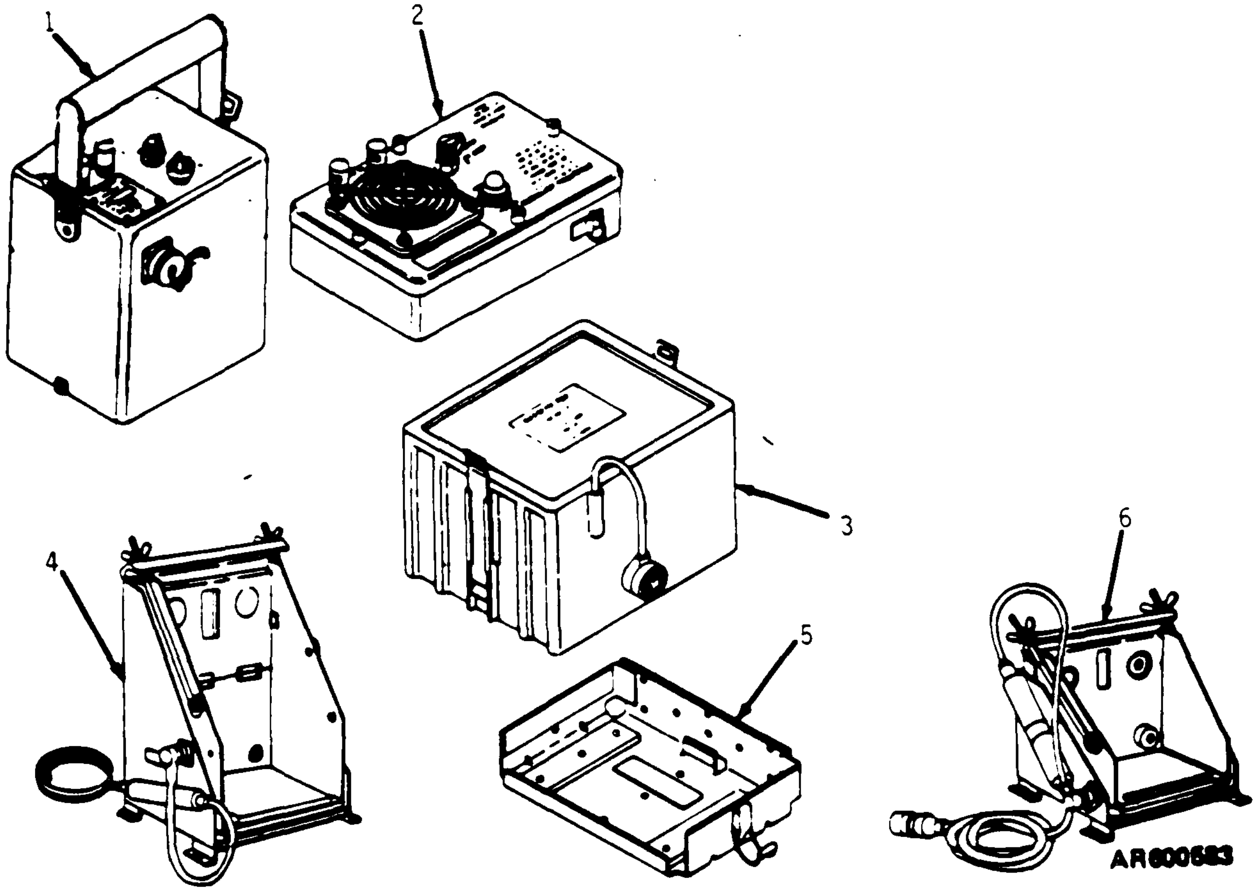
Simulating the entire M-43 detector has the advantage that actual detectors are not required nor affected, and quantities could be produced which will be adequate for training regardless of the number of actual detectors available. However, this approach appears to be the most complicated and expensive, if a detailed simulator were produced.

If a complete, stand-alone simulator is to be used the most cost-effective approach appears to be to include only selected functional controls, e.g. battery "go/no go" test, alarm volume, zero adjust test control, and remote terminal lugs. This device could use a standard battery pack (BA 3517A) which would now last orders of magnitude longer since the motors, heaters, pumps, and active electronics are not present. The simulator will have the same form as the actual device so that it can be accomodated by vehicle mounts. (See Figure 9.) There is sufficient volume in the case to protect against electrical transient shocks and to provide mechanical isolation for off-road use.

With the first approach (operate actual simulator) there was some risk that the detector might not react to the harmless agent. To reduce this risk, the concept was tested at the NTC in the 631st Battalion area.

B. Mounting Concept

Three concepts were considered for mounting:



1. Detector Unit. Chemical Agent Automatic Alarm.
2. Alarm Unit, Chemical Agent Automatic Alarm: M42
3. Battery, Dry, Medium Duty, BA3517/U
4. High profile mount, part of Mounting Kit, Chemical Agent Automatic Alarm: M228
5. Bracket, part of Mounting Kit, Chemical Agent Automatic Alarm: High Profile, M228 and Low Profile, M182
6. Low profile mount, part of Mounting Kit, Chemical Agent Automatic Alarm: Low Profile, M182

Figure 9. Major components of alarm systems.

(1) Mount the simulator as a temporary addition to, or replacement of, the carrying handle. (Figure 10)

(2) Mount the simulator on the front of the case as part of a new case. (Figure 11.)

(3) Mount the simulator on the front of the existing lower case as a temporary addition.

The M-43 has a long and short configuration; depending on the type of power pack at the bottom of the unit. In order to use mounting devices for the long unit and mounting devices for the short unit, it became apparent that the simulator package would either have to mount in the front or on the handles. Mounts used predefined bolts and wing nuts so that height could not be conveniently altered and neither could any of the three sides. Initially, consideration was given to mounting the simulator in the battery pack. However, there is a mix of the long and the short configurations and the short configuration does not use a battery pack.

Once a detector has sensed that a chemical is present, before the detector is used again, the user must take the detector apart and perform operational servicing and testing and then bring the detector on line again. It appeared that in this process, any wires requiring special attachments to the alarm connecting lugs would be a significant potential source of maintenance and would greatly decrease the reliability of the detector simulator.

Mounting the electronics and gas dispenser in an enlarged carrying handle does not affect the detector mounting options, provides a standard approach for all configurations, and is easily replaced for servicing. This arrangement was selected for the spraying type device.

C. Activating Gas Concept

The following methods of activating the detector sensor were considered:

(1) Ionization of air entering the detector

(2) Use of special valve and pressurized reservoir

(3) Use of a pressurized cannister of gas

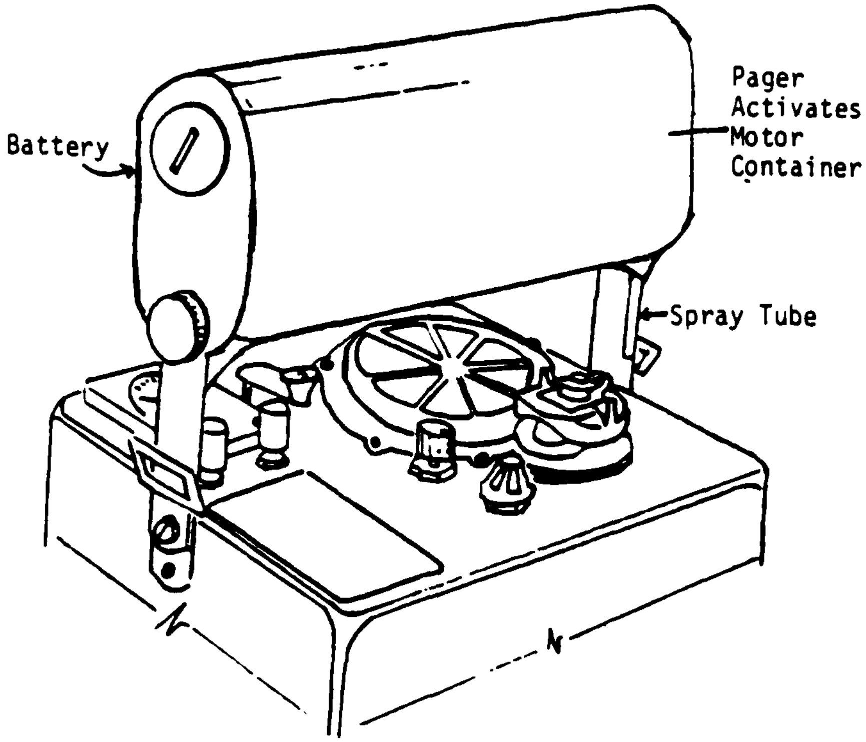


Figure 10. Simulator receiver/decoder/sprayer mounted in carrying handle.

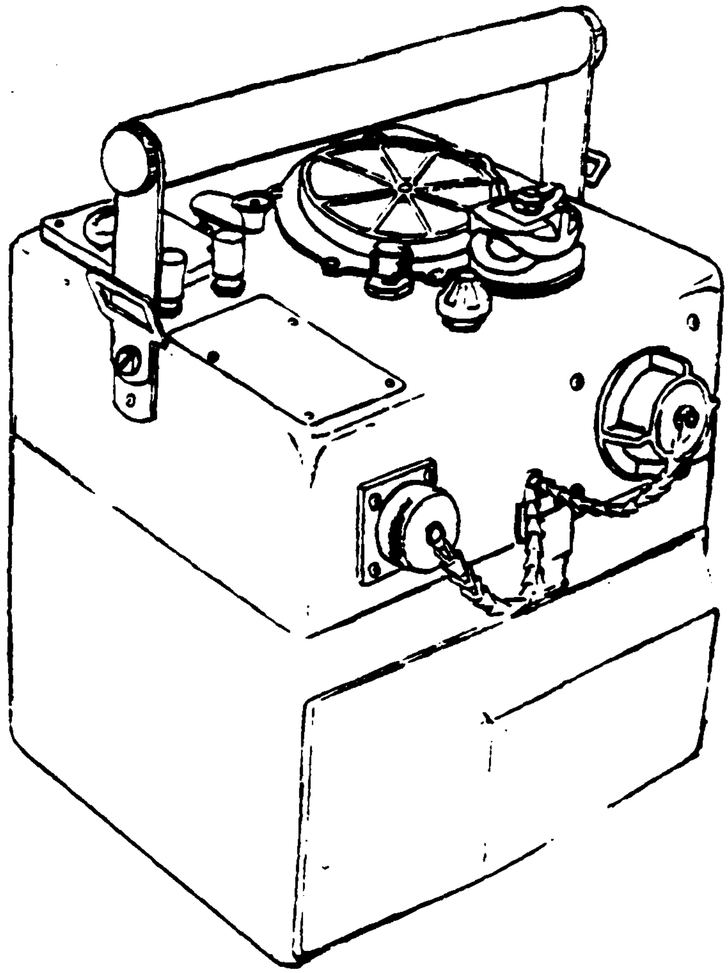


Figure 11. Chemical detector lower base mounted gas activator.

The first approach was potentially attractive since it would not require replacing a chemical agent supply. However, the approach may not necessitate servicing of the simulator between detections, an action which provides useful training by paralleling the operation of the actual M-43. There were also questions about the electrical power needed and the associated battery requirements, as well as the overall reliability of the approach.

A special reservoir, or chamber, and valve system would have the best shape to be fitted in, or on, an actual M-43, but has a higher risk of faulty operation because of obstructions and the dirty environment of the field, and would not be field replacable at the OC level. Off-the-shelf cannisters of the freon gas type are available which are tapped and have industrial trigger mechanisms and valves to operate the units. These units operate at relatively high pressure levels but have a greater volume and require clean operating surfaces.

Internally metered valving inside of the can was also investigated. These valves are commonly used in insecticides, deodorant sprays, in laboratories and food preparations. These are attractive because the volume is nearly constant and is independent of the valve depression time. This will allow a simple motor or solenoid to be used open-loop. In this application, a seven ounce can may provide up to 3400 sprayings. (See Figure 12.)

Use of an off-the-shelf chemical spray metered package (such as an insecticide) appeared to have adequate reliability, and can be completely replaced rather than maintained.

D. Operation Mechanization

Two methods of mechanizing the activation of the sprayer were considered:

(1) Motor and gear

(2) Solenoid

The first approach used a small circuit board to supply power to a small electric motor. The motor was connected to appropriate gearing and a lever to move the sprayer plunger. The length of time that the motor runs for each activation can be adjusted in a small circuit board which provides a pulse of electric power. Pulse duration is minimized to conserve battery life. Return of the sprayer plunger was accomplished by the built-in spring within the disposable cannister after the power to the motor is shut off. This required a loose gearing arrangement with considerable

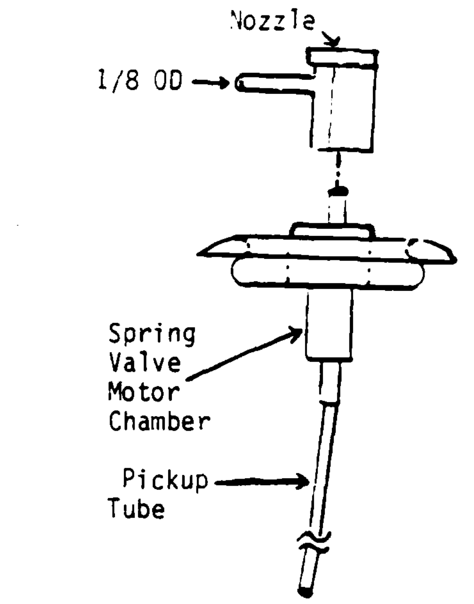


Figure 12. Meter pickup.

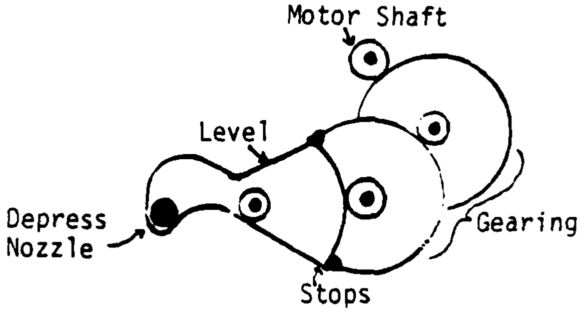


Figure 13. D.C. meter spray activator.

clearance. Such a gearing arrangement is currently used on commercial automatic deodorizers. A low-cost approach might rearrange gears and levers from this commercial application. (See Figure 13.)

The second approach using a solenoid to move the spray controller, is more simple mechanically. The amount of time that the sprayer is activated depends upon how long the power is applied. However, for positive activation of the pressure plunger on commercial spray cannisters, more energy may be required than is available in practical small batteries throughout a two-week training cycle. (See Figure 14.)

E. Type Of Gas To Be Used

There seemed to be wide spread justification in the literature and among experts supporting the position that there are several harmless chemicals that could be used to activate the M-43. (For example, Paragraph 2-11, TM3-6665-225-12). SAIC had been unable to borrow a detector for design development, and the design risk without some kind of confirmation test was unacceptable. Although a detector could not be borrowed, arrangements could be made to perform limited tests in the area of Headquarters and Headquarters Company of the 631st Battalion at Fort Irwin.

Several gases were considered for activating the detector. It was essential that the gas be safe to use, not harmful to the detector, provide reliable operation, and be readily available. Ideally the gas should be nonpersistent. The convenience of prepackaged gases in convenient off-the-shelf pressurized cannisters, (e.g., insecticide spray) was also a consideration. The following candidates were tested in using an actual M-43 alarm.

(1) Freon

(2) Malithion

(3) Polyethylene Glycol (PEG)

(4) Ammonia

(5) Dry Cleaning Fluid

(6) Pine Oil

(7) Acetone

(8) Isopropona1

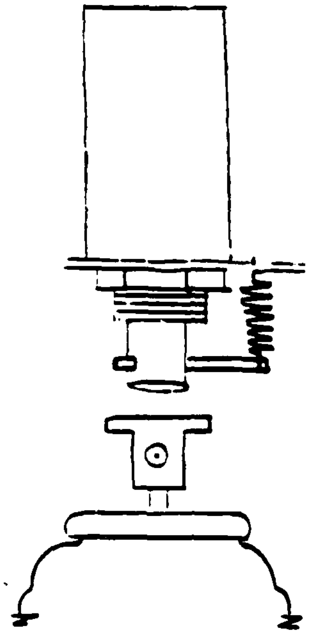


Figure 14. Solenoid activator.

(9) "Off" Insect Repellant (N,N-diethylmeta-toluamide)

(10) Fogger Bug Bomb (Isopropoxyphenyl)

(11) Spray Disinfectant (n-Alkl, 60%C14, 30%C16, 5%C12, 5%C18)

(12) "Raid" (Pryethrius, technical pipenonyl butoxide)

(13) "Curb" CN Tear Gas (Trichloroethane)

(14) "Paralyzer" CS Tear Gas (Orthochlorobenzamalononitrile)

(15) Military Tear Gas Grenade CS Type

(16) Military CS Capsules

Only PEG activated the detector, and this required six drops of the test PEG directly on the filter, so that alarm activation may have been from clogging the filter. This single alarm activation took 20 seconds.

In the tests the CS and CH in liquid form were sprayed directly on the filter and the filter reinserted into the detector, with no effect. None of the other agents produced any reaction.

The M-43 Detector which was used appeared be in good condition. It had been properly serviced, with a new agent and a new filters added. The M-43 does not have a certification nor calibration after delivery; however, there is a field test procedure for testing with PEG. The number of drops of PEG is not specified in the field test. Since, field tests are the only tests of the detector, the concentration required to activate any given detector is questionable. For reliable operation of the activation type simulator, the detector would need to be tested prior to installation of the telemetry pack, so that the amount of the activating agent needed is known.

Since only one M-43 was available, the test was somewhat inconclusive, but it did show that there is considerable risk in the design based on activating an actual M-43. Therefore an alternate design is also proposed, with the selection of the final approach to be resolved in subsequent efforts.

2.2.4 Alternate Design

From the experience with the 631st Battalion, it appears that battalions undergoing training may not have the authorized number of detectors. Therefore a concept which uses the actual detectors may not be practicable. There is also the risk associated with relying on activation of the actual alarm using a harmless chemical. The alternate approach selected was to simulate the entire M-43 from the ground up. The alternatives relating to this design had to do with the degree of detail to be provided. This design trade-off is at branch point F in Figure 8. Three options were identified:

(1) Simulation of all installation, operation, and maintenance actions

(2) Provide some working parts

(3) Provide only connectors for the M-42 remote alarm

In order to utilize all simulated funtions in the first alternative, a field controller would be required to spend considerable time monitoring the simulated actions of the operators. This is in contrast to the use of an actual alarm where the performance of procedures is self monitoring by resulting in operation or failure to operate.

There are certain functions however which are operationally desirable and which are not provided in the third approach.

Therefore the second approach was selected in which limited operational functions are to be provided.

2.2.5 Configuration Selected

The approach of using an actual chemical detector M-43 has many advantages in realism and training. However the approach may not be technically feasible. Also the quantity and quality of available M-43 may make that approach impractical. It is recommended that this approach be used if these shortcomings can be resolved. At the same time it is recommended that a concurrent approach using a simple independent simulator be followed. (See Figure 15.)

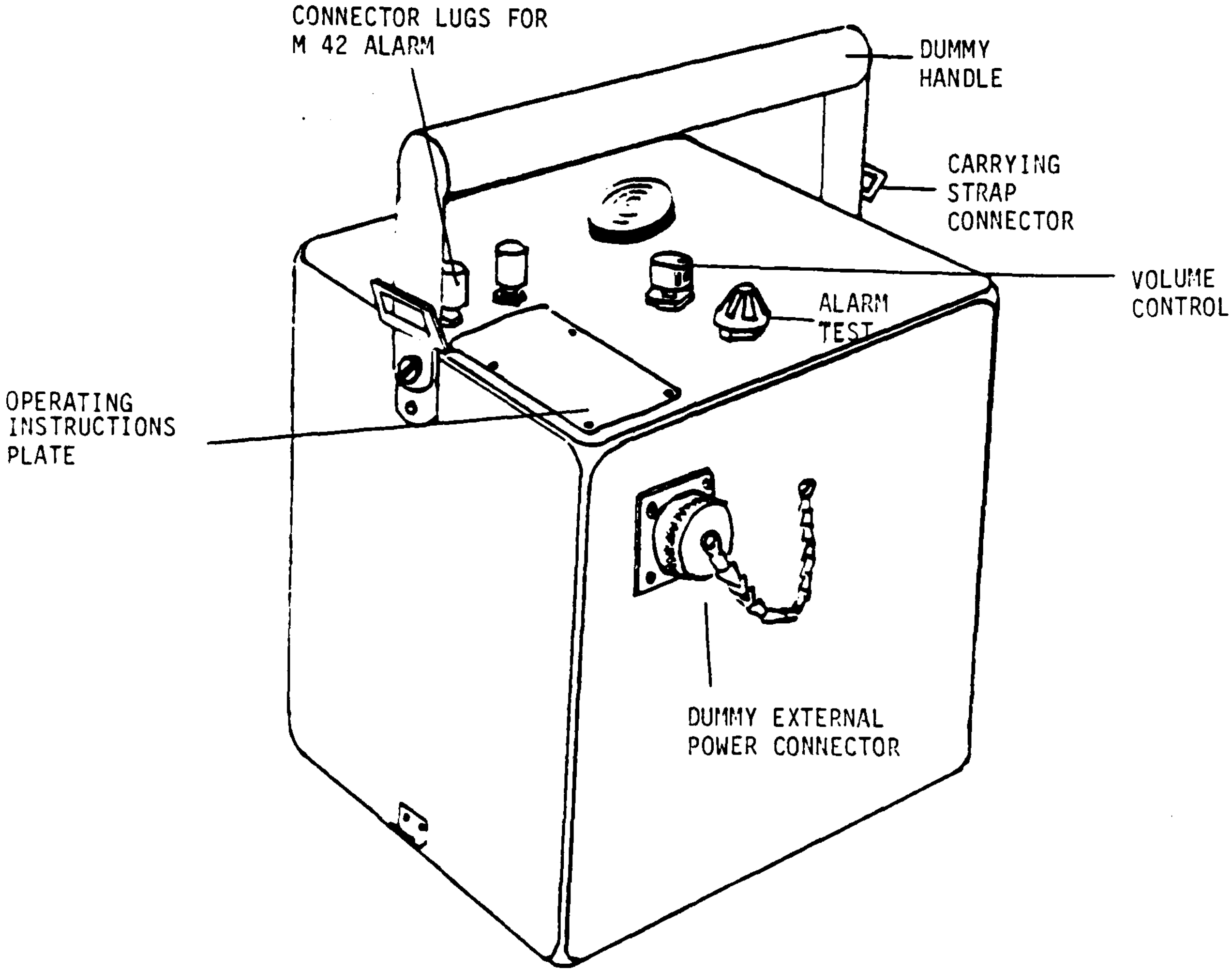


Figure 15. Alternate design for chemical detector simulator.

The second approach would have the following features:

- Operating instructions plate
- Handle and strap similar to those on the M-43.
- Same form as M-43 to conform to vehicle mounts
- Internal alarm with volume control
- Alarm test (zero adjust)
- Same operational batteries as M-43 (BA 3517/U)
- Capability to activate M-42 Alarm, including attachment lugs for remote alarm wires
- Capability to select either M-42 or internal alarm activation

2.2.6 Design Details

The chemical alarm simulator will use the discrete (on/off) pager. Discrete pagers have a coding plug and digital decoder which compares the output of the demodulator against the coding plug to check for it's address. If the data compares, then it turns on the alert logic. The alert logic has the capability of sending out a pulse up to twelve seconds in length. The alert logic pulse can be reduced by feeding the output back to the reset through a time delay. The shortest practical time delay is seven milliseconds. Therefore, any pulse from seven milliseconds to twelve seconds can be generated.

A motorized plunger, activated by the pulse would be attached to the output driver for chemical activation of an actual M-43 detector. In the alternate design, the same pulse will be used to latch a locking relay to activate an internal alarm and the remote M-42 alarm. The relay would be used since it isolates external transients from the low voltage circuits. By adjusting the zero control knob the operator could shut off the alarm (reset/unlatch).

The zeroing control which is provided in the alternate design turns off the alarm when turned in the counter-clockwise direction, and activates the alarm when turned in a clockwise direction. These functions will be implemented by using switches to ensure high reliability without the need for auxiliary interface circuits.

An alarm volume control is provided in the alternate design.

2.2.7 Design Risks

The primary design risk is the practicality of using an actual M-43 detector with a remotely controlled spray as a field simulator.

A second major uncertainty in the chemical alarm design is the need for an external antenna. An external antenna if required, would be mounted on the top corner near the alarm switch. The antenna would be quick change "rubber duck" type commonly used with walkie-talkies. Since the chemical alarms would be used frequently on vehicles which have radios, there is a possibility that these transmitters would interfere with the receipt of messages by nearby pager. An external antenna would improve receipt of messages with only a slight loss in realism in external appearance.

The external antenna in the chemical spray approach could provide the custom antenna as part of the handle. An additional "rubber duck" antenna on the top of the handle would serve as tempting, but unauthorized handle which could easily be broken.

2.3 RADIACMETER SIMULATOR

2.3.1 Function of the Radiacmeter Simulator

Radiacmeters are an important, and in many cases the only, means of monitoring the essentially invisible radiation rate in the environment created by nuclear warfare. Troops in the field are equipped with a variety of radiacmeters. The most common one, which is used to monitor the general ambient conditions, is the IM-174 Radiacmeter. The function of the field simulator is to receive a digital message via a radio frequency link, confirm that the message contains the specific address of the individual pager, and to produce a meter reading in response to the message. The reading must be in the form of a needle rotation over a scale covering an arc of about 100 degrees. The needle should maintain the set displacement until another message is received.

2.3.2 Characteristics of the Radiacmeter Simulator

Required and desired characterisics of a radiacmeter simulator are shown in Table 3.

Table 3. Required and desired characteristics of a radiacmeter field simulator.

CHARACTERISTIC	REQUIRED OR DESIRED
The field simulator shall display a radiation rate on a meter having the same appearance and the same scale as the Radiacmeter IM-174 A and B/PD.	Required
On command, the meter shall display a reading with plus or minus ten percent of the value input by a remote command.	Required
Once a reading is displayed on the meter, it shall remain displayed until updated by a subsequent command.	Required
The external appearance of the field simulator shall be the same as the Radiacmeter IM-174 A and B/PD with the possible exception of the addition of a short antenna. The weight shall be approximately the same.	Required
Development, procurement, and operating cost shall be low.	Required
Maintenance requirements shall be low.	Required
Reliability of operation shall be high.	Required
The field simulator shall remain operational throughout the operational environment associated with field maneuvers at Fort Irwin, California.	Required
Operation and storage of the field simulator shall not create a safety hazard.	Required
All operational procedures and maintenance procedures of the field simulator shall be the same as the Radiacmeter IM-174 A and B /PD.	Desired
Little or no special training shall be required to operate the field simulator.	Desired

Table 3. Required and desired characteristics of a radiacmeter field simulator (continued).

The design shall use an off-the-shelf pager, which is common to all field simulators, as a receiver/decoder.	Desired
Batteries installed in the field simulator shall last for a two week exercise rotation.	Desired
The simulator shall be useable with the same web gear as the IM-174.	Desired

2.3.3 Alternatives & Trade-Offs

The radiacmeter field simulator was analyzed from its physical, electrical and output constraints. A case the size of the Radiacmeter IM-174 provided more than ample room for the electronics and the batteries. Proper design of the simulator case should take into account the problems with the current trainer AN/TDQ-T1(V), i.e., a capability to install batteries in a reversed position and problems with the battery contacts because of the different configurations of the positive terminals on the BA33U and the BA30 batteries. The electrical interface between the paging unit and the output, which essentially requires a meter reading, was an important design consideration. The path for the design of the radiacmeter simulator is shown in Figure 16.

A. Receiver/Decoder Type

Two alternative receiver/decoder types were considered:

(1) A discrete on/off type pager as the receiving unit, with the meter reading based on the number of pulses sent.

(2) A numeric output type pager as the receiving unit, with the meter reading based on decoding the digital signal received.

The first approach would use the discrete paging unit and would count pulses for each meter movement. This would require multiple transmissions to cause an upreading in the needle, and a reset and/or reversal indication to count down from the meter position. The discrete units could provide this since they have four methods and modes with corresponding radio addresses. This approach used a less expensive pager and less complicated circuitry. The unit cost of this approach would be about two hundred to three hundred dollars less than the alternative.

Disadvantages of this approach are as follows:

(1) It requires considerably more radio transmissions. These additional transmissions drain down batteries of all pagers since all must power up to check every address which is transmitted before rejecting it and returning to a low power, listening state.

(2) If a receiver misses a number of pulses, its accuracy would be degraded.

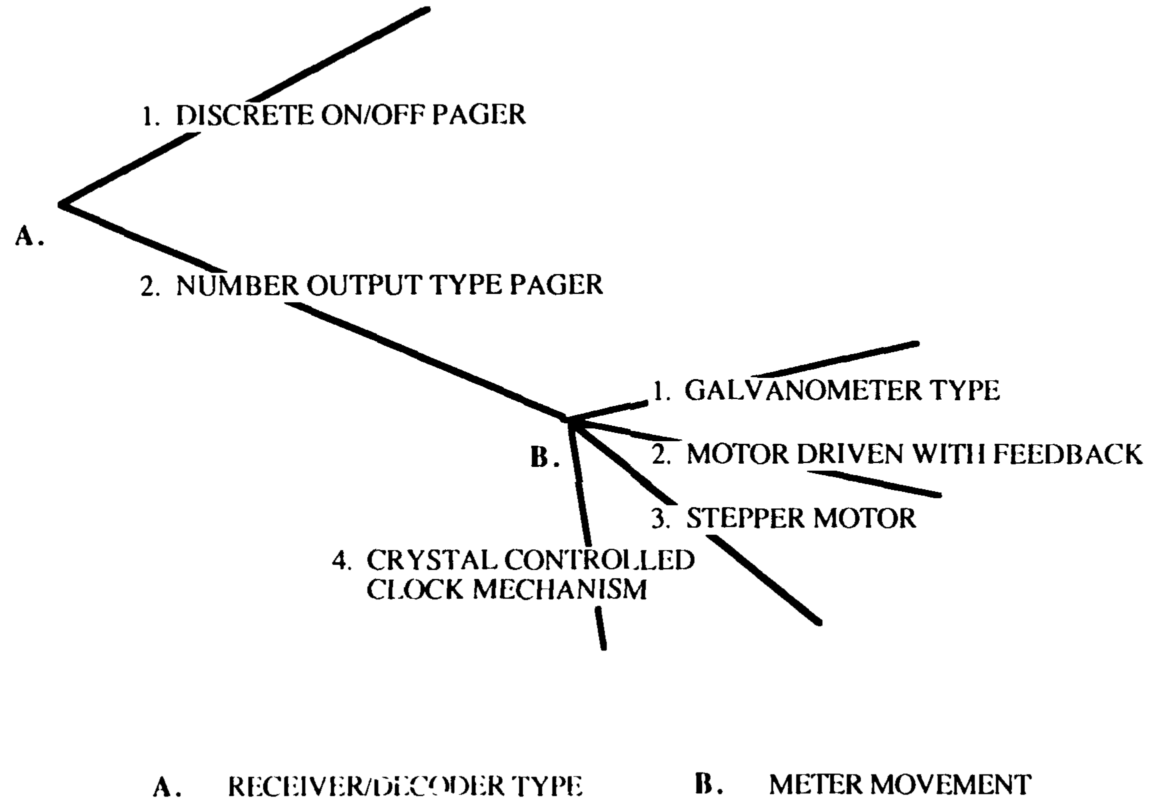


Figure 16. Path for the design of the radiacmeter simulator.

(3) The large scale and fine resolution of the meter scale would require several transmissions for each reading.

It was therefore determined that the best approach in this application would be a digital output pager which handles ten numeric characters. The output display from this pager in the commercial configuration would be removed, and the serial stream of data would be used to move a pointer on the meter face. Data from the paging is sent in a fast burst to the simulator, then the paging unit "falls asleep" in a low power, listening mode. Data sent out of the pager is in a nonuniform pattern in which each of the eight segments of the ten character display and diagnostic prompts are formatted to the display chip. A controller therefore, will be required to reformat the data into a useable format. Additionally, it will strip off other visual clues that a pager customer would want, such as, power up, the number of messages received, battery tests and an error detect in the received message.

B. Meter Movement

Four types of meter movements were considered:

(1) A galvanonmeter type

(2) A motor with feedback

(3) A stepper motor

(4) A crystal controlled clock movement

The classical way to display the information would be to store it in a register, with a digital-to-analog converter to drive circuitry in the meter. Since the radiacmeter displays a reading when nuclear radiation is present, the movement will be continuously activated in nuclear, or simulated nuclear warfare. For a galvanometer type meter this will require constant application of electrical energy, with consequent frequent changing of batteries. In addition, the meter is an easily damaged, high-maintenance, high-cost item.

A more desirable solution would be to have the meter go to a set point on the dial and stay at that position without consuming any additional power. A number of technologies can provide this capability; one being a motor with feedback, and another being a stepper motor.

The motor with a feedback approach is shown in Figure 17. This uses a motor which can run in either direction and a feedback device which compares the input signal with a signal determined by the needle position. The difference signal will move the needle until the needle is in the desired position.

The stepper motor approach is shown in Figure 18. In this case dual drive amplifiers cause the needle to move a given amount for each pulse. For each new reading the needle returns to zero before a new needle displacement is stepped off. This prevents an accumulation of any individual reading errors which may have occurred. Stepper motors can move only in discrete steps, so that once a zero point is known, they can move to a desired increment accurately without additional feedback. The cost, size and angular resolution of this technology is improving daily.

The crystal controlled clock movement approach is shown in Figure 19. The crystal controlled clock circuitry is modified so that the activating pulses do not come from the timing crystal, but are determined by the input signal. Displacement will be proportional to the number of pulses received. To preclude accumulation of errors, the needle will return to zero for each new reading.

The motor with feedback and the stepper motor require considerable control circuitry and mechanisms and have the disadvantage of noisy operation which may artificially prompt the operator that the meter has changed. A lowest cost and most attractive solution to the problem appears to be using a clock movement as the meter movement. It has a number of advantages: the movement is sturdy, can take considerable abuse such as dropping, will not jump out of its movements, will not bang against the stops, and will not require any tweaking on the dial face for zeroing. Additionally, it uses extremely low power, it is inexpensive and readily available. A mechanism from an inexpensive alarm clock using only the second hand was easily modified for this application. Movement of the second hand was controlled by the number of pulses applied to the mechanism. A circuit board could be constructed to provide these pulses based on the code received.

The major drawback in the last approach is that the needle in the clock mechanism goes only clockwise and each increment is six degrees. Rebuilding the system to provide movement in both directions does not appear to be feasible. However, in the case where a reading is to be reduced, the needle could be quickly rotated completely around the dial to return to zero, if circuitry is provided to accelerate the rate of pulses received. The new control message received would then move the needle forward to the new

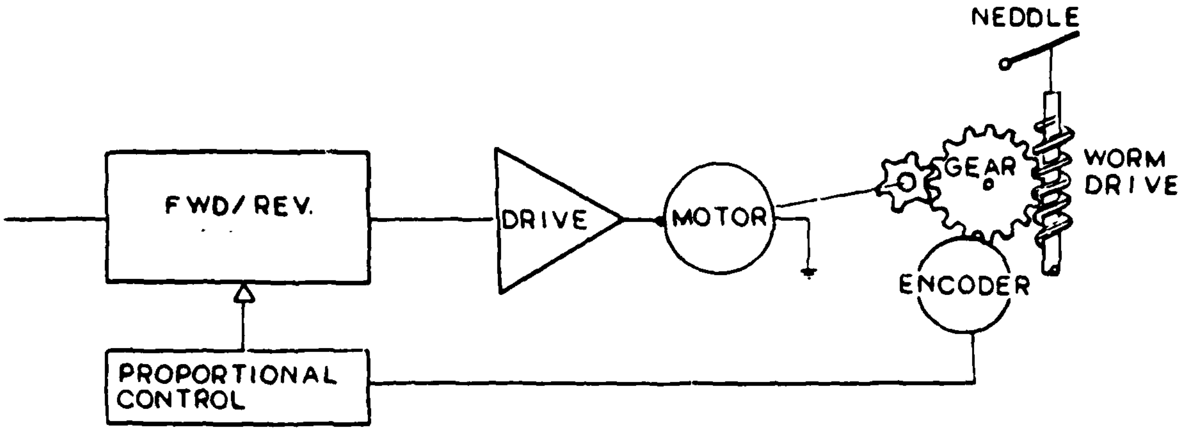


Figure 17. DC motor with feedback.

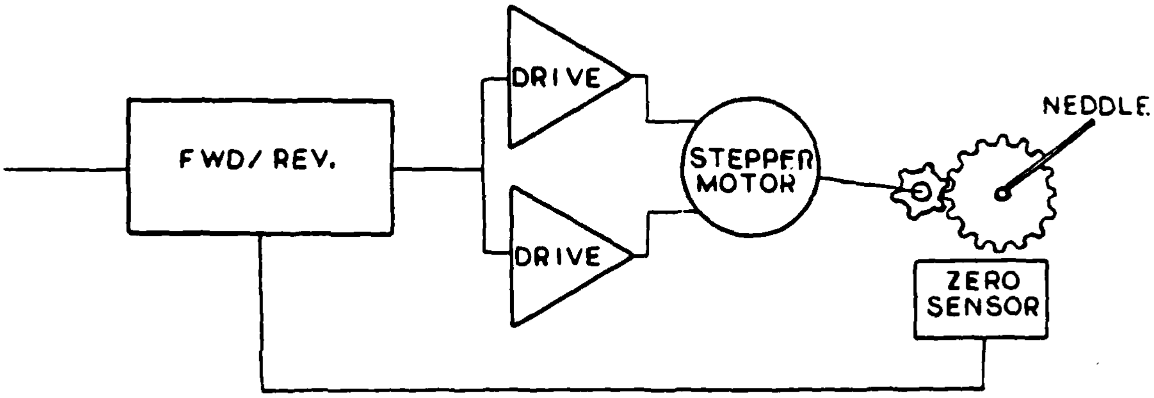


Figure 18. Stepper motor approach.

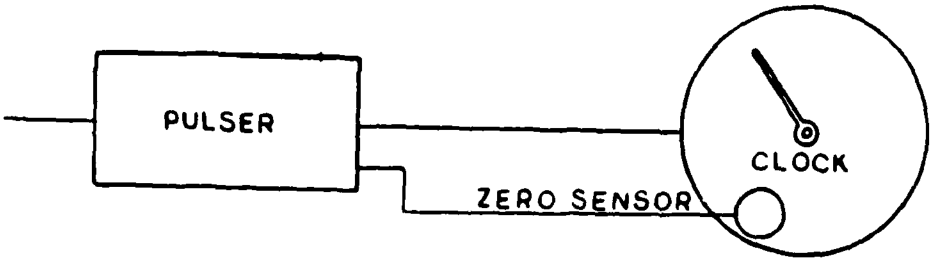


Figure 19. Clock movements.

desired position. This movement would usually not be apparent to the user. If the return to zero is observed, no reading can be made while the meter is rapidly moving, so that errors in reading will not be made.

In the latter three approaches if a signal is not received, the meter will continue to read the previous radiation rate which will usually be close to the correct readings.

2.3.4 Design Details

2.3.4.1 Description The radiacmeter has the same form as the real radiacmeter. Major components of the radiacmeter are the Motorola BPR-2000, the numeric pager, a level translator, a output controller, driver and the display movement. (See Figure 20.)

The BPR-2000 pager (See Figure 6) receives a transmission between frequencies 138 and 174 MHZ. The receiver will accept an internal antenna or an external antenna. If initial prototype tests determine the internal antenna is adequate, the external antenna will not be used in the design. The signal goes through a preamplifier and is then mixed with the first high frequency down converter. Thereafter it is filtered and goes into the second low frequency mixer. It is filtered, limited, and demodulated out to a square wave. The same chip also detects energy on its input and powers up the circuits including the microprocessor. The ouput of the demodulator goes to the microprocessor. The microprocessor compares it against the code plug, which contains its address and operational functions. The output of the microprocessor is a serial data stream and a clock. Then, the read line is momentarily grounded, and a stream of 92 bits is received from the pager/microprocessor. The data stream is level translated to a higher voltage and input to the microcontroller.

The microcontroller reformats the data into the originally transmitted character values from the segment values. The segment values are those which form a numeric character on the display. These are shown in Figure 21. In addition to reformatting the values, the microcontroller must disregard diagnostic patterns that the pager/micro-processor inserts to help standard configured users that the pager is working. These are shown in Figure 22. The first diagnostic is to check all of the segments in the display. It does this by displaying all 8's; these are formed by having characters on. The second indication is the "on" indication, which shows that the alarm is active; this consists of dashes through the center of the display. The third is low battery condition. The fourth is an indication of which one of the four addresses that the pager unit has received.

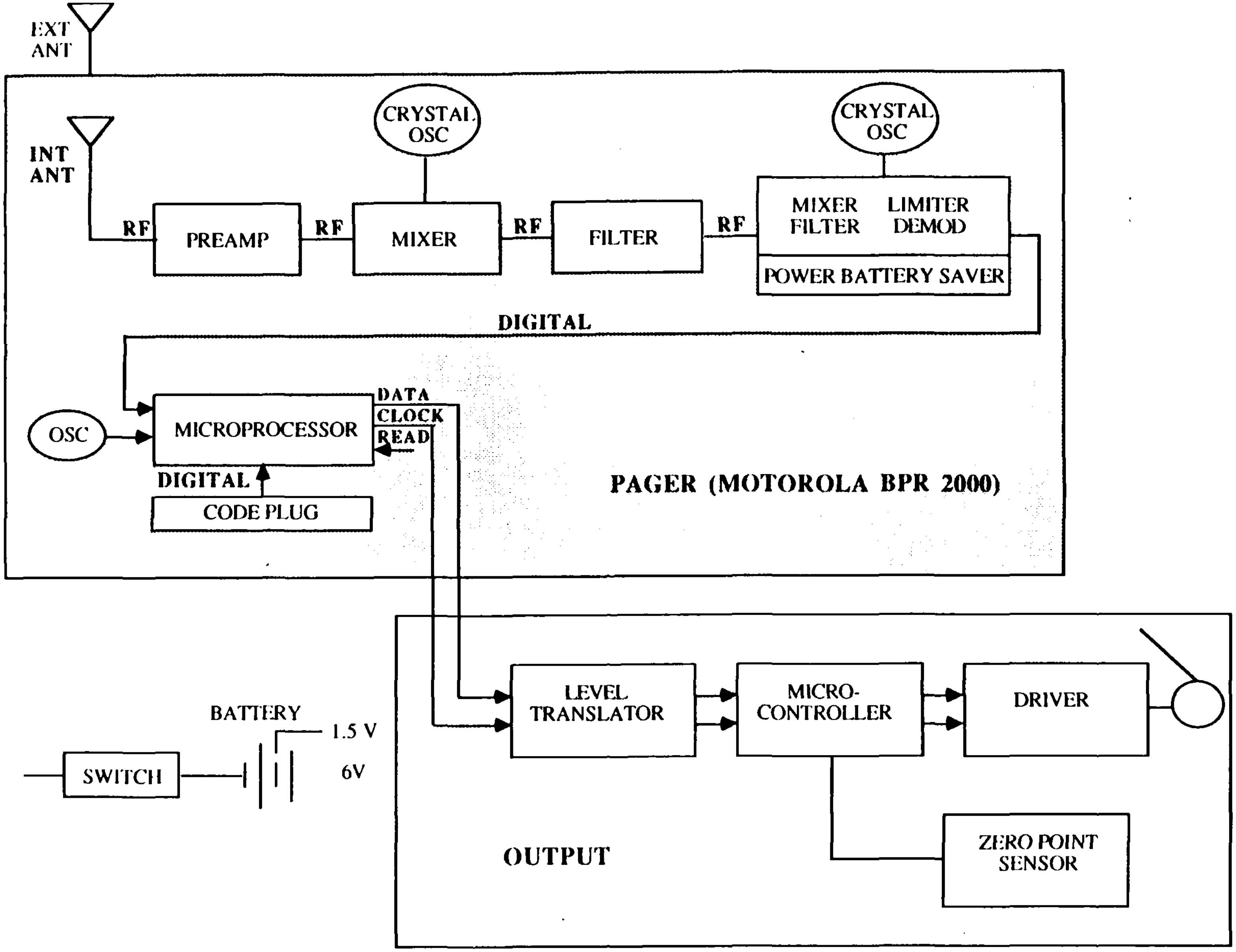
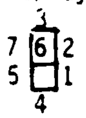


Figure 20. Radiacmeter dosimeter functional block diagram.

WRITING SEGMENTS TO BDR DISPLAY

Digit 1 is leftmost on display; Digit 12 is rightmost

Segments are numbered:



Bits are sent in the following order (In the following table "D" stands for digit and "S" stands for segment.)

4th bit sent ← 1st bit sent

	Digit 12 Seg.7	Digit 12 Seg.6	Digit 12 Seg.5	Digit 12 Seg. 4					
12th bit sent →	Digit 11 Seg.7	Digit 11 Seg.6	Digit 11 Seg. 5	Digit 11 Seg. 4	Digit 11 Seg. 3	Digit 11 Seg. 2	Digit 11 Seg. 1	Digit 12 Seg. 1	← 5th bit sent
	Digit 10 Seg.7	Digit 10 Seg.6	Digit 10 Seg. 5	Digit 10 Seg. 4	Digit 10 Seg. 3	Digit 10 Seg. 2	Digit 10 Seg. 1	Digit 12 Seg. 2	← 13th bit sent
	Digit 9 Seg.7	Digit 9 Seg. 6	Digit 9 Seg. 5	Digit 9 Seg. 4	Digit 9 Seg. 3	Digit 9 Seg. 2	Digit 9 Seg. 1	Digit 12 Seg. 3	
	Digit 8 Seg.7	Digit 8 Seg.6	Digit 8 Seg. 5	Digit 8 Seg. 4	Digit 8 Seg. 3	Digit 8 Seg. 2	Digit 8 Seg. 1	X	
	Digit 7 Seg.7	Digit 7 Seg.6	Digit 7 Seg. 5	Digit 7 Seg. 4	Digit 7 Seg. 3	Digit 7 Seg. 2	Digit 7 Seg. 1	X	
	Digit 6 Seg.7	Digit 6 Seg.6	Digit 6 Seg. 5	Digit 6 Seg. 4	Digit 6 Seg. 3	Digit 6 Seg. 2	Digit 6 Seg. 1	X	
	Digit 5 Seg.7	Digit 5 Seg.6	Digit 5 Seg. 5	Digit 5 Seg. 4	Digit 5 Seg. 3	Digit 5 Seg. 2	Digit 5 Seg. 1	X	
	Digit 4 Seg.7	Digit 4 Seg.6	Digit 4 Seg. 5	Digit 4 Seg. 4	Digit 4 Seg. 3	Digit 4 Seg. 2	Digit 4 Seg. 1	Box Annure	
	Digit 3 Seg.7	Digit 3 Seg 6	Digit 3 Seg. 5	Digit 3 Seg. 4	Digit 3 Seg. 3	Digit 3 Seg. 2	Digit 3 Seg. 1	Speaker Annure	
	Digit 2 Seg.7	Digit 2 Seg 6	Digit 2 Seg. 5	Digit 2 Seg. 4	Digit 2 Seg. 3	Digit 2 Seg. 2	Digit 2 Seg. 1	F2 Annure	
Last Bit → Sent	Digit 1 Seg.7	Digit 1 Seg.6	Digit 1 Seg. 5	Digit 1 Seg. 4	Digit 1 Seg. 3	Digit 1 Seg. 2	Digit 1 Seg. 1	F1 Annure	

'X' bits are not displayed but must be sent for proper spacing

Figure 21. BDR display segments.

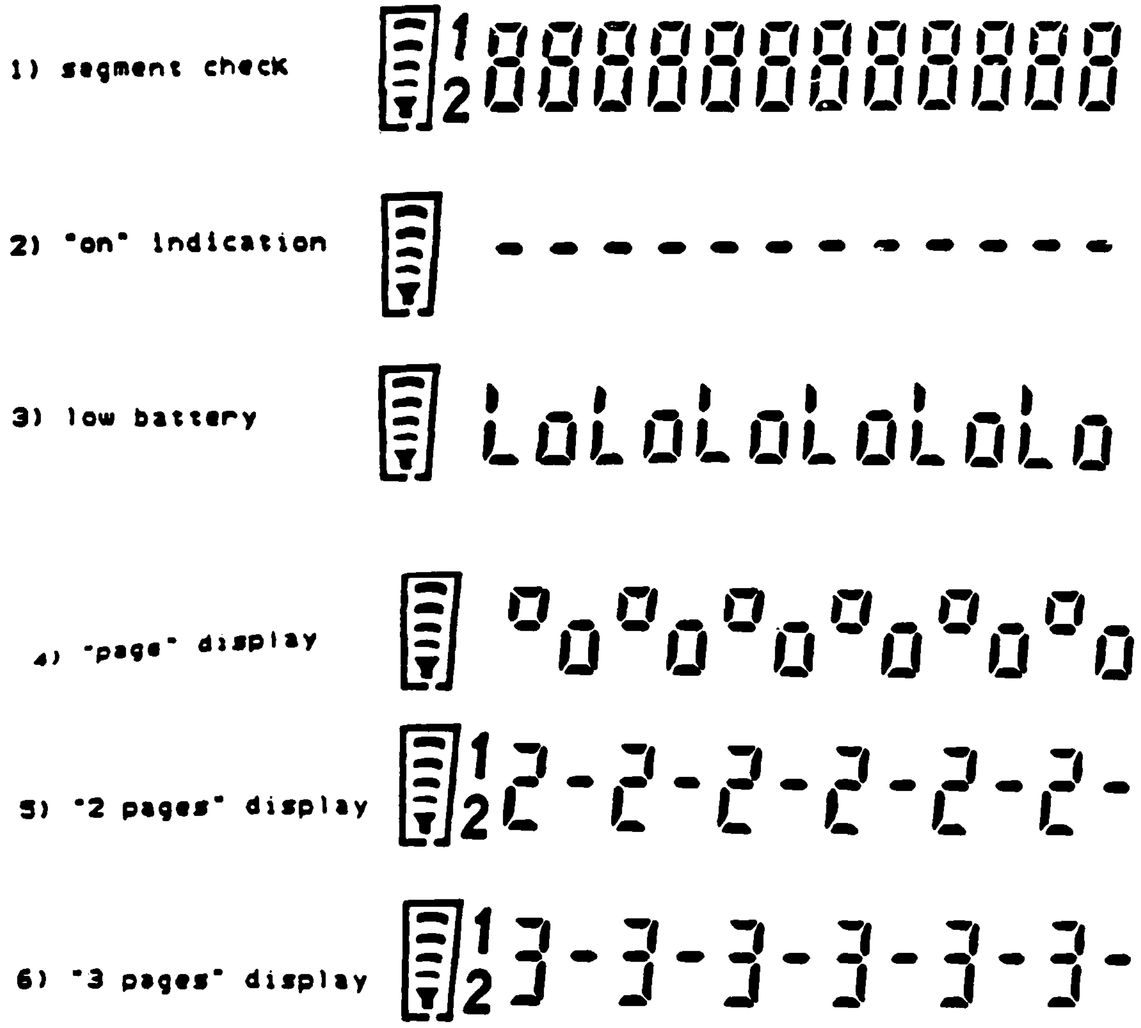


Figure 22. Diagnostic display.

The microcontroller will not use the whole range of 10 characters for indicating purposes. Depending upon which movement is selected (a function of the desired resolution), the microcontroller will convert the characters into pulses. It will provide the pulses to the driver to operate the movement. The zero point indicator will feed back to the microcontroller to determine where its position is in relation to the zero point.

The output controller first feeds the 12 bytes of data for the whole display from the pager into it local RAM. There it executes a program to extract each one of the 8 segments into 12 bytes (8 bits each) with one byte for each character in the segment as shown in Figure 21. Of the 12 bytes only 10 are useful data transmitted from the CIS computer. The other 2 bytes are diagnostic prompts. The controller will then map these 8 segments into a decimal value. This decimal value will then be used to provide a count for the pulsing of the output movement. If the new value received is greater than the current value, then the processor will caculate the difference and increment the movement to the new value. If the value is less than the current value, it will pulse the movement until it receives a zero sensor indication and then increment the movement based on the number of pulses it has received for its current value. There are a number of controllers which have local RAM and an erasable program capability onboard the chip. These require a minimum amount of support circuits and the programs can be erased when subjected to 30 minutes of ultraviolet light and then reprogrammed.

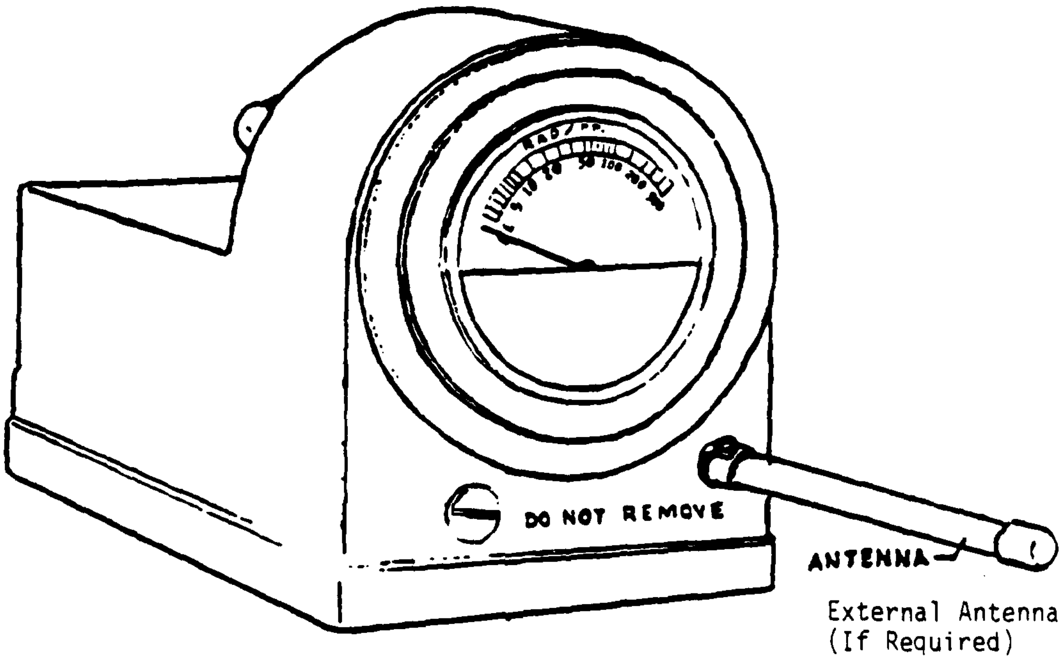
2.3.4.2 Design Risks Requirement for an external antenna can be resolved testing the prototype units in their operational environment. External antenna improve the signal strength, and therefore, the area of coverage at the risk of some damage to themselves and a slight deformation of the carrying case. The external antenna will be a "rubber duck" type commonly available for walkie-talkie use.

Interface between the microcontroller and the microprocessor within the pager is simple and straight forward as is the translation of the segments into character values.

The meter movement zero point sensor has no significant technological risk.

The case provides adequate space for the circuit boards and batteries without risk of miniaturization problems.

The proposed external configuration of the radiacmeter field simulator (see Figure 23) is very similar to the of the actual IM-174.



External Antenna
(If Required)

Figure 23. IM-174A/PD radiacmeter simulator.

2.4 DOSIMETER SIMULATOR

2.4.1 Function of the Dosimeter Simulator

In this discussion the Radiacmeter IM-93 is called a dosimeter, to differentiate it from the Radiacmeter IM-174, discussed in the previous section. The IM-174 measures radiation rates, the IM-93 measures radiation doses, and is therefore truly a dosimeter.

The dosimeter IM-93 measures the radiation dose received by the wearer. In nuclear warfare, one is carried by each of two members of each platoon sized unit. The dosimeter gives the commanders a measure of how much radiation each troop unit has received. This allows commanders to know when troops are approaching potentially dangerous thresholds and which troops have had the most and least exposure, for use in assigning missions that entail further radiation exposure. The IM-93 is zeroed every day, or every few days, by placing it in a charging device which contains a strong, controllable electric field.

The dosimeter, which is the size and shape of a large cigar, is read by looking through it from one end. The reading is displayed on a scale which is illuminated by light from the other end.

The IM-93 will eventually be replaced by the IM-95. The IM-93 and 95 are very similar in external appearance. The IM-95 has the sensing device in a vacuum chamber.

The function of the dosimeter simulator is to reproduce a reading based on a remote digital signal. As with the other field simulators, the dosimeter simulator must check the digital address of the reading, and reject all inputs except those specifically addressed to it.

2.4.2 Characteristics of the Dosimeter Simulator

Required and desired characteristics of the dosimeter field simulator are shown in Table 4. These are based on the nuclear warfare training enhancement concept for the NTC developed in Phase 1, and on the characteristics of IM-93 and IM-95.

Table 4. Required And desired characteristics for a dosimeter field simulator.

CHARACTERISTIC	REQUIRED OR DESIRED
The field simulator shall provide a total dose reading which is within 20 rads or ten percent of the value of an input command (whichever is larger). The scale range is zero to six hundred rads.	Required
The field simulator shall display the dose rate by viewing through a tube in the same manner as a Tactical Dosimeter IM-93/UD and IM-95. The display shall similar to the IM-93/UD or IM-95.	Required
Once a reading is displayed it shall remain displayed until updated by a subsequent command.	Required
Development, procurement, and operating cost shall be low.	Required
Maintenance requirements shall be low.	Required
Reliability of operation shall be high.	Required
The field simulator shall remain operational throughout the operational environment associated with field maneuvers at Fort Irwin, California.	Required
Operation and storage of the field simulator shall not create a safety hazard.	Required
All operational and maintenance procedures of the field simulator shall be the same as for the Tactical Dosimeter IM-93/UD.	Desired
Little or no special training shall be required to operate the field simulator.	Desired

Table 4. Required And desired characteristics for a dosimeter field simulator (continued).

The design shall use an off-the-shelf pager, which is common to all field simulators, as a receiver/decoder.	Desired
Batteries installed in the field simulator shall last for a two week exercise rotation.	Desired
The simulator shall fit in the breast pocket of a fatigue jacket or field jacket.	Desired

2.4.3 Alternatives & Trade-Offs in the Dosimeter Simulator Design

Several alternatives were considered in the design of the dosimeter simulator. The design path, showing these alternatives, is shown in Figure 24.

A. Operational Concept

The initial design alternative was between operation and simulation, providing the following alternatives:

(1) Operate a real IM-93 dosimeter by electrically causing it to read a certain value.

(2) Develop a new simulator to be used for training instead of the IM-93.

A. The first alternative would operate an actual functional dosimeter by placing it in a charging/discharging unit to cause it to indicate the new values. The IM-93 contains an electroscope. In zeroing the unit a charge is placed on the electroscope which causes the leaves to separate. The separated leaves appear as a zero reading. The charge which keeps the leaves separated dissipates faster in the ionizing environment caused by nuclear radition. Theoretically, the effects of the ionizing environment may be duplicated by placing the dosimeter in an electric field created by a charging unit. The charging unit would be carried by the dosimeter wearer and would be about the size of a canteen. The charging voltage would be determined by an input remote radio frequency signal. Before reading the dosimeter the operator would insert it into the charging unit to produce the reading. The charging unit would operate much like the standard zeroing unit, but is reversed, so that the unit produces a nonzero reading.

The examination of the dosimeter showed that using an actual dosimeter may not be practical. Since the dosimeter needs to be adjusted by hand while looking through it and operating a generator, the responses did not appear to be linear or consistent among different dosimeters. Different applied voltages were needed for meter initialization, depending on the meter. It therefore appeared that using a real dosimeter was not practical since consistent readings probably could not be obtained for given voltages produced in the charging device. Therefore the second alternative was selected. This consisted of building a completely new dosimeter simulator.

B. External Configuration

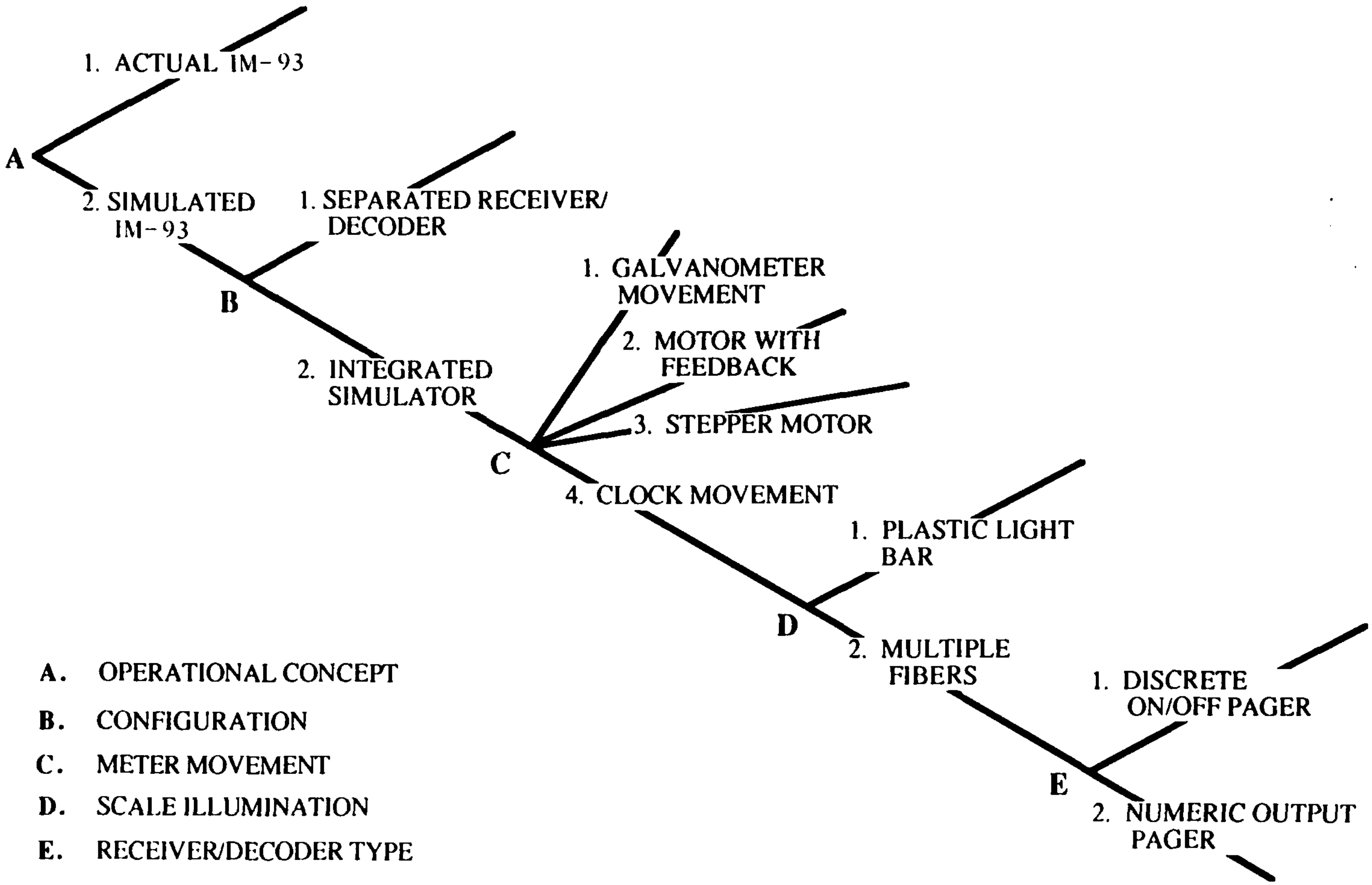


Figure 24. Path for the deisgn of the dosimeter simulator.

Two configurations were considered:

(1) A simulator the size of an actual IM-93, used with a separate setting device

(2) An integrated simulator and receiver/decoder

The first approach was to use a simulator with the same external configuration as the IM-93. This configuration is too small to contain the receiver/decoder for the remote signal, so that this approach would require a setting device into which the dosimeter simulator would be inserted to produce a reading. The setting device would contain the receiver/decoder, power supply, and circuitry to produce a movement on the dial of the simulator. The setting device would be about the size of a canteen and could be carried on the standard web belt.

The alternative was to add a package a little larger than a small paper back book to the side of a cylinder which would be the size of an IM-93.

The first alternative provides the most realistic reading device, but requires an extra step to produce a reading. It is also the most complicated. In field conditions, dirt or moisture could enter the setting device and affect its operation. Because of its sophisticated and two-step operation this approach would probably have the lowest reliability.

The second alternative looks less realistic, but the operational procedure is the most realistic. The second alternative would be the easiest to design, and inherently the integrated unit would be the most reliable. For these reasons the second alternative was selected.

C. Meter Movement

Four types of meter movements were considered:

(1) A galvanometer type movement

(2) A motor with feedback

(3) A stepper motor

(4) A crystal controlled clock movement

These same alternatives were considered in the design of the radiacmeter simulator and are described in Section 2.2.3.B. Power consumption, packaging and survivability, along with realism and cost, were prime considerations in the dosimeter design. The galvanometer movement would require too much power for a pocket application of the dosimeter, unless batteries were frequently replaced. Applicability of a DC motor with its feedback or stepper motors was not selected because of the additional complexity of the feedback mechanisms and packaging size. The stepper motor resolution decreases as size is reduced. A two inch diameter motor would have increments of about twenty degrees. Reduction gears can increase the resolution but the package size would then again increase. A watch movement proved to be the ideal candidate for display. It consumes little to no power, and is rugged enough to hold its position when power is removed and is inexpensive and readily available. A quartz movement was selected and tested, the second hand providing the meter movement action. Arranging the scale in a semicircle would increase the resolution over a more linear arrangement. (See Figure 25.) The characteristic of the watch movement of only going forward created no problem since the IM-93 itself only goes forward except in the zeroing process.

In all alternatives a simulator for zeroing the device would be simply a dummy box, with the actual zeroing signal supplied via the the RF remote control network. This is appropriate since the software for the dosimeter must have a provision for recording when the dosimeter is reset to zero. After the dosimeter is reset to zero, the software will obtain the dosimeter reading by subtracting the total current dose from the dose at the time of the most recent reset. (This will require the controller to observe and notify the CIS operations personnel when the dosimeter zeroing occurs.)

D. Scale Illumination

The IM-93 scale is illuminated by holding the hollow tube-shaped device up to a light source and looking through it. Since the simulator will probably not have a direct path, the following lighting methods were considered:

(1) Plastic lighted transmission bars

(2) Multiple individual light fibers

A number of light bars to back light the meter movement with the ambient light were tested. These plastic rods are easily scratched, and if not mirror finished on the ends, have large losses in their light transmission. The most practical way to back light the dosimeter would be to use a bundle of individual fibers around the movement to the back of the display.

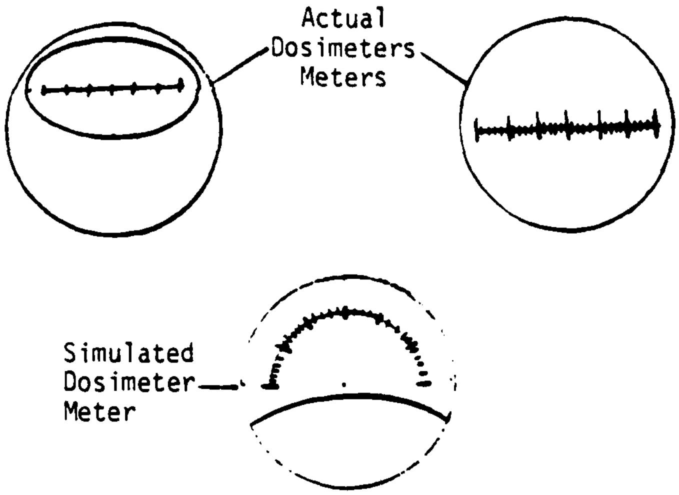


Figure 25. Dosimeter scales.

D. Receiver/Decoder Type

Two alternative receiver/decoder types were considered:

(1) A discrete on/off type pager as the receiving unit, with the meter reading based on the number of pulses sent

(2) A numeric ouput type pager as the receiving unit, with the meter reading based on decoding of the digital signal received

The evaluation of the alternatives was the same as in the radiacmeter design process (Section 2.3.3-A, above).

2.4.4 Design Details

The configuration selected is shown in Figure 26. This integral configuration was the digital output Motorola BPR-2000 Pager as a receiver/decoder, a clock mechanism for the meter movement, a controller board, battery, and a semicircular display which provides the appropriate resolution over the 0 to 600 rad scale.

2.4.4.1 Description The functional operation of the dosimeter is the same as that of the radiacmeter as described in Section 2.3.5.1 above, with the exception of the output. The output for the dosimeter, because of its small size, is ideally suited to the quartz movement. A watch movement will be used in the dosimeter to reduce the size, so that the simulator will fit in a breast pocket of a fatigue jacket or field jacket.

2.4.5 Design Risks

Risks and uncertainties with the dosimeter do not appear to be great. They are about the same as for the radiacmeter since the dosimeter uses the same essential electronics as the radiacmeter. The only significant change for the dosimeter is in the packaging. The shape and the use of the dosimeter and the fashion in which it is carried requires that the antenna be internal to the unit, therefore, the packaging must be RF transparent. The only risks involved appear to be in the packaging to provide the RF transparency for the antenna and to be rugged enough to survive carrying in the breast pocket of a jacket.

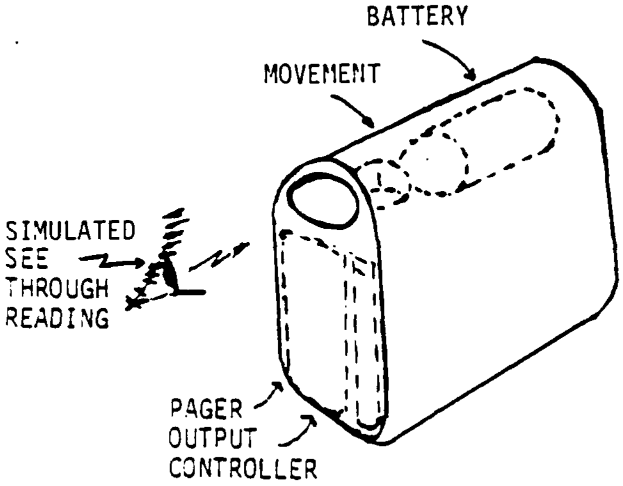


Figure 26. Dosimeter simulator.

SECTION 3
CONCLUSIONS

3.1 COMMON CONTROL SYSTEM

- A common control system based on Motorola paging systems, using off-the-shelf commercial hardware, appears to be the most cost-effective approach.
- Capability of this system to receive transmissions throughout the Fort Irwin operational area has been demonstrated.

3.2 CHEMICAL DETECTOR SIMULATOR

- There is considerable design risk associated with the design based on activating an actual M-43 detector with a harmless chemical. This is the most cost-effective design if (1) a harmless chemical will reliably activate the M-43 detector (2) there are enough M-43 detectors in the hands of troops undergoing training and (3) the degradation of M-43s resulting from use in field exercises is acceptable.
- There were not sufficient M-43s available for test to resolve the first of the above conditions (whether a harmless chemical will reliably activate the detector).
- If the use of actual M-43 detectors is not feasible, an alternate design for a simple simulator appears most cost-effective.
- Designs for both approaches are provided.

3.3 RADIACMETER SIMULATOR

- A design for a radiacmeter has been provided using a clock mechanism for a meter movement. Although the needle only moves in a clockwise direction, its other advantages make this approach most cost-effective.

- The desirability of a small external antenna needs to be determined in tests in the operational RF environment at Fort Irwin.

3.4 DOSIMETER SIMULATOR

- A design for a dosimeter has been provided using the same type of movement as the radiacmeter simulator.
- The dosimeter simulator design integrates the tube shape of the M-93 with a rectangular container for the receiver/decoder and circuit board.

SECTION 4
RECOMMENDATIONS

4.1 COMMON CONTROL SYSTEM

Confirm the operability of the common control system when all RF emitters are operating during an actual engagement simulation at Fort Irwin.

4.2 CHEMICAL DETECTOR SIMULATOR

Perform the necessary research to determine if harmless chemicals can be used to reliably activate the M-43 detector.

Determine if sufficient M-43 detectors are available in battalions to provide adequate training at the NTC.

Determine if the wear on actual M-43 detectors from use in field exercises is acceptable.

Continue the development and test of both chemical detector simulator approaches in brassboard form until the above uncertainties are resolved.

Base the incorporation of an external antenna on the results of tests in 4.1.

4.3 RADIACMETER SIMULATOR

Continue the development of the radiacmeter simulator by building and testing a brassboard.

Base the incorporation of an external antenna on the results of tests in 4.1.

4.4 DOSIMETER SIMULATOR

Continue the design at the dosimeter simulator by building and testing a brassboard.

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Armed Forces Staff College
ATTN: Library

Assist to the Sec of Def, Atomic Energy
ATTN: Mil Appl, C. Field
ATTN: R. Wagner

Defense Advanced Rsch Proj Agency
ATTN: TTO

Defense Intell Agency
ATTN: Library
ATTN: RTS-2B

Defense Nuclear Agency
ATTN: NASF
ATTN: NATF
ATTN: NAWE
ATTN: RAAE
ATTN: RAAE, K. Schwartz
ATTN: RAEE
ATTN: RAEV
ATTN: SPSS
ATTN: SPTD
ATTN: STBE
ATTN: STNA
ATTN: STRA
ATTN: STSP
4 cys ATTN: STTI-CA

Defense Tech Info Center
12 cys ATTN: DD

Dep Under Sec of Def
ATTN: S&TNF, T. Jones

Field Command, DNA, Det 2
Lawrence Livermore National Lab
ATTN: FC-1

DNA PACOM Liaison Ofc
ATTN: J. Bartlett

Field Command, Defense Nuclear Agency
ATTN: FCPRW
ATTN: FCTT, W. Summa
ATTN: FCTXE

Interservice Nuc Wpns School
ATTN: Doc Control

Joint Chiefs of Staff
ATTN: J-3, Strat Opns Div
ATTN: J-5, Nuc/Chem Plcy Br, J. Steckler
ATTN: J-5, Nuc Div/Strat Div
ATTN: J-5, Strat Div, W. McClain
ATTN: JAD/SFD
ATTN: JAD/SSD

National Defense University
ATTN: NWCLB-CR

Ofc of the Sec of Def, Net Assessments
ATTN: Doc Control

DEPARTMENT OF DEFENSE (Continued)

Principal Dep Under Sec of Def, Rsch & Engrg
ATTN: J. Wade Jr.

Program Analysis & Evaluation
ATTN: S. Johnson
ATTN: Strat Programs

US European Command
ATTN: ECJ-3
ATTN: ECJ-5

US Natl Mil Representative, SHAPE
Attention US Doc Ofc for
ATTN: Nuc Plans
ATTN: Intel
ATTN: Pol, Nuc Concepts

US Readiness Command
ATTN: J-3

Under Sec of Def for Policy
ATTN: Dir Plng & Requirements, M. Sheridan

Under Secy of Def for Rsch & Engrg
ATTN: K. Hinman

United States Central Command
ATTN: CCJ3-OX, Daigneault

DEPARTMENT OF THE ARMY

Asst Ch of Staff for Intell
ATTN: DAMI-FIT

Chemical Rsch & Dev Ctr
ATTN: SMCCR-OPR

Dep Ch of Staff for Ops & Plans
ATTN: DAMO-NCN
ATTN: DAMO-RQA, Firepower Div
ATTN: DAMO-RQS
ATTN: DAMO-SSM, Pol-Mil Div
ATTN: Tech Advisor
5 cys ATTN: DAMO-NC, Nuc Chem Dir

National Training Ctr
ATTN: TAF-NBC

US Army Armament Rsch Dev & Cmd
ATTN: DRDAR-LCN-E

US Army Ballistic Rsch Lab
ATTN: DRDAR-BLA-S, Tech Lib
ATTN: DRDAR-BLV
ATTN: R. Reisler

US Army Chemical School
ATTN: ATZM-CM-F
ATTN: ATZN-CM-CC
ATTN: ATZN-CM-N

US Army Comd & General Staff College
ATTN: DTAC
3 cys ATTN: Combined Arms Rsch Lib

DEPARTMENT OF THE ARMY (Continued)

US Army Comb Arms Combat Dev Acty
ATTN: ATZL-CAP-DT
ATTN: ATZL-SWN
ATTN: ATZL-SWP
ATTN: ATZL-SWT
ATTN: ATZL-TAS-S

US Army Concepts Analysis Agency
ATTN: CSSA-ADL, Tech Lib

US Army Engineer School
ATTN: Library

US Army Europe & Seventh Army
ATTN: AEAGC-NC-C

US Army Forces Command
ATTN: AF-OPTS
ATTN: AFOP-TN

US Army Foreign Science & Tech Ctr
ATTN: DRXST-SD-1

US Army Infantry Ctr & Sch
ATTN: ATSH-CD-CSO

US Army Intel Threat Analysis Det
ATTN: AIAIT-HI

US Army Intell Ctr & School
ATTN: ATSI-CD-CS

US Army Logistics Ctr
ATTN: ATCL-OOL, S. Cockrell

US Army Material Command
ATTN: DRCDE-D

US Army Materiel Sys Analysis Actvy
ATTN: X5, W3JCAA

US Army Mobility Equip R&D Cmd
ATTN: DRDME-WC, Tech Lib, Vault

US Army Nuclear & Chemical Agency
ATTN: Library
ATTN: MONA-CM
ATTN: MONA-NW
ATTN: MONA-OPS
ATTN: MONA-OPS, B. Thomas
ATTN: MONA-OPS, J. Ratway

US Army TRADOC Sys Analysis Actvy
ATTN: ATAA-TAC
ATTN: ATOR-TDB

US Army Training & Doctrine Comd
ATTN: ATCD-FA
ATTN: ATCD-N
ATTN: ATIC-NC

US Army War College
ATTN: AWCAC, F. Braden, Dept of Tactics
ATTN: Library
ATTN: War Gaming Facility

US Army Comb Arms Opns Rsch Acty
ATTN: ATOR-CAT-T

DEPARTMENT OF THE ARMY (Continued)

USA Military Academy
ATTN: Doc Lib

USA Missile Command
ATTN: DRSMI-RH
ATTN: DRSMI-XF

V Corps
ATTN: G-2
ATTN: G-3

VII Corps
ATTN: G-2
ATTN: G-3

DEPARTMENT OF THE NAVY

Marine Corps
ATTN: Code OTOO-31
ATTN: DCS, P&O, Requirements Div
ATTN: DCS, P&O, Strat Plans Div

Marine Corps Dev & Education Command
ATTN: Commander

Naval Postgraduate School
ATTN: Code 1424, Library

Naval Research Laboratory
ATTN: Code 2627, Tech Lib

Naval War College
ATTN: Code E-11, Tech Svc

Nuclear Weapons Tng Gp, Atlantic
ATTN: Nuclear Warfare Dept

Nuclear Weapons Tng Gp, Pacific
ATTN: Nuc Warfare Dept

DEPARTMENT OF THE AIR FORCE

Air Force Operational Test & Eval Ctr
ATTN: OA

Air University Library
ATTN: AUL-LSE

Assist Ch of Staff, Studies & Analysis
2 cys ATTN: AF/SAMI, Tech Info Div

Dep Ch of Staff, Plans & Opns
ATTN: AFXOOR, Opns, Opnl Spt

Foreign Technology Div
ATTN: SD
ATTN: TQ

DEPARTMENT OF ENERGY AGENCY

Sandia National Laboratories
ATTN: Tech Lib, 3141

DEPARTMENT OF DEFENSE CONTRACTORS

Kaman Tempo
ATTN: C. Anderson
ATTN: DASIAC

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Science Applications International Corp
ATTN: B. Packard
ATTN: D. Erickson
ATTN: J. Birney
ATTN: J. Ickler
ATTN: J. Martin
ATTN: L. Metzger
ATTN: M. Drake
ATTN: P. McKeown
ATTN: R. Plock

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Kaman Tempo
ATTN: DASIAC