

MIL-HDBK-63038-1A (TM)

15 May 1984

SUPERSEDING

MIL-HDBK-63038-1 (TM) 1 May 1977
WITH NOTICE 1 AND MIL-M-63037

TECHNICAL MANUAL WRITING HANDBOOK

This handbook is approved for use by Department of the Army and is available for use by all Departments and Agencies of the Department of Defense.

15 May 1984

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INTRODUCTION

This handbook is a general guide for a technical writer. It contains guidelines and criteria for selecting the optimum type and amount of TM (technical manual) coverage for military equipment, and related components under all mission conditions.

This handbook has been developed for use in conjunction with the technical content specifications to provide the additional guidance material needed to produce usable, user-oriented TM.

In many cases, several alternatives exist for presentation of TM information. In these cases, selection criteria are included to guide the writer's selection of the best alternative. When possible, these criteria are based on:

- a. Target audience
- b. Type of equipment
- c. Complexity of equipment
- d. Representative examples of TM's on similar equipment.

A handbook like this, by its very nature, can treat only a portion of available materials in a *general way*. Therefore, some of these rules are written in general terms by intention. The detailed technical manual required to cover a particular item or system must be planned to meet the specific and unique needs of that item or system. This planning, in turn, must consider not only the specification, but also the user's information requirements in the specific situation.

Requirements for technical writing style are contained in a companion publication:

Technical Writing Style Guide

MIL-HDBK-63038-2

NOTES

- Apply this handbook as required by the technical content specification and contract.
- Review these documents carefully to determine exactly what methods and techniques are required.

Section 1

DIVISIONS/TITLES/HEADINGS

NUMBERING

	Page		Page
Overview	1	Paragraphs, Illustrations, tables, and charts	3
Methods and Requirements	1	Subdivisions of paragraphs	3
Divisions	1	Pages	3
Titles and headings	2		

OVERVIEW

This topic contains requirements and guidelines for:

- a. Division of manuals into parts, chapters, sections, etc.
- b. Numbering of these divisions.
- c. Selection of titles and headings for various subdivisions of a manual. The requirements and guidelines include:
 - (1) Placement
 - (2) Capitalization
 - (3) Style

METHODS AND REQUIREMENTS

Divisions

Technical manuals are organized into divisions and subdivisions to make the information easy to understand, find, and correlate with equipment. The usual organizational divisions and subdivisions are:

- | | |
|-----------------------------|--------------------|
| a. front matter | c. appendixes |
| b. parts | d. glossaries |
| chapters | e. checklist items |
| sections | |
| paragraphs | f. indexes |
| illustrations/tables/charts | |
| subparagraphs | |

There should be at least two of each subdivision used - where there is a part one, there should be a part two; where there is a chapter 1, there should be a chapter 2, etc.

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A manual should be divided into parts only where it is desired to separate the coverage for the various maintenance levels; where more than one model is covered, and the difference between models is so great that coverage together is not feasible; or in any situation where a breakdown between chapter and volume can be justified. A part should always be a division of a volume, never a separate volume in itself.

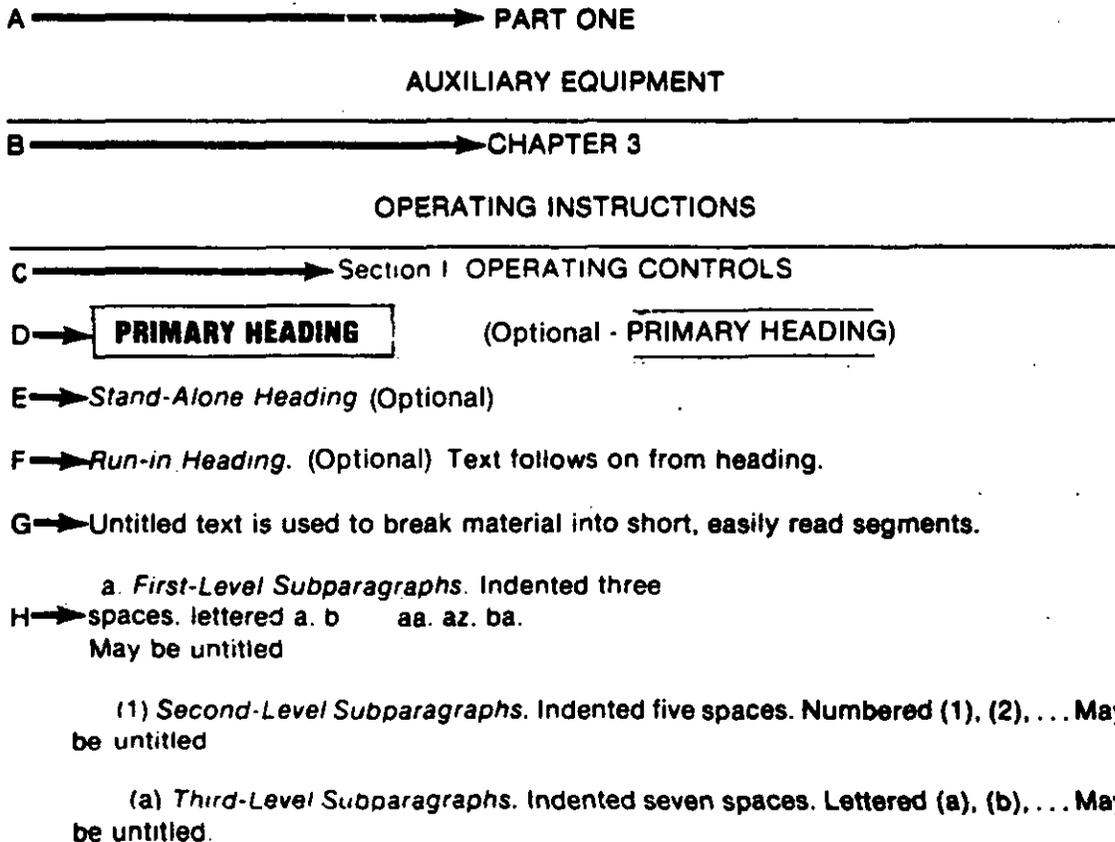
Depending on the circumstances, a manual may be divided into:

- Chapters or Sections only
- Chapters and Sections

These circumstances are prescribed by the content specification, usually on the basis of manual size and equipment complexity.

Titles and headings

The method of placing and standardizing titles and headings is shown below. (The part, chapter, and section numbers are for example purposes only (see A, B, C below))



Numbering and placement of titles for parts, chapters, appendixes, glossaries, checklists, and sections should be in accordance with MIL-M-38784 and the applicable technical content specification.

MIL-HDBK-63038-1A (TM)*Paragraphs, illustrations, tables, and charts.*

Paragraph headings should also be used as shown in D thru G, preceding page. Primary headings shall be boxed, boldface, larger type size than running text, or underlined and overlined.

The material should be prepared in integrated modules of text and associated illustrations. Each module should have an appropriate heading and be presented on one page or two facing pages whenever possible.

Paragraphs and figure numbering are optional for the text, depending upon the particular style of presentation selected; the option will be selected by the procuring activity. Modules may be assigned paragraph numbers as required. For a module of more than two facing pages, the title should be repeated at the beginning of each new left-hand page followed by "cont" in parentheses. Overview information should not have paragraph numbers.

Example:

TIMING ADJUSTMENT (CONT)

or

TIMING ADJUSTMENT (CONT)

Illustrations, tables, and charts will usually be integrated into the modules of information and will not be assigned separate numbers. If several illustrations, tables, or charts are collected together (for example, schematic diagrams or wiring tables) figure or table numbers may be assigned in accordance with MIL-M-38784.

Subdivisions of paragraphs.

Breakdowns beyond the third subdivision should not be used (see H, preceding page).

If a title is used, it should be underscored or italicized. Text beginning on the same line as the title (see F, preceding page) should be separated from the title by a period and two spaces.

Although subparagraphs need not be titled, if one subparagraph is titled, all subparagraphs of the same level within that paragraph should be titled. The second and all following subparagraph lines shall begin at the left margin.

Pages and paragraphs.

Pages and paragraphs (when paragraph numbers are used) should be numbered in accordance with MIL-M-38784.

Section 2

INDEXING

	Page		Page
Overview	1	Major Types	2
Methods and Requirements	1	Symptom index	3
Objectives and Principles	1	Other Indexes	4
Content	2	Referencing	4
Types of Indexes	2	Maintenance information indexed ...	4
		Other indexes	4

Fig. No.	Title	Page
1.	Front Cover Index	5
2.	Table of Contents	6
3.	Alphabetical Index	7
4.	Section Index	7
5.	Symptom Index	8
6.	Logic Tree Symptom Index	8
7.	Maintenance Information Index	9

OVERVIEW

The term indexing is used in its broadest meaning in the following discussions and requirements. Indexing applications in technical manuals include:

- a. Conventional alphabetical index, usually located in the back of a manual.
- b. Conventional table of contents, usually located in the front of a manual.
- c. A front cover index of major areas of a manual.
- d. Chapter or section indexes located in front of each major division of the manual. In some cases subsection indexes are required.
- e. Special indexes, such as a symptom index for locating proper troubleshooting procedures.

METHODS AND REQUIREMENTS

Objectives and Principles

Effective indexes:

- a. Tell the user where information is located within the manual based on the knowledge or equipment malfunction indication available.
- b. Enable the user to find an item under any name likely to be used for the item.

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- c. Are readily available when needed.
- d. Give the user an overview of the manual.
- e. Show the organization of the manual and the relative location of different parts of the manual including:
 - (1) Introductory and descriptive information
 - (2) Operating instructions
 - (3) Maintenance instructions
 - (4) Appendixes

Content

The content of specific indexes varies depending on the user's needs. It may include:

Codes	Headings	Symptoms
Common names	Indicators	Tasks
Controls	Part numbers	Test equipment
Equipment items	Procedures	Tests
Functions	Serial numbers	Titles

Entries in indexes should be in the everyday language of the user, and contain various multiple entries as necessary (e.g., "radio receiver" and "receiver, radio"; "ir" and "infrared"). This is necessary since the official nomenclature is not always readily recognized by the user.

Index reference columns must be clearly identified as to what is being referenced (e.g., page, paragraph, table).

If information cannot be found without a great deal of searching, the user may stop using the index and the manual. As indexes become more difficult to use, the user is more likely to avoid them rather than make an extra effort to understand them.

Types of Indexes

In addition to the detailed table of contents and list of illustrations, manuals may require standard indexes and possibly unique ones. The objective is to provide whatever indexes the user needs.

a. The major types of indexes are:

- (1) *Front cover index* (fig. 1) listing the most important areas of the manual.

The entries in the front cover index must be chosen carefully. If too many entries are used, then the type size becomes small and difficult to read, and the bleed-to-edge indicators (if used) are hard to differentiate.

The titles must be descriptive enough to prevent confusion between similar topics within the TM.

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- (2) *Table of contents* (fig. 2), located in the front of the manual, containing chapter and section title headings plus any major topic areas. Entries within the main table of contents which duplicate the entries in the front cover index should be highlighted with a box. This is in case the cover is torn off or soiled beyond legibility. Special indexing information such as that covered in (5) below may be included also in the table of contents.
- (3) *A complete, alphabetical, subject index* (fig. 3), located at the back of manual, containing entries the technician is likely to look for. Two-column, indented index format should be used.

An alphabetical index should enable the user to find important items under those names most likely to be looked for. Entries should be constructed so that they accurately label and pinpoint the applicable information. For example:

<i>List</i>	<i>Also List</i>
<i>Alarm, troop</i>	Troop alarm
<i>Blades, droop snoot</i>	Droop snoot blades
<i>Measurements, waveform</i>	Waveform measurements
<i>Motor, starter</i>	Starter motor
<i>Plates, welded</i>	Welded plates
<i>Removal, transformer 1A3</i>	1A3, transformer, removal
	Transformer 1A3, removal

The alphabetical index should be the last portion of the manual (except for foldout pages). An alphabetical index should be provided when:

- Required by the technical content specification.
- The manual size exceeds 35 pages.
- Otherwise needed to enable the manual user to quickly locate any needed information.

For a multivolume manual, each volume, as applicable, should contain its own alphabetical index.

- (4) *Chapter and section indexes* (fig. 4 or 7), located at the front of each major division of the manual. Entries should list every heading in the material. Usually, listings shall be in order of appearance; however, if more effective, other methods of listing may be used (e.g., alphabetical, equipment categories, task categories).
- (5) *Special indexes* (fig. 5 thru 7), located in the front of chapters or sections, usually referred to by the front cover index. These indexes ordinarily facilitate troubleshooting or scheduled maintenance. Listings may be by symptom, code, equipment, or otherwise as required. For example, starting with the knowledge or malfunction indications the user has available, the types of indexes required may include subject, symptom, control/indicator, equipment subunit, task, location, etc.
- *Symptom index.* A separate index for locating the applicable troubleshooting procedure when a trouble symptom is apparent should be included in every manual.

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The symptom index should be located at the front of the troubleshooting section and be indexed on the front cover as "Symptom Index." The symptom index should be arranged alphabetically and should include the indicator or location of the symptom and a statement of the symptom. References should be made to pages and figures as applicable.

Symptoms should be listed in the same terminology as they are encountered ("fuel gage reads empty," not "gas tank is empty"). Figure 5 is a conventional *symptom index*; figure 6 is an example of a logic-tree format symptom index.

- Maintenance information index. A maintenance information index (MII) which lists all parts subject to maintenance action (tasks) may be provided in every manual. If provided, it should be located at the back of the manual. It may be in alphabetical order or in lowest-to-highest numerical order by part number or reference designator (whichever is more useful) and should include the part name and the location of all information related to the component. Figure 7 is an example of an MII.
- b. *Other indexes.* Other indexes should be supplied as necessary. These may be by location, configuration, serial number of subassembly, auxiliary test equipment, control or indicator, task, or any outstanding similarity or difference that will help the user find information in the manual. Usually, each procedure section should have its own index at the beginning of the section. Examples of sections which usually require separate indexes are the following:

Periodic Maintenance
Repair Instructions
Test Instructions
Calibration Procedures
Troubleshooting Procedures

These indexes may be used in conjunction with the cover index. For example, if the cover states that periodic maintenance instructions begin on page 3-1, a periodic maintenance index on that page would help locate the exact procedure wanted.

Referencing

Make index references for subjects, titles, topics, symptoms, etc., as follows:

Chapter	}	By number	
Section			
Paragraph	}		If unnumbered, by page number
Subparagraph			If numbered, by number.
Illustration, table, or chart			

The security classification of any classified title appearing in an index should be indicated.

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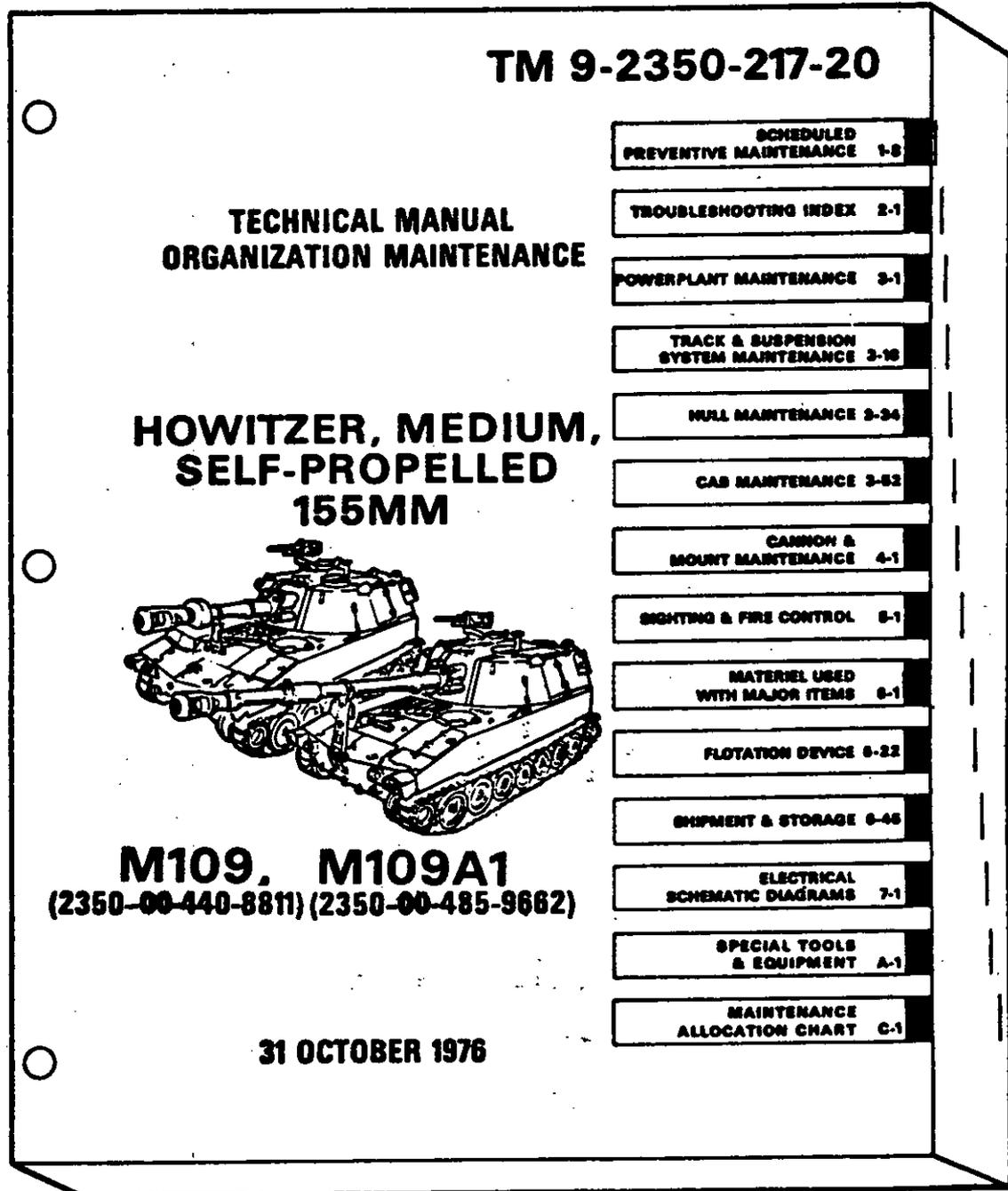


Figure 1. Front Cover Index

Organizational Maintenance Manual

SELF-PROPELLED GUIDED MISSILE EQUIPMENT CARRIER

XM727 (1450-00-933-4704)

You can help improve this manual by calling attention to errors and by recommending improvements and stating your reasons for the recommendations. Your letter or DA Form 2028, (Recommended Changes to Publications) should be mailed directly to (insert name of procuring activity). a reply will be furnished directly to you.

		Page
	HOW TO USE THIS MANUAL	xi
CHAPTER 1	INTRODUCTION	1-0
Section I	Chapter Overview	1-0
Section II	General Information	1-1
	Equipment Description	1-2
CHAPTER 2	TECHNICAL PRINCIPLES OF OPERATION	2-0
Section I	Chapter Overview	2-0
Section II	Integrated System	2-1
	Major Systems	2-2
CHAPTER 3	CARRIER MAINTENANCE INSTRUCTIONS	3-0
Section I	Chapter Overview	3-0
Section II	Tools and Equipment	3-1
Section III	Service Upon Receipt	3-2
	Preventive Maintenance Checks and Services	3-2
CHAPTER 30	COMMUNICATION SYSTEM	30-0
Section I	Chapter Overview	30-0
Section II	Preventive Maintenance Checks and Services	30-1
Section III	Troubleshooting Procedures	30-2
	Maintenance Procedures	30-3

Figure 2. Table of Contents
2/6

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TMX-XXXX-XXX-20	
ALPHABETICAL INDEX	
Subject, Para	Subject, Para
A	H
Armament Subsystem, Helicopter, TOW Guided Missile: XM 65, 1-1	Holdback Pin Extension Verification (See Shear Pin Depression Verification). 3-12
B	
Built-In-Test, 2-3, 3-7	
C	
Checks controls and indicators, 3-2 Cleaning, Controls and Indicators Check, 3-2 Cross-References, 1-5	L
D	Launchers Data, 1-10 Description, 1-9

Figure 3. Alphabetical Index

Section V. LAUNCHER AND LAUNCHING-HANDLING RAIL CHECKS AND ADJUSTMENTS

	Para		Para
Air Servicing the Accumulator	3-36	Mobile Launcher Checks	3-38
Axle Brake Adjustment	3-40	Test Station Air Pressure Check	3-34
Axle Brake Servicing Procedures	3-41	Test Station Oil Flush and Air Bleed Procedure	3-32
Downlock Switch Checks	3-20	Uplock Switch Checks	3-21
Launcher Air Bleed Procedure	3-28	Wedgelock Switch Checks	3-17
Launcher Leveling Checks	3-36		
Launcher Oil Drain Procedure	3-21		

Figure 4. Section Index

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SYMPTOM INDEX		Troubleshooting Procedure (Para)
COOLING SYSTEM		
Radiator		
Boils over		3-12
Leaks		3-17
Temperature Gage		
No indication		3-29
Runs cold		3-11
Runs hot		3-13
ENGINE		
Misses		3-34
Overheats		3-72
Won't start		3-27
EXHAUST SYSTEM		
Excessive smoke		3-33
Water vapor		3-33

Figure 5 Special Index - - Symptom Index

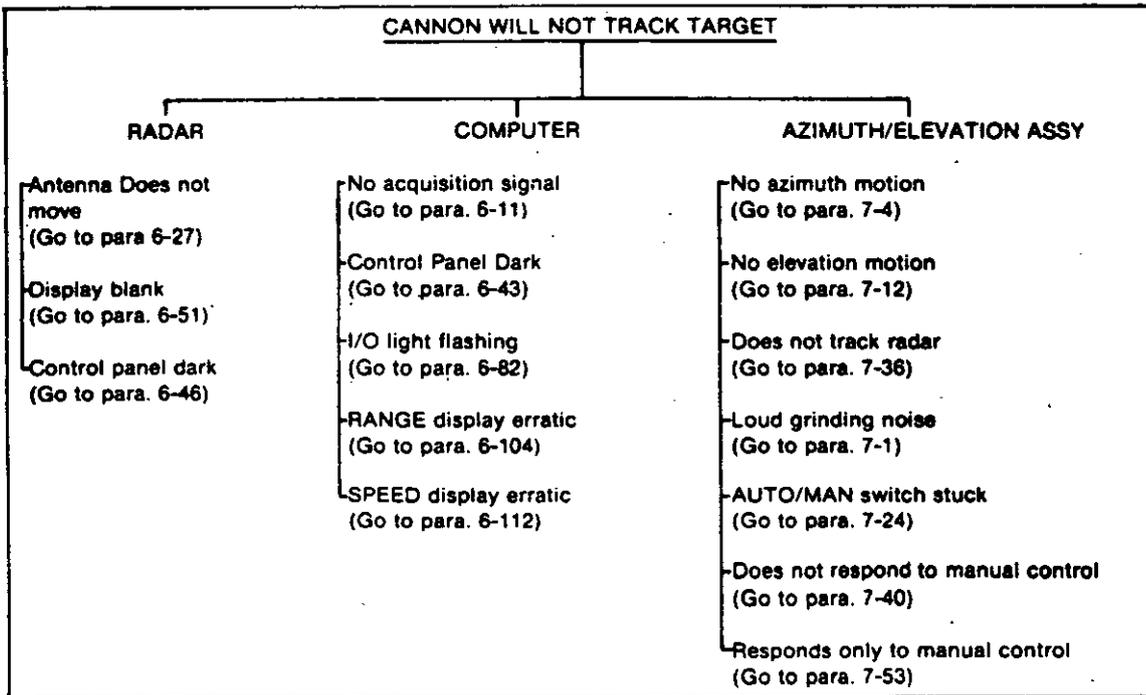


Figure 6. Logic Tree Symptom Index

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Nomenclature	P/N	Disassemble	Clean	Inspect	Repair	Replace	Reassemble	Test/Troubleshoot
Aperture Corrector	320885	3-11	3-14	5-69	7-25	7-58	3-17	8-9
Crystal Clock and Logic	319004	3-42	---	5-28	12-14	7-16	3-45	11-74
Elevation Motor Assembly	318272	3-5	3-7	5-6	7-23	7-53	3-9	8-7/Table 8-1
Logic Card A6	318319	---	---	5-14	7-87	4-21	---	8-22
Summing Amp Card A27	318557	---	---	5-14	7-63	4-27	---	9-14
Sync Generator	325322	---	3-67	5-8	---	7-61	---	8-96

NOTE: Reference is to page unless otherwise indicated.

Figure 7. Maintenance Information Index

Section 3

ACCESSING

	Page		Page
Overview	1	Methods	1
Methods and Requirements	1	Requirements	1
Objectives and Principles	1		

OVERVIEW

The term *accessing* as used in the following discussions is limited to physical entry features that help a technician quickly find the particular section of a manual that contains the needed information.

Other aspects of accessing are discussed elsewhere in this handbook. These other aspects include:

- a. Indexing (Section 2)
- b. Divisions, Titles, Headings, Numbering (Section 1)
- c. Text Associated with Illustrations (Section 5)

METHODS AND REQUIREMENTS

Objectives and Principles

Any effective accessing method should improve the usability of the manual by the following:

- a. Lowering performance time by allowing quicker access to information.
- b. Reducing number of errors in finding information.
- c. Increasing efficiency and convenience of use of the manual.

Methods

Methods which may be used to improve accessing includes but is not limited to:

- a. Black box at edge of pages.
- b. Different colored stock.

Requirements

Black box at edge of page (fig. 1) is the preferred physical entry feature because it is a less expensive and more effective method. The black box at edge of page is used in conjunction with the front cover index discussed in Indexing (Section 2). Criteria for black box locators are:

- a. Manuals which have more than 35 pages should include black box locators as shown in the following figure.

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b. Each page within a major topic area should include identically placed black box bled to the edge opposite binding.

c. Care should be taken to achieve near perfect alignment between boxes within a topic area. Trim marks should be placed on each page which has a bleed-to-edge indicator so that the printer will correctly position the page for printing.

d. Manuals of less than 35 pages need contain no physical entry feature but should retain the front cover index.

This method is recommended for ease of entry, minimum added size, and wear resistance. (However, printing lead time will be greater and quality control more difficult.)

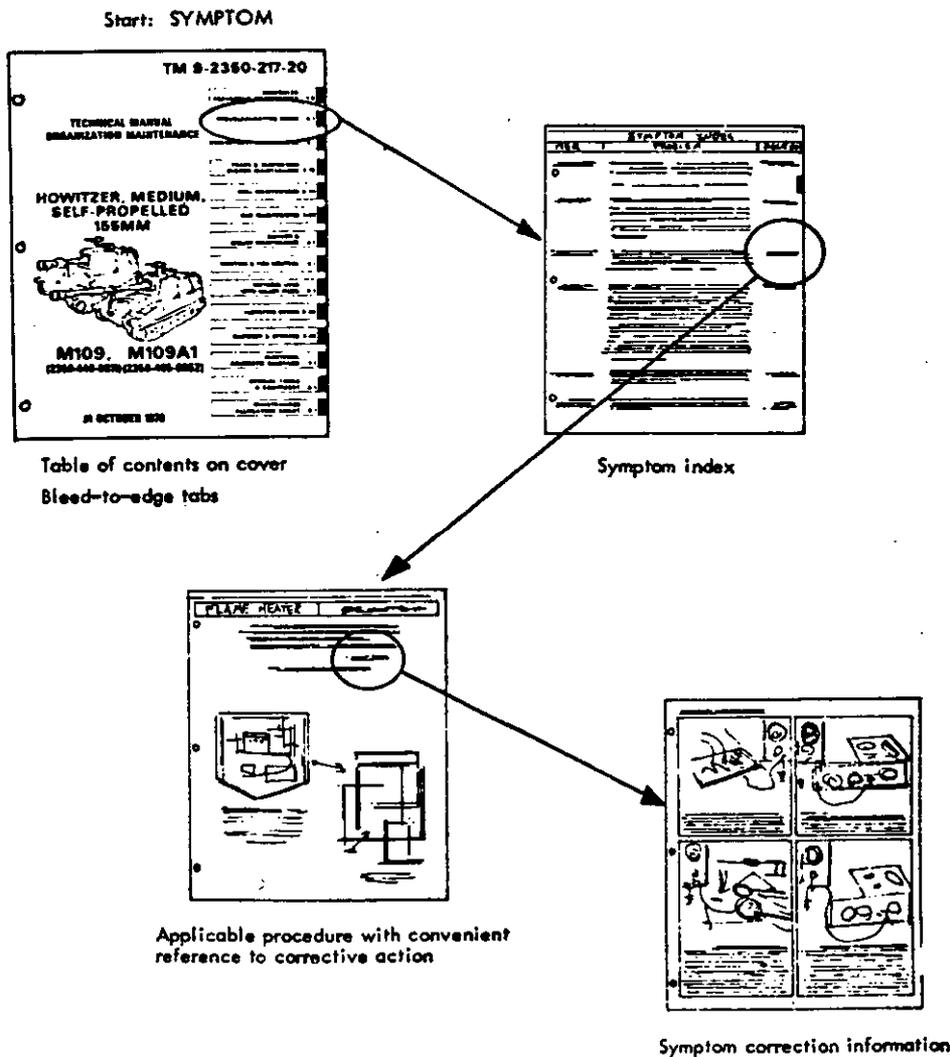


Figure 1. Accessing Sample

Section 4

TEXT PREPARATION

	Page		Page
Overview	1	Methods and Requirements (Cont)	
Methods and Requirements	2	Determining user reading level	2
Objective	2	Development of text	3
Preparation for writing	2	Use of Stylized text	4

OVERVIEW

This section provides general guidelines for various aspects of text preparation for technical manuals. The majority of principles for standard English composition apply to technical manual writing. This section summarizes some salient principles which are especially important:

- a. Preparation for writing
- b. Determining user reading level
- c. Development of text
- d. Use of modular instructions.

Alternatives to text which are discussed under other sections are also valuable to make information easy to find, read, and understand and they include:

- a. Tables
- b. Illustrations
- c. Text Associated with Illustrations
- d. Lists

When these approaches are utilized effectively, they reduce or eliminate the following problems with conventional (paragraph, sentence) text format:

- a. Writing style difficult to understand.
- b. Paragraphs and sentences lengthy.
- c. Specific bit of information difficult to find quickly.
- d. Text which explains illustration difficult to find because it is not on same or facing page.
- e. Frequent cross-referencing.

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For additional coverage of this topic, see the Technical Writing Style Guide, MIL-HDBK-63038-2.

METHODS AND REQUIREMENTS

Objective

The objective of technical writing is to convey information to a reader in a style and format which is easy to understand and use. The style and format should make it as easy as possible for the reader to do the job.

Preparation for writing.

You, as a technical writer, must first analyze your writing task, collect source material, and organize your ideas and materials to meet the requirements of this handbook and the technical content specification. You can do this best through preparation of a detailed outline. (In many cases, the detailed outline is contractually required.) An outline encourages change and thereby encourages improvement of the organization, content, and format. What has worked in other manuals on similar equipment may not work in a new manual for new equipment. Another important part of the preparation process is to allow adequate time for review, validation, and change/revision.

Determining needs of target audience.

The technical manual can be effective only if you use words and ideas the user understands. Unfamiliar terms and abbreviations may be necessary at times for preciseness and clarity, but they must be explained thoroughly. Be sure you are thoroughly familiar with various users of the manual and know their needs, experience levels, and basic required schooling.

Example of Conventional Text Improvement

Poor

The steering system consists of steering wheel, forward steering tube, steering quadrant, two rudder levers, two rudder clevises, a transverse steering rod, and two rudder plates. A rotary motion of the steering wheel causes a rotary motion of the forward steering tub box bevel gears. The forward steering tube engages the teeth of

Improved

STEERING SYSTEM consists of:

1. Steering wheel
2. Forward steering tube
3. Steering quadrant
4. Rudder levers (2)
5. Rudder clevises (2)
6. Transverse steering rod
7. Rudder plates (2)

STEERING WHEEL. Rotary motion causes rotary motion of box bevel gears in forward steering tube.

FORWARD STEERING TUBE. Engages teeth of . . .

Development of text. Text is usually the most difficult part of the manual to use. For this reason, illustrations, tables, lists, and charts should be considered as ways of presenting technical information. Where text is required, it should be carefully prepared to be as easy as possible to read and understand.

The following principles should be used:

- a. Use alternatives to conventional paragraph/sentence text wherever possible:
 - Illustrations (See Section 7)
 - Tables
 - Lists
 - Charts
- b. When conventional text is used, limit:
 - (1) Paragraphs to a single idea
 - (2) Sentences to a single thought
 - (3) Words to those which are short and familiar to the target audience
- c. Place an illustration on the same or a facing page with associated text, or key non-procedural text to illustrations whenever possible. (See Section 5).

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- d. Develop text in logical order.
- e. Make text consistent in terminology, style, and format. Be consistent with other portions of the technical manual. Be consistent in the organization, style, and format of similar publications. But don't be consistent just for consistency's sake, be consistent where it helps the reader.
- f. Simplify long or complex sentences and paragraphs by using lists. Parallel portions of sentences can be individually listed rather than run together.
- g. When needed, request approval to use color to highlight important information (See Section 16.)

Section 5

TEXT ASSOCIATED WITH ILLUSTRATIONS

	Page		Page
Overview	1	Methods and Requirements (cont)	
Types of Text	1	Alternate Methods and Requirements	.2
Methods and Requirements	2	Keying Method Selection Criteria	.....3
Objectives and Principles	2	Content and Style Requirements	.....4

OVERVIEW

This section applies to text associated with (keyed to) all types of illustrations in technical manuals including locator illustrations, diagrams (schematic, functional, block, etc), and exploded views. The discussion includes:

- a. Methods of keying text to illustrations
- b. Selection criteria
- c. Content and style of text associated with illustrations

Types of text. The style and format described in this section for text keyed to illustrations can be used in almost any situation. The main purpose of keyed text in technical manuals is to provide the following:

- a. Principles of equipment operation
- b. Physical description of equipment components
- c. Control and indicator descriptions

NOTE

This section does not include procedure and illustration relationships; see the Procedures section. For complete discussions of illustrations see the following:

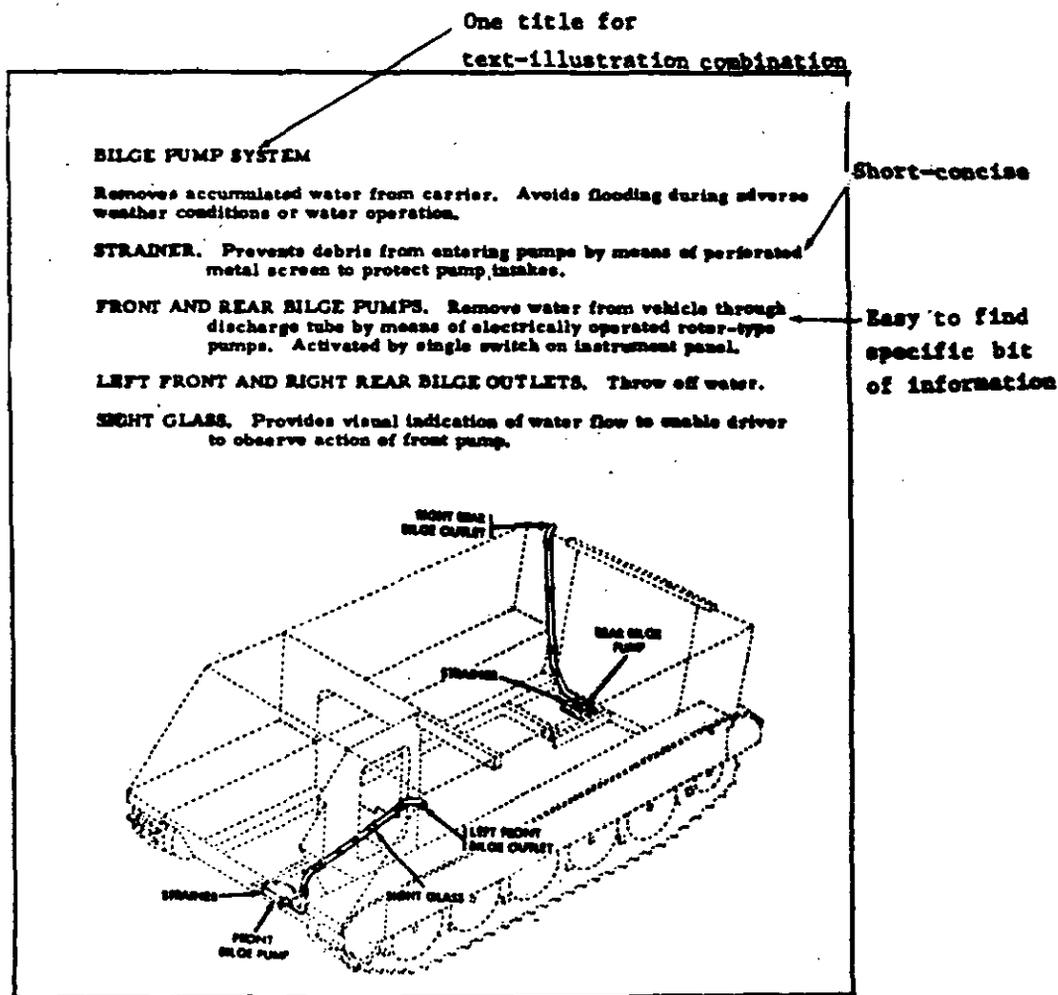
- (1) Quality Presentation Techniques for TM Volume Control (Section 6)
- (2) Illustration Development (Section 15)
- (3) Color (Section 16)
- (4) Locator Illustrations (Section 17)
- (5) Schematics/Functionals (Section 18)
- (6) Wiring/Interconnection Data (Section 19)

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METHODS AND REQUIREMENTS*Objectives and Principles*

Text should be keyed to its corresponding illustration to make the combination as usable as possible. Keyed text has several advantages over conventionally correlated text and illustrations:

- a. Faster to locate information - - text and illustration in close, correlated proximity.
- b. Fewer cross-references.
- c. Easier to understand - fixed, easy-to-read style.
- d. Fewer redundant words.



Example of text keyed to illustration

Alternate Methods and Requirements

Any of the following methods of keying text to illustrations will improve the usability of TM. Additional examples are given at the end of this section. In order of preference, they are:

a. Leader line between text and illustration (page 5/4).

- (1) Paragraphs are titled, boxed, and located on the illustration.
- (2) Paragraphs are located close to items and connected by leader lines.

b. Name, letter, or number (page 5/5).

- (1) Paragraphs are assigned name, letter, or number (which corresponds to item on illustration) and listed in logical sequence.
- (2) Text and illustration should be on same or facing pages to eliminate page turning.

c. Integrated with illustration (page 5/5).

- (1) Text is located on illustration as integral part of illustration proper.
- (2) Text appears on illustration immediately adjacent to associated illustration element.

Keying Method Selection Criteria

Alternates a and b have only one minor disadvantage: the information may not be as compact as with conventional text. Any increase in pages, however, is more than offset by the increase in usability. With careful planning, any increase in the number of pages would be negligible.

In addition, keying method b (name, letter, or number) can be used where information is placed in separate sections or even separate volumes.

Alternate c (the integration of text within the illustration) has one serious limitation: By integrating the text within the illustration, the use of the illustration is made more difficult when the text is not needed. For example, with a block diagram, the user is forced to always scan the text whether or not the material is of any interest. If the user is solely interested in the diagram, then the text is a handicap, particularly after he or she has learned the information in the text and no longer needs it. Alternate c is useful for showing overall system operation and interrelation. It is a good method for introduction of system information.

If the primary purpose of the illustration is signal tracing, then alternate b would be preferred.

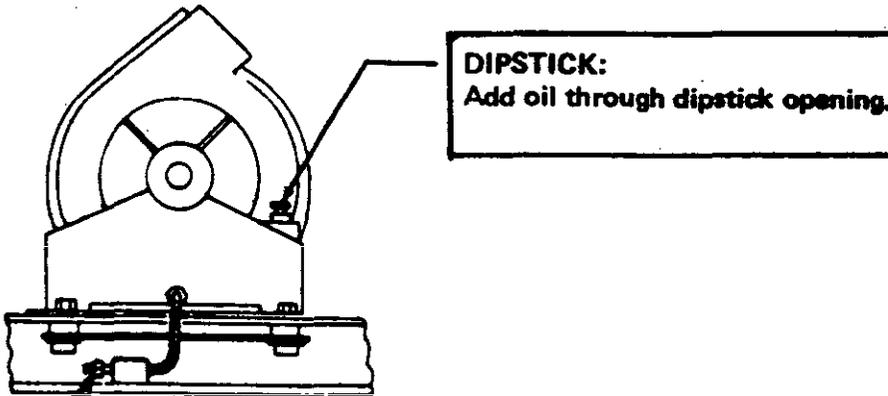
MIL-HDBK-63038-1A (TM)

Content and Style Requirements

a. Paragraphs are titled.

- (1) Title is noun name of part or signal being described in text.
- (2) Title must agree with name appearing on part.
- (3) If no name appears on part, then an easily recognized functional title should be used.
- (4) All capital letters in title are preferred as an attention directing device.

b. Content, style, and sentence structure requirements for text keyed to illustrations are same as for stylized text (Section 4).



CENTRIFUGAL BLOWER

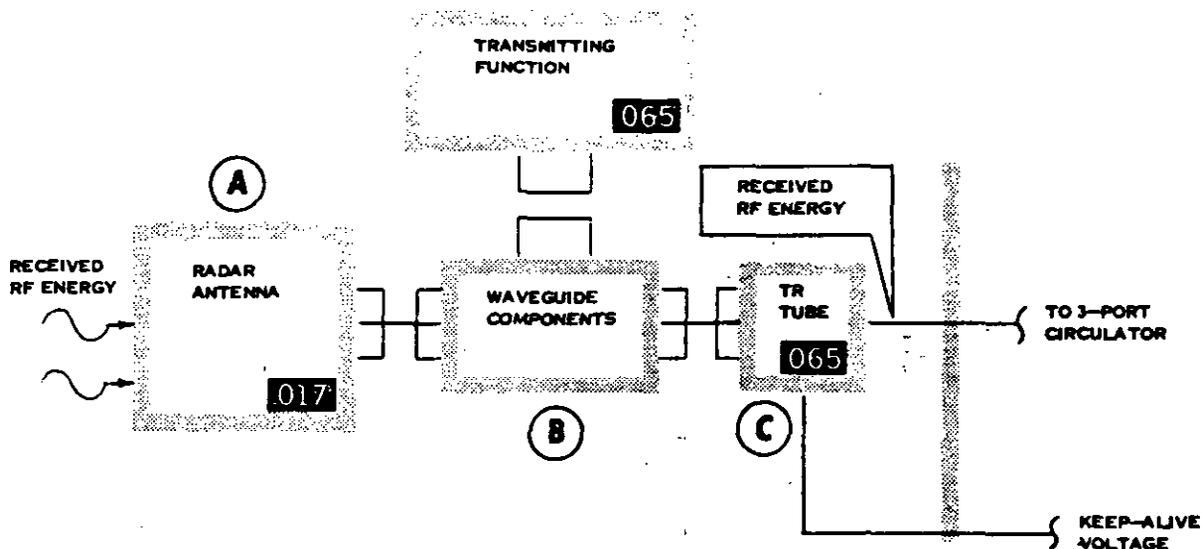
**Example of Alternate a - Leader Line
Between Text and Illustration**

MIL-HDBK-63038-1A (TM)

2-16. RECEIVING FUNCTION

Receives reflected rf energy from target. Channels energy to processing circuits for display on radar screen.

- (A) **RADAR ANTENNA.** Parabolic reflector which collects reflected energy from targets along antenna boresight axis. Mechanically positioned to search for and track targets. Modulates signal to develop azimuth and elevation pointing-error signals for positioning.
- (B) **WAVEGUIDE COMPONENTS.** Permit use of a single antenna for both transmitting and receiving. Circulate energy from transmitting function to antenna and from antenna to tr tube. Circulate any energy reflected from tr tube to resistive load.
- (C) **TR TUBE.** Short-circuits rf pulse leakage to prevent its entering receiving section when rf leakage may be of sufficient amplitude to damage paramp or image rejection mixer diodes. Keep-alive voltage maintains ionization during transmission but allows received weak signals to pass through tube without ionization. Voltage applied only during radar on operation.



Example of Alternate b - Keying Method.

Section 6

QUALITY PRESENTATION TECHNIQUES FOR TM VOLUME CONTROL

	Page		Page
Overview	1	Specification Requirements for Detailed Step-by-Step Procedures	13
Methods and Requirements	1	Use of Locator Views	15
Objectives and Principles	1	Use of Human Figures	18
Volume Reduction Techniques	2	Use of Tabular Presentation	21
Quantity of Illustrations	2	Use of References	26
Opposite Hardware and Like Items	6	Use of Curtailed Text	26
Overkill	10	General	28
Coverage of Maintenance Procedures as Logical Tasks	12		

OVERVIEW

This section contains examples of good and bad presentation techniques for coverage of maintenance procedures. It also identifies several presentation approaches which contribute to unnecessary increase in volume of pages. In addition, the concepts covered in this section are intended to reduce cost by controlling the overall page count and extraneous illustrations. The technical writer must exercise prudent judgement in selecting the type of presentation commensurate with target audience and equipment consideration (i.e., the detail coverage must be sufficient for optimum procedures but not redundant or excessive).

METHODS AND REQUIREMENTS

Objectives and principles

Control of TM volume (number of pages) can be obtained by applying quality presentation techniques to the following subjects which are discussed in detail and with examples under Volume Reduction Techniques paragraph. Sample TM pages are included to provide guidance for the particular presentation technique being emphasized. Examples should be considered as guidelines and are marked "DON'T" and "OK" to illustrate the type of coverage required.

1. Quantity of illustrations.
2. Coverage of symmetrically opposite hardware and like items.
3. Overkill (too much detail for simple procedures).
4. Coverage of maintenance procedures as logical tasks/jobs rather than piecemeal type coverage of every item listed in the maintenance allocation chart (MAC).
5. Specification requirements for detailed step-by-step procedures.
6. Use of locator views.
7. Use of human figures.
8. Use of tabular presentation.
9. Use of references.
10. Use of curtailed text.

MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES

1. Quantity of illustrations.

Excessive repetition of illustrations on same or facing pages to illustrate every step is not required as shown in the following two examples.

REPLACE UPPER DOOR HINGE

DESCRIPTION

This task covers: Remove (page 18-4). Install (page 18-7).

INITIAL SETUP

Tools:

General mechanic's tool kit: automotive —
5180-00-177-7033

Materials/Parts:

Spring pin — MS30086-288
Lock washer (3) — MS122034
Hinge half — 4187968-1 (80212)

Personnel Required:

Organizational mechanic 83710

Equipment Conditions:

Carrier on level surface
Hand brake set
THROTTLE handle OFF
FUEL handle OFF
MASTER POWER switch OFF
LAUNCHER INTERCONNECT switch OFF

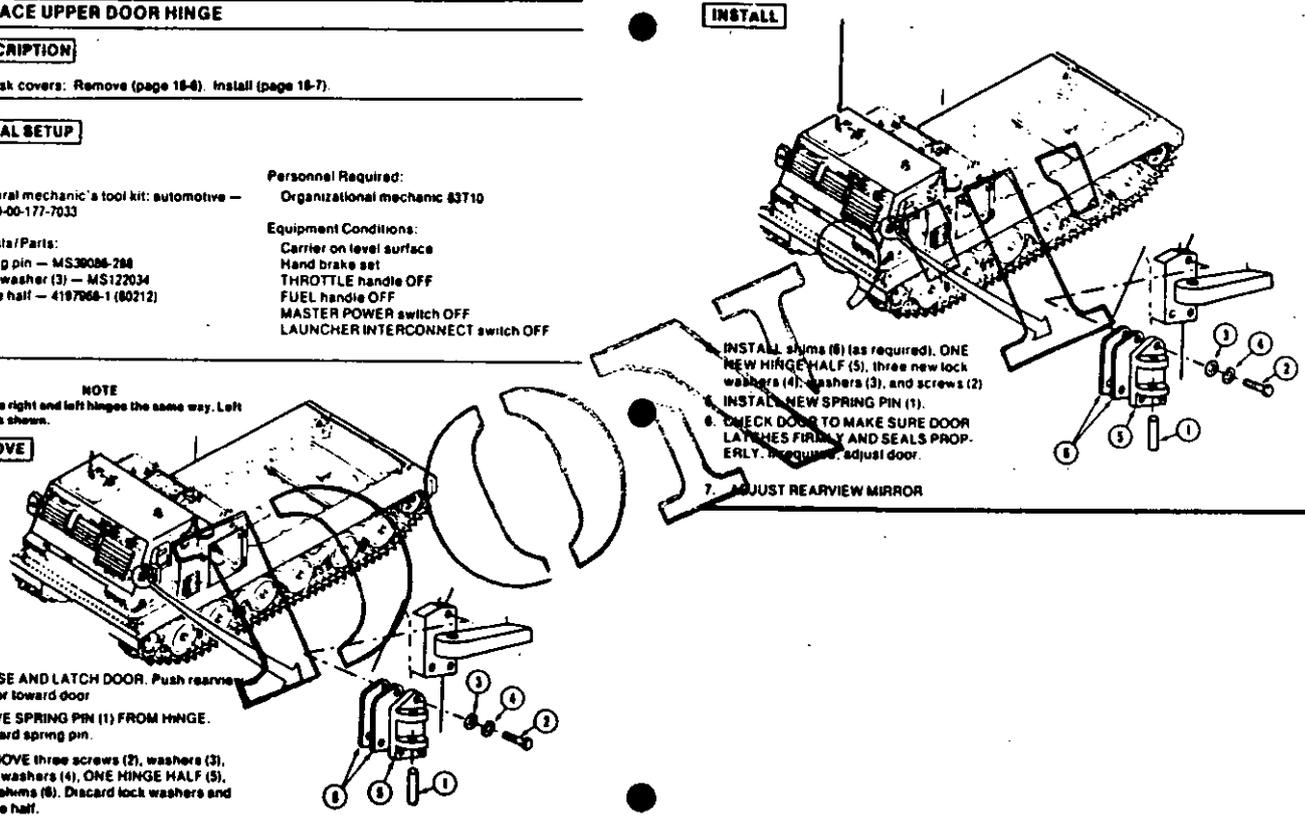
NOTE
Replace right and left hinges the same way. Left hinge is shown.

REMOVE

1. CLOSE AND LATCH DOOR. Push rearview mirror toward door.
2. DRIVE SPRING PIN (1) FROM HINGE. Discard spring pin.
3. REMOVE three screws (2), washers (3), lock washers (4), ONE HINGE HALF (5), and shims (6). Discard lock washers and hinge half.

INSTALL

4. INSTALL shims (6) (as required), ONE NEW HINGE HALF (5), three new lock washers (4), washers (3), and screws (2).
5. INSTALL NEW SPRING PIN (1).
6. CHECK DOOR TO MAKE SURE DOOR LATCHES FIRMLY AND SEALS PROPERLY. If required, adjust door.
7. ADJUST REARVIEW MIRROR.

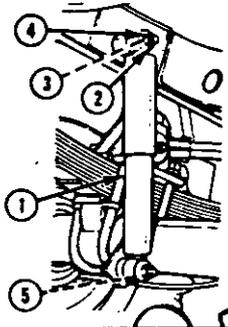


VOLUME REDUCTION TECHNIQUES (cont)

1. Quantity of illustrations (cont).

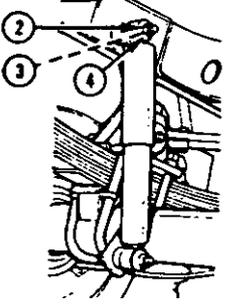
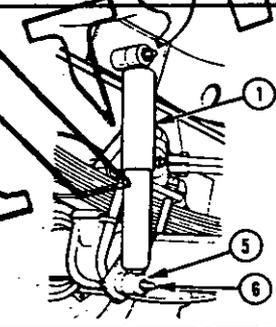
REMOVAL

- 1 Remove nut (2), lockwasher (3), and washer (4).
- 2 Remove shock absorber (1) with rubber bushings (5) installed.



INSTALLATION

- 1 Install shock absorber (1) on mounting studs (6) with rubber bushings (5) attached.
- 2 Install and tighten washer (4), lockwasher (3), and nut (2).



The diagrams illustrate the removal and installation of a shock absorber. The first diagram shows the removal of the nut (2), lockwasher (3), and washer (4) from the top of the shock absorber (1). The second diagram shows the shock absorber (1) being installed on the mounting studs (6) with rubber bushings (5) attached. The third diagram shows the final assembly with the washer (4), lockwasher (3), and nut (2) installed and tightened.

MIL-HDBK-63038-1A (TM)**VOLUME REDUCTION TECHNIQUES (cont)**

1. Quantity of illustration 5 (cont).

Develop illustrations for maximum use where one illustration can support several steps as shown in the following two examples.

REPLACE LOWER DOOR HINGE**DESCRIPTION**

This task covers: Remove. Install.

INITIAL SETUP**Tools:**

General mechanic's tool kit: automotive

Equipment Conditions:**References**

Carrier on level surface
Hand brake set
THROTTLE handle OFF
FUEL handle OFF
MASTER POWER switch OFF
LAUNCHER INTERCONNECT switch OFF

Materials/Parts:

Spring pin — MS39088-288
Lock washer (3) — MS122034
Hinge half — 4197966 (80212)

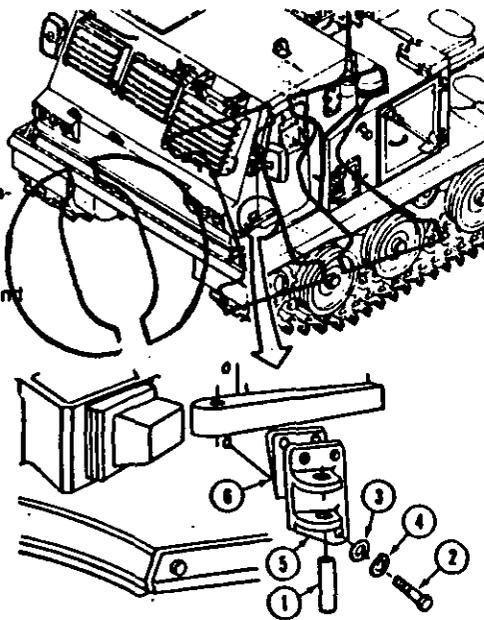
NOTE
Replace left and right hinges the same way.
Left hinge is shown.

REMOVE

1. CLOSE AND LATCH DOOR.
2. DRIVE SPRING PIN (1) FROM HINGE. Discard pin.
3. REMOVE three screws (2), washers (3), lock washers (4), ONE HINGE HALF (5), AND WEDGE (6). Discard lock washers and hinge half.

INSTALL

1. INSTALL WEDGE (6), NEW HINGE HALF (5), three new lock washers (4), washers (3), and screws (2).
2. INSTALL NEW SPRING PIN (1).
3. CHECK DOOR TO MAKE SURE DOOR LATCHES FIRMLY AND SEALS PROPERLY. If required, adjust door. See page 16-2.



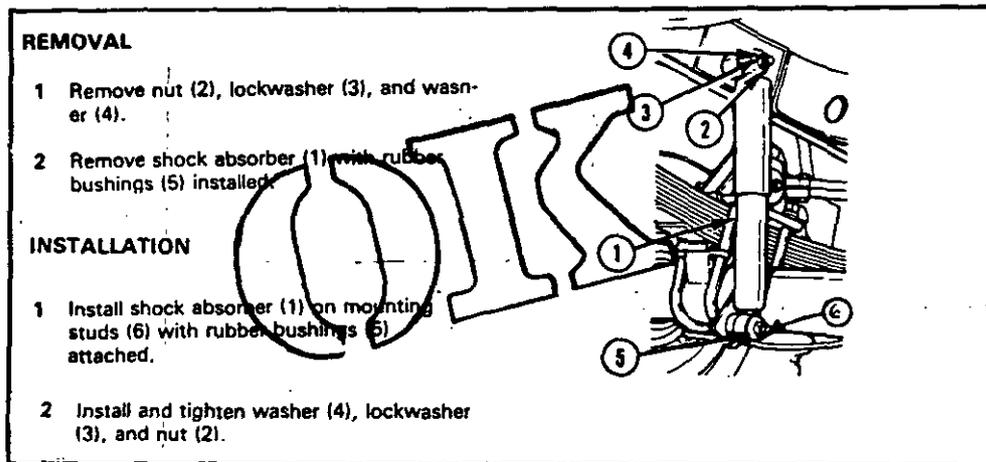
16-8

NOTE

When developing illustrations for maximum use within a task, avoid busy or confusing type illustrations.

VOLUME REDUCTION TECHNIQUES (cont)

1. Quantity of illustrations (cont).

**NOTE**

Further reduction of TM pages can be realized when using the technique of coverage of symmetrically opposite hardware and like items (there are two of the above shock absorbers).

MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

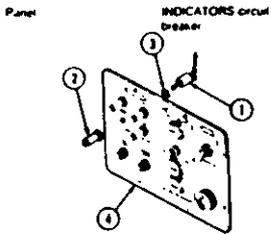
2. Coverage of symmetrically opposite hardware and like items.

When separate maintenance tasks are written and illustrated for simple like items (e.g., circuit breakers), the TM pages may develop as shown in the following two examples.

2-15. COMPARTMENT CONTROL MODULE - MAINTENANCE INSTRUCTIONS (Cont.)

LOCATION	ITEM	ACTION
----------	------	--------

REMOVAL INSTALLATION



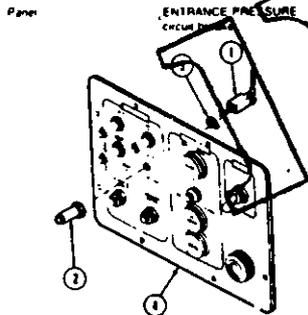
REMOVAL

- 1 Disassemble CCM (p 2-171)
- 2 Remove wire leads from INDICATORS circuit breaker (1)
- 3 Unscrew and remove waterproof boot (2)
- 4 Remove circuit breaker (1) and keying washer (3)

INSTALLATION

- 1 Insert INDICATORS circuit breaker (1) with keying washer (3) in panel (4) and secure with waterproof boot (2)
- 2 Connect wire leads Refer to page 2-184
- 3 Reassemble CCM (p 2-171)

REMOVAL INSTALLATION



REMOVAL

- 1 Disassemble CCM (p 2-171)
- 2 Remove wire leads from ENTRANCE PRESSURE circuit breaker (1)
- 3 Unscrew and remove waterproof boot (2)
- 4 Remove circuit breaker (1) and keying washer (3)

INSTALLATION

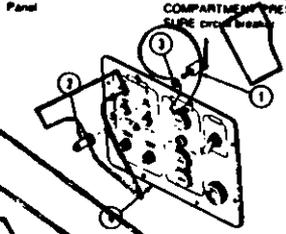
- 1 Insert ENTRANCE PRESSURE circuit breaker (1) with keying washer (3) in panel (4) and secure with waterproof boot (2)
- 2 Connect wire leads Refer to page 2-184
- 3 Reassemble CCM (p 2-171)

2-178

2-15. COMPARTMENT CONTROL MODULE - MAINTENANCE INSTRUCTIONS (Cont.)

LOCATION	ITEM	ACTION
----------	------	--------

REMOVAL INSTALLATION



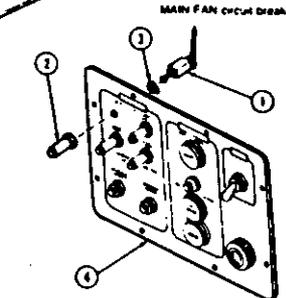
REMOVAL

- 1 Disassemble CCM (p 2-171)
- 2 Remove wire leads from COMPARTMENT PRESSURE circuit breaker (1)
- 3 Unscrew and remove waterproof boot (2)
- 4 Remove circuit breaker (1) and keying washer (3)

INSTALLATION

- 1 Insert COMPARTMENT PRESSURE circuit breaker (1) with keying washer (3) in panel (4) and secure with waterproof boot (2)
- 2 Connect wire leads Refer to page 2-184
- 3 Reassemble CCM (p 2-171)

REMOVAL INSTALLATION



REMOVAL

- 1 Disassemble CCM (p 2-171)
- 2 Remove wire leads from MAIN FAN circuit breaker (1)
- 3 Unscrew and remove waterproof boot (2)
- 4 Remove circuit breaker (1) and keying washer (3)

INSTALLATION

- 1 Insert MAIN FAN circuit breaker (1) with keying washer (3) in panel (4) and secure with waterproof boot (2)
- 2 Connect wire leads Refer to page 2-184
- 3 Reassemble CCM (p 2-171)

2-178

VOLUME REDUCTION TECHNIQUES (cont)

2. Coverage of symmetrically opposite hardware and like items (cont).

2-3-15. PILOT SEAT INSTALLATION (cont)

2-3-15

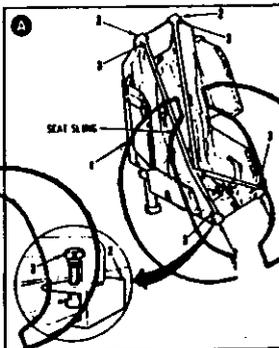
WARNING

There is an upward spring preload on the seat at all times. The seat must be occupied whenever it is adjusted. If the seat vertical adjust handle is pulled when the seat is unoccupied, the seat will snap to the full up position. This could cause severe personnel injury. Seek immediate medical aid.



1. INSTALL SEAT SLING (Y38).

- a. Put sling (Y38) on seat (1).
- b. Put two upper clamps (2) on seat (1) and tighten handles (3).
- c. Put two lower clamps (2) on seat (1) and tighten handles (3).



2-3-17. CPG SEAT INSTALLATION (cont)

2-3-17

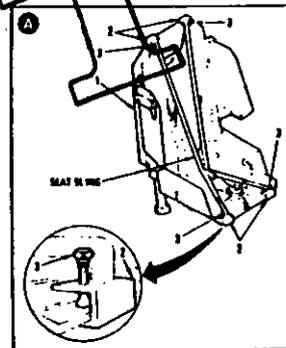
WARNING

There is an upward spring preload on the seat at all times. The seat must be occupied whenever it is adjusted. If the seat vertical adjust handle is pulled when the seat is unoccupied, the seat will snap to the full up position. This could cause severe personnel injury. Seek immediate medical aid.



1. INSTALL SEAT SLING (Y38)

- a. Put sling (Y38) on seat (1).
- b. Put two upper clamps (2) on seat (1) and tighten handles (3).
- c. Put two lower clamps (2) on seat (1) and tighten handles (3).



GO TO NEXT PAGE

2-82

GO TO NEXT PAGE

2-88

NOTE

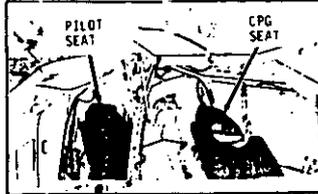
The examples shown are the first pages of separate procedures for pilot seat and CPG seat. Both seats are identical.

MIL-HDBK-63038-1A (TM)**VOLUME REDUCTION TECHNIQUES (cont)****2. Coverage of symmetrically opposite hardware and like items (cont).**

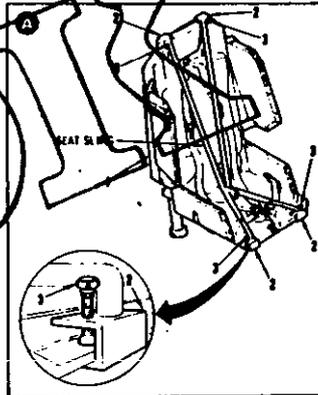
Symmetrically opposite and like items can often be covered in one procedure to reduce volume as shown in the following two examples.

2-3-15. PILOT/CPG SEAT INSTALLATION (cont) 2-3-15**WARNING**

There is an upward spring preload on the seat at all times. The seat must be occupied whenever it is adjusted. If the seat vertical adjust handle is pulled when the seat is unoccupied, the seat will snap to the full up position. This could cause severe personnel injury. Seek immediate medical aid.

**1. INSTALL SEAT SLING (T38).**

- a. Put sling (T38) on seat (1)
- b. Put two upper clamps (2) on seat (1) and tighten handles (3).
- c. Put two lower clamps (2) on seat (1) and tighten handles (3).

**NOTE**

Further reduction of TM pages can be realized when using the technique of covering maintenance procedures as logical tasks (e.g., Pilot/CPG Seat replacement in lieu of separate Pilot/CPG removal and Pilot/CPG seat installation procedures).

VOLUME REDUCTION TECHNIQUES (cont)**2. Coverage of symmetrically opposite hardware and like items (cont).****2-15. COMPARTMENT CONTROL MODULE-MAINTENANCE****NOTE**

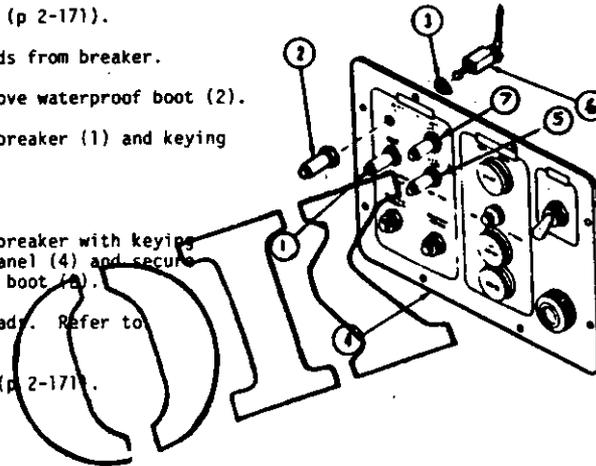
This procedure is typical for the following circuit breakers.
INDICATORS (1), ENTRANCE PRESSURE (5),
MAIN FAN (6), and COMPARTMENT PRESSURE (7).

REMOVAL

1. Disassemble CCM (p 2-171).
2. Remove wire leads from breaker.
3. Unscrew and remove waterproof boot (2).
4. Remove circuit breaker (1) and keying washer (3).

INSTALLATION

1. Insert circuit breaker with keying washer (3) in panel (4) and secure with waterproof boot (2).
2. Connect wire leads. Refer to page 2-184.
3. Reassemble CCM (p 2-171).

**NOTE**

Where one step might differ between items, it can be covered by a table or matrix listing the difference. Locate each item covered at the beginning and add note that procedure is typical.

MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

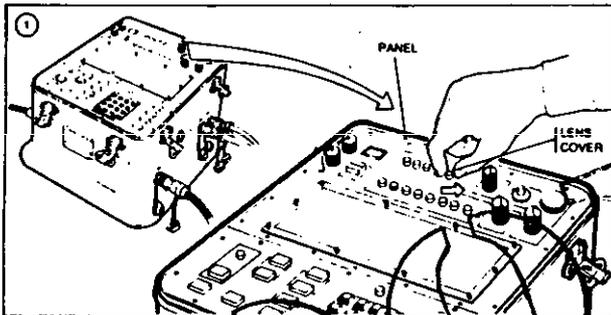
3. Overkill.

Overkill is providing detailed instructions and illustrations for simple or common knowledge procedures (e.g., instructions that specify turning screwdriver clockwise to tighten screw; directional arrow illustrations to support a common lamp (light bulb) replacement procedure) as shown in the following example.

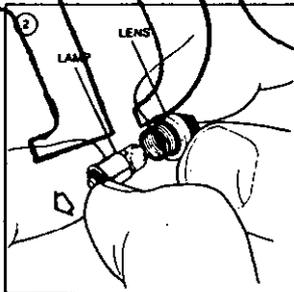
Section IV. MAINTENANCE PROCEDURES

5-16. CALL STATUS LAMP REMOVAL AND REPLACEMENT.

a. Remove lamp.



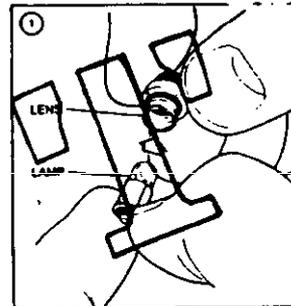
Uncrew lens cover from panel



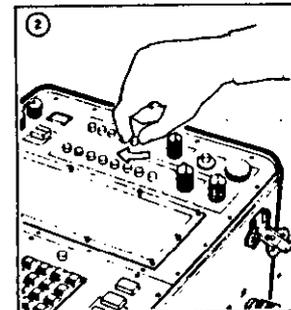
Pull lamp from lens

5-16. CALL STATUS LAMP REMOVAL AND REPLACEMENT. (Cont.)

b. Replace lamp.



Insert lamp into lens cover



Screw lens cover with attached lamp into panel

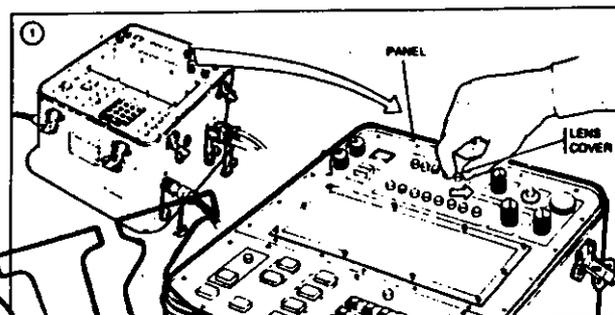
VOLUME REDUCTION TECHNIQUES (cont)

3. Overkill (cont).

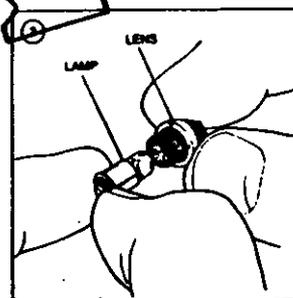
Eliminate overkill as shown in the following example.

8-16. CALL STATUS LAMP REPLACEMENT.

- a. Remove lens cover from panel to remove lamp.
- b. Install lamp in lens cover.
- c. Install lens cover and lamp in panel.



COIL



MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

4. Cover maintenance procedures as logical tasks/jobs rather than piecemeal coverage of every item listed in the maintenance allocation chart (MAC).

Piecemeal coverage generates redundant initial setup and location view of each piecemeal item or maintenance function as shown in the following example.

2-83. RIGHT HANDGRIP (RHG) REMOVAL	2-83	2-84. RIGHT HANDGRIP (RHG) INSTALLATION	2-84
This task covers removal.		This task covers installation.	
INITIAL SETUP		INITIAL SETUP	
Applicable Configuration: All	References: TM 55-1520-238-23	Applicable Configuration: All	References: TM 55-1520-238-23

Develop procedures/paragraphs as maintenance function tasks (e.g., Replace) rather than submaintenance function tasks (e.g., Remove and Install) as shown in the following example.

2-83. RIGHT HANDGRIP (RHG) REPLACE
This task covers removal and installation.
INITIAL SETUP

NOTE

Piecemeal coverage can result if source data is not analyzed.

VOLUME REDUCTION TECHNIQUES (cont)

5. Specification requirements for detailed step-by-step procedures.

Do list task summary submaintenance function tasks horizontally rather than vertically.

Do list only those topics that are utilized and provide useful information.

Do prepare detailed procedures to experience level of user.

Do prevent oversimplification of detailed procedures.

Do prepare data in language free of vague and ambiguous terms.

Do include all essential information.

Do be consistent in use of terminology.

Do prepare sentences that are short and concise.

MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

5. Specification requirements for detailed step-by-step procedures (Cont).
 Don'ts are shown in the following example.

9-33. REAR BRAKE SHOES MAINTENANCE (M915):		
THIS TASK COVERS: (APPROXIMATE TIME REQUIRED FOLLOWS TASK DESCRIPTION.)		
a. Removal.	(15)	
b. Inspection.	(15)	
c. Installation.	(20)	
50 Minutes Total.		
<p>Don't list vertically; place horizontally.</p> <p>Don't reference time; times are listed in MAC.</p>		
INITIAL SETUP	EQUIPMENT CONDITION	CONDITION DESCRIPTION
APPLICABLE CONFIGURATIONS M915.	PARAGRAPH 10-15A.	Hub and Drum removed.
TEST EQUIPMENT None.		
SPECIAL TOOLS None.		
MATERIALS/PARTS (P/N) None.		
<p>Don't list heading if there are no entries.</p>		
<p>Don't list heading and entry, if only one target audience person needed.</p>		
PERSONNEL REQUIRED One (MOS-63820).	SPECIAL ENVIRONMENTAL CONDITIONS Vehicle Parked on Level Ground.	
REFERENCES (TM) None.	GENERAL SAFETY INSTRUCTIONS Engine OFF. Transmission in Neutral Park Brake Set.	
TROUBLESHOOTING REFERENCES 9-1.		
<p>Don't list maintenance tasks that do not apply.</p>		

NOTE

Close up text; eliminate white space

VOLUME REDUCTION TECHNIQUES (cont)

6. Locator views.

Locator view illustrations for common equipment items (e.g., headlights, tires, and tracks) as shown in the following three examples should be avoided.

HEADLIGHT ASSEMBLY (LEFT AND RIGHT) REPLACEMENT (Sheet 1 of 1)

TOOLS: Hammer

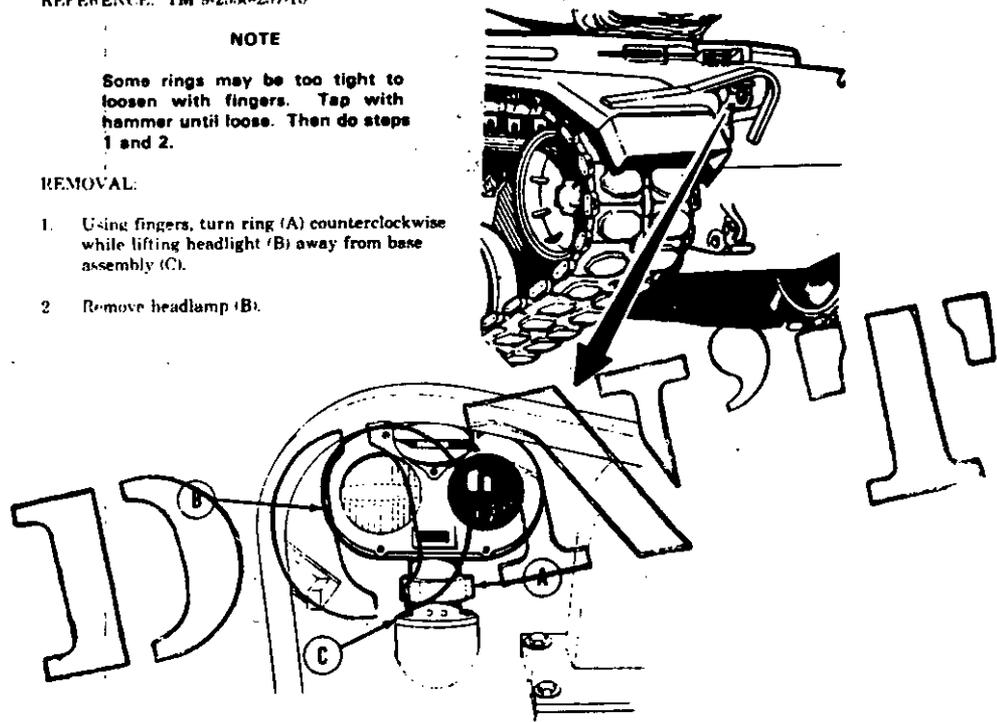
REFERENCE: TM 9-2350-257-10

NOTE

Some rings may be too tight to loosen with fingers. Tap with hammer until loose. Then do steps 1 and 2.

REMOVAL:

1. Using fingers, turn ring (A) counterclockwise while lifting headlight (B) away from base assembly (C).
2. Remove headlamp (B).



INSTALLATION:

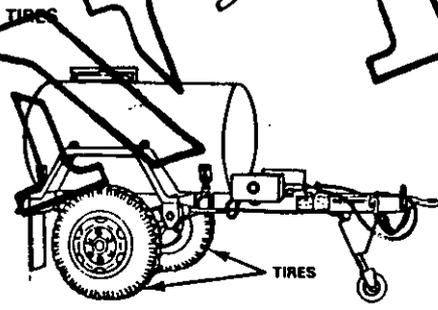
1. Place headlight (B) in position on base assembly (C).
2. Using fingers, turn ring (A) clockwise while pressing down on headlight (B). Tighten ring.
3. Check operation of headlight (TM 9-2350-257-10).

MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

6. Locator views (cont).

Table 4-2. Organizational Preventive Maintenance Checks and Services (cont)

Item No.	Interval						ITEM TO BE INSPECTED Procedures: Check for and have repaired, filled, or adjusted as needed.
	Q	S	A	B	H	MI	
7							 <p>Rotate and match tires according to tread design and degree of wear. See TM 9-2610-200-20 for acceptable limits in matching tires. Torque wheel nuts to 450 pound-feet (610.2 N·m).</p>

TRACK ASSEMBLY REPLACEMENT (Sheet 1 of 10)

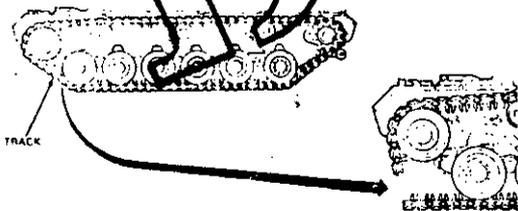
PROCEDURE	PAGE
FIGURE	
Form 1	14 R2
Installation	14 R4
TOOLS	
Sl-jaw hammer	
15/16 in socket with 3/4 in drive	
Thread handle (breaker) bar with 3/4 in drive	
Ball nut with 3/4 in drive	
2 lb hammer	
Crowbar, punch point	
1.5-16 in socket with 3/4 in drive	
1-1/2 in socket with 3/4 in drive	
Torque wrench with 3/4 in drive (0-600 lb-ft) (0-814 N·m)	
10 in extension with 3/4 in drive	
SPECIAL TOOLS	
End connector puller (Item 10, Chapter 3, Section II)	
SUPPLIES	
Heavy rope (50 lb)	
PERSONNEL	
Two	
REFERENCE	
TM 9-2190-3-10	
PRELIMINARY PROCEDURES	
Loosen track tension (C of 9-2330-257-10)	
Remove rear fender and shield (if required) (page 18-75)	

T142 TRACK LINK REPLACEMENT (Sheet 1 of 3)

TOOLS	
15/16 in socket with 3/4 in drive	
Ball nut with 3/4 in drive	
1-1/2 in socket with 3/4 in drive	
10 in extension with 3/4 in drive	
Thread handle with 3/4 in drive	
Ball nut with 3/4 in drive	
10 in extension with 3/4 in drive	
T Nick handle with 1/4 in drive	
End connector puller	
SPECIAL TOOLS	
Hydraulic end connector puller (Item 10, Chapter 3, Section I)	
REFERENCE	
TM 9-2330-257-10	
PRELIMINARY PROCEDURE	
Disconnect track (TM 9-2330-257-10)	

NOTE

There are two track designs - T142 and T87. Do not mix tracks on same tank.



VOLUME REDUCTION TECHNIQUES (cont)**6. Locator views (cont).**

Illustrate the locator view of item once when needed at the beginning of the procedure or the first time the item is called out as shown in the following example.

MAINTENANCE OF RECEIVER ASSEMBLY**2-27. FUNCTIONAL TEST OF DRIVE MOTOR****INITIAL SETUP****Tools**

Power Supply 10-32 vdc, 0-50 amps
Part No. TC-32-50

Equipment Conditions**References**

Drive Motor removed
TM 9-1005-200-206P

1. SETUP POWER SUPPLY ON BENCH.

- a. Position power supply (1) on work surface. Connect power lead to 220 volt source.
- b. Position ON/OFF switch (2) to OFF.
- c. Rotate OUTPUT knob (3) to zero.

2. CONNECT INTERCONNECT HARNESS TO DRIVE MOTOR.

- a. Position interconnect harness (4) and drive motor (5) on work surface.
- b. Connect interconnect harness plug (6) to drive motor receptacle (7).

3. CONNECT INTERCONNECT HARNESS (4) TO POWER SUPPLY (1).

- a. Connect both black wires (8) to the negative post (9) on the power supply (1).
- b. Connect both red wires (10) to the positive post (11) on the power supply (1).

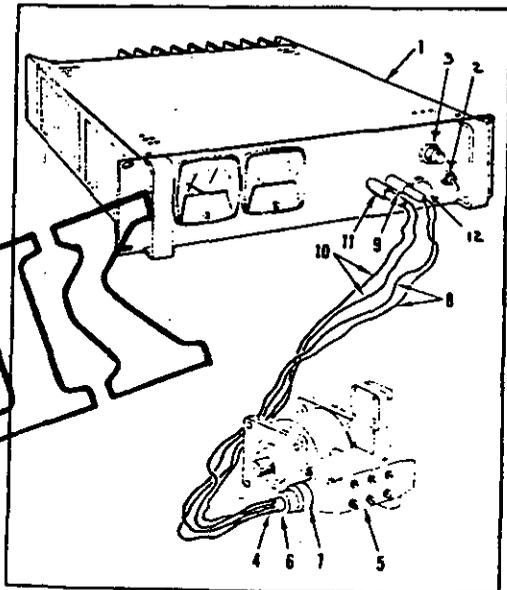
**NOTE**

Illustration of locator view should not be used when item is located in maintenance function reference procedure.

MIL-HDBK-63038-1A (TM)

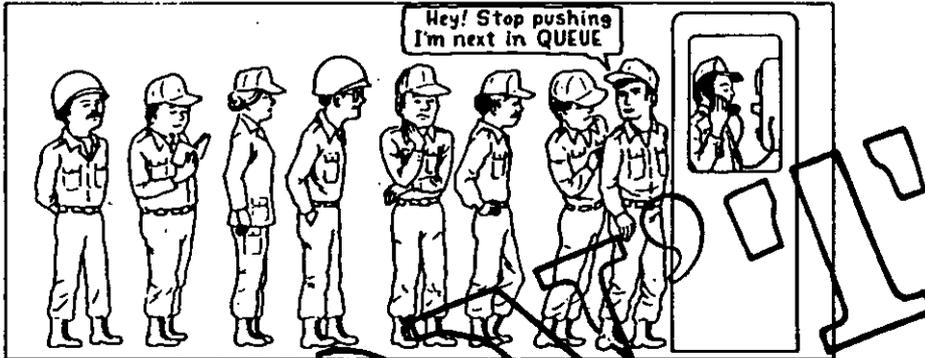
VOLUME REDUCTION TECHNIQUES (cont)

7. Human figures.

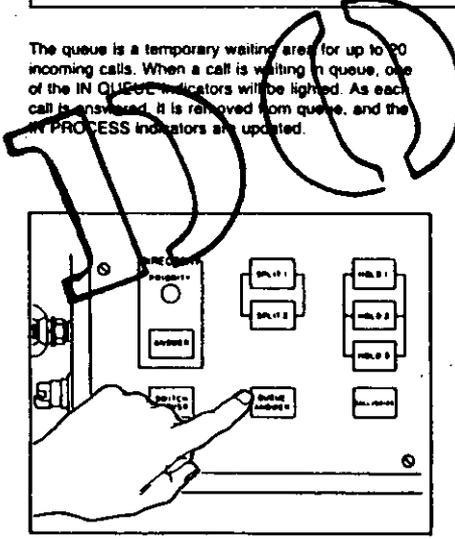
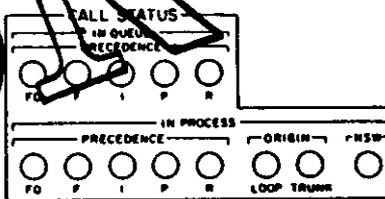
The use of human figures should not be used inappropriately as shown in the following example.

2-8. QUEUE ANSWER.

The QUEUE ANSWER pushbutton is used to answer incoming calls which are waiting in "queue".



The queue is a temporary waiting area for up to 90 incoming calls. When a call is waiting in queue, one of the IN QUEUE indicators will be lighted. As each call is answered, it is removed from queue, and the IN PROCESS indicators are updated.



- RESULT:**
- A call is removed from queue and you can talk to caller.
 - IN QUEUE indicators are updated.
 - IN PROCESS indicators are updated.

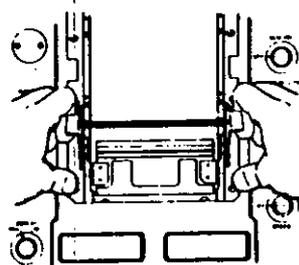
Press QUEUE ANSWER pushbutton to talk to waiting call. (QUEUE ANSWER pushbutton lights)

VOLUME REDUCTION TECHNIQUES (cont)

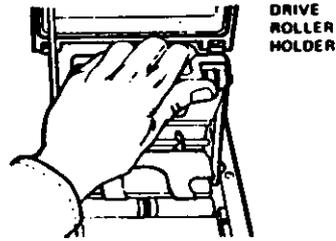
7. Human figures (cont).

Illustrations of human figures or hands should be used only when required to show how a specific function or procedure is performed as shown in the following two examples.

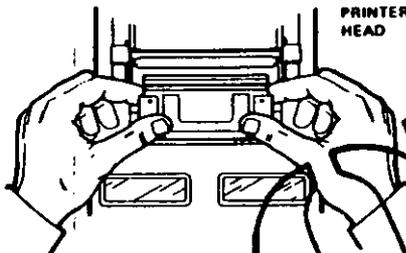
b. PAPER REMOVAL



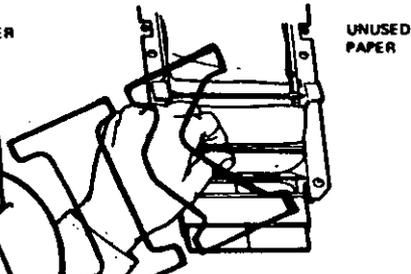
1. LIFT HEAD HOLD DOWN ARM.



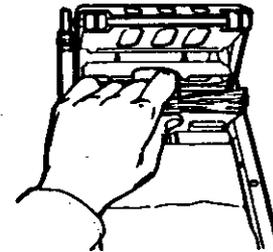
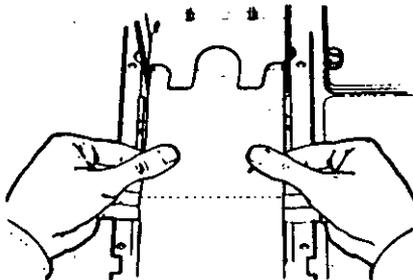
2. LIFT DRIVE ROLLER HOLDER.



3. RAISE PRINTER HEAD.



TEAR OFF ANY UNUSED PAPER AND REMOVE FROM PAPER STORAGE COMPARTMENT.



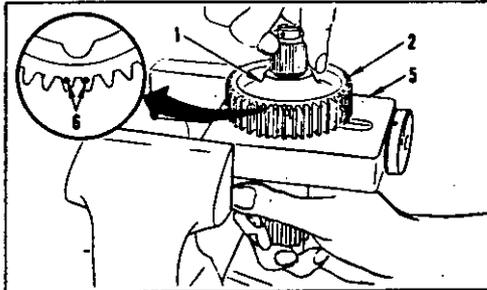
5. REMOVE PRINTED PAPER BY FEEDING FORWARD THRU GUIDE AND REMOVING FROM COMPARTMENT.

MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

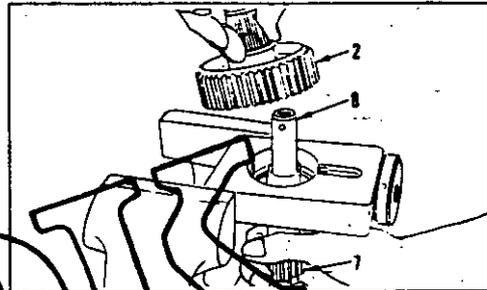
7. Human figures (cont).

d. Place gear clutch assembly (1) in assembly tool (5) with the clutch spur gear (2) on top as shown.

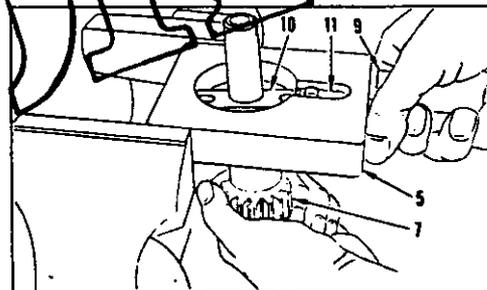


e. Rotate gear clutch assembly (1) until timing marks (6) are in position as shown.

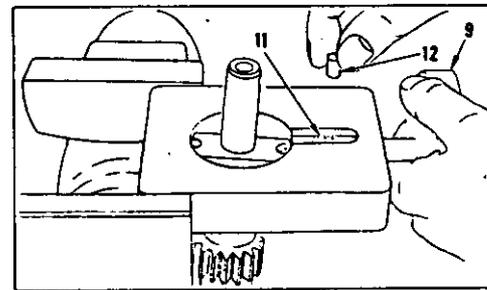
f. Grasp small spur gear (7) and pull down while lifting the clutch spur gear (2) from spur gear shaft (8).



g. Push in on handle (9) of tool (5) and hold tightly while turning small spur gear (7) until lugs (10) are in line with shaft (11).



h. Slowly release pressure on handle (9) and remove roller (12) next to shaft (11).



VOLUME REDUCTION TECHNIQUES (cont)

8. Tabular presentation.

Tabular presentation is not effective for presentation of maintenance procedures. This presentation method results in greater volume for maintenance procedures. "Location" and "Item" columns are often blank as shown in the following four examples.

6-5. Gas Producer Fuel Control - Idle Check

INITIAL SETUP

Applicable Configuration
AllSpecial Tools
Wrench, Tool No. 6798292

LOCATION/ITEM	REMARKS	ACTION
---------------	---------	--------

AIRFRAME/

Check the idle speed setting with the engine running. Stabilized idle speed should repeat every time, whether the twist grip is slowly rolled or snapped to the IDLE position. Failure of the stabilized speed to repeat is cause for a recheck of the rigging. Check for proper idle adjustment rigging as follows:

1. Twist Grip

Roll twist grip to IDLE and let N1 stabilize. Mark (pencil) the precise position of pointer tip on the fuel control quadrant.

Release the idle detent on twist grip. Very slowly roll twist grip in direction of cutoff just enough to obtain perceptible movement of pointer tip (approximately the width of the pencil mark). If N1 idle speed decreases take the following corrective action:

a. If the pointer is at or above the 30 degree mark, rereg aircraft linkage to move pointer tip to a point just below to 30 degree mark.

b. If pointer is more than 5/65 in. (2.0 mm) below 30 degree mark, rereg aircraft linkage to move pointer closer to the 30 degree mark.

6-5

MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

8. Tabular presentation (cont).

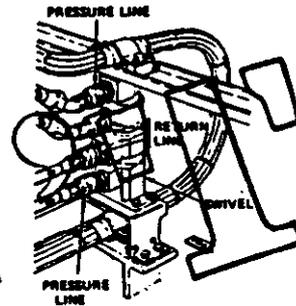
6-12. HYDRAULIC SWIVEL ASSEMBLY MAINTENANCE INSTRUCTIONS - Continued

ITEM	ACTION	REMARKS
------	--------	---------

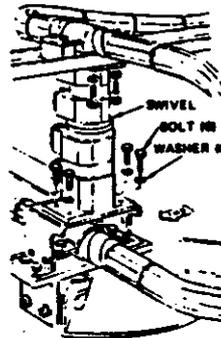
1. Swivel assembly

a. Remove

(1) Disconnect two pressure and two return line quick-disconnects from swivel. Install protective caps on open line.



(2) Using 10mm socket, remove six bolts and six washers. Remove swivel assembly.



6-29

VOLUME REDUCTION TECHNIQUES (cont)

8. Tabular presentation (cont).

ITEM	ACTION	REMARKS
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REASSEMBLY AND LUBRICATION (CONT)

AIMING CIRCLE M2 AND M2A2 ORIENTATION PARTS (CONT)

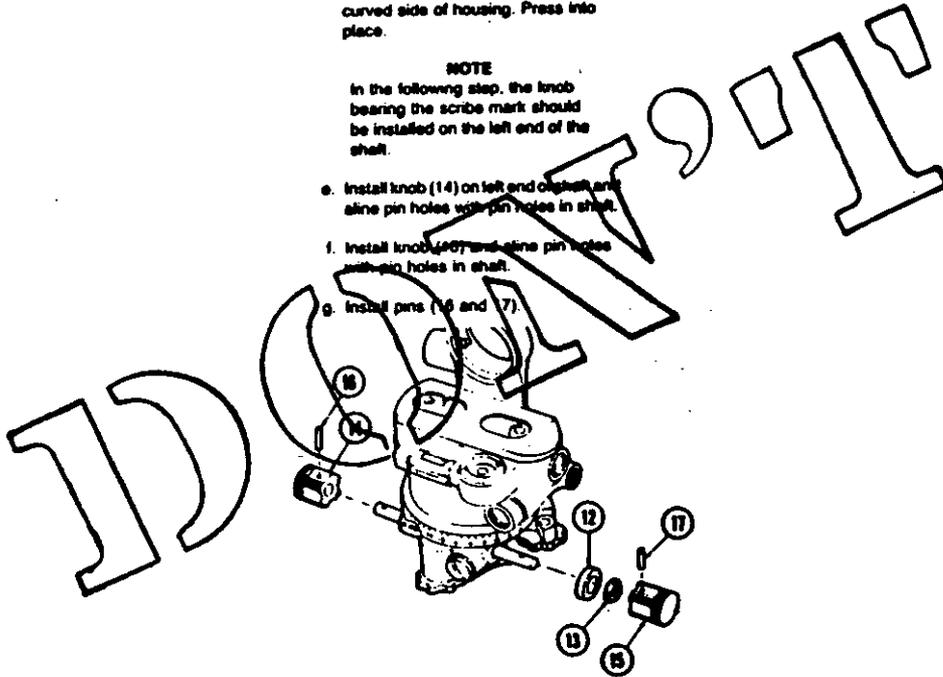
Shoe (12), felt washer (13), knob (14), knob (15), and pins (16 and 17)

- a. Lightly lubricate shoe (12) and felt washer (13) with grease (Item 6, app C).
- b. Press the new felt washer (13) into groove in shoe (12).
- c. Install shoe (12) with felt washer (13) facing outward.
- d. Align curved side of shoe (12) with curved side of housing. Press into place.

NOTE

In the following step, the knob bearing the scribe mark should be installed on the left end of the shaft.

- e. Install knob (14) on left end of shaft and align pin holes with pin holes in shaft.
- f. Install knob (15) and align pin holes with pin holes in shaft.
- g. Install pins (16 and 17).



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VOLUME REDUCTION TECHNIQUES (cont)

8. Tabular presentation (cont).

9-32. FRONT BRAKE SHOES MAINTENANCE (M916 THRU M920) (Continued).		
LOCATION/ITEM	ACTION	REMARKS
D. ADJUSTMENT.		
WARNING		
If jack is used, support truck with blocks so that it will not fall if jack slips.		
18. Wheel.	Jack or hoist free of ground.	
19. Two dust covers (27).	a. Remove. b. Insert adjusting tool. c. Turn starwheel bolt (inside slot) until brakes drag heavily on drums. d. Back off starwheel just until wheels turn freely. e. Replace dust covers (27).	

VOLUME REDUCTION TECHNIQUES (cont)**8. Tabular presentation (cont).**

Tabular presentation can be effective for presentation of operator technical manual operation procedures as shown in the following example.

1-12. EQUIPMENT CONFIGURATION. (CONT)

The switch positions for each of the five modes are shown in the following table:

MODE	OPERATING MODES		REMARKS
	MODE SELECTOR SWITCH	LB/CB SWITCH	
Point to point	POINT TO POINT	LB	For direct connection of two telephone sets.
DC supervision-local battery	DC SUPV	LB	For connection to a switching facility using dc signaling. The telephone set operates on internal batteries.
AC supervision-local battery	AC SUPV	LB	For connection to a switching facility using ac signaling. The telephone set operates on internal batteries.
DC supervision common battery	DC SURV	DC/CB	For connection to a switching facility using dc signaling. The telephone set is powered from the switching facility.
AC supervision common battery	AC SUPV	AC/CB	For connection to a switching facility using ac signaling. The telephone set is powered from the switching facility.

SPECIAL USES**Extension Service:**

Provides for more than one telephone set connected to one line.

Up to four phones can be connected together.

All telephone sets are wired the same, and have the same functions and capabilities.

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VOLUME REDUCTION TECHNIQUES (cont)

9. References.

Reference may be made to any task that exceeds more than a half page in length or that is required as part of three or more other tasks in the manual. Maintenance procedures from other TM's should be included rather than referenced when:

- a. The material is needed in three or more procedures.
- b. The material consists of less than five pages.

10. Curtailed text.

Use of an illustration instead of written procedures may be used for simple maintenance procedures (e.g., remove and install hose/tube clamps using screw/bolt, washer and nut; remove and install hydraulic/fuel/oil lines and fittings) as shown in the following example.

NOTE

A large number of callouts requiring numbering in disassembly sequence would not be an acceptable candidate for this method.

When unique reassembly instructions are involved, this method should not be used.

VOLUME REDUCTION TECHNIQUES (cont)
10. Curtailed text (cont).

RIGHT-HAND SUSPENSION SYSTEM HYDRAULIC LINES AND FITTINGS: REMOVAL AND INSTALLATION (CONTINUED)

REMOVAL

1. Relieve hydraulic pressure (p. 4 162)
2. Remove lines and fittings using illustration and legend as a guide.

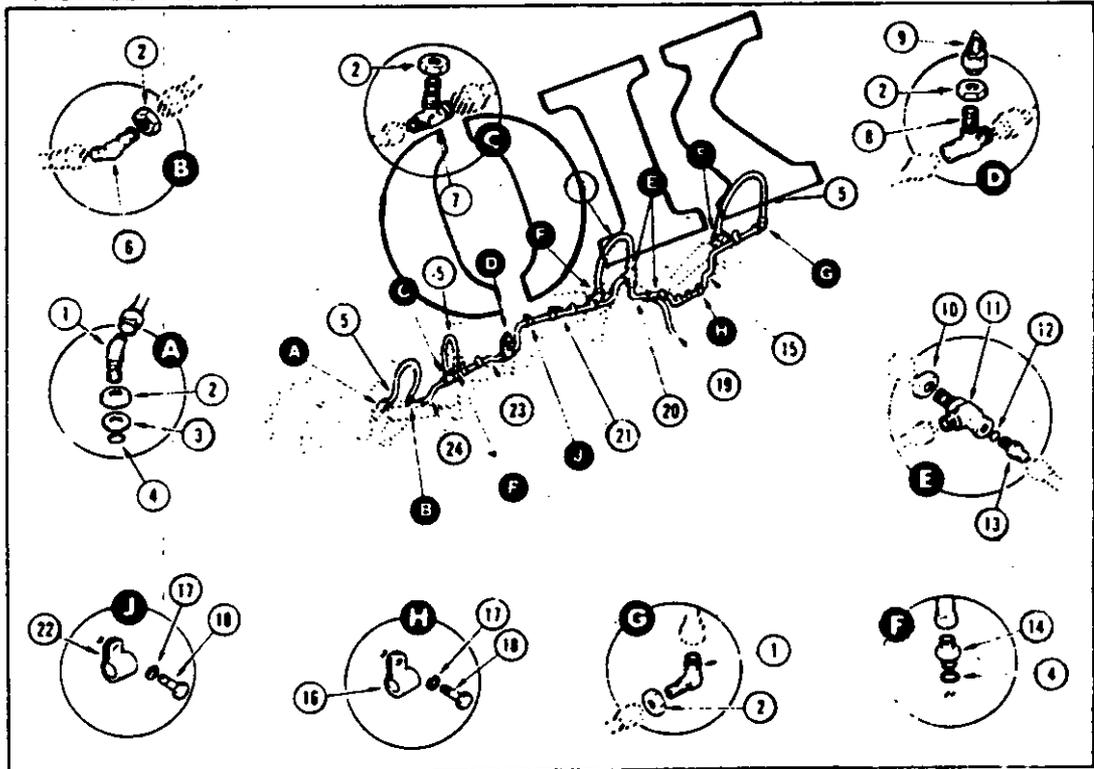
INSTALLATION

Install lines and fittings using illustration as a guide.

LEGEND

- | | |
|-------------------------|--|
| 1 Elbow | 6 Elbow |
| 2 Locknut | 7 Right no. 2 hose lockout cylinder tee |
| 3 Backup washer | 8 Lockout cylinder tee |
| 4 Packing | 9 Pressure seal cap |
| 5 Lockout cylinder hose | 10 Locknut |
| | 11 Tee |
| | 12 Packing |
| | 13 Restrictor |
| | 14 Nutplate |
| | 15 Right no. 4 lockout cylinder line tube assembly |
| | 16 Clamp |
| | 17 Washer |
| | 18 Screw |
| | 19 Right to left crossover pressure line tube assembly |
| | 20 Right no. 3 tee to right no. 4 tee tube assembly |
| | 21 Right no. 3 tee to right capped tee tube assembly |
| | 22 Clamp |
| | 23 Right capped tee to right no. 2 tee tube assembly |
| | 24 Right no. 2 tee to right no. 1 hose elbow tube assembly |

RIGHT-HAND SUSPENSION SYSTEM HYDRAULIC LINES AND FITTINGS: REMOVAL AND INSTALLATION (CONTINUED)



MIL-HDBK-63038-1A (TM)

VOLUME REDUCTION TECHNIQUES (cont)

GENERAL

The good examples of volume reduction techniques will reduce volume and cost of technical manuals while increasing usability by eliminating extraneous material. Other areas of TM presentation techniques that can reduce volume and cost are as follows.

Troubleshooting The wrong type of troubleshooting method can drastically increase volume. Examples in Section 8 of troubleshooting methods should fit hardware and target audience.

Source Data Unavailable, inaccurate, or improperly analyzed source data can dramatically increase volume.

Color Technical manual pages using color should be restricted. Color should not be used in areas such as chapter titles, appendix titles and common tool illustrations for Basic Issue Items list in operator type manuals.

Section 7

DETAILED PROCEDURES: ORGANIZATION AND CONTENT

	Page		Page
Overview	1	Detailed procedure types	8
Material to be covered	3	Maintenance procedures	8
Methods and Requirements	3	Operating procedures	10
Objectives and Principles	3	Test procedures	10
General description	3	Quality control check	12
Initial setup	3	Ways to omit information	12

OVERVIEW

This section explains how to organize and prepare Detailed (step-by-step) Procedures. Different styles and formats are discussed to aid in selection of the best presentation technique for each specific task and conditions. The main purpose of Detailed Procedures is to guide the user through the operating and maintenance tasks that must be performed while providing a level of detail commensurate with the user's knowledge and skills. To prepare Detailed Procedures with the proper level of detail, the writer must have a thorough understanding of the user's experience level. This understanding concerns details of the user's specific knowledge and skill (target audience description) about the following.

- a. Location of components, including controls, indicators, modules, units, parts, etc.
- b. Familiarity with specific procedure. For example, is it sufficient to tell the user to start the engine or obtain lock-on (assuming he or she knows the several operations involved from memory), or must step-by-step information be provided?
- c. Use of test equipment. Does the user know how to use test equipment without additional instructions (except for location of a test point and the expected value of a signal), or must you explain exactly how to connect and set up the test equipment?

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The Detailed Procedure should also increase the user's technical knowledge and understanding of the job to be done. This additional knowledge and skill will enable the user to perform the job more efficiently, prepare for advancement, and work on similar equipment.

Three basic formats are used to present all Detailed Procedure information. These formats are outlined below:

- a. Maintenance procedure format. Used to present maintenance instructions (e.g., removal, disassembly, repair, assembly, installation, packaging and shipping).
- b. Operating procedure format. Used to present operating instructions for all anticipated conditions (e.g., starting, operation, operating in standby, and shutdown of equipment).
- c. Test procedure format. Used to present all test, and checkout instructions.

NOTE

The examples shown in this section should not be construed as the only acceptable methods of presentation for the above three formats.

In addition, Detailed Procedure units contain the following information:

- a. Initial setup. Lists the information needed by the user before starting the Detailed Procedure.
- b. General description. Provides purpose and technical principles on selected tasks to increase the user's technical knowledge and understanding of the job.

NOTE

For additional information on procedures and information on specific aspects of procedures see the following sections:

TITLE	TITLE
Procedures: Organization	Warnings/Cautions/Notes
Troubleshooting	Measurements/Tolerances
Multiple Experience Level Coverage	Locator Illustrations
Skill Enhancement Materials	

Material to be covered:

- a. The objectives of detailed procedures.
- b. A description of detailed procedures.

METHODS AND REQUIREMENTS

Objectives and Principles

Technical manual Detailed Procedures should have the following characteristics:

- a. Be accurate and reliable.
- b. Reflect the real-world job which needs to be done.
- c. Contain all needed information. (All initial conditions, tools, test equipment, parts, and personnel required to complete the job.)
- d. Reflect the most efficient way to do the job.
- e. Easy to use:
 - (1) Making information easy to find.
 - (2) Organizing the information for most efficient use.
 - (3) Short, terse statements.
 - (4) Illustrations correlated with procedure.
- f. Contain the proper level of detail to match the user's experience level.

Requirements

1. General description. Provides purposes and technical principles on selected tasks to increase the user's technical knowledge and understanding of the job. A general description may precede each Detailed Procedure. Refer to Section 12 for use of Skill Enhancement Materials.

2. Initial setup. Lists the information required by the user before starting the Detailed Procedure. This shows how to prepare the work area, what tools are needed, and other essential information. The format should be arranged to present the information clearly, it should make optimum use of the page space, and it should be consistent throughout the manual. Detailed format requirements are shown below.

MIL-HDBK-63038-1A (TM)**Examples of initial setup****INITIAL SETUP****Applicable Serial Numbers**

CA-105 thru CA-450

Tools

Vehicle tool kit 407425

Materials

Light bulb (Spare bulb carried in vehicle map box)

INITIAL SETUP**Test equipment**Missile guidance test set
(Model Number or Part Number)

Multimeter AN/URM-105

ToolsVehicle tool kit 407426
Wrench P/N 8078683
Eyebolt P/N 500348
Chain hoist P/N8750109**References**

TM 9-4910-474-20

Personnel Required: 2

- a. Applicable configurations. When the procedure does not apply to all configurations of the equipment, different configurations covered by the same procedure will be brought to the user's attention. The method for identifying the information that applies to each configuration will be explained. Omit this portion if the same instructions apply to all configurations.

Example:**Applicable configurations**

CA-105 thru CA-450

NOTE

Information preceded by **105-200** applies only to CA-105 thru CA-200.

Information preceded by **201-450** applies only to CA-201 thru CA-450.

For b, c, and d below, list designations (e.g., part number, model number) only if this information is not contained in an overall list elsewhere in the TM. If such a list exists, refer to it instead of repeating the information throughout the TM.

- b. Test equipment. All test equipment required to perform the procedure shall be listed by name and part/model number. Example:

Test Equipment:

Multimeter	AN/URM 105
Oscilloscope, Type 454	13057
Optical Sight Test Set	GVB225-700-PK22

- c. Tools and special tools. When the tool kit which will be used in maintenance of a particular equipment is known, that tool kit, SC, or TM number shall be listed. Special tools shall be listed by name and part number. Example:

Tools:

Vehicle tool kit (SC number)
Wrench P/N 8078683
Eyebolt P/N 500348
Chain hoist P/N 8750109

- d. Materials/Parts. All expendable items and support materials shall be listed. The item number and appendix which lists these items shall be given. Mandatory replacement parts shall be listed by name (and part number, if any). The number, quantity, or size necessary to complete the task shall be listed, when applicable. Example:

Materials/Parts:

Grease	Item 5, Appendix D
Safety wire	Item 16, Appendix D
Range lock	P/N 8675309
Range lock flange kit	P/N 8675310

- e. Personnel required. Personnel required to perform a task will be identified if the task requires more than one. The MOS designation is not necessary but it may be included in those cases where more than one MOS is required.

Personnel Required: (2)

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- f. **References.** All Detailed Procedures or other technical manuals which will be needed are listed here. References may be to a paragraph, page, figure, or TM number, as applicable. Only list references not listed in equipment conditions. They will also be referenced when needed for each task, but this summary allows a technician to select everything needed at the start of the job without checking through the task listing. It also makes selections of frames easy if microfilm storage and retrieval are used. Example:

References:

Para. 2-4 Oil Change Detailed Procedure, 6-Ton Truck, Model B-2

- g. **Equipment conditions.** Any special equipment conditions required before the procedure can be started shall be listed here and cross-referenced to the appropriate paragraph in the text for setting up the condition. Example:

Equipment Conditions:

References

Pg. 4-1 External power must be connected to vehicle.

Fig. 5-2 Left side of vehicle must be jacked up.

- h. **Special environmental conditions.** Any special environmental conditions (such as ventilation, lighting, or temperature) that are required shall be listed here. The reason that such conditions are needed shall be explained. Example:

Special Environmental Conditions:

Darkened area required so lights can be seen.

- i. **General safety instructions.** Any general safety information that applies throughout the procedure shall be included. Specific warnings must also precede steps in the procedure which expose personnel to a hazardous condition.

DETAILED PROCEDURES

Criterion for use

A Detailed Procedure covers a basic maintenance task. The task covers a complete sequence in itself, but may require other tasks to be included or references, e.g., preliminary or follow-on tasks.

Description

The Detailed Procedure contains all information necessary to perform the complete task.

Examples of Detailed Procedure subjects:

Replace a part or an assembly.

Repair an assembly.

Adjust frequency of a transmitter, adjust tension in control cables in an aircraft, or adjust front end of a truck.

Troubleshoot an assembly or functional group (e.g., a servosystem, radio, lighting system, or truck transmission).

The Detailed Procedures are written and grouped to provide the most logical coverage of the authorized maintenance. Depending on size, there may be more than one procedure on a page, or one procedure may require several pages.

The Detailed Procedure:

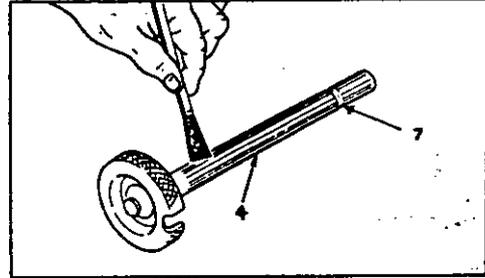
- a. *Provides a concise statement of all that the task includes.*
- b. *Identifies the equipment or part of equipment and the work to be performed.*
- c. *Includes:*
 - (1) *Title. Identifies part, unit, or assembly involved, and the operation which is to be performed.*
 - (2) *Initial Setup. The requirements on pages 3 thru 6 of this section apply here also.*
 - (3) *Task Description. Includes descriptive text in sufficient detail for a technician to understand the task and equipment functional performance to the level needed to perform the task.*

NOTE

See Skill Enhancement (Section 12).

2-46. REPLACE DRIVE SHAFT (cont)**INSPECTION****INSPECT DRIVE SHAFT.**

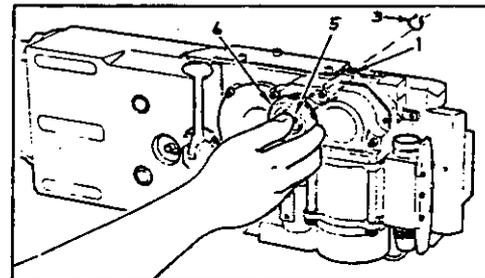
- a. Visually inspect new drive shaft (4) for bends and cracks.
- b. Get a new drive shaft if above conditions are found. Repeat steps a. and b.

**LUBRICATION****LUBRICATE DRIVE SHAFT.**

Apply light coat of grease to entire length of drive shaft (4) splines.

INSTALLATION**1. INSTALL DRIVE SHAFT.**

- a. Insert small end of drive shaft (4) in opening in bottom of receiver assembly.
- b. Push drive shaft (4) in as far as it will go. Push button (5) in center of drive shaft handle (6). Release button.
- c. Pull on drive shaft handle (6) to make sure that drive shaft is locked in place.
- d. Use retaining ring pliers. Install retaining ring (5) in groove (7) on drive shaft (4).

**2. PERFORM RECEIVER MANUAL CYCLE CHECK (para 2-10).****NOTE**

FOLLOW-ON MAINTENANCE:
Install receiver (gun) assembly (para 2-42).

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- b. Operating procedures. See MIL-M-63036.
- c. Test procedures. Test procedures are used to present all test, alignment, adjustment, and similar procedures. Test procedures consist of action and indication statements.

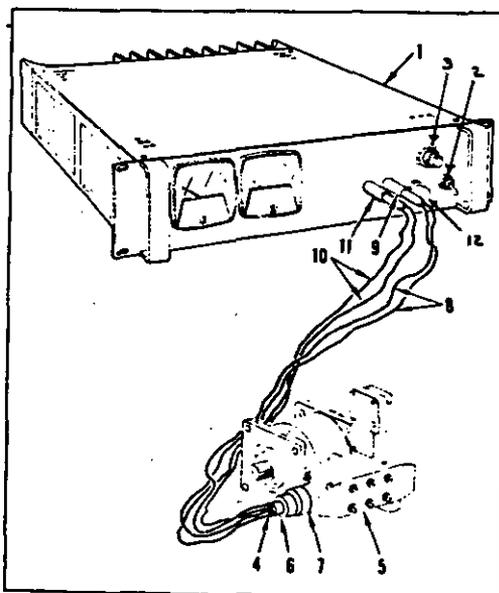
MAINTENANCE OF RECEIVER ASSEMBLY**2-27. FUNCTIONAL TEST OF DRIVE MOTOR****INITIAL SETUP****Tools**

Power Supply 10-32 vdc, 0-50 amps
Part No. TC-32-50

Equipment Conditions:

Reference
Drive motor removed,
TM 9-1005-200-20&P

1. SETUP POWER SUPPLY ON BENCH.
 - a. Position power supply (1) on work surface. Connect power lead to 220 volt source.
 - b. Position ON/OFF switch (2) to OFF.
 - c. Rotate OUTPUT knob (3) to zero.
2. CONNECT INTERCONNECT HARNESS TO DRIVE MOTOR.
 - a. Position interconnect harness (4) and drive motor (5) on work surface.
 - b. Connect interconnect harness plug (6) to drive motor receptacle (7).
3. CONNECT INTERCONNECT HARNESS (4) TO POWER SUPPLY (1).
 - a. Connect both black wires (8) to the negative post (9) on the power supply (1).
 - b. Connect both red wires (10) to the positive post (11) on the power supply (1).



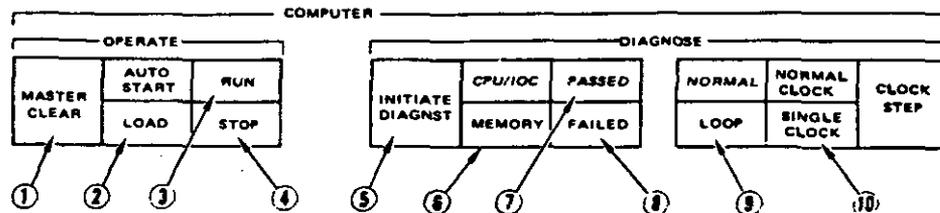
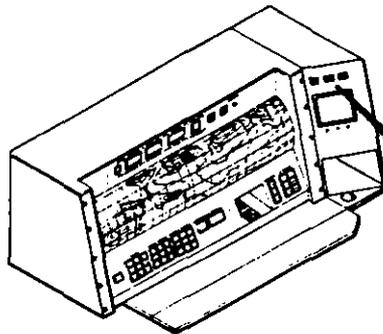
COMPUTER TEST (2 of 2)

MEMORY TEST

CAUTION

This test destroys the data that is stored in computer memory. If you wish to retain the data that is stored in computer memory, do not perform this test.

1. Press CPU/IOC/MEMORY switchlamp (6) so that MEMORY legend lights.
2. Momentarily press MASTER CLEAR switchlamp (1).
3. Momentarily press INITIATE DIAGNST switchlamp (5).
4. Verify that PASSED (7), FAILED (8), and RUN (3) indicators light.
5. When STOP indicator (4) lights, PASSED indicator (7) will remain lit and FAILED indicator (8) will go out if the test is successful. If a fault is detected, FAILED indicator (8) will remain lit.



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- d. Quality control check. Include a quality control check at the end of the Detailed Procedure (for instance, before covers or cases are reinstalled) so the technician can be sure he or she did the job correctly. Quality control checks should be highlighted.

Examples:

Check that wheel turns freely.

Check that lights go on.

- e. Ways to omit information. Follow the rules below to determine if any information can be omitted. Omit information under any of the following conditions or combination of these conditions.

CONDITION**INFORMATION OMITTED**

- | | |
|--|---|
| a. The user already knows the information. | Location
Locator illustration |
| b. All items or indicators are at the same location. | Location |
| c. The information is shown in locator illustration and doesn't need to be repeated for clarity. | Location
Item or Indicator |
| d. The information is obvious or not needed. | Location
Locator illustration
Remarks |

- f. If desired, the material may be landscaped (turned 90 degrees) on the page. If landscaping is used, it should be used for the entire manual. When a detailed procedure covers both facing landscaped pages, the column titles which appear on the top page need not be repeated on the bottom page.

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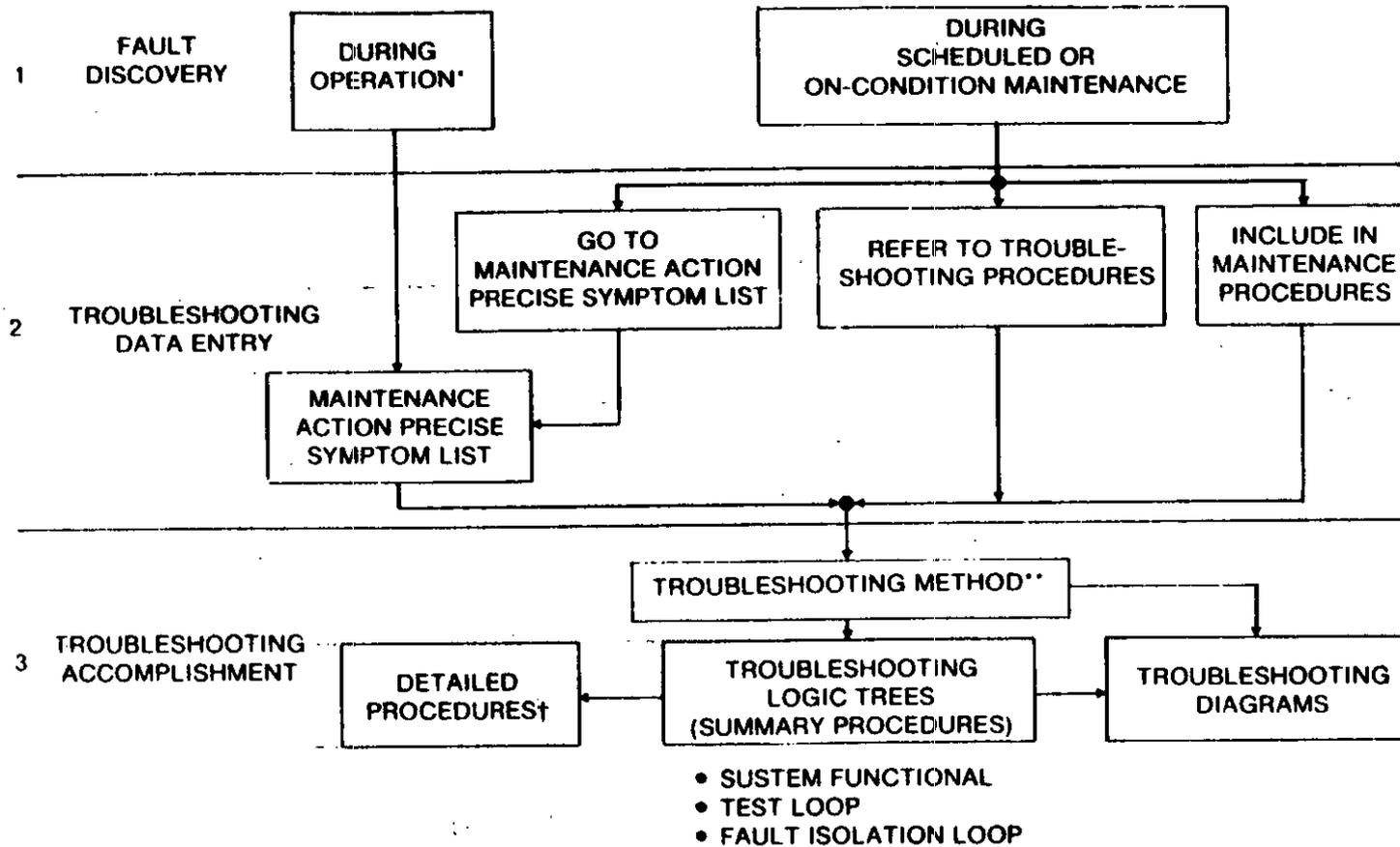
Section 8

TROUBLESHOOTING

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* Also includes "DURING INSTRUMENTATION ANALYSIS" such as recorders, telemetry, etc.

** Initial troubleshooting steps should include performance of any applicable self tests, alinements, and inspections.

† Detailed procedures are referred to in the troubleshooting logic tree (Summary Procedure) for specific tests, adjustments, calibrations, removals, repairs, etc., which are required during troubleshooting, but which are too lengthy to include in the troubleshooting procedure.

Figure 1. Troubleshooting Methodology

OVERVIEW

Technical manual troubleshooting data must promote rapid fault isolation in a system or equipment item. This allows the technician to quickly remedy the problem and return the equipment to operational status. Quick turnaround with accurate solutions is the essence of troubleshooting.

Troubleshooting data should get the technician directly from the symptom(s) of the problem to the proper solution with a minimum of unnecessary information. Any troubleshooting data that is hard to use will probably not be used. If a technician dislikes the method in the manual, it is likely he or she will develop a method - - which may be inaccurate or even unsafe.

Troubleshooting data should be test and fault-isolation oriented. Repair by replacing parts until the problem disappears is to be avoided if at all possible.

Many things must be taken into account when generating troubleshooting data. These include:

- | | |
|--------------------------|---|
| a. Maintenance concept | f. Automated vs manual testing |
| b. Ease of testing | g. Test equipment requirements and availability |
| c. Test access time | h. User environment |
| d. Component reliability | i. Technician experience (target audience) |
| e. Test Time | j. System quick-turnaround requirements |

This discussion divides troubleshooting into three major steps (fig. 1): fault discovery, troubleshooting data entry, and troubleshooting accomplishment. Each of these steps has alternatives that are discussed in detail. They include:

- a. Fault Discovery
 - (1) By operator
 - (2) During scheduled or on-condition maintenance by maintenance personnel.
- b. Troubleshooting data entry
 - (1) During Operation - - Go to Maintenance Action Precise Symptom (MAPS) List
 - (2) During maintenance - -
 - (a) Include in maintenance procedures
 - (b) Refer to troubleshooting procedures
 - (c) Go to Maintenance Action Precise Symptom (MAPS) List
- c. Troubleshooting Accomplishment
 - (1) Logic trees
 - (2) Troubleshooting diagram(s)

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d. *Troubleshooting procedures.* A troubleshooting procedure consists of action, normal indication, and corrective action statements.

Example of Troubleshooting Procedure

Step	Operation Normal Indication Corrective procedure
1.	<p style="text-align: center;">NOTE</p> <p>The key numbers shown below in parentheses refer to figure 5-1 unless otherwise indicated.</p> <p>Quick-Disconnect Couplings and Handpump Air Purge.</p> <p>Open the handpump access panel (10, fig. 1-3) and insert the handpump handle into the handpump.</p> <p>Handpump unloading valve (16, fig. 2-11) full cw.</p> <p>HAND PUMP PRESSURE UNLOADING VALVE (13) partial cw.</p> <p>Actuate the handpump handle six to seven strokes to purge the handpump of air.</p> <p>Connect hose assembly MS28762-4-0250 with quick-disconnect coupling 9194688 to the HAND PUMP PRESSURE PORT (12).</p> <p>Actuate the handpump handle to purge the handpump system of air.</p> <p style="padding-left: 40px;">Hydraulic fluid flows from the open-end hose assembly.</p> <p style="padding-left: 80px;">HAND PUMP PRESSURE PORT, quick-disconnect coupling.</p> <p>Remove the hose assembly.</p>
2.	<p>Handpump Low Pressure.</p> <p>a. HAND PUMP PRESSURE UNLOADING VALVE full cw.</p> <p>Actuate the handpump handle until the 0-100 PSI GAGE (1) indicates 10 psig; maintain this pressure for 3 minutes.</p> <p style="padding-left: 40px;">The 0-100 PSI GAGE reads 10 psig. No fluid leakage is observed.</p> <p style="padding-left: 80px;">Gage, handpump, HAND PUMP PRESSURE UNLOADING VALVE.</p> <p>b. Actuate the handpump handle until the 0-100 PSI GAGE indicates 90 psig, and maintain this pressure for 3 minutes.</p> <p style="text-align: center;">CAUTION</p> <p>Do not exceed the 100-psig indication on the 0-100 PSI GAGE if the gage protector is not functioning properly.</p> <p style="padding-left: 40px;">The 0-100 PSI GAGE reads not less than 88 psig. No fluid leakage is observed.</p> <p style="padding-left: 80px;">Gage, handpump, HAND PUMP PRESSURE UNLOADING VALVE.</p> <p>c. Actuate the handpump handle until the 0-1000 PSI GAGE (2) indicates 500 psig. Observe all connections for leakage.</p>

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Other sections of this handbook which may aid troubleshooting data development are:

- | | |
|---------------------------|---------------------------------------|
| a. Procedures | d. Indexing |
| b. Schematics/Functionals | e. Accessing |
| c. Locator Illustrations | f. Text Associated with Illustrations |

METHODS AND REQUIREMENTS

Objectives and Principles

Properly developed troubleshooting procedures have the following desirable characteristics:

- a. Failure verified as first step in troubleshooting process.
- b. Technician not left high and dry by troubleshooting data.
 - (1) Sufficient descriptive data provided so technician knows what to do and why.
 - (2) When troubleshooting procedures are not successful, references are provided to troubleshooting diagrams or functionals so troubleshooting of rare or difficult problems can be continued easily.
- c. Troubleshooting data keyed to failure symptoms encountered during operation and maintenance procedure performance.
- d. All data complete and correct.
- e. Data easy to update to account for new equipment or newly discovered problems.
- f. Specific troubleshooting information easy to locate quickly.
- g. Data and format simple to use and easy to understand.
- h. Only data required to understand/perform specific troubleshooting task included.
- i. Parts verified faulty before replacement, whenever possible.
- j. Proper operation verified after parts replacement to ensure trouble has been repaired.

Requirements

General. Troubleshooting data that fault-isolates possible malfunctions shall be included in technical manuals.

Where required by the technical content specification, step-by-step, proceduralized (logic-tree) troubleshooting shall be included. The logic-tree troubleshooting shall consider all possible malfunctions, whether the symptoms occur during equipment operation or normal maintenance.

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The logic trees, when used in conjunction with any "built-in" test/troubleshooting aids, shall enable troubleshooting to faulty replaceable parts with a high degree of certainty -- the logic trees shall cover as many malfunctions as possible which actually occur in the equipment.

For those malfunctions that are not covered by logic trees, the manual user shall be directed to a troubleshooting aid with which further fault analysis of available information is possible.

Troubleshooting data should be designed so that the user cannot fail eventually to isolate a malfunction. This is accomplished by a pyramid approach that starts at a general level and works down to details -- the modified half-split approach, which isolates a fault to "half" of the remaining system at a time until the final half remaining is an individual system replaceable part. The half-split technique must be properly employed to consider test time, test access time, reliability, and test equipment requirements.

Fault Discovery. Malfunctions in a system are discovered in one of two ways:

- a. The symptoms of a fault occur during normal operation.
- b. The fault shows up during normal maintenance such as inspection, alignment, check procedures, or scheduled testing/checkout.

The symptom that appears in either case may be one that is either common or unusual, but the determination of that symptom is the first step of the troubleshooting process.

Troubleshooting Data Entry - - Trouble Discovered During Operation. When a malfunction is discovered, the entry into the troubleshooting procedure is based on the actual symptom.

The maintenance technician, if possible, should debrief the operator for a general description of the problem and should then attempt to verify the fault. In so doing, the technician may or may not observe the same fault symptom. If the same fault symptom is observed, the technician should attempt to define the symptom as accurately as possible. The malfunction description is then used to refer into the Maintenance Action Precise Symptom (MAPS) List -- a list that correlates the symptoms to precise troubleshooting procedures.

- a. The MAPS List (fig. 2 and 3) is required for all operation-discovered-fault troubleshooting data entries. It must meet the following requirements:
 - (1) Contains fault symptoms for all known malfunctions.
 - (2) For complex systems, lists symptoms by sub-subsystem categories if necessary and may use codes that help identify specific items.
 - (3) Catalogs symptoms by method of detection if this aids usability.
- b. *Maintenance Action Precise Symptom (MAPS) List Preparation.* The Maintenance Action Precise Symptom (MAPS) List can be prepared using either the tabular or branching method. The symptom descriptions that make up the list are derived from those formulated from the logic trees and are identical. For medium-complex systems, either is acceptable provided the list contains the minimum data of precise symptom description and troubleshooting procedure reference. For simple systems, figure 2 gives an example of a tabular method that could be used. The tabular method may be used for medium-to-heavy complex systems.

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Troubleshooting Data Entry - Trouble Discovered During Maintenance. When the fault is discovered during scheduled/on-condition maintenance, three choices exist for entry into the troubleshooting data.

These alternatives are listed in order of preference. Specific requirements, advantages, and limitations for each of these follow:

- a. Troubleshooting Integrated into Scheduled or On-Condition Maintenance Procedures (fig. 4)
 - (1) Designed so technician does not have to shift to other part of manual.
 - (2) Suitable for simple to medium-complex systems.
 - (3) Should be used wherever data bulk permits.
- b. User Referred to Separate Troubleshooting data (fig. 5 and 6)
 - (1) Refers technician directly to proper troubleshooting data at each step of procedure where a fault could be encountered.
 - (2) Refers to troubleshooting aids for complex/unusual faults.
 - (3) Preferred to less precise MAPS list method below.
- c. User Referred to MAPS List by Symptom
 - (1) Refers to MAPS List either at beginning of procedure or at point where malfunction could be encountered.
 - (2) May use MAPS entry code in lieu of troubleshooting reference.
 - (3) Requires additional searching/decision making by technician thru *a* and *b* above.

Troubleshooting Methods. The following methods may be used in the preparation of troubleshooting data:

- Logic trees
 - (1) Tabular
 - (2) Branching
 - (3) Narrative
- Troubleshooting diagrams

The above methods differ widely in cost, with Logic Trees being more expensive. Whatever method is used should require performance of any applicable self-tests, alignments, and inspections before accomplishing other troubleshooting.

- a. **Logic Trees.** Logic-tree, proceduralized-troubleshooting format is a programmed information method that involves user interaction. The user is given a particular instruction, then is asked a yes-no question about the result of his or her action. Based on the answer, the user is *referenced* to another instruction. All troubleshooting employs some variation of this method. The logic trees are based on failure symptoms and include the most probable faults with the most probable causes. Faults that occur on a rare or random basis are excluded and the technician provided with a reference to a troubleshooting aid such as a diagram.

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Logic trees must be prepared using a modified half-split fault isolation technique. Accurate fault isolation in the least amount of time is a must and cannot be overemphasized. The actual logic-tree procedure must optimize among the following for *minimum* fault isolation time:

- (1) Test time
- (2) Test access time
- (3) Replaceable part reliability
- (4) Test equipment requirements

Abbreviated logic trees may be produced as a form of condensed troubleshooting data, if the checkout is to be performed by an experienced technician. This will result in a much reduced checkout time requirement. Abbreviated logic trees should be used only as an adjunct to complete logic tree procedures, as is the case with any condensed information.

Logic trees should contain all essential and pertinent information that would be included in any other form of procedure. This includes warnings, cautions, notes, power turn-on procedures, precheckout procedures, reference diagrams, and initial switch settings.

Logic trees shall be prepared assuming only one malfunction at a time is being corrected. The first steps in the logic trees shall verify the reported failure actually exists and the proper logic tree is being used. An operational check shall be specified to be performed after the fault is corrected to ensure correct operation of the system.

Logic trees shall be used in conjunction with troubleshooting diagrams such as those described later. This allows greater flexibility for the isolation of unusual faults, improved conceptualization of the system by the technician, and a slight reduction of the information that must be presented in the procedures proper.

Three formats for logic tree troubleshooting procedures and their advantages and limitations are listed below.

Logic Tree Format	Advantages	Limitations
a. Tabular (fig. 7 and 8)	<p>Compact on page.</p> <p>Can be produced on preprinted forms.</p> <p>Relatively easy to use.</p>	<p>Procedure flow may not be easily seen.</p>
b. Branching (fig. 9 and 10)	<p>Procedure flow readily apparent.</p> <p>Suitable for computer generation.</p>	<p>Requires more space than tabular.</p>
c. Narrative (fig. 11)	<p>Easy to write and produce.</p>	<p>Requires more time to use.</p> <p>Procedure flow not evident.</p> <p>Tedious to use.</p>

Logic Tree Preparation

The logic tree should provide the maintenance technician with a means of isolating system failures to the probable faulty line replaceable item. The depth of coverage in the logic tree may range from a unit to a subassembly. (In most cases, troubleshooting of wiring and connectors should be accomplished by referencing troubleshooting diagrams which show the necessary information.) To prepare the troubleshooting logic tree, exercise the following general ground rules.

- (1) Using schematic diagrams, functional diagrams, available engineering documentation such as test specifications, design descriptions, trouble and failure reports, field squawks, and any other available documents, study the system in detail. Understand the system operation and note what functions are performed by the units associated with the system. If possible, visit user sites and obtain actual information on fault symptoms and causes resulting from hardware usage. Understand the user's method of troubleshooting and his or her problems.
- (2) Knowing all the variables about the system such as test equipment available, repair level, technician experience level, number of technicians, etc, perform a fault analysis on paper, listing all problem areas and faults that could possibly occur. Actual usage of the hardware during the fault analysis is very helpful and should be used as much as possible. Because fault isolation must be accomplished in the least amount of time, the logic tree should begin with tests of components with the least reliability or tests which require the least time to be performed.
- (3) All components that produce the same malfunction symptom must be considered as possible causes of the fault. All components should be associated through their failure mode to a malfunction symptom. Once the failure mode of the component is determined, determine all outputs that would be incorrect for each failure and describe what the incorrect measurement would be.
- (4) Note any effect on other outputs downstream from the failing output.
- (5) Develop the logic tree based on tests, measurements, and decisions that must be made in order to reach the final outcome of isolating the fault to a replaceable component related to the symptom. All of the most probable faults and causes should be considered.
- (6) Include any information that will aid the technician such as waveshapes, voltage levels, references to test diagrams, functional diagrams, text, etc., and alignment procedures, checkout procedures, or other scheduled maintenance procedures. The end result must be repair of the system.
- (7) List any self-tests that are associated with the system and understand to what extent the self-test is conducted on the system. Self-test schemes should be the prime troubleshooting tool, with manual troubleshooting by logic tree taking over where self-test leaves off or fails to locate malfunction.
- (8) Prepare a rough draft of the logic tree and include safety precautions such as notes, cautions, and warnings.

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- (9) Build the procedure using system self-tests first before using external test equipment. Avoid as much as possible procedures that use excessive test equipment or require measurements to be made in locations difficult to access
- (10) Ensure that actions required of the technician are reasonable to perform. For example, do not ask the technician to connect a meter at one point and set a switch at another point where he or she cannot observe the meter reading. Be practical.
- (11) When a rough draft procedure is completed, validate proper operation of the procedure by the most efficient and practical method - preferably on the actual hardware.
- (12) Whenever possible, create the fault conditions on the system by inserting faults and verifying results and corrective actions.
- (13) When all possible faults have been determined and described, prepare the MAPS list using the exact description of the fault as the symptom description. Group symptoms to common system areas. For example, if a system has a data link, communications, radar, display, and tracking systems, the symptoms would be grouped into each related area. All fault symptoms of a communications nature would fall into the communications group. The symptoms could be further divided into functions within the communications group that would be common. The same would be done for radar, data link, display, and tracking systems
- (14) Ensure that the logic tree contains all the required references to other troubleshooting aids and that all references are correct.
- (15) For those faults that are not identifiable through a fault analysis on paper, collect data through the field failure reporting system.

Logic Tree Content

The following content information is the recommended content for the logic tree format (figure 7). Refer to the procedures section of this handbook for information on methods of preparation, procedure writing style, highlighting, step grouping, blank columns, ways to omit information, and ways to save space

- *Location*
- *Item or Indicator*
- *Action*
- *Indication*
- *Corrective Action* -
 - (1) If Indication is obtained
 - (2) If Indication is *not* obtained
- *Remarks*

- b. *Troubleshooting Diagrams* Troubleshooting diagrams can be used to supplement logic tree troubleshooting data or as stand-alone troubleshooting aids. The three types of diagrams commonly used for troubleshooting purposes are:

- (1) System functional diagrams

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(2) Test-loop functional diagrams

(3) Fault-isolation diagrams

For troubleshooting diagrams to be used as stand-alone aids requires a rather highly experienced technician who has considerable system experience. Even when used effectively, diagrams require more time than the two other methods to accomplish most troubleshooting.

Requirements for troubleshooting diagrams are as follows:

(1) System function diagrams

(System functional diagrams are not specifically designed for troubleshooting.)

- (a) Depict functional operation of system.
- (b) Show system broken down by real-world functions.

(2) Test-loop functional diagrams (fig. 12)

- (a) Show all circuits involved in test loop.
- (b) Are stimuli- and response-oriented.
- (c) Show built-in or automatic test provisions.
- (d) Include all test conditions:
 - Test stimuli
 - Component under test
 - Test measurement equipment
- (e) Show pre-test setup conditions.
- (f) Show other pertinent data.

(3) Fault-isolation diagrams

- (a) Show all circuits involved in troubleshooting loop.
- (b) Are symptom-or indication-oriented.
- (c) Show, otherwise, same information as test-loop functional diagrams above.

Text shall explain diagrams to provide the maintenance personnel with a description of the diagram in an overall terse manner. Enough material shall be presented to allow an understanding of what the troubleshooting is trying to accomplish and what the expected result(s) will be.

Troubleshooting diagram preparation instructions are given in the following sections of this handbook:

- Schematic/Functional Diagrams (Section 18)
- Text Associated with Illustrations (Section 5)

Troubleshooting Method Selection Criteria

The writer must select the kind of troubleshooting data the technician needs to get the job done quickly. Two methods are available that differ widely in cost - listed from most to least

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expensive they are:

- a. Logic trees
- b. Troubleshooting Diagrams

The factor that complicates selection decisions is that a large number of pertinent selection criteria exist, each of which must be considered. The Troubleshooting Methods Selection Criteria Matrix below can be used by the writer to aid in making the choice.

The matrix is arranged to be used by a writer who has at least a fair idea of how to classify the selection criteria listed down the side of the matrix. Each of these categories contains two criteria, which may apply to the troubleshooting job at hand. The first step taken to use the matrix is to choose which of the criteria apply.

The columns of the matrix show the alternative troubleshooting methods.

Beginning with the top row of the top group, the writer should determine how many of the criteria he or she has chosen and intersect each column at a dot.

The method that intersects *all* chosen selection criteria is the preferred method. If no method fulfills all the criteria, or more than one method does, the writer must determine the relative importance of each factor in the case and make a decision accordingly.

Little difficulty should be encountered by the writer when choosing logic tree formats. The narrative type should not usually be considered for any but simple mechanical systems. Because the tabular and branching formats are equally effective for step-by-step troubleshooting, either can be used in most situations.

For applications where space is at a premium, the tabular may have a slight edge. If it is desired to promote understanding of the system as troubleshooting is performed, the writer might choose the branching format—accepting that it will probably require more space. An example of the branching format is shown in figure 16.

Branch and Flow isolation technique.

This fault isolation technique is composed of a series of operation and decision routines. These troubleshooting routines are presented graphically in functional order and are supported by functional diagrams.

Each troubleshooting routine appears as a table containing three graphic symbols: oblongs, squares, and diamonds. Each symbol has its own purpose and meaning:

- a. Oblong. Provides directive information.
- b. Square. Provides instructions for a step to be performed. The instruction is presented in abbreviated format. For example, CODING SWITCH: CODING OFF, is interpreted as "Set the CODING SWITCH to the CODING OFF position."
- c. Diamond. Proposes a question to be answered "yes" or "no." If the answer were "yes," you would follow instructions branching off from "yes" leg; with "no," you would follow the "no" leg.

To isolate a fault, the technician begins at the top of the appropriate table and proceeds downward. This is done by performing the instructions given in the squares and answering "yes" or "no" to the questions proposed in the diamonds. The path the technician will take through the tables is determined by the "yes" or "no" answers, and by the directive information given in the oblongs. By following this procedure the fault is ultimately isolated and corrected. See figure 17 for sample pages done to the branch and flow-fault isolation technique.

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TROUBLESHOOTING METHOD SELECTION CRITERIA

Selection Criteria	TROUBLESHOOTING METHOD	
	Logic Trees	Troubleshooting Diagrams
Hardware Complexity		
Simple		•
Complex	•	•
Quantity Produced		
Few		•
Many	•	•
Built-in Test		
Little	•	•
Extensive	•	
No. of Personnel		
Few		•
Many	•	•
Personnel Experience or Training		
Little	•	
Extensive		•
Tasks		
Simple		•
Complex	•	
Extent of Parts, Replacement		
Unit, Assembly, Module	•	•
Component Part		•
Mission Importance		
Unimportant		•
Essential	•	
Frequency of Fault Occurrence		
Rare		•
Common	•	•
Environment		
Sheltered	•	•
Exposed	•	
Working Area		
Ample	•	•
Limited	•	

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SYMPTOM INDEX

	Troubleshooting Procedure (Para)
COOLING SYSTEM	
Radiator	
Boils over	3-12
Leaks	3-17
Temperature Gage	
No indication	3-29
Runs cold	3-11
Runs hot	3-13
ENGINE	
Misses	3-34
Overheats	3-72
Won't start	3-27
EXHAUST SYSTEM	
Excessive smoke	3-33
Water vapor	3-33

Figure 2. Maintenance Action Precise Symptom
(MAPS) List Sample
(For Simple To Medium-Complex Systems)

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CODE	DESCRIPTION	FAULT ISOLATION PROCEDURE
DM-1	080 unit target marker circle range incorrect - radar dominant	3-12
DM-2	080 unit target marker circle elevation incorrect - IR dominant	3-12
DN	<input type="checkbox"/> TSD target bug range and HSI target range incorrect - data link	8-17
DN-1	<input type="checkbox"/> TSD target bug bearing and HSI target bearing incorrect - data link	8-3
DN-2	<input type="checkbox"/> HSI miles indicator incorrect - data link	8-17
DT-5	<input type="checkbox"/> AMI command Mach incorrect - manual	8-10
DIGITAL COMPUTER		
EA	Computer malfunction - can be cleared	8-3
EA-1	Computer ASIA information incorrect	2-10
EA-2	Computer value of WSEM parameter/CCM signals incorrect	2-4
EA-3	Temperature call up incorrect on AVVI or 980 unit	...
EB	Computer malfunction - can not be cleared	8-4
EB-1	Computer manual steering erroneous - all modes	3-16
EB-2	Computer manual and AFCS steering erroneous - all modes	8-5
ARTIFICIAL HORIZON		
FA	Artificial horizon - no erection - roll	8-2
FA-1	Artificial horizon - no erection - pitch	8-2
FC	Artificial horizon - drifts/tumbles - pitch	8-1
FD	Artificial horizon - incorrect erection - pitch	8-2
FJ	Artificial horizon - missing	3-12
FJ-1	Artificial horizon - distorted	3-12
FK	905 unit annunciator incorrect	8-4
RADAR SEARCH AND DETECTION		
GA	B-sweep missing - on and stby	3-1
GA-1	B-sweep missing - on	3-1
GA-2	B-sweep missing - stby	3-1
GB	B-sweep intensity incorrect	3-2
GC	B-sweep super search - inoperative	3-3
GC-1	B-sweep super search width incorrect	3-3

Figure 3 Maintenance Action Precise Symptom (MAPS) List Sample
(For Medium-To-Heavy Complex Systems)

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Item	Action	Normal Indication	Corrective Action
g.	Calculate card extender noise by subtracting DVM (5A2) indication in step 2. f. from DVM (5A2) indication in step 35. d. of figure 7-2.		
h.	On WRA, adjust A15R33 for normal indication.	DVM (5A2) displays -743 +49 mV plus card extender noise.	Replace SRA A15. if indication not normal.
3. High Threshold Adjustment 137 (A4R34, A4R80)			
a.	Perform item 1 of figure 7-5 to remove top cover from WRA.		
b.	Press and release WRA POWER ON pushbutton.	WRA POWER ON pushbutton lights.	
c.	Press and release FUNCTIONAL TEST/FAULT ISOLATION pushbutton.	FAULT ISOLATION portion of pushbutton lights.	
d.	Press and release DVM pushbutton.	DVM pushbutton lights.	
e.	Select signal number 011.	DVM (5A2) displays 110 +10 mV.	PASS: Step 3 m FAIL: Step 3 f
f.	Record DVM (5A2) indication for use in step 3. k.		
g.	Press and release WRA POWER OFF pushbutton.	WRA POWER OFF pushbutton lights.	
h.	On WRA, extend SRA A4 using card extender (3070702-3).		
i.	Press and release WRA POWER ON pushbutton.	WRA POWER ON pushbutton lights.	
j.	Record DVM (5A2) indication for use in step 3.k.		

WRA 042 Alinement Procedure (Sheet 2 of 7)

Figure 4. Example of Troubleshooting Integrated into Maintenance (Alinement) Procedure

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Item	Action	Normal Indication	Troubleshooting Ref.
15.	Display Test 005		
a.	on WRA, perform the following:		
	(1) Set ASPECT switch (S7) to TAIL.		
	(2) Set MLC switch (S8) to AUTO.		
	(3) Set XMTR CHAN thumb-wheel (S9A) to 2.		
	(4) Set MSL CHAN thumb-wheel (S9B) to 3.		
b.	Select test number 005.	TEST IN PROGRESS readout displays 005.	
c.	On WRA, press and hold SPL (S5A) and ALT DIF (S5B) pushbuttons.		
d.	Press and release TEST EXECUTE pushbutton twice.	TEST RESULT readout displays NO GO and SSI BIT FAULT 29 and 30 indicators light (-165 and up configuration WRAs) or TEST RESULT readout displays GO and all SSI BIT FAULT indicators are off (-155 thru -161 configuration WRAs).	3
		On WRA, IROT indicator (A1DS4) is lit.	30
		On WRA, SPL (S5A) and RDR (S11A) pushbutton light green.	32
		On WRA, RANGE readout (A1M1) displays 50.	21
		On WRA, WCS MODE readout (M3) displays MRL.	22
		TEST STATUS E indicator is lit.	29
		TEST STATUS FF indicator is lit.	33
		TEST STATUS BB indicator is off.	24
		(Keyed to Legend that follows for Location of Troubleshooting Data.)	

Figure 5. Example of User Referred to Separate Troubleshooting Data (Sample 1)
(Sheet 1 of 2)

EXPANDED REMARKS

	17	Fault Isolation I-10-4/7. Electrical Alignment I-10-3/7 thru 21 Physical Alignment I-10-3/22. Functional Diagram III-5-19, 20, 21.	34	Fault Isolation I-10-4/10.
Fan. 39, 40, 43, 44.	18	Fault Isolation I-10-4/2. Functional Diagram II-5-5.	35	Fault Isolation I-10-4/5 Functional Diagram III-5-5, 6, 7, 8, 15, 23.
	19	Replace SRA A11A10. Disassembly/Reassembly I-10-5/23, 24	36	Fault Isolation I-10-4/11
1, 2, 15, 16.	20	Fault Isolation I-10-4/3.	37	Fault Isolation I-10-4/6, 8. Functional Diagram III-5-5, 8, 23.
13. 35, 36. -10-4/3.	21	Fault Isolation I-10-4/5.	38	Fault Isolation I-10-4/33.
	22	Fault Isolation I-10-4/5.	39	Replace SRA A11A14. Disassembly/Reassembly I-10-5/23, 24.
23, 24. pushbutton. 45, 46, 55, 56,	23	Fault Isolation I-10-4/6.	40	Replace SRA A11A10. Disassembly/Reassembly I-10-5/23, 24.
	24	Fault Isolation I-10-4/35.	41	Fault Isolation I-10-4/3. Functional Diagram III-5-5, 8, 15, 23.
	25	Fault Isolation I-10-4/2. Replace PULSE GAIN control (R13, S13) Functional Diagram III-5-5.	42	Fault Isolation I-10-4/12.
75, 76.	26	Fault Isolation I-10-4/9. Electrical Alignment I-10-3/7 thru 21. Physical Alignment I-10-3/22.	43	Fault Isolation I-10-4/13.
(R2) 69, 70.	27	Replace PULSE VIDEO control (A1R1) Disassembly/Reassembly I-10-5/47, 48. Functional Diagram III-5-16, 19, 20, 21.	44	Fault Isolation I-10-4/36.
69, 70.	28	Replace ERASE control (R7). Disassembly/Reassembly I-10-5/61, 62. Functional Diagram III-5-14, 19, 20, 21.	45	Fault Isolation I-10-4/8.
(R4) 69, 70.	29	Replace SRA A11A3. Disassembly/Reassembly I-10-5/23, 24.	46	Fault Isolation I-10-4/14.
1(R3). 69, 70.	30	Fault Isolation I-10-4/3. Functional Diagram III-5-5, 7, 8.	47	Fault Isolation I-10-4/5. Functional Diagram III-5-5, 8, 14, 23.
(R4, S14). 69, 70.	31	Deleted.	48	Fault Isolation I-10-4/15.
			49	Fault Isolation I-10-4/5. Functional Diagram III-5-5, 8, 23.
61, 62.			50	Fault Isolation I-10-4/4. Functional Diagram III-5-7, 8, 23.
			51	Replace IFF pushbutton (S11C). Disassembly/Reassembly I-10-5/55, 56.
			52	Fault Isolation I-10-4/3. Functional Diagram III-5-5, 8.
			53	Fault Isolation I-10-4/16.
			54	Fault Isolation I-10-4/24. Functional Diagram III-5-5, 6.

Figure 5. Example of User Referred to Separate Troubleshooting Data (Sample 1)
(Sheet 2 of 2)

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- d. Sequence 3 (which may reference sequences 5 through 8)
- 3. Sequence 4 (which may reference sequence 6)

WARNING

On hcu (figure 21, detail B) ensure WCS switch (7) is set to OFF when disconnecting or connecting electrical connectors and when removing or replacing units.

NOTE

Ensure that pretest setup procedures (para 42) have been performed before proceeding.

44. Power Turn-on.**45. To perform WCS turn-on, proceed as follows:**

- a. On hcu (figure 21, detail B) set WCS switch (7) to STBY and check that power indicator comes on in 30 + seconds. _____ TN000

NOTE

As a function of the tactical program, the computer test (sequence 2) is performed automatically during the 30 second displays time-in. At the successful completion of sequence 2 a normal BIT presentation with a pass symbol () is displayed for approximately 10 seconds. At this time the tid switches to a tactical display. If sequence 2 fails an fi display appears. This display may be removed by pressing PRGM RESTRT pushbutton on CAP. A manual sequence 2 should be run if the automatic sequence 2 fails.

- b. Check that power reset indicator remains out _____ TN0005
- c. Press and hold LIGHT TEST switch and check that proper indicators (figure 8) come on.

Figure 6. Example of User Referred to Separate Troubleshooting Date (Sample 2)

TEST OR PROCEDURE			INDICATION			INDICATION OBTAINED?	
LOCATION	ITEM	ACTION	LOCATION	INDICATOR	INDICATION	YES	NO
1. TRANSMITTER CHASSIS	A1J1	CONNECT O-SCOPE	O-SCOPE	SCOPE PUSHBUTTON LIGHT	LIGHTS	GO TO 2	REPLACE A1 IN ACCORDANCE WITH PARA 3-12
2. O-SCOPE	SCOPE PUSHBUTTON	PRESS AND RELEASE	O-SCOPE	CHANNEL B		GO TO 3	REPLACE A1 IN ACCORDANCE WITH PARA 3-12
3. TRANSMITTER CHASSIS	A2J1	CONNECT O-SCOPE	...	...		...	...
4. O-SCOPE	a. DISPLAY TRIG SOURCE SWITCH	DISPLAY A	...	...		...	...
	b. TIME/DIV SWITCH	10 USEC	O-SCOPE	CHANNEL A		GO TO 5	REPLACE A2 IN ACCORDANCE WITH PARA 3-13

Figure 7. Tabular Logic Tree (Sample 1)

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STEP	INSTRUCTION	INDICATION	YES	NO	REMARKS
WARNING					
In the following procedure, operation of the armament bay doors and missile launchers is a potential safety hazard to personnel in the vicinity of the aircraft. Adhere to all safety precautions in T.O. 1F-106A-2-12.					
1	[TM 27-2] ATS Check: Perform	[Master warning panel] MISFIRE: Goes off when TEST MISFIRE FWD and TEST MISFIRE AFT are set to down (off)	2	[054] [Launcher harness] [596] [Inter-valuator] [Misfire relay]	MISFIRE remains on after the fire signal if either a ground path is maintained to the misfire relay hold-in coil or +28 v is maintained to the misfire relay pull-
NOTE					
Perform steps 2 and 3 on suspected faulty rail only, or all rails for a complete system check.					
2	[054] Missile gone switch: Actuate to the up position for entire step [Missile simulator] MISSILE SIMULATE: GONE [27-2] ATS Check: Perform with S96 TEST MISFIRE switches in the down (off) position	[Master warning panel] MISFIRE: Blinks on momentarily when the fire signal is delivered	3	[054] [Launcher harness] -----	Missile gone switch circuit in launcher may be faulty
3	[054] Missile gone switch: Actuate to the up position for entire step [Missile simulator] MISSILE SIMULATE: PRESENT [TM 27-2] ATS Check: Perform	[Master warning panel] MISFIRE: Remains on after the fire signal is delivered [Armament bay] Doors: Remain open Launchers: Remain extended	▲	[054] [Launcher harness] -----	Checks the ability of the system to stop the armament sequence when a misfire condition is simulated

Figure 8. Tabular Logic Tree - Sample 2

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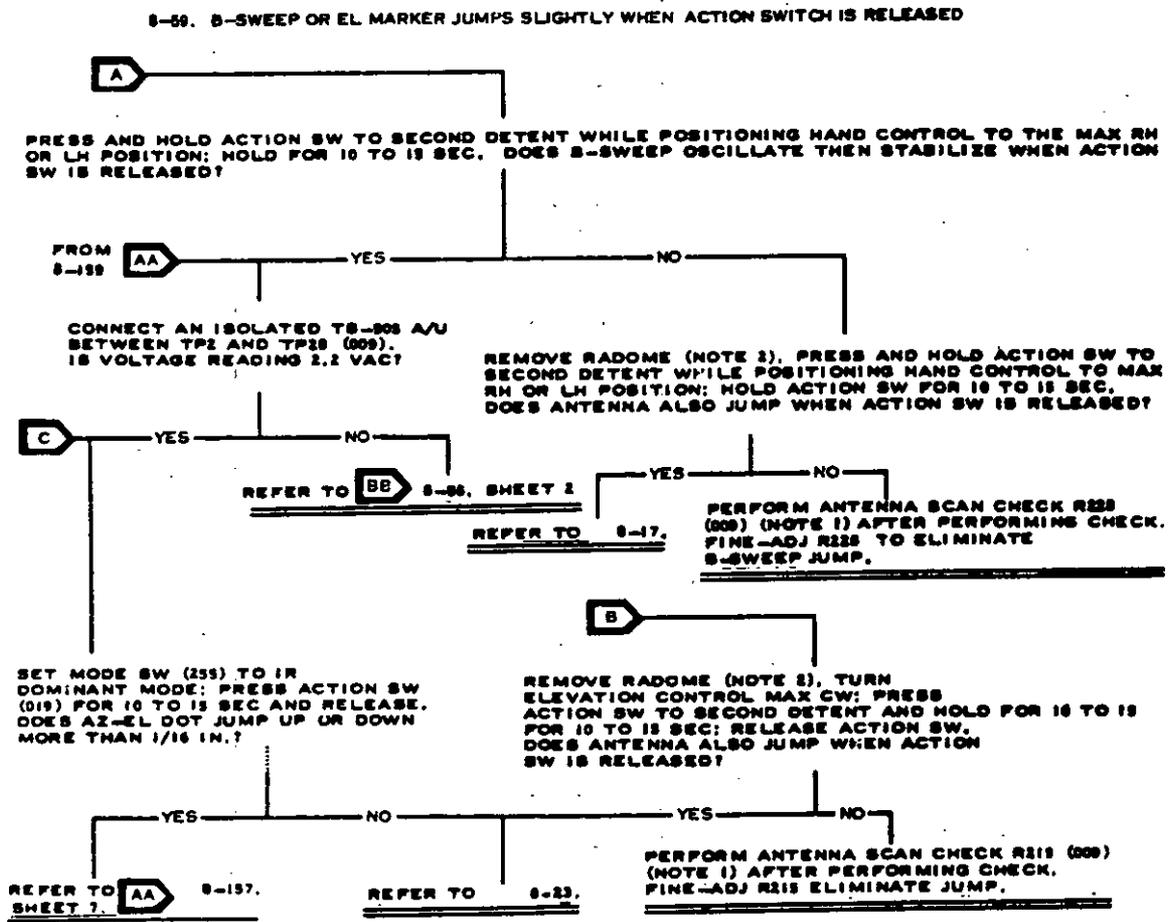


Figure 9. Branching Logic Tree

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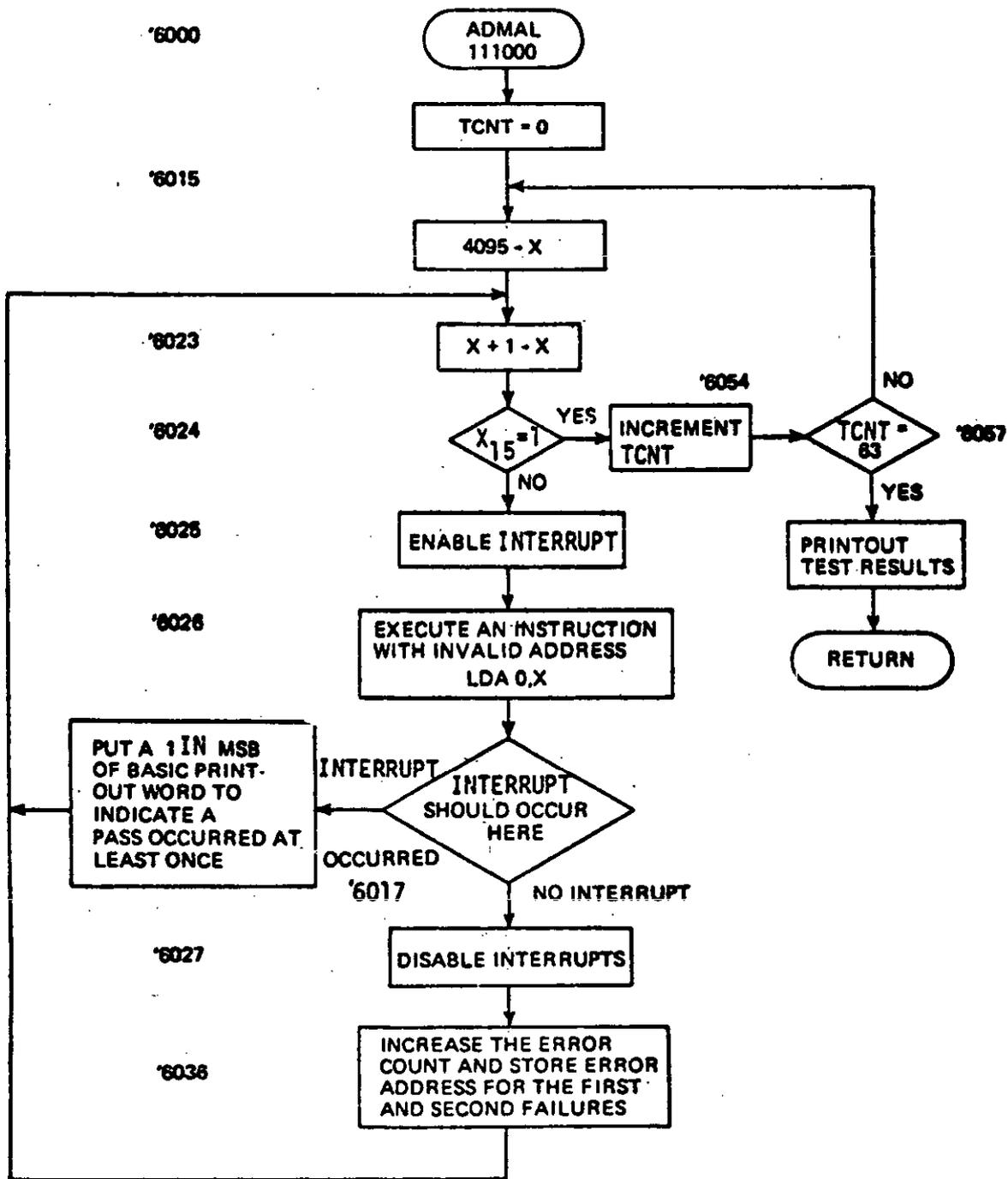


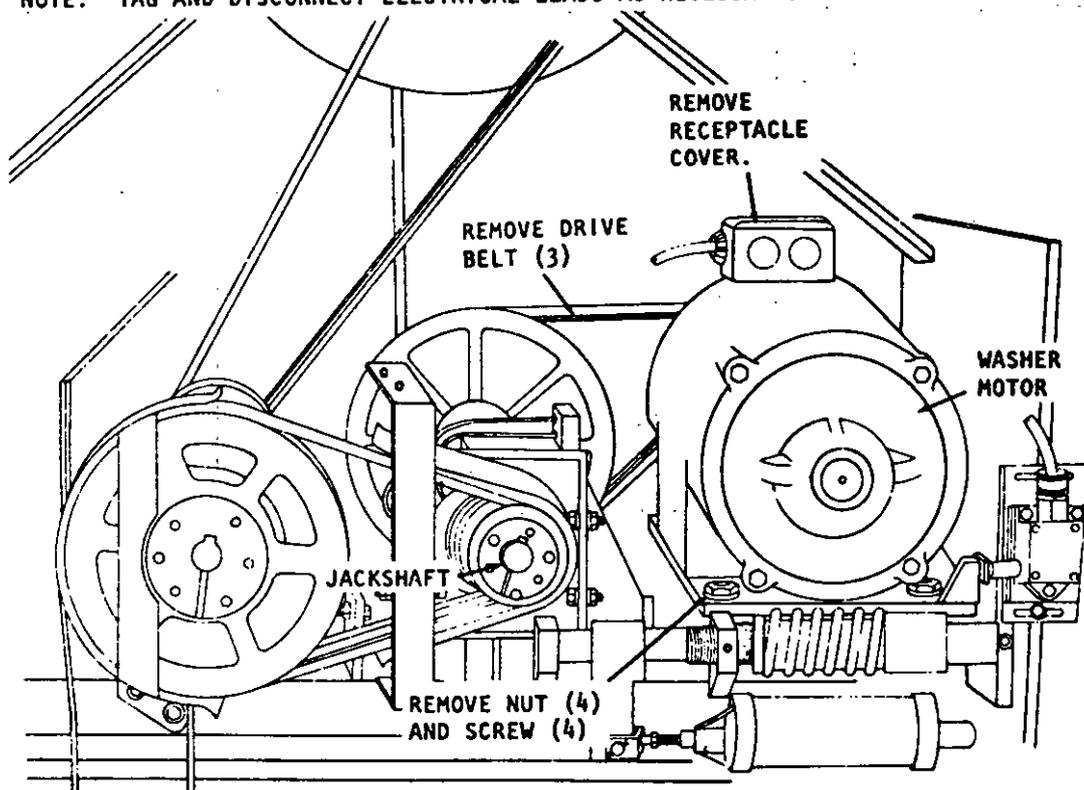
Figure 10. Branching Logic Tree (Computer Generated)

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
-------------	--------------------	-------------------

16. WATER PUMP FAILS TO ROTATE	Step 1. Check for a broken or cracked motor, damaged shaft threads, and bent shaft.	Replace motor, if defective. Remove the motor using illustrations and instructions listed in figures 4-11 and 4-12.
	Step 2. Check for a clogged impeller.	Clean the impeller.

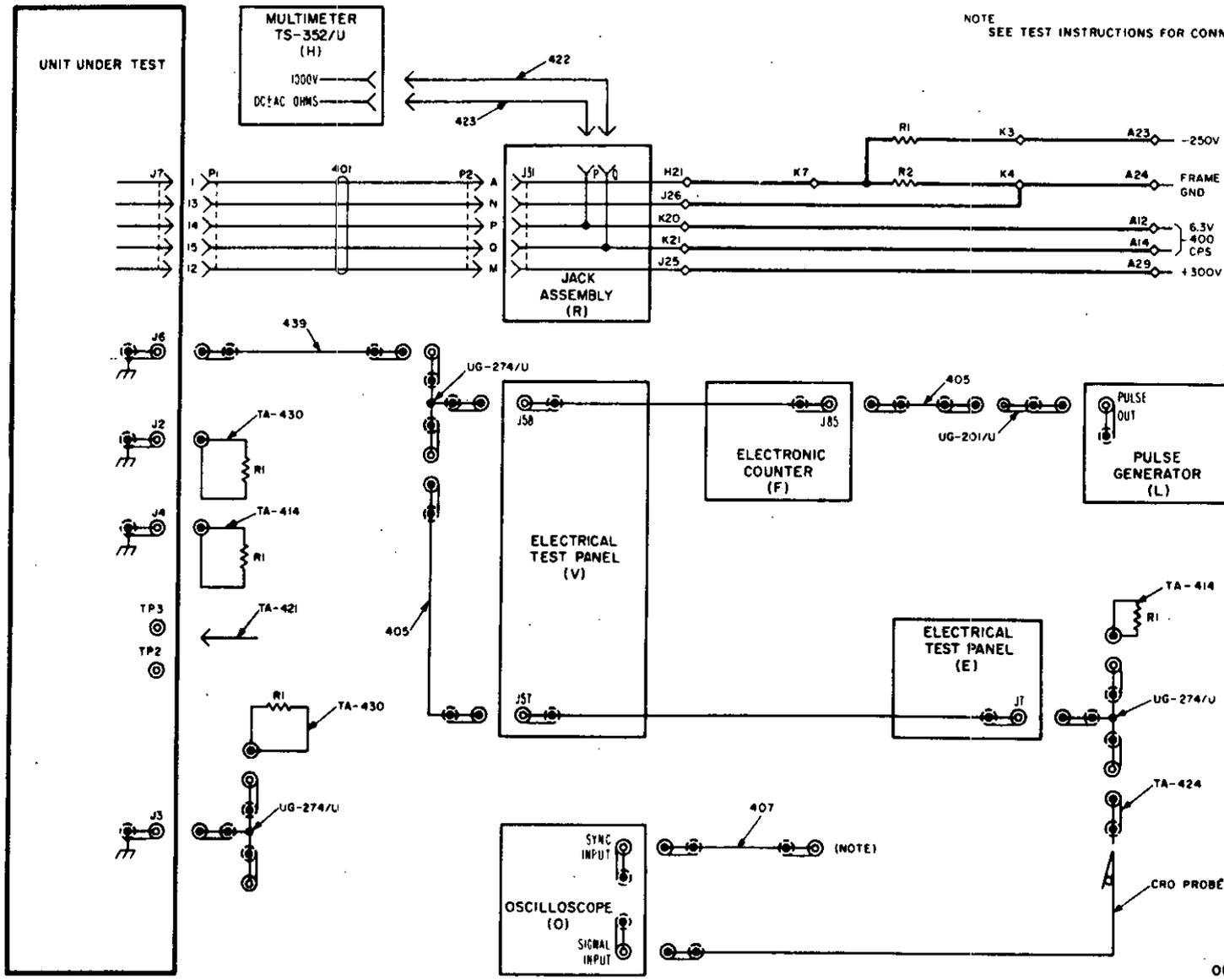
17. WASHER-EXTRACTOR BASKET WILL NOT ROTATE	Step 1. Check for locked brake assembly.	Correct pressure or replace possible defective air cylinder (fig. 4-9).
	Step 2. Check for a broken or cracked motor, damaged shaft threads, and bent shaft.	Refer to figure 4-13 (Eidal Model) and figure 4-14 (Edro Model) and replace motors.

NOTE: TAG AND DISCONNECT ELECTRICAL LEADS AS NECESSARY.



NOTE: FOR REMOVAL OF DRIVE BELTS ONLY, LOOSEN NUT (4) AND SLIDE WASHER MOTOR TOWARD JACKSHAFT. REMOVE OTHER DRIVE BELTS IN A SIMILAR MANNER.

Figure 11. Narrative Logic Tree



NOTE
SEE TEST INSTRUCTIONS FOR CONNECTIONS

Figure 12. Test Loop Diagram

Figure 39. Pulse generator (2 μ sec and 15 mc) 9140520—test layout diagram.

Figure 13. Fault-Isolation Diagram (Sample 1)

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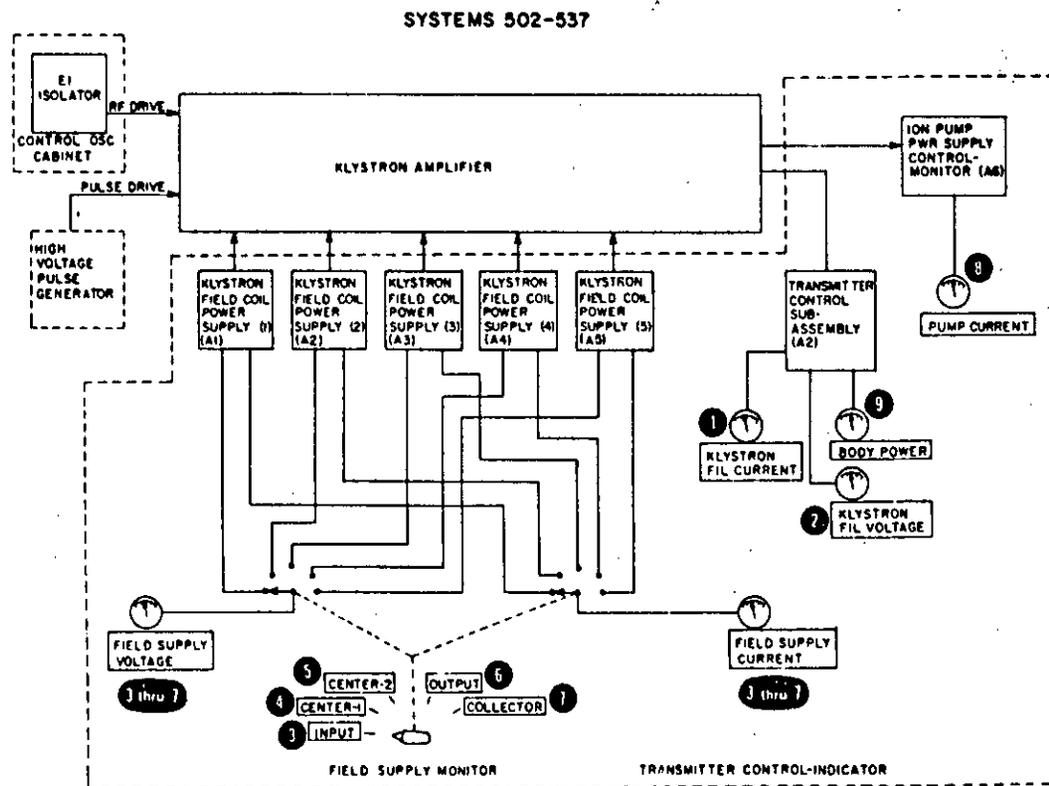


Figure 4. Key RF Amplifier Indicator (Sheet 2 of 2)

Preliminary: Energize the system through operate.

- 1 The KLYSTRON FIL CURRENT meter indicates between 3.7 and 3.9 amperes.
- 2 The KLYSTRON FIL VOLTAGE meter indicates between 85 and 115 volts.

Note. In steps 3 through 7 below, the voltage values are valid only if the field coils have been energized for 2 1/2 hours or more.

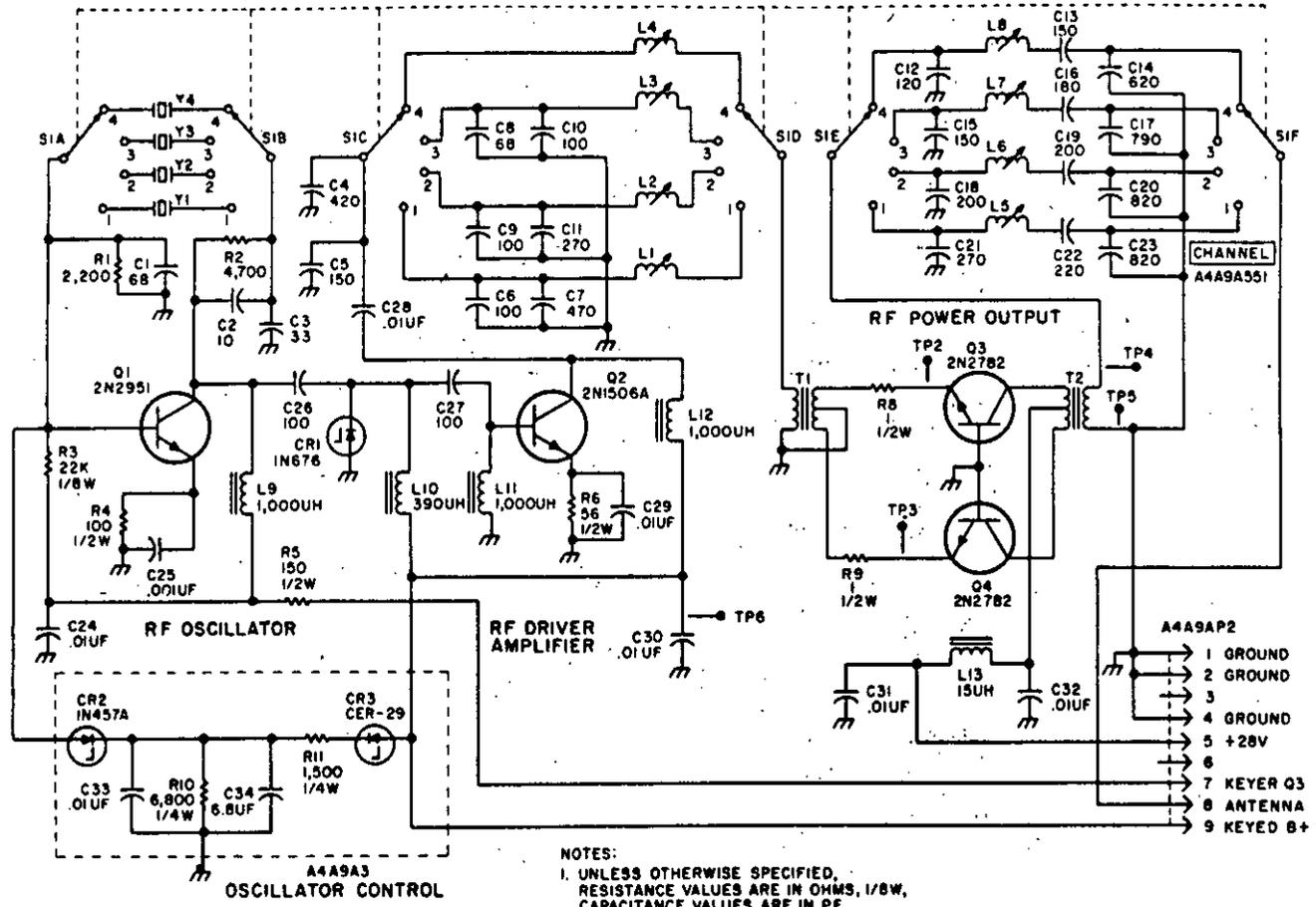
- 3 Set the FIELD SUPPLY MONITOR switch to INPUT. The FIELD SUPPLY VOLTAGE and FIELD SUPPLY CURRENT meter indications are equal to the recorded values.
- 4 Set the FIELD SUPPLY MONITOR switch to CENTER-1. The FIELD SUPPLY VOLTAGE and FIELD SUPPLY CURRENT meter indications are equal to the recorded values.
- 5 Set the FIELD SUPPLY MONITOR switch to CENTER-2. The FIELD SUPPLY VOLTAGE and FIELD SUPPLY CURRENT meter indications are equal to the recorded values.
- 6 Set the FIELD SUPPLY MONITOR switch to OUTPUT. The FIELD SUPPLY VOLTAGE and FIELD SUPPLY CURRENT meter indications are equal to the recorded values.
- 7 Set the FIELD SUPPLY MONITOR switch to COLLECTOR. The FIELD SUPPLY VOLTAGE and FIELD SUPPLY CURRENT meter indications are equal to the recorded values.
- 8 The PUMP CURRENT meter indicates less than 100 microamps.
- 9 The BODY POWER meter indicates not more than the peak value recorded for the klystron in use.

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Figure 14. Fault Isolation Diagram (Sample 2)



NOTES:
 1. UNLESS OTHERWISE SPECIFIED,
 RESISTANCE VALUES ARE IN OHMS, 1/8W,
 CAPACITANCE VALUES ARE IN PF,
 INDUCTANCE VALUES ARE IN UH.
 PRECEDE OSCILLATOR CONTROL CIRCUIT BOARD
 ASSEMBLY REFERENCE DESIGNATIONS WITH A4A9A3.
 PRECEDE ALL OTHER REFERENCE DESIGNATIONS WITH
 A4A9A2 UNLESS OTHERWISE SHOWN.

EL2BC001

CHANNEL
A4A9A551

- A4A9A2
- 1 GROUND
 - 2 GROUND
 - 3
 - 4 GROUND
 - 5 +28V
 - 6
 - 7 KEYS Q3
 - 8 ANTENNA
 - 9 KEYED B+

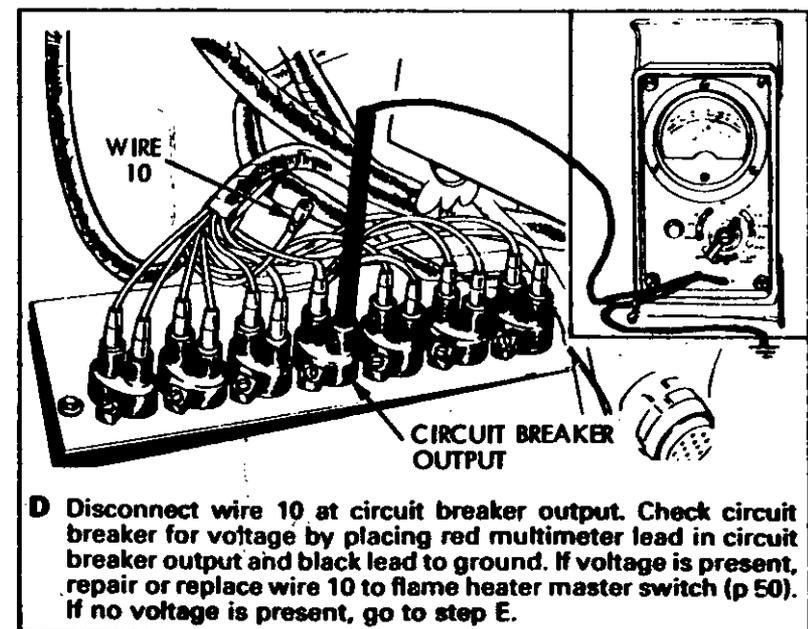
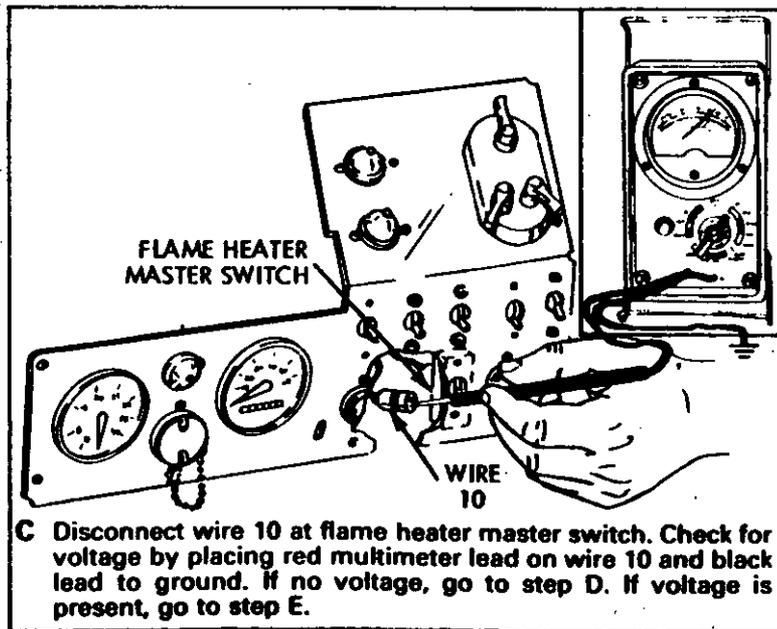
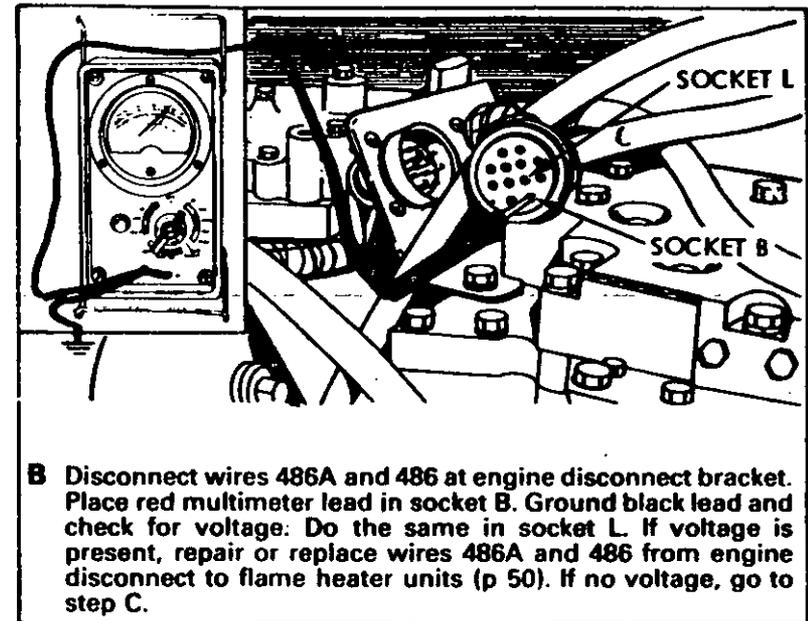
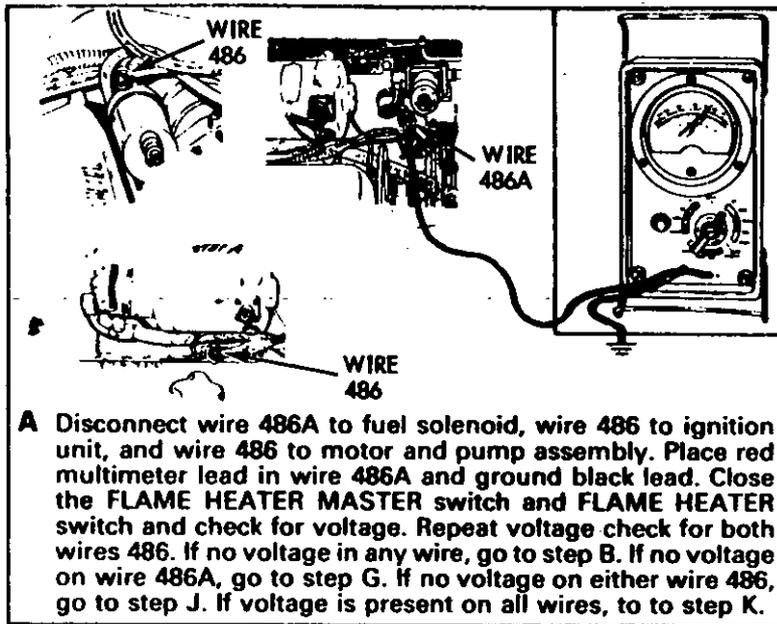


Figure 15. Illustrated Troubleshooting Table

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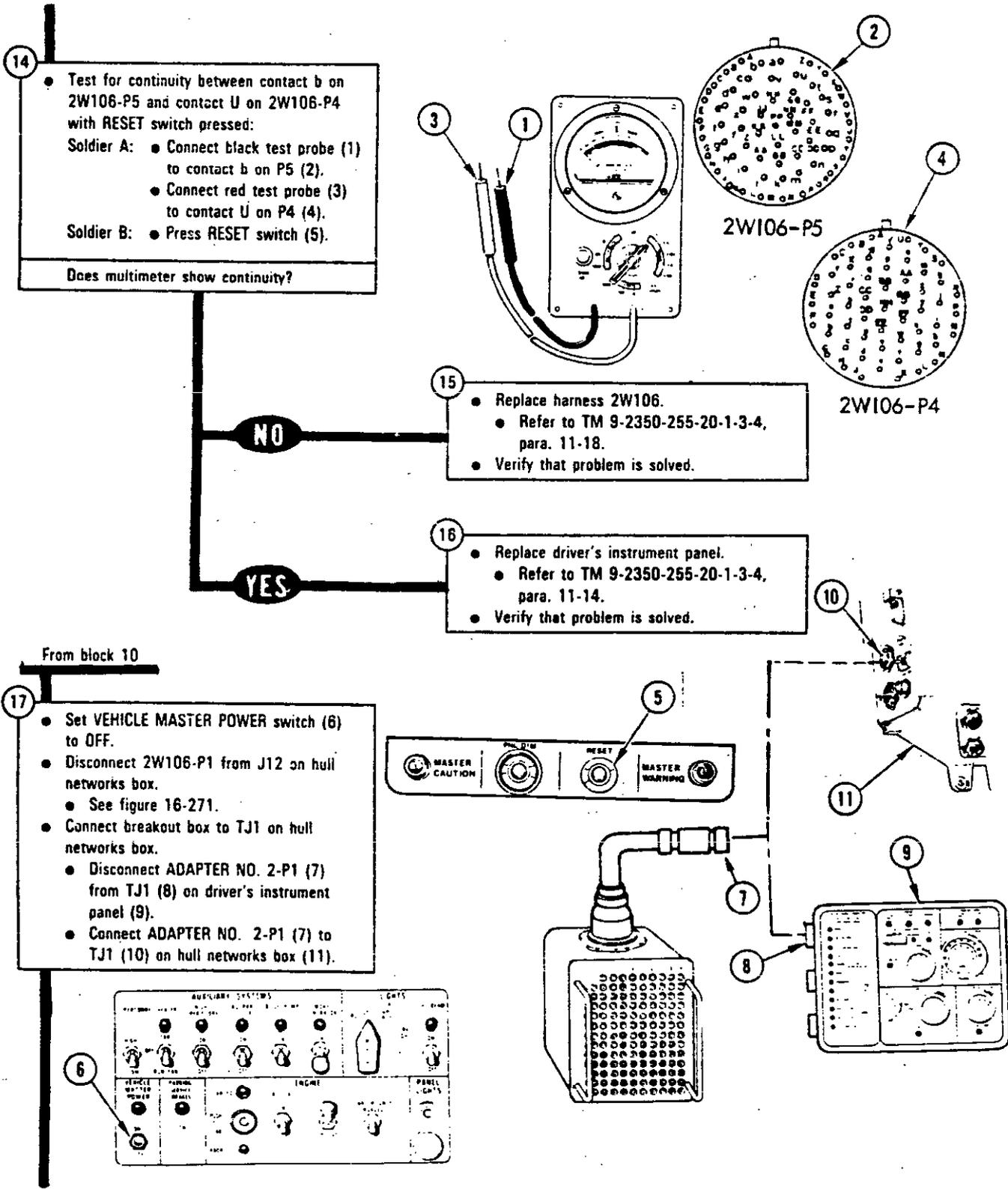


Figure 16. Branch Format for Troubleshooting

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TABLE 17-2.9. ELEVATION LEAD ANGLE - ROUTINE 9 (FIG. 17-2A)

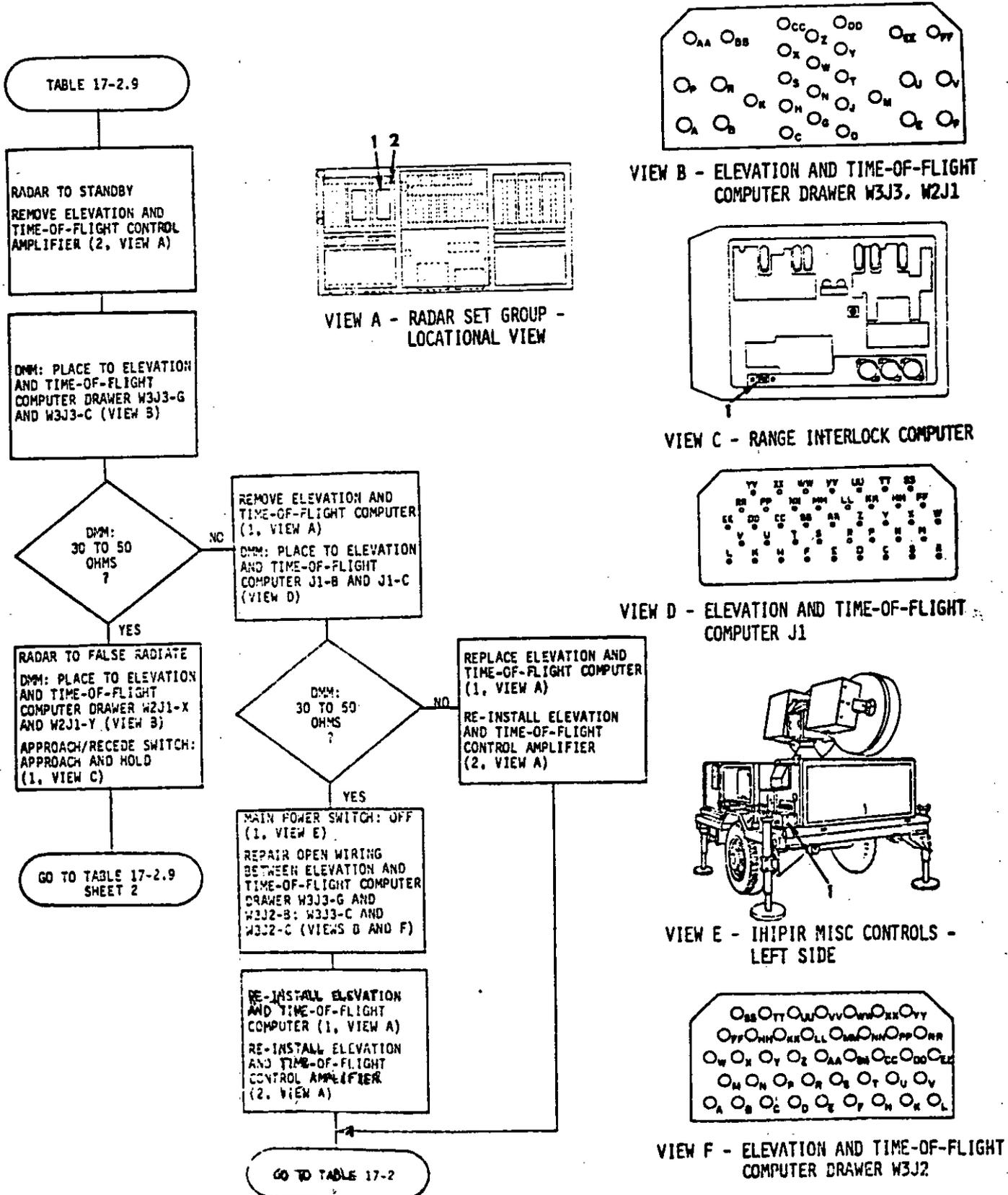


Figure 17. Branch and Flow-Fault Isolation Techniques

Section 9

MULTIPLE CONFIGURATION COVERAGE

	Page		Page
Overview	1	Objectives and Principles	1
Methods and Requirements	1	Requirements	1

OVERVIEW

Multiple configuration coverage concerns covering more than one configuration of a system, equipment, unit, assembly, or part in the same manual.

METHODS AND REQUIREMENTS

Objectives and Principles

Effective coverage of multiple configurations in a manual will have the following results:

- a. Showing the reader the *differences* between configurations in an easily understood manner.
- b. Reducing bulk required for separate coverage when configuration *differences* are small.
- c. Easy use without confusion concerning applicability of material to any given configuration.
- d. Material arranged so that all information doesn't have to be completely read to determine instructions for individual models.

Requirements

More than one configuration of a system equipment, unit, assembly, or part may be covered in the same manual when the applicability of information to each configuration can be clearly shown and usability of the manual is not impaired. Care must be taken to ensure that information concerning each configuration remains clearly distinct from information that applies to other configurations.

The primary consideration in *multiple configuration coverage* is ease of use of information. The following guidelines should be followed:

- a. Show differences in configuration throughout the basic publication at the point where the differences occur.
- b. Use difference data sheets (where differences are summarized separately) only as a last resort under the following conditions:

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- (1) Many configurations exist.
 - (2) Differences are minor or localized in a few parts of the manual. (Difference data sheets are difficult to use because of the cross-referencing involved and are not suitable to cover multiple changes scattered throughout a manual.)
 - (3) Any one user will encounter only a few of the many configurations.
 - (4) Each difference data sheet for each configuration is self-contained and does not require concurrent use of another sheet.
- c. Cite models or types to show configuration differences wherever possible rather than part numbers or serial numbers. Use part numbers if the differences exist in the same model or type of equipment. Use serial numbers only where the differences cannot be clearly stated otherwise.

Examples:

Serial No. 1 thru 41:

Remove 3 bushings and 3 screws.

Serial No. 42 and up:

Remove 3 plastic-coated screws.

- d. Explain in the introduction or foreword that the manual applies to all configurations of the equipment and differences between configurations will be indicated where necessary throughout the manual. Explain which models may be treated as a single configuration.
- e. Where clarity will be improved, establish a short, easily remembered abbreviation or symbol for each configuration covered. Explain the method used in the introduction or foreword.

Examples of Configuration Symbols

Model	Configuration Reference
Liquid Cooler LC-908	8
Liquid Cooler LC-909	9
or	
Portable Shelter SV-17A	A
Portable Shelter SV-17B	B

Section 10

MULTIPLE EXPERIENCE LEVEL COVERAGE

	Page		Page
Overview	1	Objectives and Principles	1
Methods and Requirements	1	Requirements	1

OVERVIEW

The detail to which operating and maintenance procedures are described should match the experience level of the user. This is important because high-experience users may fail to read critical information while skimming to avoid reading familiar details. Conversely, low-experience users will seek other sources when the information in the manual fails to explain at the step-by-step level of detail they require. The manual may be prepared to satisfy the needs of all experience levels likely to be using it. This may be done by selectively highlighting information.

The Procedure sections of this handbook should be referred to for additional information.

METHODS AND REQUIREMENTS

Objectives and Principles

Any manual developed for multiple experience level users should meet the following basic criteria:

- a. High level of detail for novice.
- b. Critical information for experienced operator or technician.
- c. Information easy to use by the above experience levels.

Requirements

Highlighting important information enables the experienced user to utilize that information more quickly and easily. For example, highlighting allows the user to scan a procedure quickly and pick out the information needed without reading the entire procedure. The following techniques are ways to highlight information.

underlining
italics

boldface type
indenting

special symbols
upper case letters

NOTE

Underlining is the least expensive and easiest method to produce and is recommended for most highlighting situations.

Section 11

HOW-TO-USE-THIS-MANUAL INFORMATION

	Page		Page
Overview	1	Requirements	1
Methods and Requirements	1	Usage statement	1
Objectives and Principles	1	Manual overview	1

OVERVIEW

How-to-Use-this-Manual Information describes the manual content, format, features, use, and value to its user.

METHODS AND REQUIREMENTS

Objectives and Principles

The manual should contain information which:

- a. Tells the user what he or she must know to use the manual effectively and to operate or maintain the equipment effectively.
- b. Explains any unusual aspects of the manual.
- c. Gives practice using the manual to solve real problems.
- d. Gets the user actively involved with the manual.

Requirements

How-to-use information is generally contained in a separate section at the beginning of a manual. For very complex manuals, it may be preferable to have this information at the beginning of each major division.

The how-to-use information includes:

- *Usage Statement:*

"You must familiarize yourself with the entire maintenance procedures before beginning the maintenance task."

- *Manual Overview*

- (1) Provides a general description of entire manual.
- (2) Clearly and concisely explains important features of the manual contents and

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organization, stressing any unusual or unique features.

- (3) Describes any special or unusual features; this description to include short, interesting, "real-life" examples that make use of the feature(s) and enable the user to practice using it while reading the example.
- (4) May include practice problems, where the inclusion of such problems combined with (3) above more effectively covers the unique features of the manual.

PROBLEM

As a maintenance technician, you are responsible for maintaining and repairing equipment. During training they told you the surest and quickest way to fix your truck was by using your manual, so you grab your manual.

1. How do you start?

Turn to the cover of your manual.

On the right side you will find a listing for "TROUBLESHOOTING Symptom Index." It tells you to go to page 3-105. (To find that section quickly, open the manual by using the black tab on the side of the manual that lines up with the "TROUBLESHOOTING SYMPTOM INDEX" listing.)

2. What kind of problems do you have?

Open your manual to page 3-105.

In the "Symptom Index" find the listing for the equipment category, "ENGINE SYSTEM." There you find your symptom, which is "Engine cranks but doesn't start." Next to the symptom is the page number of the troubleshooting procedure that will help you solve your problem. This procedure is on page 3-122.

3. How do you determine what is causing your problem?

Turn to page 3-122.

You find there the troubleshooting procedure you need. The procedure has columns with headings: "Step," "Action," "Indication," "Remarks." Starting at step 1, read the procedure horizontally across the page. Each step tells you what to do ("Action" column) and what to look for ("Indication" column) at that time. The "Remarks" column has answers or explanations to some of the the questions you may have in your mind as you are following the instructions. Let's assume when you check the air filter (step 6) you discover the filter element is clogged. To replace the filter element, step 6 tells you to go to the maintenance procedure on page 3-142.

4. How do you fix it?

Turn to page 3-142.

This is the maintenance procedure for replacing the air filter element. This procedure is arranged the same way as the troubleshooting procedure. Start at step 1, read horizontally across, and perform the action in each step. When you have finished the last step, you will have replaced the air filter element. Now you are ready to go.

Figure How-to-use-this-manual practice problem

Section 12

JOB/SKILL ENHANCEMENT MATERIALS

	Page		Page
Overview	1	Methods and Requirements (cont)	
Methods and Requirements	1	Requirements (cont)	
Objectives and Principles	1	Overviews (Complicated Tasks)	2
Requirements	1	Procedures	2

OVERVIEW

Job/skill enhancement materials increase the user's understanding of the job and the equipment. The procedures in a manual cannot possibly cover all situations the manual user may encounter, therefore, this additional understanding will motivate and help the user to become more effective in a larger variety of situations. Job/skill enhancement materials include:

- a. Overviews For job/skill reinforcement of complicated tasks or information
- b. Procedures For job/skill upgrading beyond present job

METHODS AND REQUIREMENTS

Objectives and Principles

Job/skill enhancement materials should have the following characteristics:

- a. Introduced subtly so as not to interfere with using the manual to perform regular job.
- b. Presented so as to motivate the technician to use it to do a better job.
- c. Included so as not to disturb the experienced operator in using the manual.
- d. Packaged so as to add minimum bulk to the manual.
- e. Formatted so as to easily determine whether information is for the novice or experienced user.

Requirements

Overviews (Complicated tasks). Job/skill reinforcement should be provided only for complicated tasks or information which can't be easily learned after a few times of use. The skill reinforcement should be in the form of overviews located before the complex task or

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information. Where the material to be reinforced is lengthy, the overview information should be interspersed throughout the material. Overview information should not have paragraph numbers.

Overviews present the material that will be covered and prepare the reader to use it. A very brief outline format, as in the example below, should be used to improve readability, thus encouraging use of the material.

Overview of Ammunition Chapter

This chapter has some very important information that you need to know about the organizational maintenance requirements of ammunition for the TOW system. This information includes:

- a. Identification of TOW encased missiles.
- b. Normal care of the encased missiles.
- c. Visual inspection of the encased missiles.
- d. Missile color coding data.
- e. Shipment and handling data.

Procedures. The best time for the technician to improve his or her understanding of the workings of the equipment is while carrying out the procedures in the manual. Skill upgrading materials should be included in procedures to:

- Provide the user with an opportunity to understand the job better.
- Motivate the user to do a better job - - most people have a natural desire to learn and progress.
- Enable the user to gain general technical knowledge which can be transferred to a similar job or other equipment.
- Enable the user to progress beyond the "robot" level in cases where fully proceduralized maintenance information is used to do the job.

Skill upgrading materials shall be used only in cases where obvious skill upgrading benefits will accrue - - not as filler material with every trivial procedure or step. Skill upgrading materials are particularly useful for procedures which are unusual or unique.

- a. *Purpose.* This shall be a brief statement of what the task will accomplish.
- b. *General technical principles.* This shall be a brief functional description, written in general terms, giving task related technical principles. Such data increases user knowledge of the type equipment being repaired and enables transfer of this information to similar equipment. An illustration or functional diagram may be included if it will aid in the explanation.
- c. *Task description.* This shall be a brief description of how the general technical principles relate to the specific task to be accomplished. This also gives the technician an overview of the procedure by explaining the purpose of each major group of steps that form the procedure. An illustration or functional diagram may be included if it will aid in the explanation of the task.

Section 13

WARNINGS/CAUTIONS/NOTES

	Page		Page
Overview	1	Methods and Requirements (cont)	
Definitions	1	Placement Requirements	4
Methods and Requirements	2	Format Requirements	5
Objectives and Principles	2	Pictorial Symbology	
General Content Requirements	2	Requirements	6
Radiation and Laser		Warning Matrix	7
Warnings	3		
Warning Topics for			
Aircraft Manuals	3		

OVERVIEW

WARNINGS, CAUTIONS, and NOTES are means of attracting attention to essential or critical information in a manual. The types of information included under each are outlined below.

Definitions

WARNING

Conditions, practices, or procedures which must be observed to avoid:

- a. Personal injury
- b. Loss of life

CAUTION

Conditions, practices, or procedures which must be observed to avoid:

- a. Damage to equipment
- b. Destruction of equipment
- c. Long-term health hazard

NOTE

Essential information of special:

- a. Importance
- b. Interest
- c. Aid in job performance which - -

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- (1) Should be remembered
- (2) Will facilitate decision
- (3) Would otherwise be difficult to find
- (4) Would otherwise be difficult to incorporate

METHODS AND REQUIREMENTS

Objectives and Principles

The technical manual user's attention must be attracted to practices, procedures, and conditions which could lead to injury or equipment damage. In addition to safety considerations, the manual should highlight essential information of special interest or importance which will aid in, or simplify job performance. Critical safety information or information to be highlighted should:

- a. Be located with the material to which it applies.
- b. Stand out on a page full of other material.
- c. Attract the user's eye, but not be overpowering.
- d. Be apparent to the user no matter what method is used to access information and enter the manual.
- e. Contain all necessary information.
- f. Be easy to read and understand.

General Content Requirements

The text of WARNINGS and CAUTIONS should contain the following information, ordinarily in the order indicated:

- a. The specific nature of the hazard
- b. The steps to be taken to avoid or minimize the hazard
- c. The location or source of the hazard
- d. The consequences of failing to heed the warning or caution
- e. Corrective or first-aid actions to be taken if the hazard materializes
- f. Time considerations, when critical

The information should be presented in a few simple words, in a straightforward, non-exaggerated manner. It should be self-contained; to obtain the above information, the user must not be referred elsewhere. However, when the location of a hazard, its consequences,

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and remedial actions are clearly implied by the type of hazard, or have appeared elsewhere on the same page, such information may be omitted.

NOTES do not have special content requirements because these depend upon the material being presented. NOTES simplify the user's task by highlighting the information that must be remembered, thus making it unnecessary to search for it.

Radiation and Laser Warnings

Nuclear and electromagnetic radiation and laser warning notices similar to those shown in MIL-M-38784 shall be prepared as reproducible illustrations for printing on the page facing the inside front cover. The radiation and laser symbols shown shall be used. Active chemical elements present in the equipment shall be listed by chemical symbol (e.g., Co 60, Sr 90), immediately below the radiation symbol. Reference shall be made to the location of the hazard and to paragraphs where the pertinent safe handling notice instructions are given. When applicable, electromagnetic warning shall be placed immediately below the nuclear radiation warning notice. If applicable, the procuring activity will provide the contractor with the first aid and disposal instructions extracted from TB 43-0116 and AR 755-15.

- ***Nuclear radiation warnings.*** Nuclear warning notices shall be placed at the beginning of any instruction covering procedures that will expose personnel to a nuclear radiation hazard. In addition, the tabulated data shall include a list of radioactive parts or components and the type and quantity of radioactive material. When radioactive parts or components are shown on a parts location diagram, each component shall be marked with an asterisk and suitable warning notice shall be included on the diagram. Procedures to be followed in the event of breakage of radioactive parts or components shall also be included.
- ***Electromagnetic radiation warnings.*** When the equipment being covered radiates electromagnetic waves in frequencies from 100 megahertz to 100,000 megahertz with power densities above 10 milliwatts per square centimeter, the procuring activity will furnish the contractor with a warning notice in compliance with AR 40-583. Warnings specifying the radiating element and indicating that portion of the surrounding area in which radiation with average power densities above 10mw/cm² will exist shall be included.

Warning topics for Aircraft Manuals.

For aircraft manuals, the following warning topics shall be covered, as applicable, along with other topics pertinent to subject aircraft.

- a. Starting aircraft.
- b. Operation of aircraft on the ground. (Refer to AR 95-13.)
- c. Grounding aircraft.
- d. High voltage.
- e. Use of fire extinguishers in confined areas (e.g., bromochloromethane, monobromotrifluoromethane).
- f. Armament.

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- g. Ejection seats.
- h. Carbon monoxide.
- i. Toxic fumes or fuels, solvents, etc.
- j. Handling fuel.
- k. Acids or electrolyte (handling, mixing, diluting, etc.).
- l. Dangers of jet blast and rotor blades.
- m. Noise level warning.

Placement Requirements

To be effective all warnings, cautions, and notes should be placed at the point where they apply. For example, placing the warning, caution, or note just before the procedural step to which it applies is the most logical action. Also, with most items of equipment there are general warnings or cautions that apply to several procedures for that item. In this case, it is desirable to put all these general warnings and cautions inside the front cover or on a warning page at the front of the manual and then reference them where they apply.

The following rules should be observed:

- a. WARNINGS and CAUTIONS should precede and appear on the same page as the text or procedural steps to which they apply.
- b. NOTES may precede or follow applicable text depending on the material to be highlighted.
- c. A NOTE should always precede a procedural step to which it applies.
- d. WARNINGS, CAUTIONS, and NOTES should not contain procedural steps.
- e. When a WARNING, CAUTION, or NOTE consists of two or more paragraphs, the heading WARNING, CAUTION, NOTE should not be repeated above each paragraph.
- f. If it is ever necessary to precede a paragraph by both a WARNING and a NOTE, or a CAUTION and a NOTE, etc., they should appear in the sequence noted, namely, WARNINGS, CAUTIONS, NOTES.
- g. When several WARNINGS, CAUTIONS, or NOTES appear together, the heading should appear only once. They may be separately identified by the use of "bullets" (•).
- h. General WARNINGS and CAUTIONS should be placed on the inside front cover or a WARNING page at the front of the manual.

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Format Requirements

The format for WARNINGS, CAUTIONS, and NOTES is intended to:

- a. Attract the user's attention
- b. Visibly differentiate it from any other text
- c. Enable critical information to be obtained quickly

Two general format conditions can exist: where the material appears alone on a single page and where the material appears within the context of other text.

The appropriate headings: (WARNING, CAUTION, or NOTE) should appear above the information in bold capital letters or capital letters.

Color may be used as an attention-getting device when authorized:

When only WARNINGS and CAUTIONS appear together on a page they should be ordered from the most to the least critical. The general heading and symbol indicative of the most critical item in the series should be used at the top and no others are needed.

When one type of danger may come from several sources or may require more than one remedial action, the danger may be referred to once in bold type to the left of the page and the various alternatives listed in outline form below it. Each alternative should be suitably separated by space to make it a distinctively different entity from other alternatives. See following example:

WARNING

CAUSTIC CHEMICALS IN NICAD BATTERIES

- Use rubber gloves, goggles and apron to avoid severe burns.
- If chemicals get on your skin, clothes, or equipment, wash immediately with water.
- If chemicals get in your eyes, wash them with plenty of water and get medical help immediately.

When space permits, the type size may be larger than normal to make the material easier to read. The following illustrations show how format and typography may be used to emphasize critical information when WARNINGS are separated from the text.

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When WARNINGS and CAUTIONS are to be used within the context of other text, they should be indented approximately five spaces from both margins and centered between the left and right margins preceding the text to which they apply. These extra margins will highlight warnings and cautions as visibly distinct from the remainder of the text.

Paragraph format need not be used. The information should be listed to make it easier to read and remember; sentences need not be complete, providing the meaning is clear.

Pictorial Symbology Requirements

Any one set of the following may be used.

- | | | | |
|----|------|---|---|
| a. | NOTE |  |  |
| b. | NOTE | <u>CAUTION</u> | <u>WARNING</u> |
| c. | NOTE | <u>CAUTION</u> |  |

To draw attention to the WARNINGS, CAUTIONS, and NOTES certain symbols may be employed to identify specific situations *when authorized*.

- | | | |
|--------------------|---|---|
| Radiation hazard |  |  |
| Laser light hazard |  |  |

The following specific WARNING symbols are optional:

- | | | |
|-----------------------------|---|---|
| Electrical hazard |  |  |
| Gas and respiratory hazards |  |  |
| Heat |  |  |

For CAUTIONS, the following general symbol is optional:



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Name		Aircraft	Weapons	Missiles	Electronic Communications	Vehicles & Vehicle Equipment	Construction Equipment	Power Generating Equipment
Machinery in Operation	Moving Belts, Cables, Gears, Linkages, etc.	.	.	.	.	.	.	.
	Pressure Line Whiplash	.	.	.	.	.	.	.
	Traversing Part	.	.	.	.	.	.	.
	Refueling during Operation	.	.	.	.	.	.	.
	Moving Propellor, Fan, Turbine, Rotor	.	.	.	.	.	.	.
	Engine Kick	.	.	.	.	.	.	.
Physical	Moving Vehicle	.	.	.	.	.	.	.
	Surface Grade	.	.	.	.	.	.	.
	Equipment Rolling	.	.	.	.	.	.	.
	Slippery Ground	.	.	.	.	.	.	.
	Low Head Clearance	.	.	.	.	.	.	.
	Slippery Equipment Surface	.	.	.	.	.	.	.
Gas/Vapor	Sharp/Protruding Edges	.	.	.	.	.	.	.
	Carbon Monoxide	.	.	.	.	.	.	.
	High Pressure	.	.	.	.	.	.	.
	Poisonous	.	.	.	.	.	.	.
	Explosive	.	.	.	.	.	.	.
	Low Temperature	.	.	.	.	.	.	.
Firing Mechanisms	High Temperature	.	.	.	.	.	.	.
	Oxygen	.	.	.	.	.	.	.
	Water in Barrel	.	.	.	.	.	.	.
	Obstruction in Barrel	.	.	.	.	.	.	.
	Safety Off	.	.	.	.	.	.	.
	Loaded	.	.	.	.	.	.	.
Radiation	Pointed at Personnel/Equipment	.	.	.	.	.	.	.
	Nuclear	.	.	.	.	.	.	.
	Electromagnetic	.	.	.	.	.	.	.
	Laser	.	.	.	.	.	.	.
Ammunition	High Intensity Light	.	.	.	.	.	.	.
	Handling	.	.	.	.	.	.	.
	Disposal	.	.	.	.	.	.	.
	Hangfire/Misfire	.	.	.	.	.	.	.
Liquids	Cook-off	.	.	.	.	.	.	.
	High Pressure	.	.	.	.	.	.	.
	High Temperature	.	.	.	.	.	.	.
Vertigo	Low Temperature	.	.	.	.	.	.	.
	Ejection Seats	.	.	.	.	.	.	.
Chemicals	Corrosive/Caustic	.	.	.	.	.	.	.
	Poisonous	.	.	.	.	.	.	.
	Explosive	.	.	.	.	.	.	.
Tension	Torsion Bar	.	.	.	.	.	.	.
	Spring	.	.	.	.	.	.	.
	Cable	.	.	.	.	.	.	.
Blas/Noise	Hearing Damage	.	.	.	.	.	.	.
	Jet Blast	.	.	.	.	.	.	.
	Back Blast	.	.	.	.	.	.	.
Explosives	Handling	.	.	.	.	.	.	.
	Disposal	.	.	.	.	.	.	.
Temperature	Low	.	.	.	.	.	.	.
	High	.	.	.	.	.	.	.
Weight/Mass	Heavy/Bulky	.	.	.	.	.	.	.
	Overloaded	.	.	.	.	.	.	.
	Center of Gravity	.	.	.	.	.	.	.
Electrical	High Voltage	.	.	.	.	.	.	.
	Grounding	.	.	.	.	.	.	.
Radar/Radio Altimeter over Ice or Snow		.	.	.	.	.	.	.
Flammable Material		.	.	.	.	.	.	.
Fire Extinguisher Type	
Protective Covers in Place	

Warning Applicability Matrix

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Section 14

MEASUREMENTS AND TOLERANCES

	Page		Page
Overview	1	Objectives and Principles	1
Methods and Requirements	1	Requirements	1

OVERVIEW

This section concerns the representation of numerical values and tolerances in technical manuals. Considerations include:

- | | |
|-----------------------------------|---|
| a. Units | e. Units of measurement, time, and quantity |
| b. Numerical values or tolerances | f. Decimal numbers |
| c. Torque | g. Numerical ranges |
| d. Temperature values | h. Waveform data |

METHODS AND REQUIREMENTS

Objectives and Principles

Measurement and tolerance data in a technical manual should meet the following criteria:

- Numerical values expressed in easily understood, unambiguous manner.
- All waveform illustrations reflect actual oscilloscope display with all data required for equipment setup.
- Tolerance values given in terms of normal use or wear limits rather than original manufacturer's values (if these values differ).
- Measurements and tolerances must be expressed in values that can be measured with equipment authorized at the maintenance level(s) covered by the manual.

Requirements

- Use the same units as written on the equipment.

If no units are written on the equipment, use U S units first, followed by metric values in parentheses.

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2. For numerical data, all values of measurement should have tolerances given in the form of a range of values. Thus: 128 (125 to 129), where 128 is the desired value; or 125 to 129, where there is no desired value.

All numerical values should be given to the number of decimal places readable on the instruments provided. Tolerances should have the same number of decimal places as the desired value. For example: +12.00 V (+11.05 to +12.15 V).

Generally, all checks or adjustments require the statement of tolerances. Express the tolerance in the style that agrees with the use to be made of the information:

USE	STYLE	EXAMPLES
Checking	Upper and Lower tolerance limits	between 25 and 31 vdc 12-15 psia
Adjusting	Optimum value, and upper (+) and lower (-) values	28 (25 to 29) vdc 0.10 (0.09 to 0.11) in.

3. For torque measurement, use values that conform to the calibration of the tool being used (e.g., FT LB, POUND INCHES, etc). The value term for each tool must be used consistently throughout the manual. The metric equivalent measurement should appear in parentheses following U.S. Customary (e.g., 20 foot pounds (27 N·m)). When metric wrenches are primarily used, the U.S. Customary equivalent should follow in parentheses. Where possible, state specific torque required, rather than a range. For clarity, a note similar to the following should appear in the manual introduction:

Torque wrenches are normally marked with a measurement term (FT LB, POUND INCHES, etc.). The term(s) used within this manual are (insert term(s)) unless otherwise noted in the text.

4. For temperature values, show temperatures in the same scale used on the equipment. If degrees Fahrenheit is used, give degrees Celsius parenthetically. For example: 194°F (90°C).

Where necessary for clarity, include a parenthetic reading in the other (C or F) temperature scale. If a less familiar scale (such as Kelvin or Rankine) is used, clarify it in this same manner.

70°F (21.1°C) 50°C (122°F)
 . . .
 459.6° Rankine (32°F) or 459.6° R (32°F)

5. Usually express units of measurement, time, and quantity in numerals regardless of magnitude.

EXAMPLES:

Age: 6 years old; of 41 years' duration

Time: 0025 hours; 15 April 1960; 25 hours later

Decimals: 0.25 inch; 1.25 inches

Degrees: 35 degrees of elevation, 5°C (41°F)

...

Measurements: 1-1/2 miles (1½ miles if typeset), 2500 feet, 1 ohm, 0.5 ampere

...

Money: \$3.65, \$0,65

...

Unit modifiers: 5-day week, 5-percent increase, 1-ohm resistor

6. Use a zero before the decimal point for any decimal number less than one; treat such a number as singular grammatically.

EXAMPLES

0,15 inch, 0,9547 centimeter, but 1,0001 inches

7. To indicate a range of numbers occurring in condensed data, use a hyphen between the limit numbers. (The hyphen then means "thru.") If ambiguity is possible, spell out "thru."

EXAMPLES.

1-4 feet, pages 264-381, the 1950-1960 period.

8. To show waveform data, use a photograph or line drawing of the waveform taken from the oscilloscope measurement. Make sure all the equipment conditions necessary to obtain the waveform are clearly stated.

Section 15

ILLUSTRATION DEVELOPMENT

	Page		Page
Overview	1	Board Art (cont)	
Methods and Requirements	1	Art Work Standards	2
Objectives and Principles	1	Paste-Up	10
Requirements	1	Camera-Ready Copy	18
Board Art	2	Introduction	18
Introduction	2	Preparing Camera-Ready Pages	19

OVERVIEW

Illustration development is an extremely broad subject which includes many topics. This section deals only with the general aspects of illustration development in technical manuals.

Illustration topics covered separately in their own sections are:

- a. Color
- b. Locator Illustrations
- c. Schematic and Functional Diagrams
- d. Wiring Interconnection Data

METHODS AND REQUIREMENTS

Objectives and Principles

Style and techniques should be of a quality which will produce illustrations that clearly, adequately, and economically portray the information to be illustrated. Illustrative material should be used to:

- a. Describe an item or idea when this can be done more efficiently and effectively by graphic methods.
- b. Clarify text.
- c. Supplement information which is difficult to describe by text alone.
- d. Call attention to details.
- e. Furnish graphic identification of parts and special tools for critical applications.

Requirements

The following general instructions apply to illustrations

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- a. In each case, use the minimum number of illustrations essential.
- b. Integrate text and illustrations into modules of information. Whenever possible, keep text and illustrations together so they are visible simultaneously. (For more detail, see Text Associated with Illustrations.)
- c. Minimize use of full-page illustrations that must be placed horizontally on a page particularly if associated text appears on the facing page. If a figure number is required, place it in the same viewing position as the art.
- d. Subordinate or delete extraneous or unnecessary details which may be a source of confusion. Highlight the item of interest. Some techniques for clarity are:
 - (1) Presenting effective angle of view.
 - (2) Using varying line weights.
 - (3) Avoiding excessive shading.
- e. Engineering drawings may be used for schematics, wiring diagrams, component layout diagrams, aircraft station diagrams, cabling diagrams, and other similar purposes when authorized by the procuring activity. Such drawings must meet the reproducibility requirements and provide information in a clear, easily used format. Border, title blocks, manufacturer's notes, and irrelevant material should be removed in most cases.
- f. Ensure that lettering on illustrations is not reduced to the point where it cannot be easily read.

BOARD ART

Introduction

When preparing board art to accompany manuscript copy, the illustrator prepares mounts and crops the illustrations. Illustration cutlines are indicated by the writer on the manuscript and the printer decides where each illustration appears on the page.

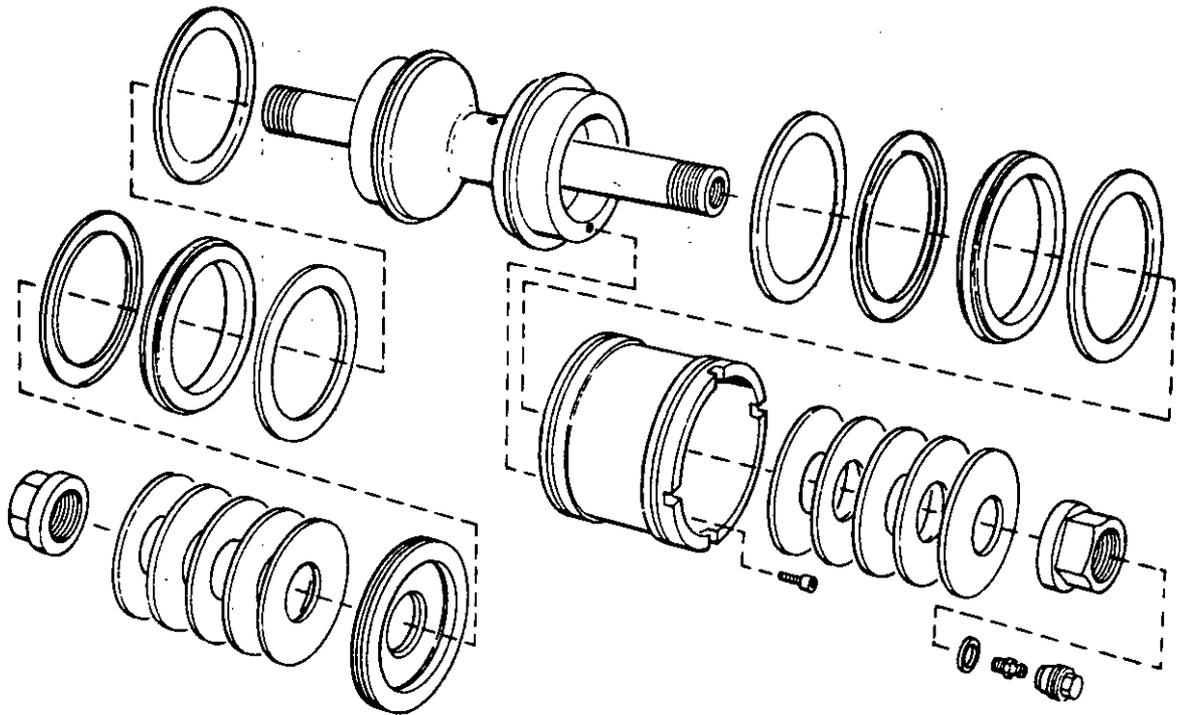
The next two sections will demonstrate the quality of illustration required and tell you how to crop and size artwork for the printer.

Artwork standards

This section is divided into two areas: Line Drawings and Exploded Views. Both categories have production requirements unique to themselves. In all areas, the appearance of the reproduced illustration in the TM determines the quality requirements of the board art.

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Line Drawings



The above inking illustrates the quality of line drawing required. It has been reduced by one third.

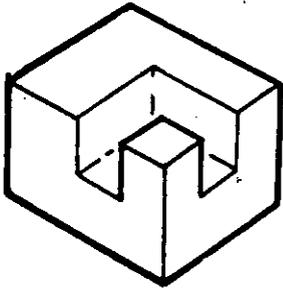
Pencil is not acceptable for line drawings. You can use pencil on drafting film (which looks like ink when copied) only if you furnish a sharp stat or a photo copy of the drawing. Any broken lines must then be relined with ink.

On the above inking, notice that the screw threads are spaced further apart than normal. If you ink threads as close as they really are, the ink will run together when the drawing is reduced.

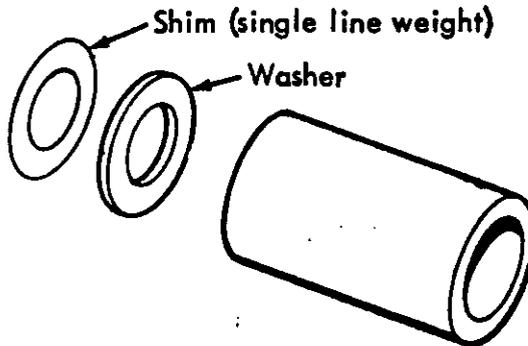
MIL-HDBK-63038-1A (TM)

Line Weights

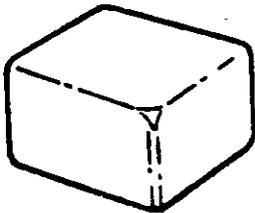
The following line weight standards demonstrate an acceptable publications method of drawing. Drawings are done in perspective with thick and thin line weight. Normally, original size line weights will approximate 00 pen for highlight and a No. 2 pen for heavy line.



An object will have a heavy outline and a thin highlight line.



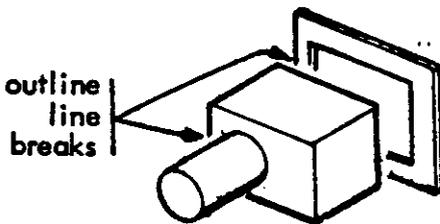
A cylinder will have an extra heavy shadow line on the bottom. Holes will have a shadow line on top.



A rounded edge will be shown with a broken line or lines same weight as the highlight line.



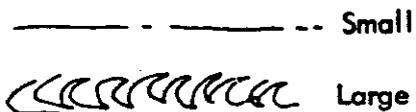
Knurling will be a straight cross hatch.



When a form is in front of another form, it should be outlined. This isn't mandatory, but it does help clarify the illustration.

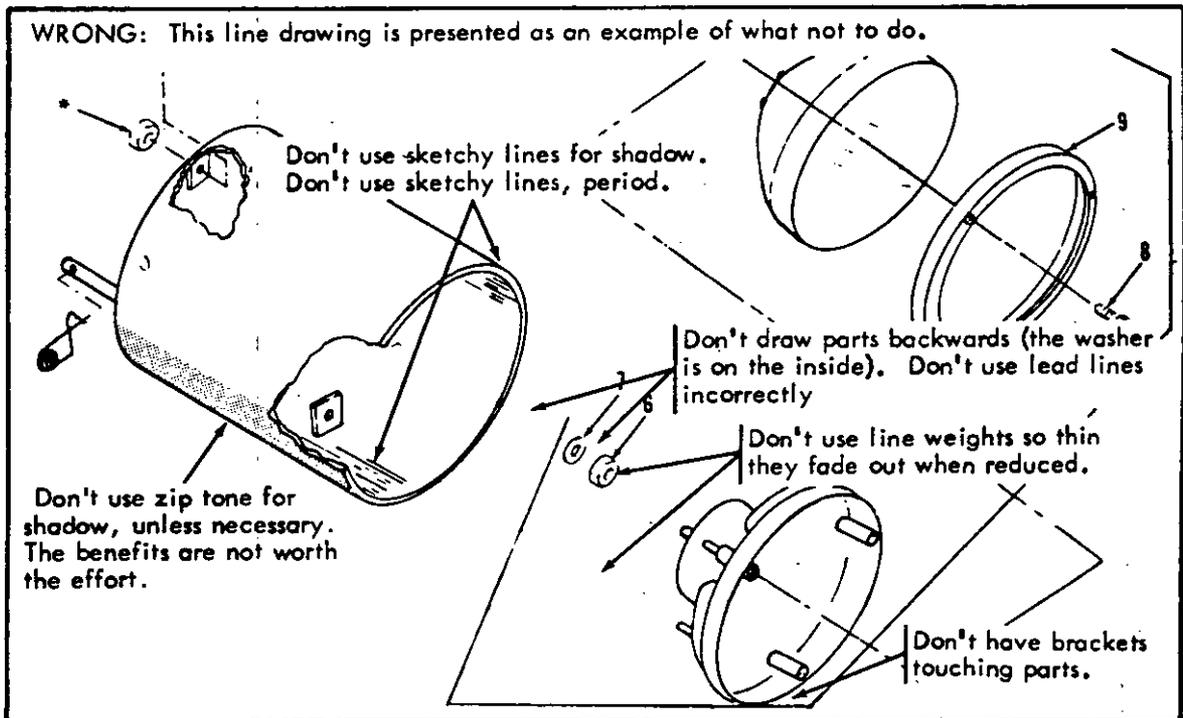
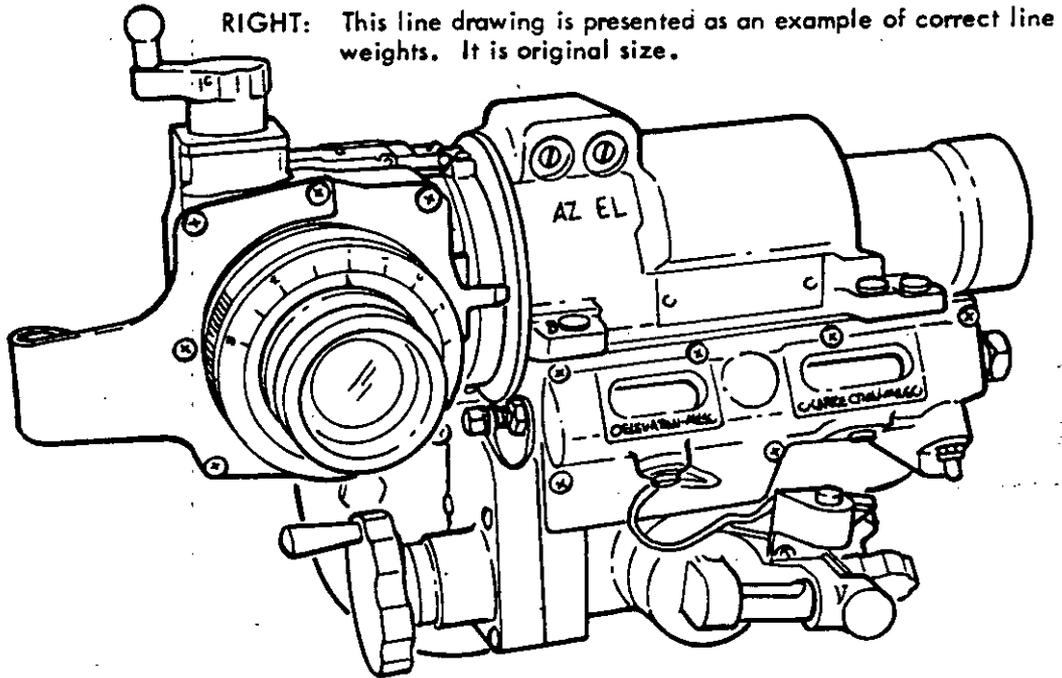


For shadow purposes, the light source is considered to be the upper left.



Welding presentation will vary according to the size of drawing.

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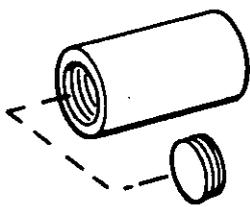
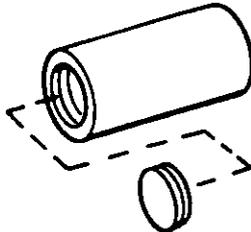
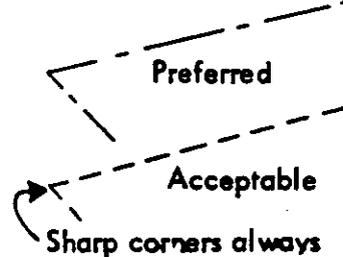


Exploded Views

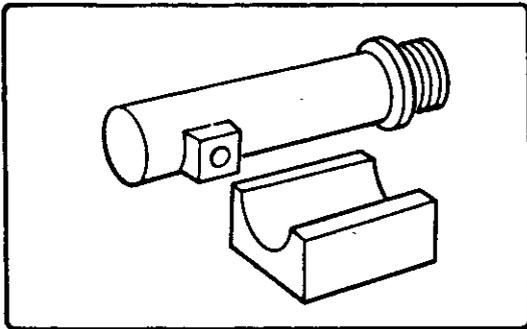
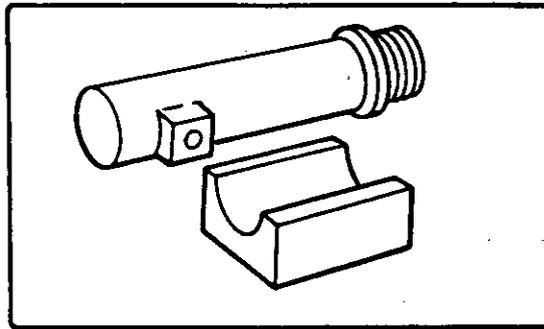
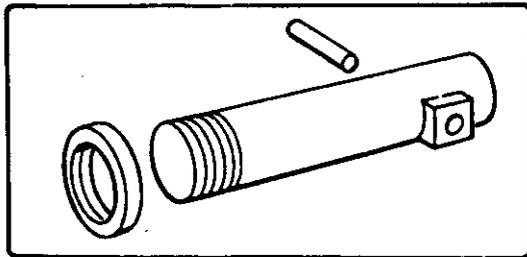
Exploded view line drawings are used for both parts manuals and maintenance manuals. There are a few requirements unique to exploded views which will be covered below.

MIL-HDBK-63038-1A (TM)**Lead Lines**

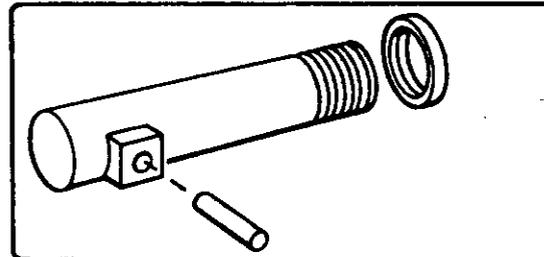
Use lead lines to make clear to the user how the item was disassembled, and how it goes back together. Lead lines aren't required when it's obvious where the exploded part belongs, but the drawing must be clear to the user. Use lead lines correctly:

**WRONG****RIGHT****LEAD LINE STYLES:****Viewing Angle**

If a major item is being disassembled with a series of exploded views, the project leader should insure that all (or as many as possible) of the illustrations are shown from the same angle:

**Figure 1. Right Rear View****Figure 1. Right Rear View****Figure 2. Left Front View**

WRONG: Viewing angle has been reversed from figure 1.

**Figure 2. Right Rear View**

RIGHT: Viewing angle is the same in both figure 1 and figure 2.

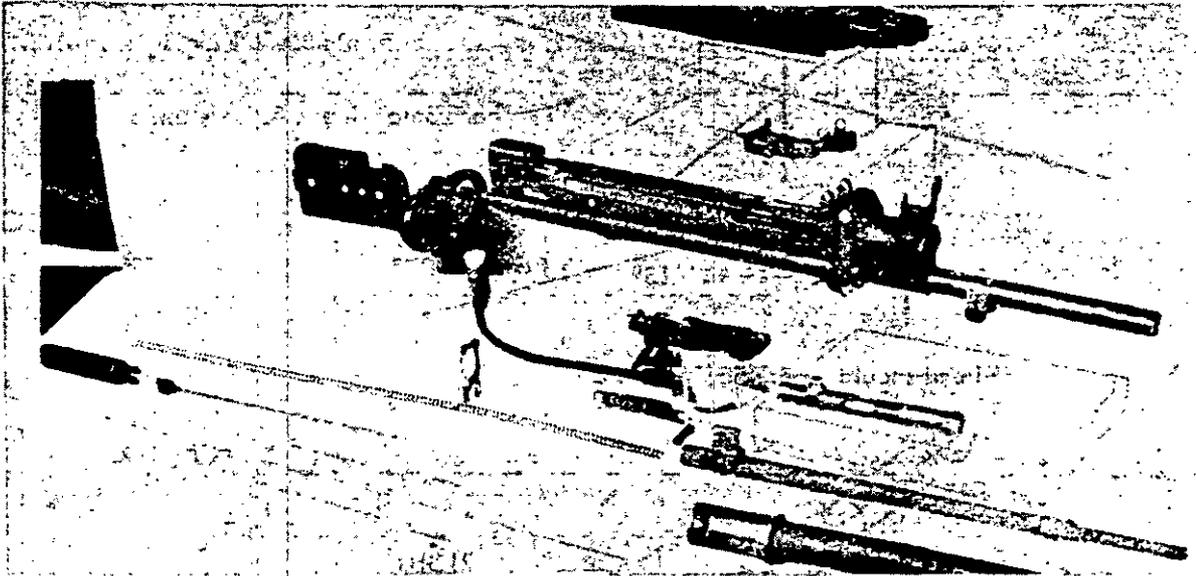
Exploded views, often shown in perspective, are drawn either from photographic setups or from blue prints. Perspective comes naturally when tracing a photo, but must be drawn in, if desired, when working from blue prints.

Photographic Set-ups

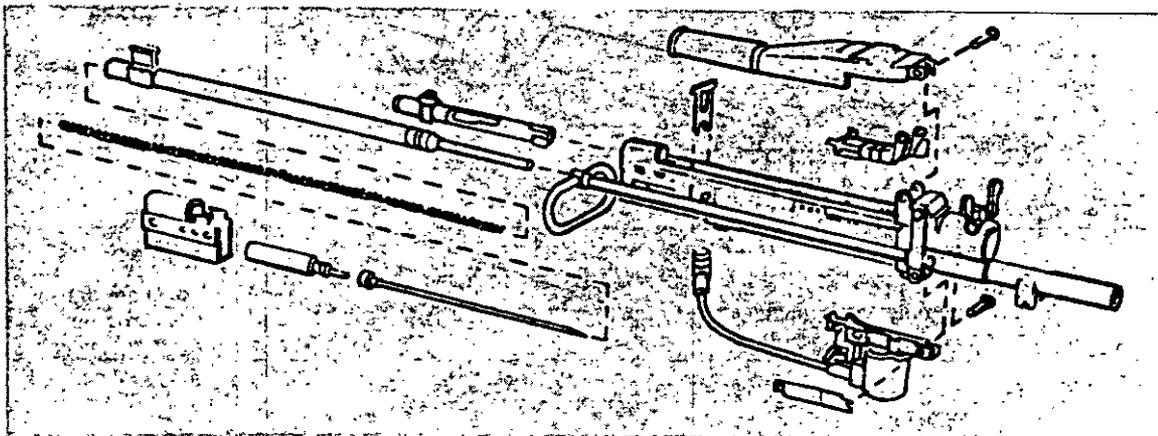
The illustrator should try to be present during weapon tear down and photo taking. When assisting the photographer in making exploded view set-ups, always remember the requirement to use the same viewing angle.

Since all exploded views are done as line drawings, it is not necessary to lay out the parts in exactly the right order. Keep the angle correct and rearrange when making the pencil layout. See below:

Photographic set-up with parts approximately located



Pencil line drawing with parts correctly located

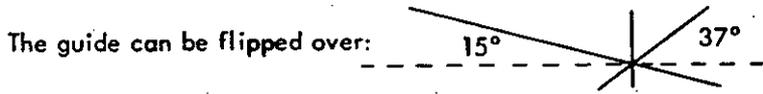
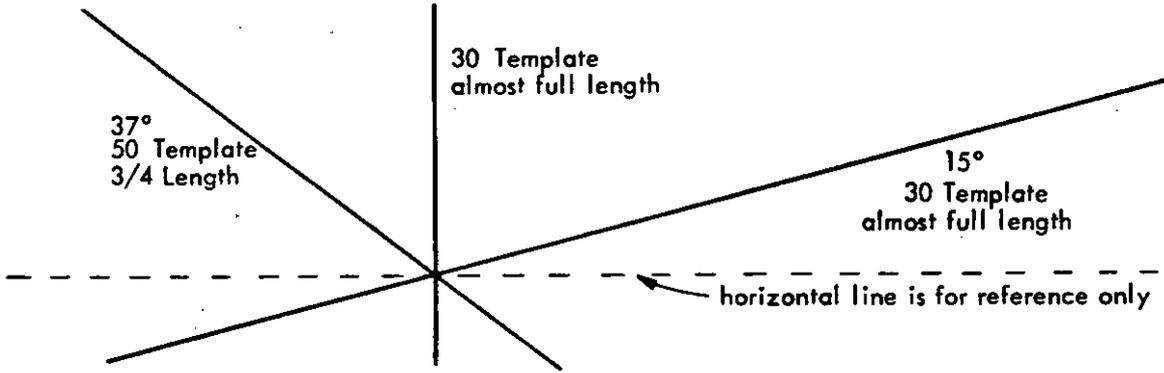


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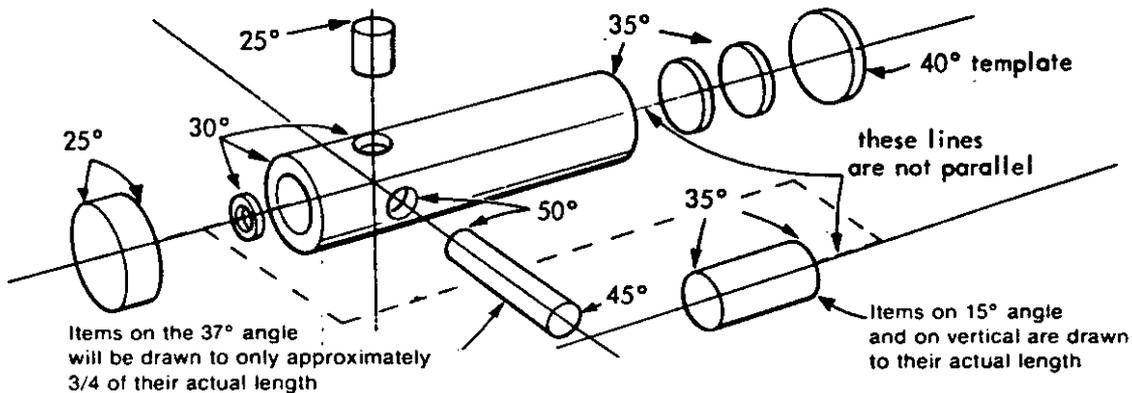
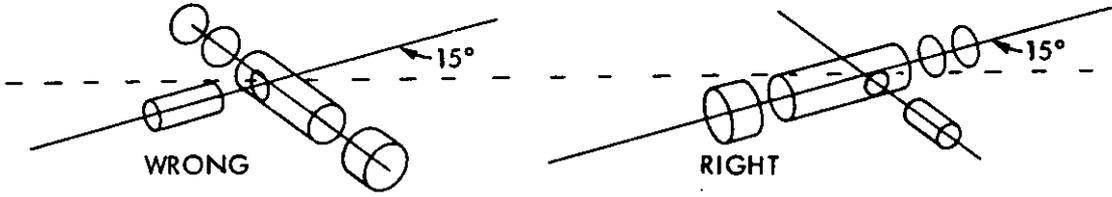
Drawing From Blue Prints

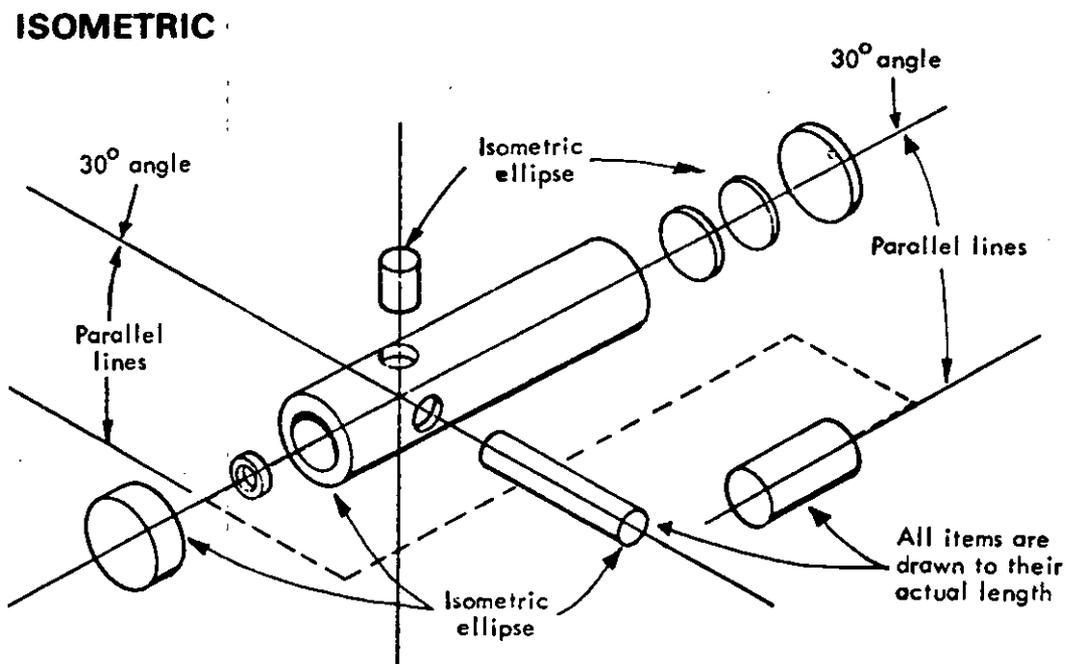
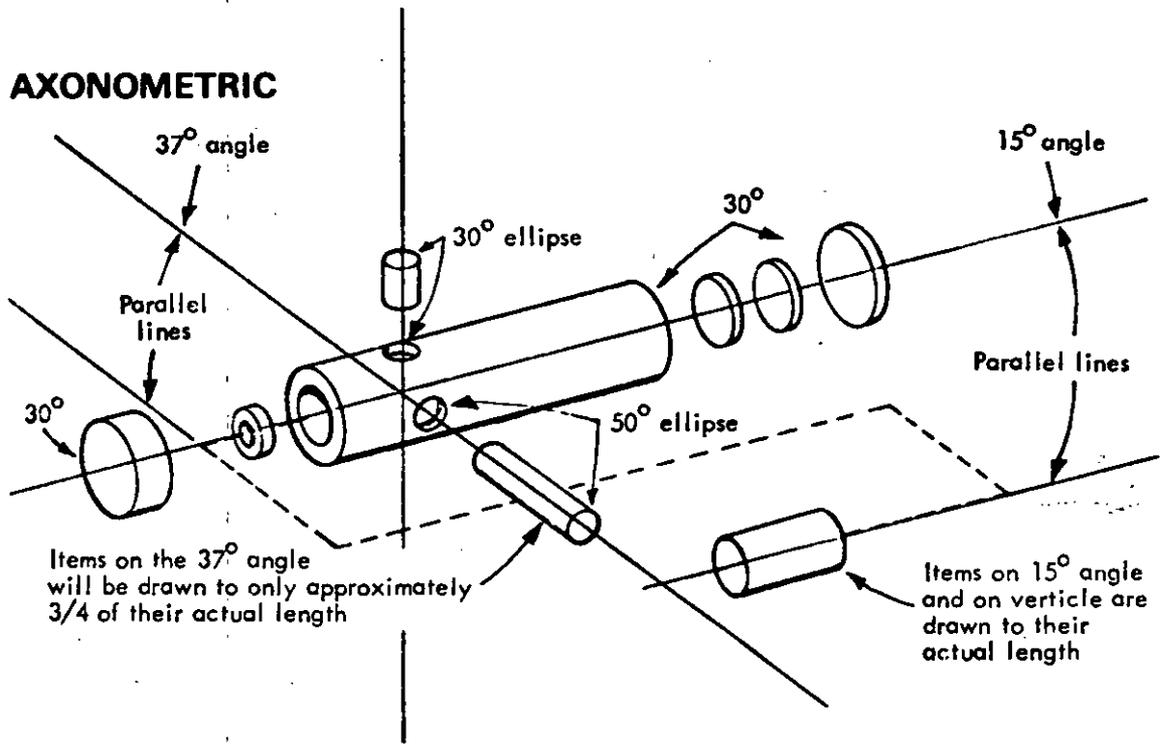
To achieve some degree of uniformity in exploded view illustrations done from blue prints, three layout guides are provided below and on the next page.

PERSPECTIVE



The major line of items should be on the 15° angle:





MIL-HDBK-63038-1A (TM)*Pasteup*

Technical illustrations may require pasteup work. This consists of placing callout numbers or nomenclature on the illustration, indicating the reproduction size with crop marks, and covering the art board with tissue and flap.

Mounting

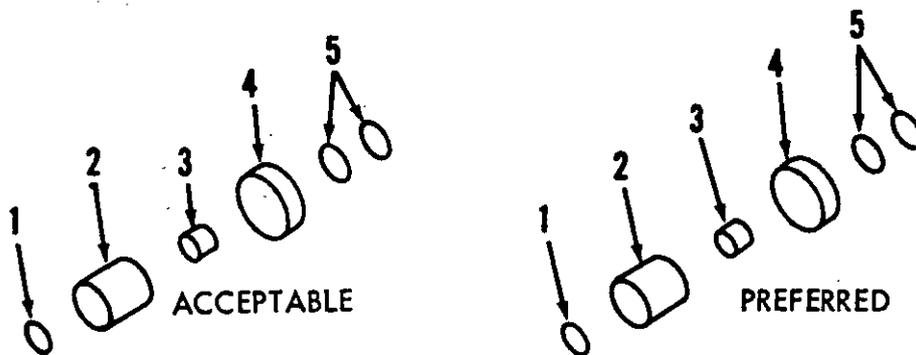
All artwork must be mounted. Three suggested standard board sizes are: 9 x 13 in., 12x16 in., and 14x 18 in. There is no requirement to use these sizes. However, you should not use more than three or four different board sizes on any one job (unless foldout pages are involved). Mounting board must be at least 14-ply. When mounting an illustration, allow at least 1-1/2 in. margin for crop marks.

Illustrations should be either dry mounted or rubber cemented. Dry mounting is preferable and is mandatory for retouchings. There is a demountable mounting tissue available which is excellent. There is one exception to this rule: if an inking is done on flat, unwrinkled paper, it may be taped to the mounting board.

Pasteup Standards

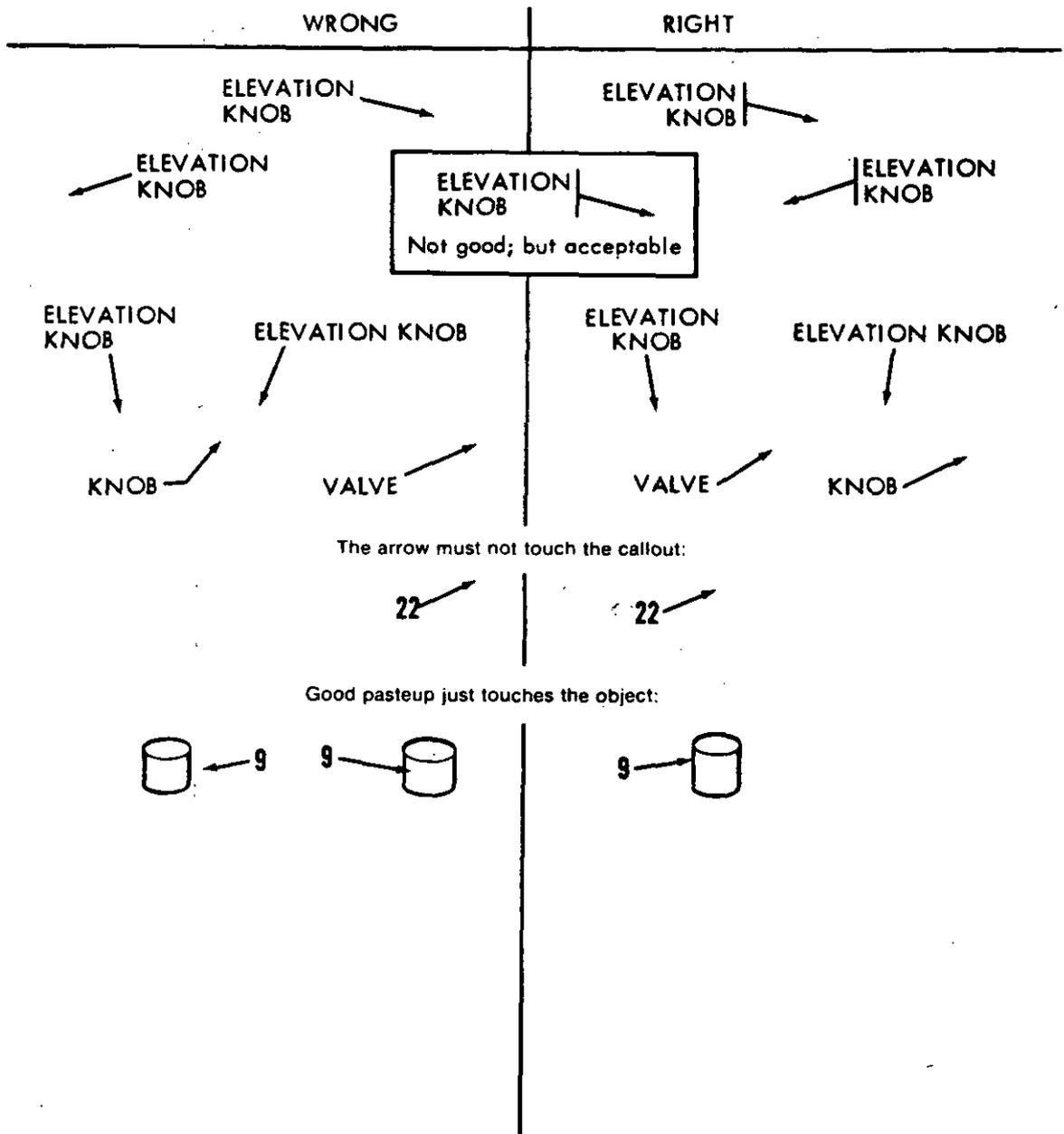
The pasteup of callouts and arrows is one of the most critical phases in the preparation of quality artwork. A sloppy pasteup can ruin an otherwise good piece of art.

Callouts and arrows must be cut neatly, as the outline of the callout will appear on the final copy. Allow 1/16 in. white margin around type. All typed callouts must be sprayed with a fixative to prevent smearing. Callouts shall be neatly arranged and straight.



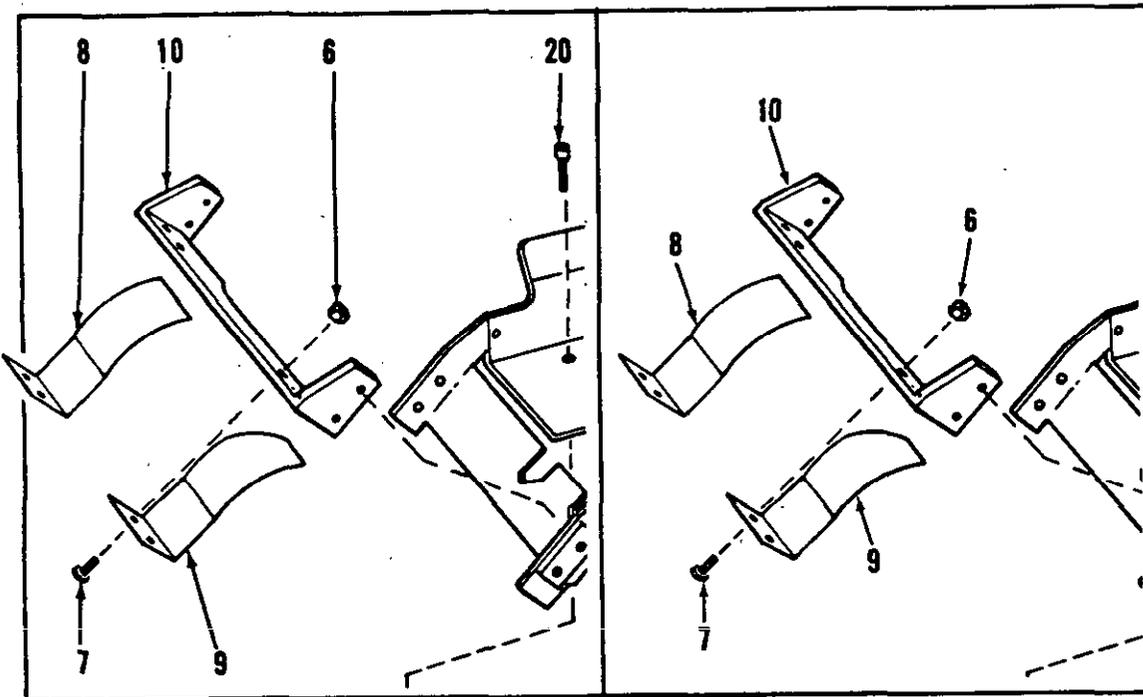
MIL-HDBK-63038-1A (TM)

Callouts should be right-hand justified when the arrow comes from the right side. Arrows which come from the center of the callout are not preferred, but acceptable. Avoid bending arrows, although this is occasionally unavoidable. Do not cross arrows. Arrows should not cross any part which is called out. Avoid arrows that are too short or too long.



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When alining numbers with each other, don't overdo it. The example below left demonstrates a misplaced effort at good pasteup layout. Keeping the numbers even requires arrows much too long. The example below right demonstrates good pasteup layout.



WRONG

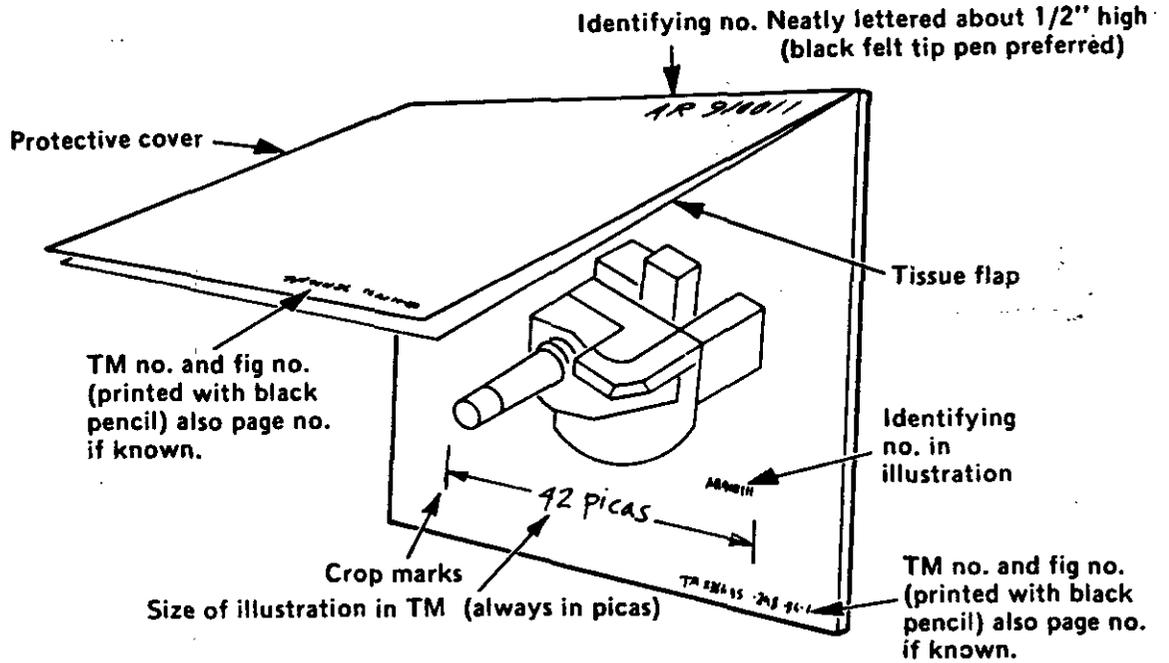
RIGHT

Illustrations may have an identifying number on the the illustration, if desired by the procuring activity. These identifying numbers will be provided by the proponent command. The number will be placed in the lower right-hand corner of the illustration, even with the bottommost line of the inking or slightly below.

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Cropping and Sizing

Cropping and sizing is that part of the paste-up operation which marks up the board art for the printer. The drawing below shows what is required on each board:



COVERS

All board art shall be protected by an inner flap of non-oily tissue and an outer flap of heavy paper. These are secured to the back of the board and folded over the face of the illustration. Brown wrapping paper is acceptable.

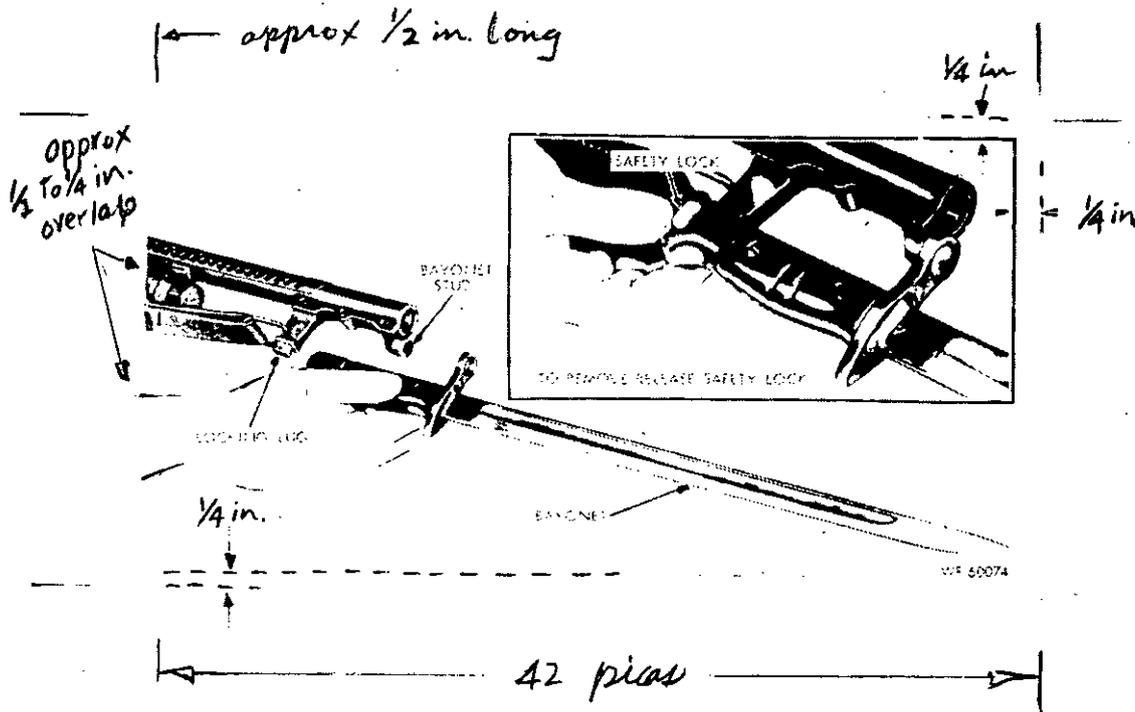
MIL-HDBK-63038-1A (TM)

Crop Marks

Illustrations are to be cropped and sized in pencil (not ink or grease pencil). The crop marks will start about 1/4 in. from the edge of drawing and be about 3/8 to 1/2 in. long. How an illustration is cropped depends on whether it's a halftone or line.

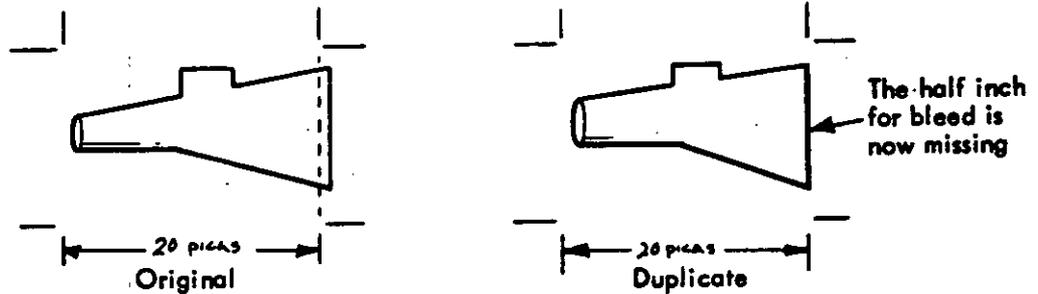
Cropping Halftones

Halftones must be cropped on all four corners as illustrated below. Crop marks will be about 1/4 in. out from edge of retouching. If a retouching extends beyond crop marks, allow about 1/4 to 1/2 in. bleed. This bleed area must be retouched like the rest of the photo.



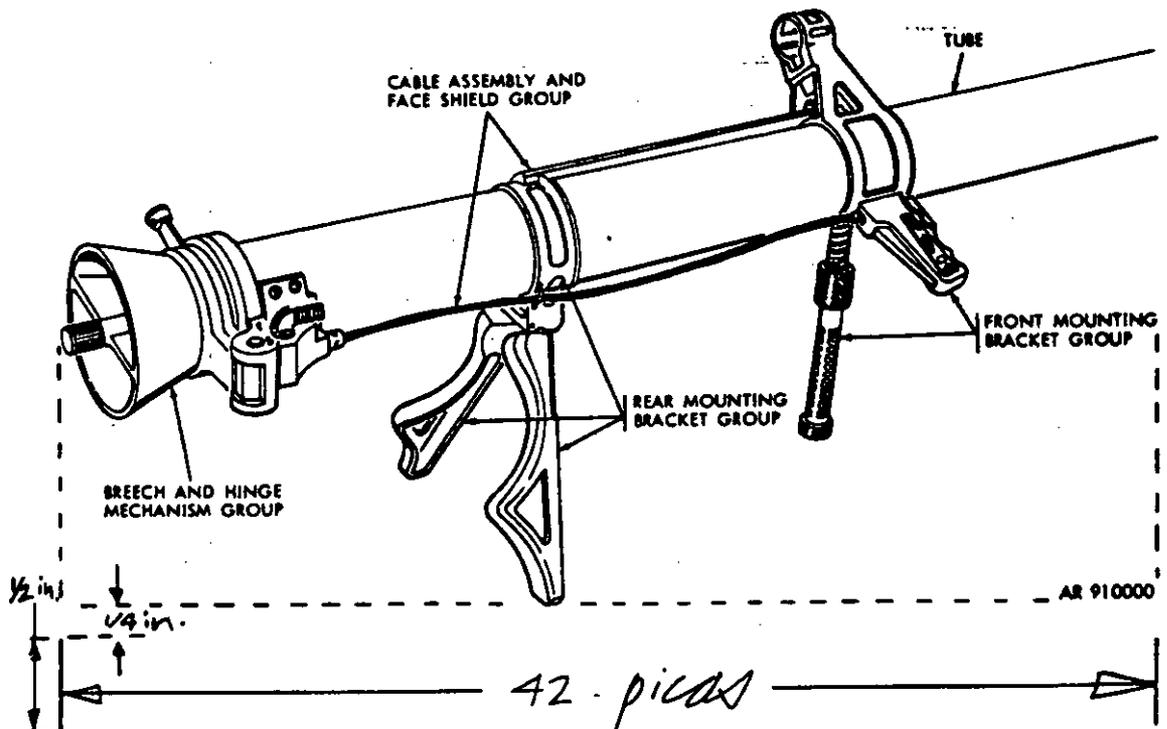
Duplicate Artwork

An artboard which consists of a photographic copy print of an original illustration is called a duplicate. This is treated just as if it were an original. The only difference in cropping is that halftones cannot be cropped a half inch in to allow for bleed, but must be cropped on the extreme edge:



Even though duplicates are already reduced to the final print size, do not write as is for the size. Always write the size in picas.

Cropping Line Drawings

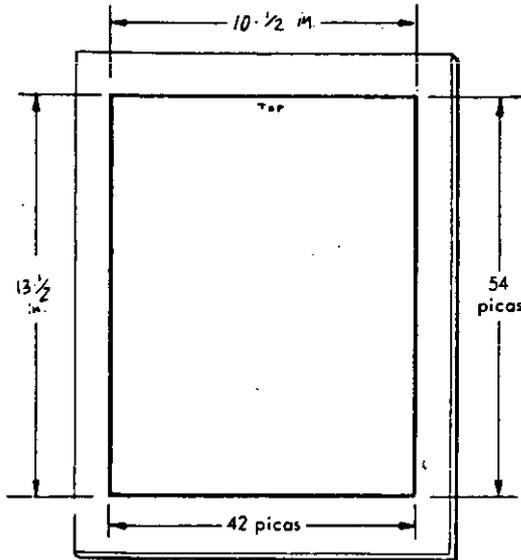


Line drawings are cropped even with the extreme edge of the drawing. They need only be cropped on the bottom or right side, whichever dimension is critical.

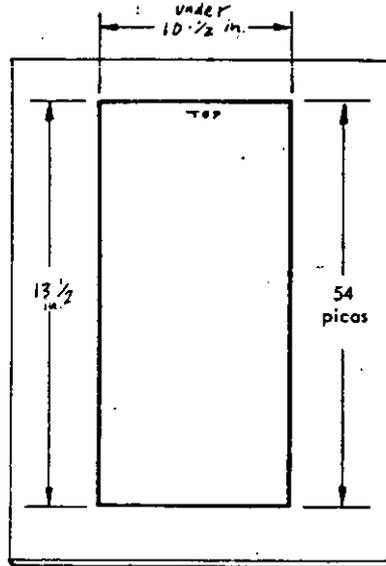
MIL-HDBK-63038-1A (TM)

Doing artwork oversize has several advantages, and one is that the drawings sharpen when they are reduced. However, the callouts should not be smaller than 8 pt. You can reduce your drawing by one quarter, which changes 12 pt. type to 9 pt., you can use 16 or 18 pt. type on the original drawing and reduce it by half, or you can work same size.

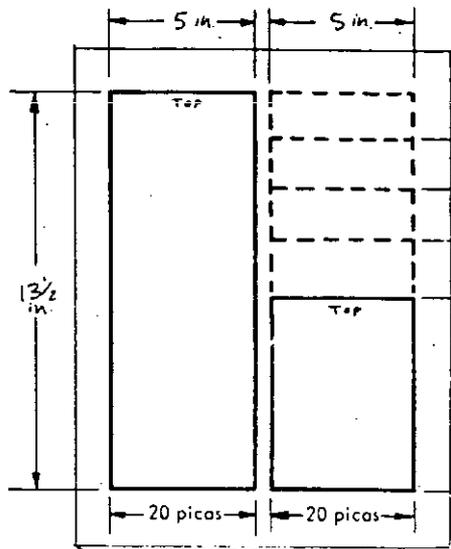
Artwork is usually cropped on the bottom. The following pages explain when and how to crop artwork on the side. The hand written dimensions are the size of the original. The typed dimensions (in picas) are the reduced sizes.



FULL PAGE VERTICAL (FPV)
Full height and page width or proportion can be cropped on width or height.

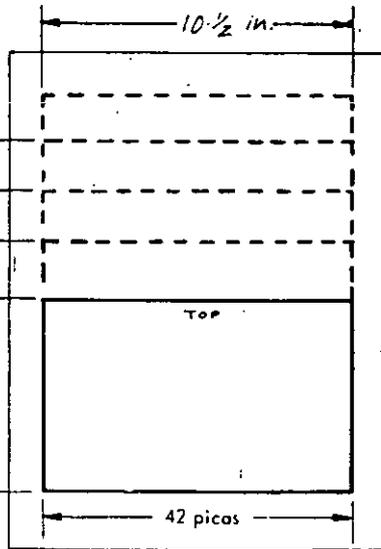


FULL PAGE VERTICAL (FPV)
Crop on height when width is less than page width.



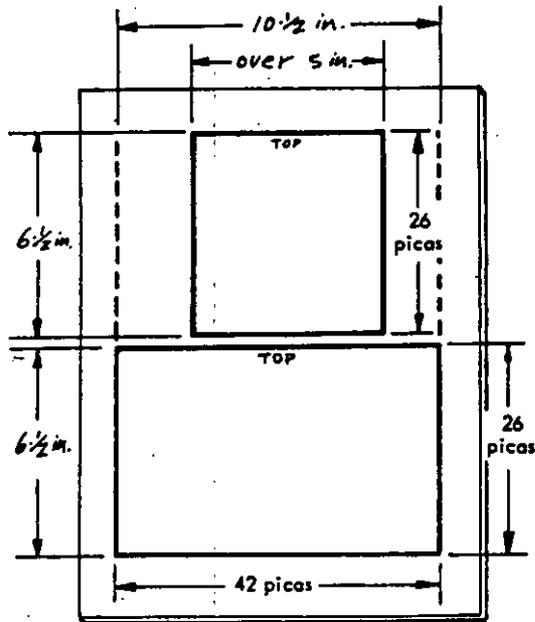
SINGLE COLUMN
Crop on width up to 13-1/2 in. high, Crop as FPV if height is more in proportion to width.

Less than
13 1/2 in.

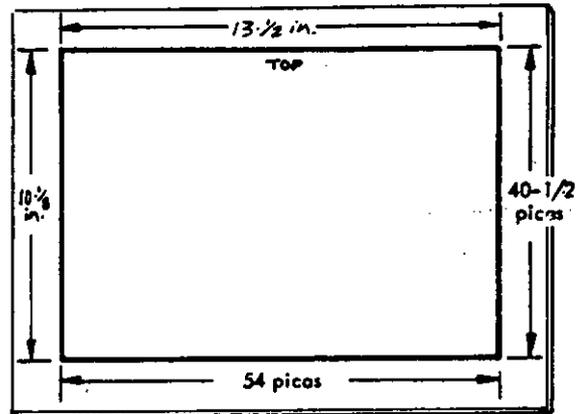


HALF PAGE VERTICAL (HPV)
Crop full page width on the width up to FPV size.

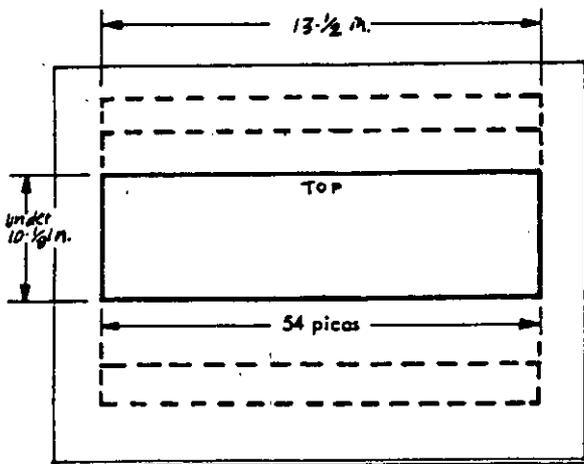
MIL-HDBK-63038-1A (TM)



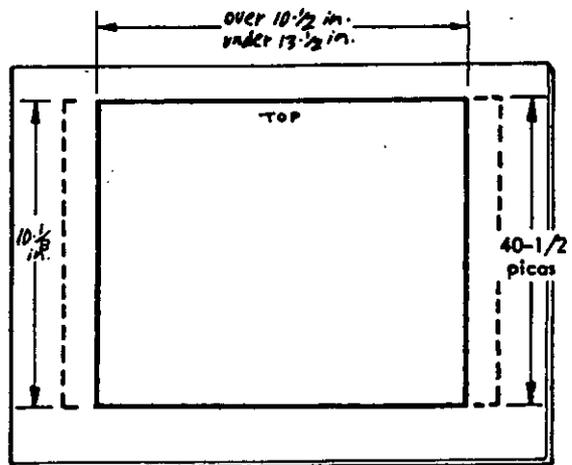
HALF PAGE VERTICAL (HPV)
 May be cropped on height if width is less than 10-1/2 in. and height is 6-1/2 in. or proportionate.



FULL PAGE HORIZONTAL
 Crop horizontal (54 picas) when dimensions are exact limit or proportion.



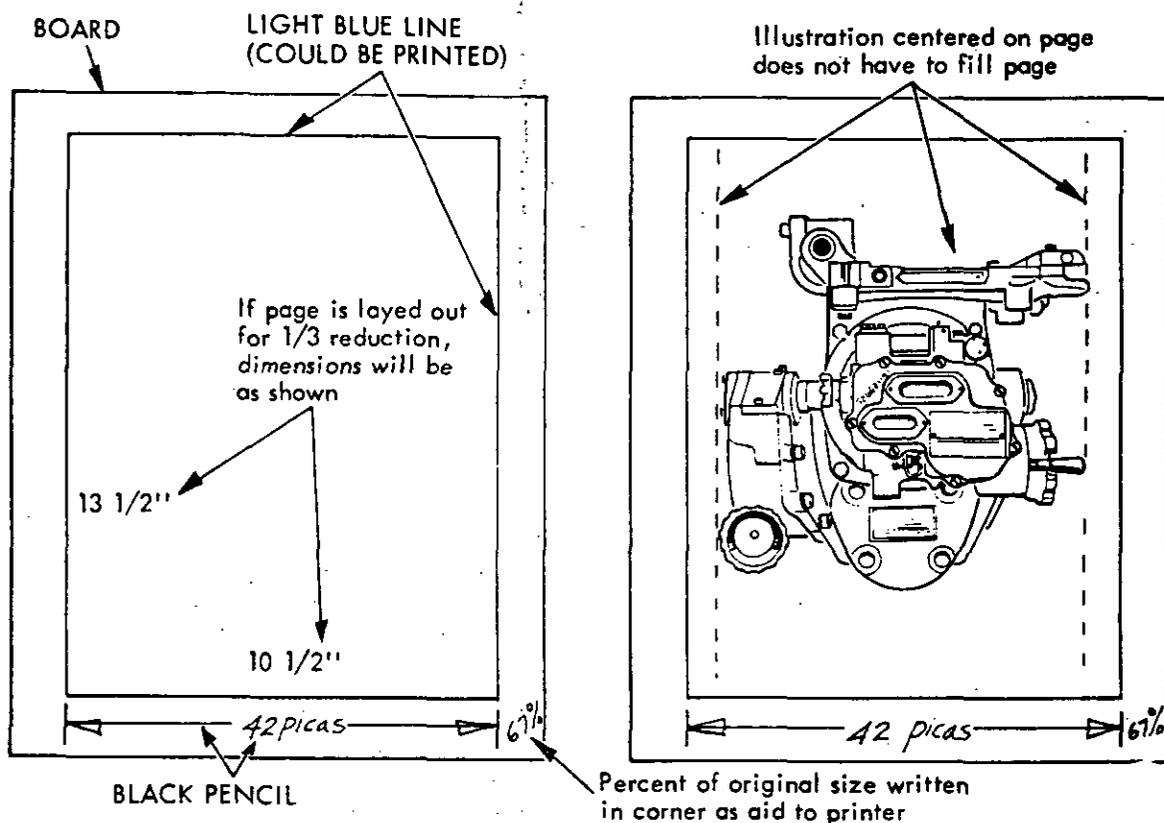
FULL PAGE HORIZONTAL
 Crop width when height is less than 10-1/8 in. but width is 13-1/2 in.



FULL PAGE HORIZONTAL
 Crop height when width is less than 13-1/2 in.

MIL-HDBK-63038-1A (TM)

An acceptable alternative to the sizing requirements just given would be to have boards pre-layed out:



You would center the illustration on the board, even if it isn't big enough to touch the edges. This method has several advantages: It makes cropping easier. Since every board will take the same reduction percentage, all callouts will be the same size when printed. It will save time for the printer because the plate maker will not have to measure and then adjust his camera for each illustration.

The disadvantages to this method are that most illustrations will not fill the page and that extra large inkings would have to be copied and reduced (before paste-up) to fit the pre-layed out area.

One third reduction is best for books with exploded views, e.g. parts manuals. A 20% or 25% reduction may be best for operator manuals, which would have small illustrations. Whichever original art size you choose, keep it the same for the whole manual.

CAMERA-READY COPY

Introduction

Camera-ready copy consists of manual pages sent to the printer requiring no typesetting or layout work on the part of the printer.

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The text may be typeset or typed on an office cold-type composing machine. An ordinary typewriter is not acceptable. Text or legend in an illustration do not have to be right hand justified.

Remove handle retainer (9) from each of two turnbuckles and extend turnbuckle handles (10). Turning in a clockwise direction, tighten turnbuckles evenly until all slack is removed from the travel lock chains (5).

Right hand justified

10 Move extractor away from obturator nut (18), support firing mechanism block (20) and housing (19) and unscrew obturator nut with spanner wrench (21). Remove firing mechanism housing and block.

Unjustified

The size of the page when printed must match the requirements of MIL-M-38784. Text may be all the way across the page or divided into two columns. Type size should be no smaller than 10 pt. If you are using 12 pt. composing machine and are working same size text all the way across the page would be good. If you are working on an oversize sheet, two columns would be better.

Preparing Camera-Ready Pages

To prepare camera-ready pages you'll need page layout sheets. These are sheets of paper with ruled or printed guidelines to aid in making layouts. They don't have to be boards; card stock or even good stiff bond paper is acceptable.

Preprinted sheets make layout work faster and easier and assure uniformity of page layout. The guidelines should be light blue; either pencil or printed in non-reproducible ink.

If you are using 12 pt. type you cannot reduce your page more than 20%, since MIL-M-38784 requirements for camera-ready copy require at least 10 pt. type. The dimensions given on the sample sheet are for a 20% reduction.

When placing text and illustrations on a page, always try to practice good layout principles.

Layout of Text

Use the table in MIL-M-38784 regarding type styles. A manual done with office cold-type composing machines does not have to match exactly the type styles given in MIL-M-38784. However, type styles must have the approval of the procuring activity.

You must do the following when laying out camera-ready text:

- a. Conserve space and avoid blank pages.
- b. Begin all chapters on a right hand page. All right hand pages are odd numbered. Two chapters can appear on the page.
- c. Begin sections on either right or left hand pages, unless the TM has no chapters. In this case sections can start only on right hand pages. Two sections can appear on one page.

MIL-HDBK-63038-1A (TM)

- d. Place the TM number on the same side of the page as the page number.

When laying out camera-ready text:

- a. Do not divide the last word on a page.
- b. Do not divide a paragraph so that the first line appears at the bottom of a page or column, or the last line at the top of a page.
- c. Do not place headers at the bottom of a column or page with the following paragraph at the top of the next page.
- d. Do not divide a NOTE, WARNING or CAUTION.

Layout of Illustrations

Fulltone artwork is prepared as board art. It can be prepared for any reduction percentage. The artboards are sent to the printer along with the camera-ready pages. A black or dark red square, cut to the correct proportions, will be pasted onto the page where the illustration will appear. MIL-M-38784 also allows a screened halftone print (instead of a black square) to be pasted on a camera-ready page.

Line drawings can also be prepared oversize. A reduced print of the line drawing will be pasted on the page. A line drawing which matches the reduction percentage of the oversize layout sheet still has to have a print made. If the original line drawing is pasted on an ordinary layout sheet, the callouts and arrows could get knocked off before printing. If camera-ready pages are mounted on boards and covered, the original line drawing can be pasted right on the layout page.

When placing illustrations on the page, keep the illustrations close to the appropriate text, but practice good layout principles.

Section 16

COLOR

	Page		Page
Overview	1	Methods and Requirements (cont)	
Methods and Requirements	1	Requirements (cont)	
Objectives and Principles	1	Color Printing Costs	4
Requirements	4	Separation of Colors	5
		Register Marks	5

OVERVIEW

Color refers to the use of any color other than black (including gray shades, patterns, white, etc.) for illustrative purposes in a technical manual.

Related section:

Illustration Development (Section 15)

METHODS AND REQUIREMENTS

Objectives and Principles

Use color in a technical manual when essential for one or more of the following functions:

- a. Highlight important information
- b. Complex schematics
- c. Complex wiring diagrams

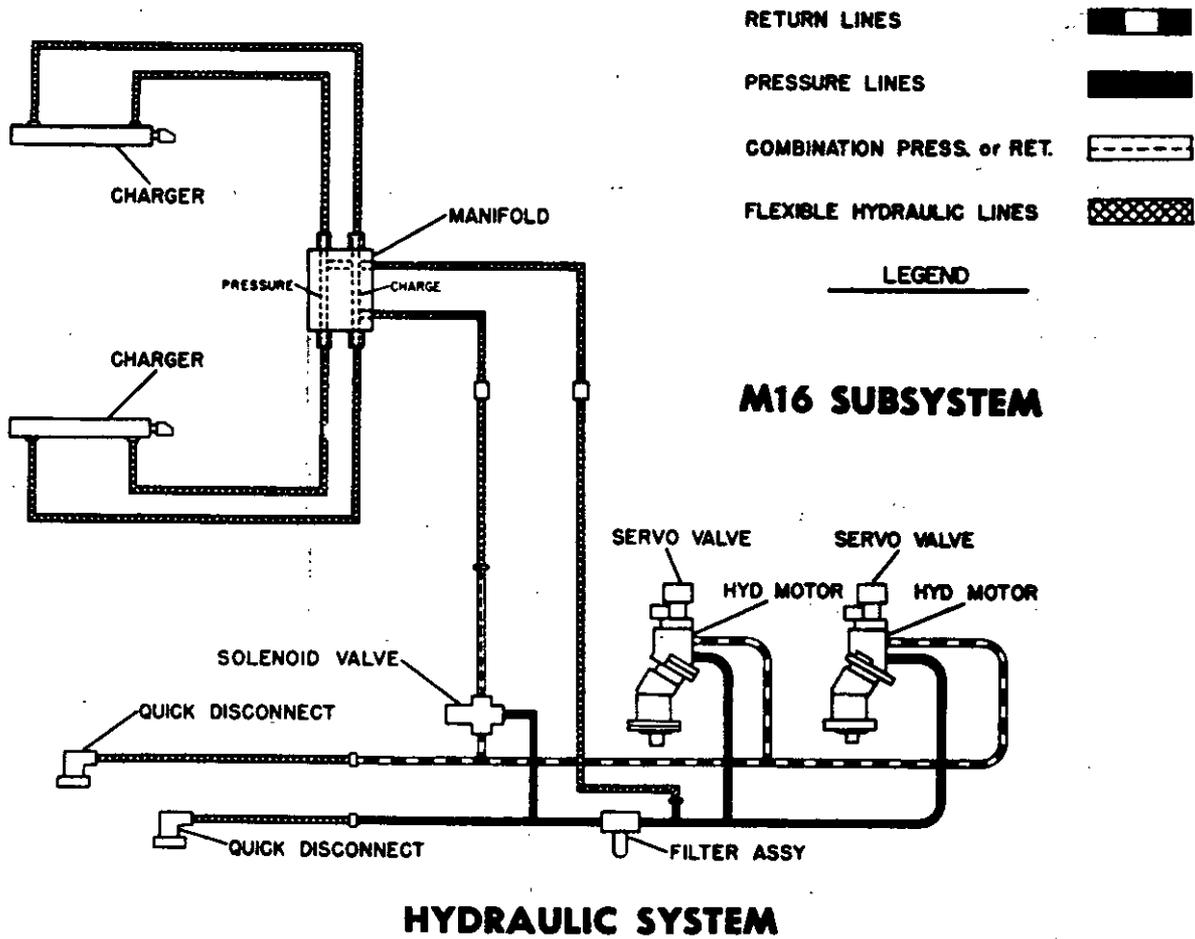
MIL-HDBK-63038-1A (TM)

Avoid the unnecessary use of color. Wherever possible, use:

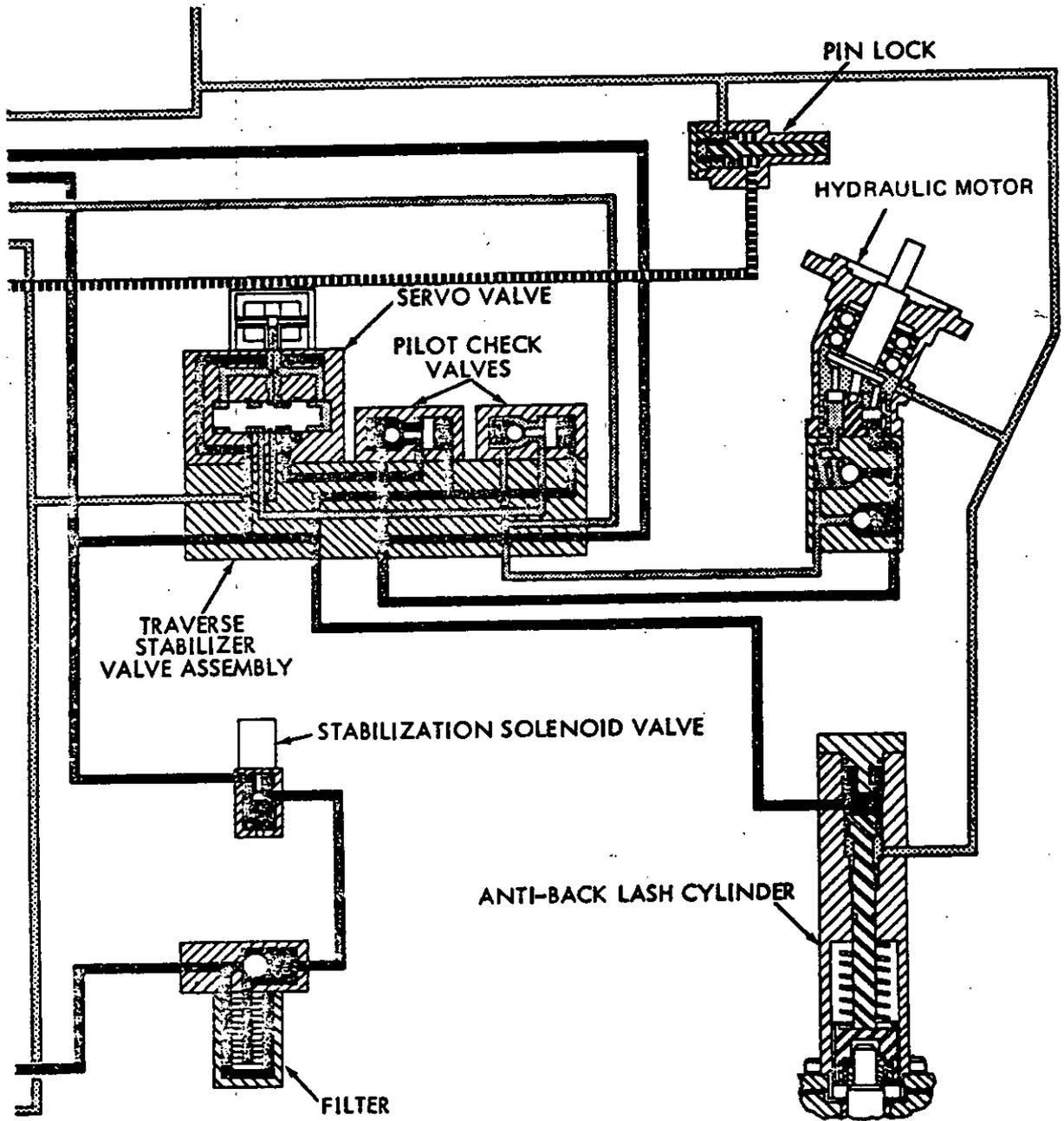
- a. Shading
- b. Cross hatching
- c. Patterned Lines

EXAMPLE

Avoiding
Unnecessary
Use of Color



Example of Color-Keyed Functional Flow



-  RETURN PRESSURE (Blue)
-  REGULATED AUXILIARY PRESSURE 100-150 PSI (Blue)
-  PUMP AND MAIN ACCUMULATOR PRESSURE (Red)
-  OPERATING PRESSURE (Red)
-  DRAIN AND RESERVOIR PRESSURE (Red)

MIL-HDBK-63038-1A (TM)**Requirements**

Authorization shall be obtained from the contracting agency for use of a color in printing. (Black, white, shades of gray, patterns, etc. are not considered colors for the following discussions.)

Any color used should be compatible with the user's environment. It must be easily visible under the ambient light conditions in which the manual may be used.

Select the density of print and background stock so as to achieve maximum brightness contrast in the light environment in which the manual will be used. In normal daylight, black print on highly reflective, white-matte background gives maximum brightness contrast.

Use of a second color should be restricted to special circumstances where one color, shades, and tints are not adequate.

The second color should be chosen very carefully. By various printing processes an additional color can be created by overprinting the one color on another. If overprinting to create a third is not being considered, then any color pair would be acceptable. (That assumes both are compatible in the environment in which they will be used.) If overprinting is being considered, then the following pairs should be avoided because they produce a mud-brown color: (The separate colors below may be used if overprinting is not used.)

- | | | |
|--------------------|---|--------|
| a. Red + Green | } | AVOID! |
| b. Blue + Orange | | |
| c. Yellow + Purple | | |

Listed below are the colors that primary pairs will produce:

- | | | |
|--------------------------|---|------|
| a. Blue + Yellow = Green | } | USE! |
| b. Yellow + Red = Orange | | |
| c. Red + Blue = Purple | | |

(Reference MIL-STD-595)

Color Printing Costs. Printing costs are usually determined by the number of separate press runs on each sheet of paper. This factor is not as important in cases where modern printing presses are available which can print two colors in a single run. Whenever the use of color

printing is authorized, the costs of separate printing runs should be minimized by restricting the number of distinct colors.

Using separate colors for closely spaced lines, on a schematic drawing for instance, is difficult because of excessively close color printing tolerances.

Another cost factor is color separation (see below). When several colors are used, separation becomes difficult (and costly).

Separation of colors.

The black and white (or key) illustration may be prepared on the illustration board or on acetate. Each succeeding color overlay should be made on acetate, or equivalent, and attached securely to the key illustration. Each color overlay should be marked with its correct color.

A color legend should be an integral part of an illustration. The legend should contain the exact duplicate of each solid, tint, or pattern of color and identify the usage in the illustration.

Register marks.

The key illustration and each overlay should contain a minimum of three register marks located outside the reproduction area at the sides, top, and bottom. The register marks on each acetate overlay should accurately align with one another and with the key art.

Interpretation of color use.

Use of a color refers to the primary (black, red, yellow, blue) color ink used during the printing process. Any number of shades of a primary color used are considered as one color (e.g., a two-color printing could consist of black and three shades of red).

Section 17

LOCATOR ILLUSTRATIONS

	Page		Page
Overview	1	General Requirements (cont)	
Methods and Requirements	1	Successive Locators	6
General Requirements	1	Parts Locators	8
Showing Relationship of Parts to		Exploded Views	8
Overall Equipment	6		

OVERVIEW

This section describes how to use illustrations to identify and locate equipment parts including ways to cross-reference between:

- a. Illustration
- b. Legend, parts lists, text
- c. Actual equipment

Emphasis is given to:

- a. Placing nomenclature and reference designators directly on the illustration where possible instead of in a legend.
- b. Showing the relationship between the component parts and overall equipment.

For additional information see the sections on:

Text Associated with Illustrations (Section 5)

Procedures (Section 7)

METHODS AND REQUIREMENTS

General Requirements

1. Place nomenclature directly on the illustration where possible instead of in a legend.
2. Always show reference designators directly on the illustration.
3. Don't show stock numbers or SMR (source, maintainability, and recoverability) codes on illustrations
4. When space permits, write nomenclature or reference designators directly on items - otherwise use leader lines. Leader lines may be used with or without arrowheads and should be straight rather than dog-legged if possible

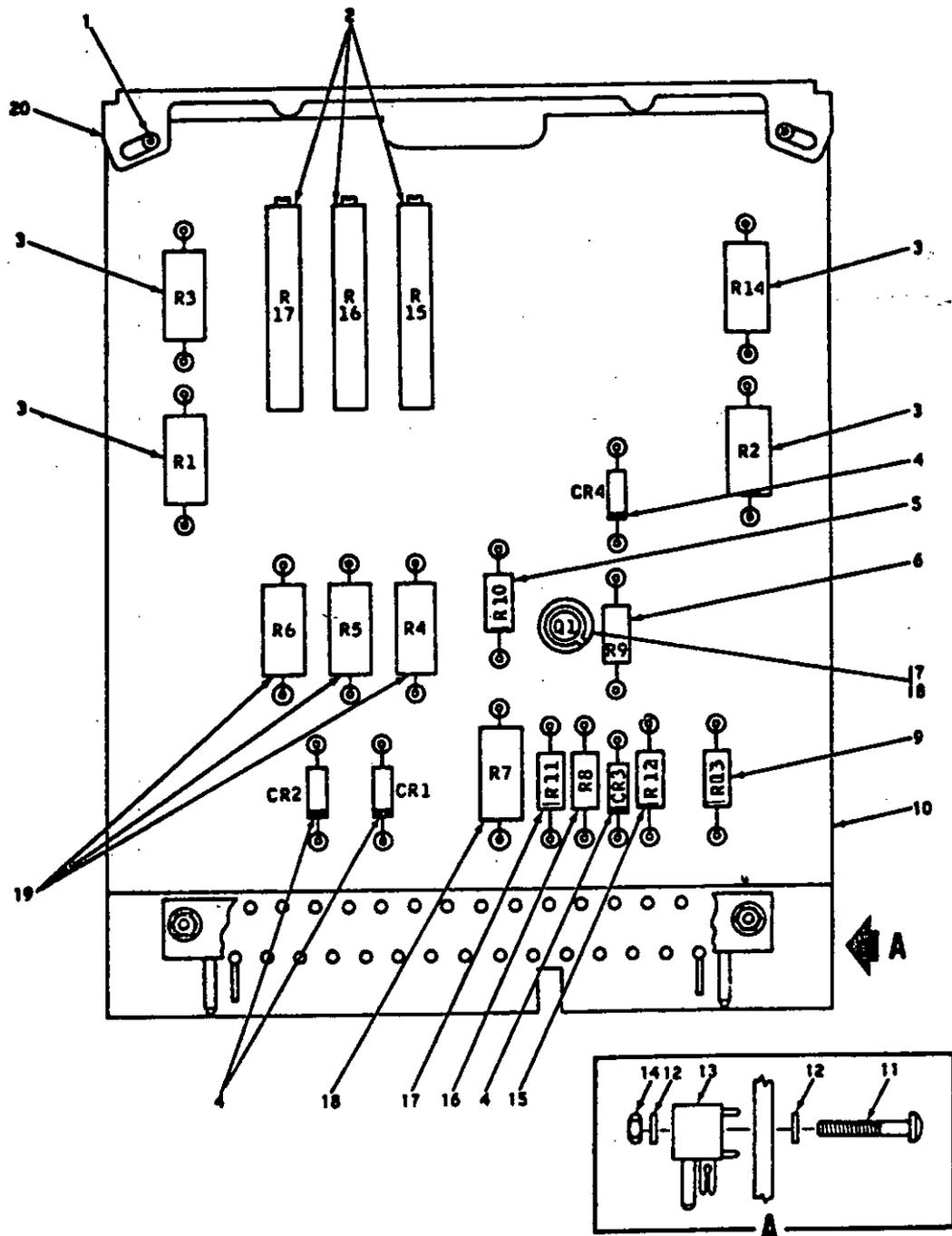
MIL-HDBK-63038-1A (TM)

5. Ordinarily, don't use grids for parts location — use leader lines.
 - a. Use grids only to go from parts list-to-illustration-to equipment.
 - b. Don't use grids to go from equipment-to-illustration-to-parts list or from illustration to parts list.
6. Make type size consistent within each illustration. Use 8-10 point type. (Diagram callouts may be as small as 7 points.) Lower case letters should be used only if absolutely necessary, and only if the type size is 10 point.
7. Use nomenclature and reference designators wherever possible for callouts instead of index numbers.
8. Call out no more than 20 items in a 7x9 in. area if nomenclature or reference designators are used. If index numbers are used, there may be as many as 50 if they meet the criteria in 9 below.
9. When text is not cued directly to an illustration, index numbers and legends may be used. Illustration complexity, space limitations, and quantity of parts or text must be taken into consideration. When index numbers and legends or listings are required:
 - a. Always place the legend or listing on the same or facing page with the associated illustration.
 - b. Use Arabic numbers for index numbers.
 - c. If an index number is subsequently deleted from an illustration, don't necessarily renumber. Place the word "Deleted" in parentheses after the appropriate legend or listing number. Renumber when substantial change has to be made, illustration usability would be impaired, or added costs are not significant.
 - d. If an index number is subsequently added to an illustration, use a suffix letter (26A, 26B) if desired. Suffix letters do not have to be eliminated in future revisions unless the illustration is also changed substantially, usability is impaired, or costs are not significantly affected.
 - e. Assign index numbers clockwise in sequence starting at 11 o'clock.
 - f. There should be no more than 5 index number callouts in any given one-square-inch area.
 - g. All callouts should be outside the boundaries of the parts being called out.
10. Orient illustrations to reflect technician's view during task performance.

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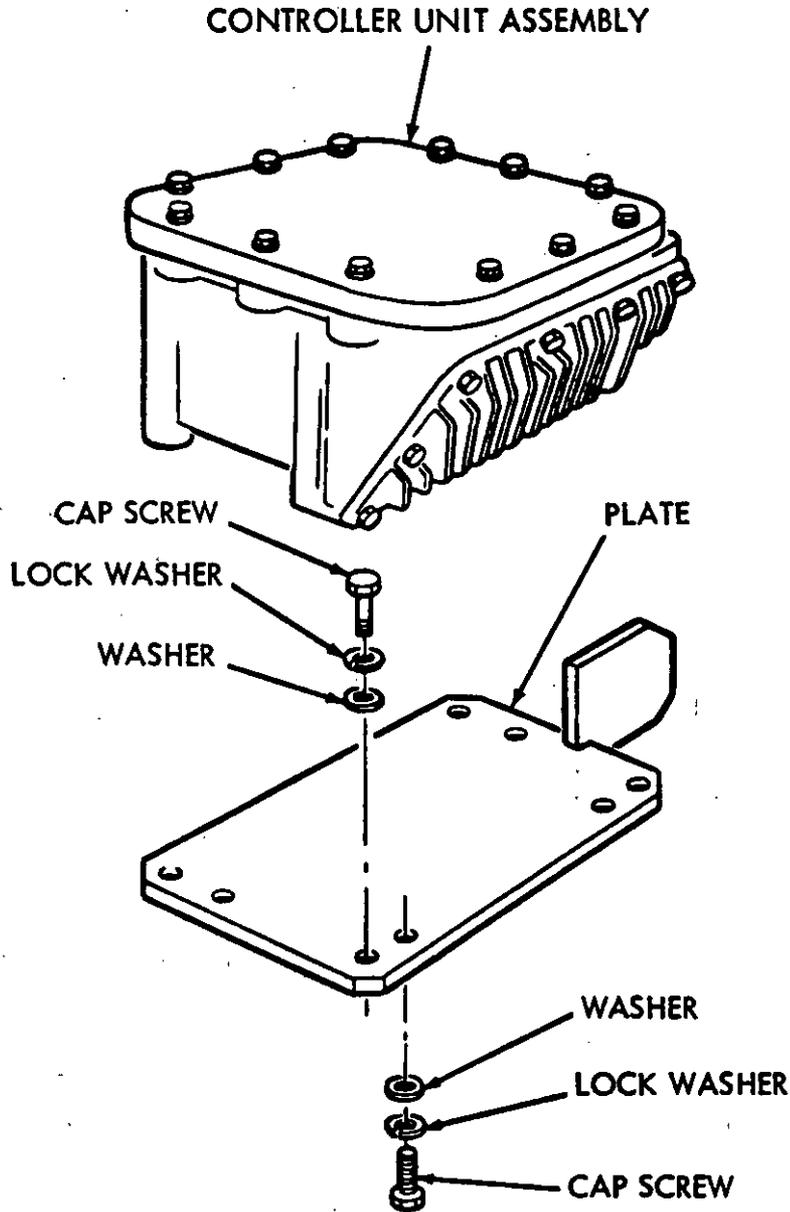
11 Control line weights so that the heaviest lines are used for part outlines. Details and callout lines should be medium weight. Axis lines should be somewhat lighter. Reference parts (not called out) should be shown with phantom lines. The lightest lines used should be 0.3mm (0 pen).

Example of index numbers and leader lines with reference designators directly on items.



MIL-HDBK-63038-1A (TM)

Example of Nomenclature Callouts



Nomenclature is preferable to item numbers for use as callouts.

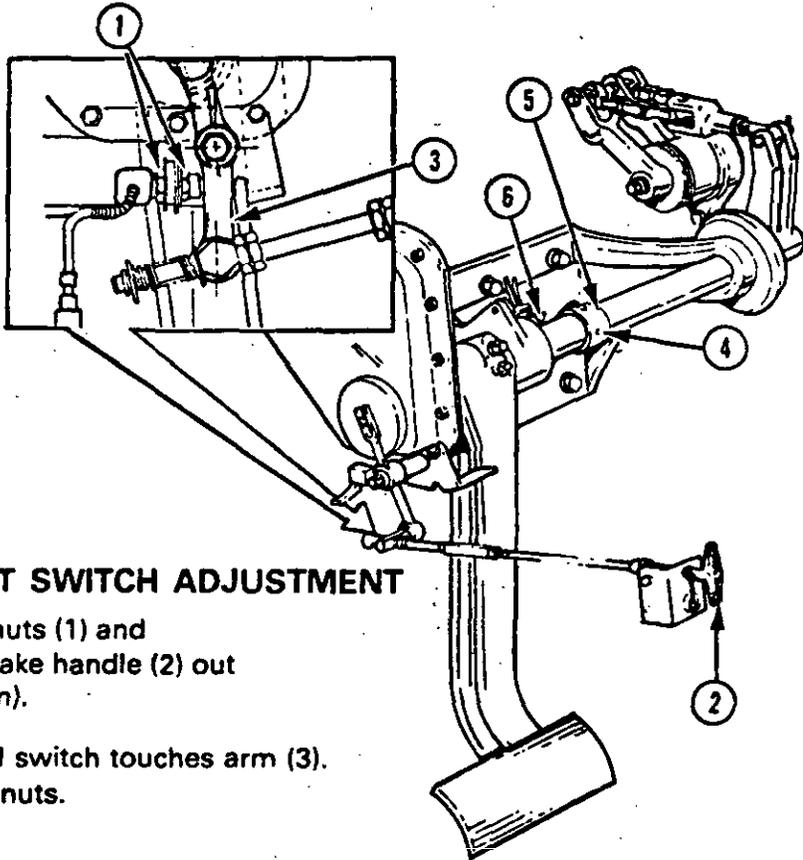
Exceptions

1. Index numbers are required by procuring activity.

2. If callouts must show sequence, use index numbers instead of nomenclature. (Use nomenclature and index numbers together, if necessary.)

Example of locator illustration with procedural steps showing the method generally used to enlarge and clearly indicate component detail and locate specific component features.

WARNING LIGHT AND STOPLIGHT SWITCH: ADJUSTMENT



WARNING LIGHT SWITCH ADJUSTMENT

- A** Loosen locking nuts (1) and move parking brake handle (2) out 3/8 inch (0.95 cm).
- B** Adjust nuts until switch touches arm (3). Tighten locking nuts.

STOPLIGHT SWITCH ADJUSTMENT

- A** Depress brake pedal 3/4 inch (19-mm) and lock brakes.
- B** Loosen socket head screws (4) and turn stoplight actuator (5) until it touches stoplight switch (6).
- C** Tighten screws (4).

MIL-HDBK-63038-1A (TM)

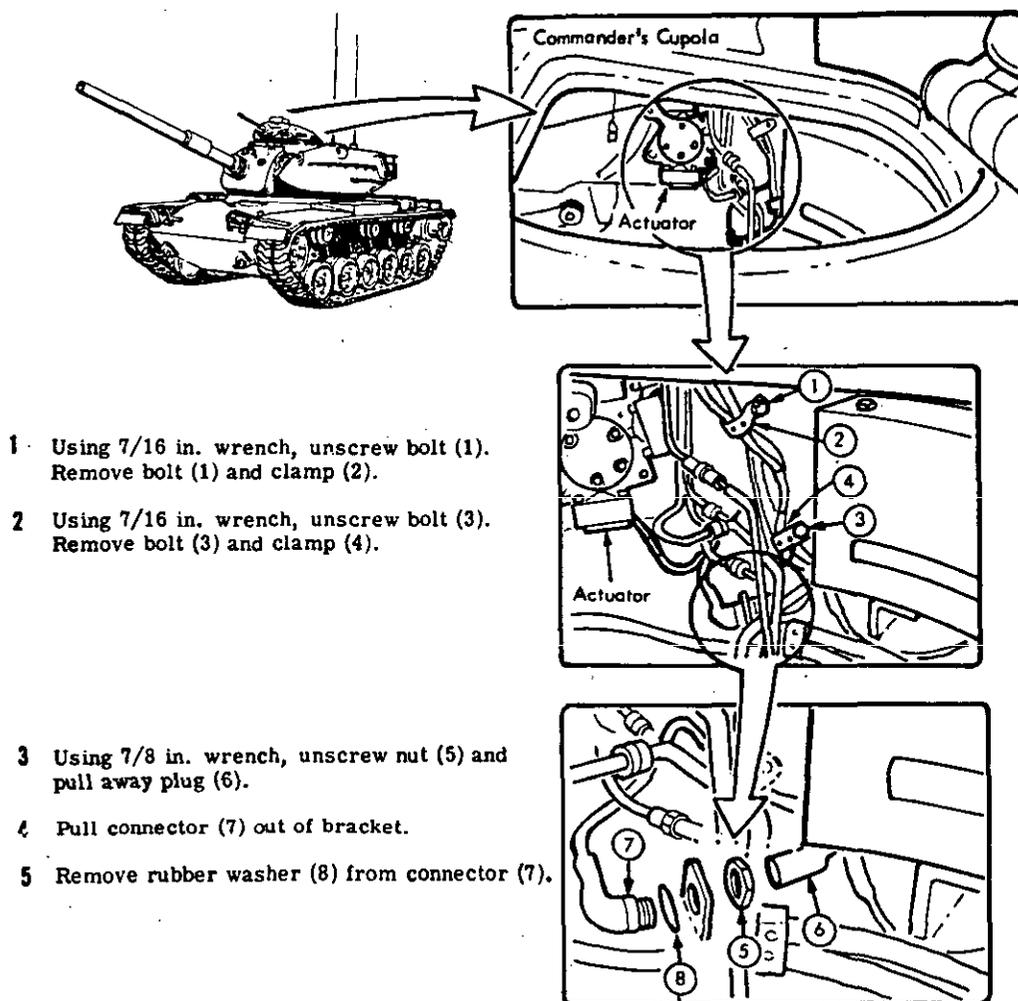
The illustration should be placed adjacent to the step to which it applies. Several adjacent steps may use the same illustration if all the items can be clearly shown in the illustration and it is clear which illustrations apply to which steps.

In procedures, illustrations that cannot be made small enough to fit in locator illustration or remarks column should be placed between steps, providing it is clear which step the illustration applies to. In such cases, horizontal lines may be used to group the procedural steps with the appropriate illustration; or, if necessary, the illustration may be placed on the facing page.

Showing Relationship of Parts to Overall Equipment.

The following discussion provides the requirements for successive locators used in procedures only and gives examples of methods used in parts lists.

- a. *Successive locators* - where the reader is led systematically from the large, overall view to successively lower level views as shown below:



The successive locator series helps the inexperienced technician pinpoint a part's location with a logical search routing - from general to specific. The successive locators take the user from the most general (and familiar) view of the equipment to the location of a specific small item.

Successive locators are most useful on larger items of equipment such as trucks, combat vehicles, and aircraft. Item exploded views are necessary only where further disassembly is required.

- Limits and disadvantages of successive locators:

- *Require more space*
- *Expensive*
- *Unnecessary information for experienced user*

- *Conditions of Use.* Successive locators are to be used only with procedural steps when:

- *Reader is not familiar with the location of equipment major components.*
- *Task is performed infrequently.*

The successive locator consists of:

General locator - shows location of item in system as solid black area.

Specific locator (at least 1¼ inches from general locator) - shows location of item in general locator.

Item enlargement (at least ¾ inch from specific locator) - shows closeup of item standing alone.

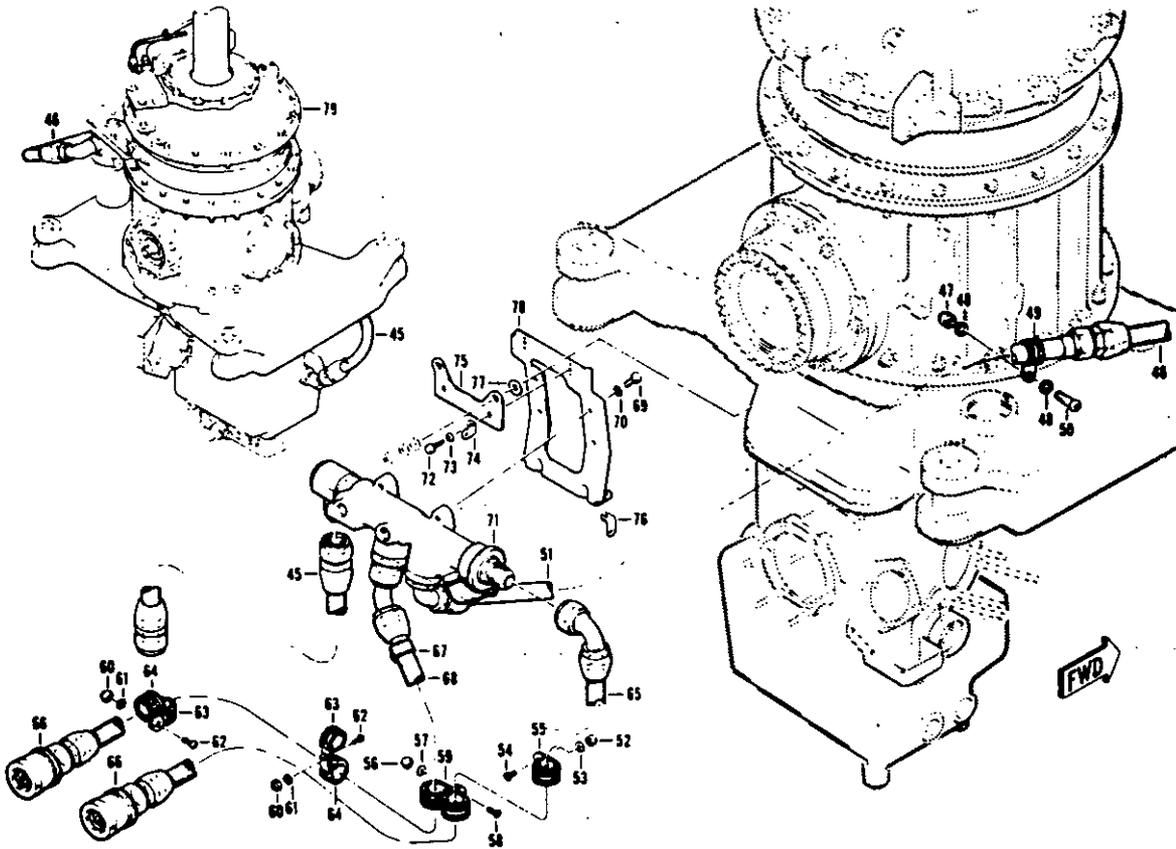
Item exploded view - shows exploded parts on dashed lines to indicate actual locations.

Sequence arrows should be:

- *Tapered*
- *Open-bodied*
- *Unnumbered*
- *Within ¼ inch of enlarged view.*

MIL-HDBK-63038-1A (TM)**b. Parts Locators**

The example below is a way to show the physical relationship of parts to the higher assembly.

**Exploded Views**

An exploded view is a line drawing of an assembly (or part of an assembly) that has been separated into its component parts .

Exploded views are used for:

- a. Parts identification and location
- b. Disassembly and reassembly procedure illustrations.
- c. Removal and installation procedure illustrations.
- d. Parts locator illustrations.

Exploded views must meet the general requirements for locator illustrations. In addition, they must faithfully represent the real orientations of all parts in the actual assembly.

Section 18

SCHEMATICS AND FUNCTIONAL DIAGRAMS

	Page		Page
Overview	1	Methods and Requirements (cont)	
Definitions	1	Detailed methods and	
Forms and purpose of schematics		requirements (cont)	
and functionals	1	Pictorial	22
Methods and Requirements	4	Cutaway	24
Principles	5	Logic	25
General methods and requirements...	6	Simplified	27
Specification Requirements	6	Partial	28
General Methods	6	Indicator	28
Portraying Signal Flow	6	Test	30
Detailed methods and requirements ..	15	Troubleshooting	34
Conventional	15	Power distribution	34
Schematic	15	Pyramid	36
Functional	15		

OVERVIEW

Definitions

Schematic diagram - a graphic representation showing the interrelationship of each component or group of components in the equipment. The essential characteristic of these diagrams is that every maintenance significant *functional* component is separately represented.

Functional diagram - a modified schematic diagram in which each group of maintenance significant components that together perform one or more functions is represented by a single symbol or block. The symbol or block representing the group of components shows all input and output signals.

Forms and Purposes of Schematic and Functional Diagrams

This section covers the various forms of schematic and functional diagrams. Each form differs in the equipment covered, method of representation, manner of grouping, or selection or content. Depending on the intended purpose, schematic and functional diagrams may combine one or more of the major features from the various forms.

NOTE

In actual practice, schematic and functional diagrams usually are combinations of one or more of the below types.

MIL-HDBK-63038-1A (TM)

Form	Major Features										
	Type		Method of Representation and Special Content	Manner of Grouping	Equipment Coverage						
	Schematic	Functional			System	Subsystem	Unit	Module	Assembly	Subassembly	Component
<u>Conventional:</u>											
Schematic	✓		Symbols for each functional component	None			✓	✓	✓	✓	✓
Functional		✓	Symbols or blocks: a. <u>Blocks</u> used to represent functional groups of components b. <u>Symbols or line drawings</u> used to represent functional groups of components	Equipment function	✓	✓	✓	✓	✓	✓	✓
Pictorial	✓	✓	Physical (isometric) drawings of significant components -- shows relative physical relationships, appearance, size, and interconnection to identify parts and describe operation	Physical location and/or equipment function	✓	✓	✓	✓	✓	✓	✓
Cutaway	✓		Cutaway views of significant components -- shows internal details and operation	Actual Construction		✓	✓	✓	✓	✓	✓
Logic	✓	✓	Standard logic symbology for each functional component or logic circuit -- shows digital equipment operation	Equipment function			✓	✓	✓	✓	✓

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Form	Major Features											
	Type		Method of Representation and Special Content	Manner of Grouping	Equipment Coverage							
	Schematic	Functional			System	Subsystem	Unit	Module	Assembly	Subassembly	Component	
Simplified	✓	✓	Key components for explanatory purposes; omits selected components, groups of components, or details for simpler, clearer explanation	Equipment function				✓	✓	✓		
Partial	✓	✓	Selected portion of equipment in complete detail	Equipment function						✓		
Indicator	✓	✓	All components involved in activating indicator	Indication chain	✓	✓	✓	✓	✓	✓		
Test	✓	✓	Components involved in test loop: test stimuli, item under test, and test measurement circuitry	Test chain	✓	✓	✓	✓	✓	✓		
Troubleshooting	✓	✓	Components involved in failure symptom, facilitates troubleshooting	Troubleshooting loop	✓	✓	✓	✓	✓	✓		
Power Distribution	✓	✓	Components involved in power input, power form generation, and power distribution	Power flow	✓	✓	✓	✓	✓	✓		
Hardware and function oriented	✓	✓	Shows both equipment functioning (by grouping functional components or groups of components) and hardware boundaries by indicating location in replaceable hardware item a. Blocked Schematic b. Precise-Access Block Diagram	Hardware boundaries and equipment function	✓	✓	✓	✓	✓	✓	✓	✓
Pyramid		✓	An interrelated hierarchy of diagrams	Progressively increasing level of detail from/overall system to component	✓	✓	✓	✓	✓	✓		

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METHODS AND REQUIREMENTS

Schematic and functional diagrams play a critical role in maintenance manuals. Properly drawn and organized, these diagrams help the maintenance technician do the job faster and more efficiently by making the necessary data easier to locate, understand, and use. The material that follows shows how to create properly drawn and organized schematic and functional diagrams.

Action	Topic	Section 18 Page No.
1. Determine where diagrams are needed.	-----	-----
2. Choose proper form (or combination of forms); understand method of presentation, special content, and equipment coverage of each form; select the form (or combination) that best fulfills intended purpose.	Forms and Purposes of Schematic and Functional Diagrams	1
3. Be guided by general principles.	Principles	5
4. Follow methods and requirements for chosen form (or combination)	General methods and requirements:	6
	Specification Requirements	6
	General Methods	6
	Portraying Signal Flow	6
	Detailed methods and requirements:	15
	Conventional:	15
	Schematic	15
	Functional	15
	Pictorial	22
	Cutaway	24
Logic	25	
Simplified	27	
Partial	28	
Indicator	28	
Test	30	
Troubleshooting	34	
Power distribution	34	
Pyramid	36	

MIL-HDBK-63038-1A (TM)**Principles**

Schematic and functional diagrams should conform to the following principles:

a. Properly Organized Layout

- (1) Left-to-right, top-to-bottom signal flow
- (2) Uncluttered, uncrowded appearance
- (3) Minimum of crossed lines
- (4) Sufficient spacing for legibility

b. Consistent

- (1) Standard referencing system for:

Associated text
Signal flow
Other diagrams

- (2) Standard names for:

Hardware	Controls
Functions	Indicators
Signals	Switches

- (3) Standard graphic symbols (special symbols in chart)

c. Complete detail

- | | |
|--|--------------------------------------|
| (1) Hardware | (7) Terminal boards |
| (2) Function | (8) Pin numbers |
| (3) Signal identification | (9) Signal names |
| (4) Measurement data
(voltages and waveforms) | (10) Reference designators |
| (5) Explanatory text | (11) Component values and tolerances |
| (6) Connectors | (12) Replaceable components |

d. Pertinent detail

- (1) Information not pertinent to purpose of diagram omitted.
- (2) Details of nonrepairable and nonreplaceable components minimized.

MIL-HDBK-63038-1A (TM)**General Methods and Requirements****Specification Requirements**

<i>Subject</i>	<i>Equipment Covered</i>	<i>Specification</i>
Abbreviations	All	MIL-STD-12
Drafting Practices	Mechanical Electrical and electronic Fluid power	ANSI Y14.14 ANSI Y14.15 ANSI Y14.17
Engineering Drawings	All	MIL-STD-100, MIL-D-1000
Graphic Symbols	Electrical and electronic Mechanical Digital (Logic) Fluid power	ANSI Y32.2 MIL-STD-17-1 and -2 ANSI Y32.14 ANSI Y32.3
Reference Designators	Electrical and electronic	ANSI Y32.16
Unit Symbols	All	ANSI Y10.19

General Methods. The drafting practices specifications referenced give useful general methods. Some important recommendations follow:

- a. **Layout** - - for most diagrams, order signals and components functionally (for example, don't show signals in connection pin number order, but in functional order). Avoid clutter - - no more than 3 components per square inch or 15 crossed lines per 4 square inches. Allow 1/8 in. between parallel lines. Use a left-to-right functional flow with right-to-left feedback.
- b. **Consistency** - - use standard graphic symbols when possible; if special graphic symbols are required, make them visually distinctive from other graphic symbols used and include them in special symbols chart.
- c. **Appropriate detail** - - include all information required to fulfill intended purpose of diagram; be careful not to overcrowd - - when necessary, use text keying methods discussed in Text Associated with Illustrations section. Clearly label all inputs and outputs and place them near edges of diagrams.
- d. **Inappropriate data** - - leave out data not related to purpose of diagram.

Portraying Signal Flow

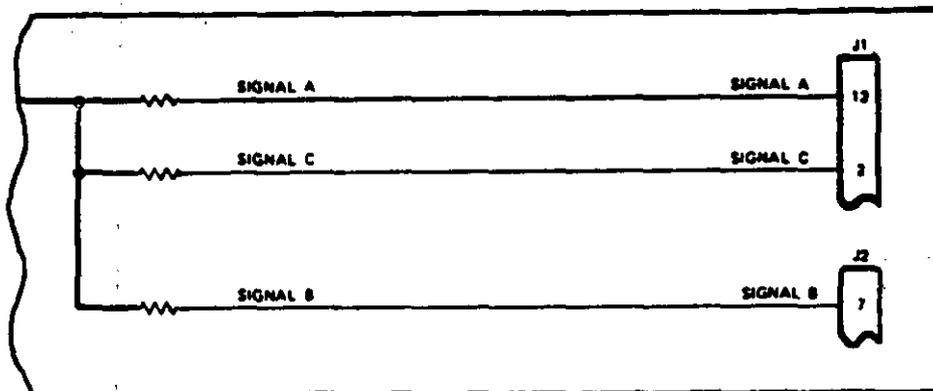
Signal flow, especially for electrical and electronic equipment, critically affects the understandability of diagrams. Use the recommended methods for portraying signal flow discussed below.

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1. Signal Connections

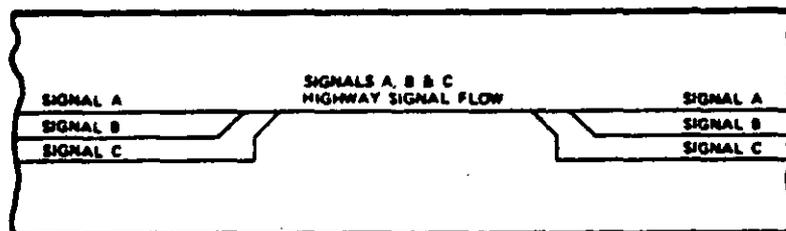
Three methods are available to represent signal connections:

- a. *Point-to-Point Method* - Shows each signal separately with a continuous line to represent its flow.



Point-to-Point Method for Signal Flow

- b. *Highway Method* - Blends two or more signals together in a single line. This method is useful in showing the flow of a group of related signals.



Highway Method for Signal Flow

Rules for Using Highway Method

1. Any number of signals can be blended together.
2. Any signal that has been blended into the main line will be blended out at some other point on the line.
3. Once a signal has been blended out of a line it is no longer present on that line.
4. Each signal blended in or blended out of line must be identified.

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c. *Interrupted Flow Method* - - uses special symbols to interrupt signal flow. This method may be used within a single sheet of a diagram, between sheets of a diagram, or between diagrams.

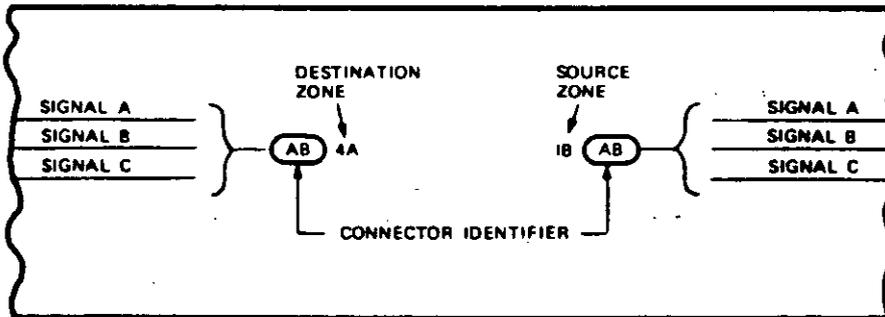
(1) Within a Single Sheet of a Diagram. Three techniques are available for using the interrupted flow within a single sheet of a diagram:

(a) *Oval Connector* - - use to continue signals from one area of a sheet to another area.

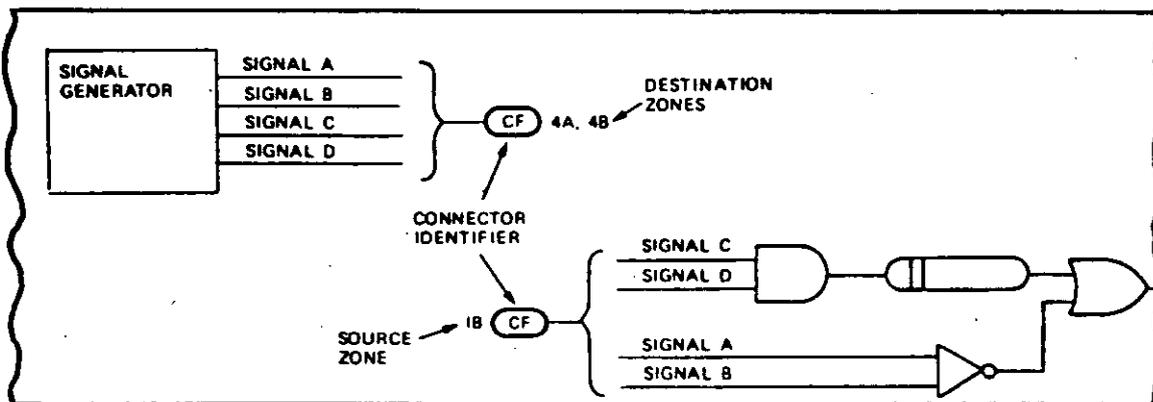
Rules for Using Oval Connectors

1. Any Number of signals can be bracketed together.
2. Each signal must be identified at its source bracket and destination bracket.
3. Oval connectors will have unique letter identifier inside the oval.
4. The position of the source and destination connectors will be identified by zone numbers.

EXAMPLES:

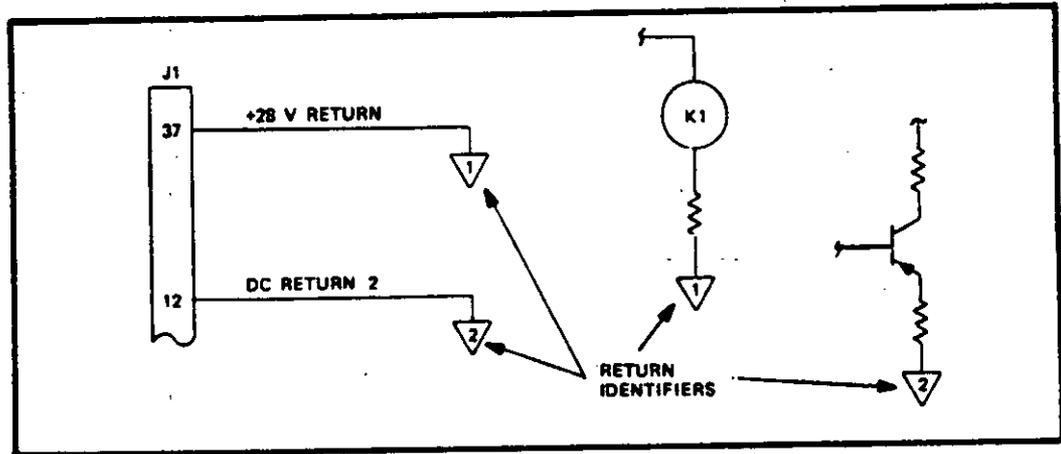


Oval Connectors Used to Continue Signals



Oval Connectors Used to Continue Signals to More Than One Destination.

(b) Signal Returns -- use to continue signal returns within a single sheet of a diagram.

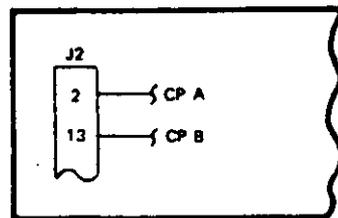
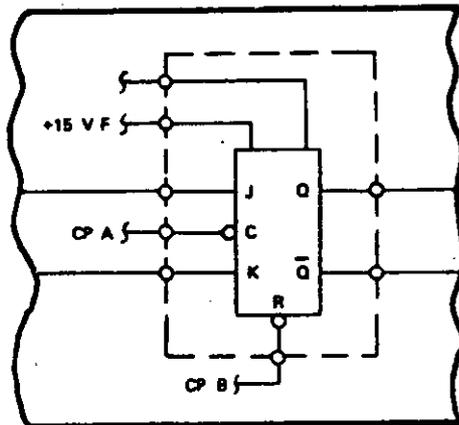
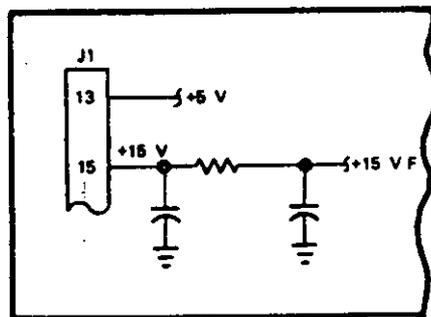


Signal Returns Used to Continue Signal

Rules for Using Signal Returns

1. Returns will have a unique number identifier inside the network.
2. Each return will be labeled the first time it appears on the diagram (preferably on the left edge of diagram).

(c) Breakoff Symbols () -- use to continue power forms, clock pulses or other multi-use minor signals.



Breakoff Symbols Used to Continue Signals

MIL-HDBK-63038-1A (TM)**Rules for Using Breakoff Symbols**

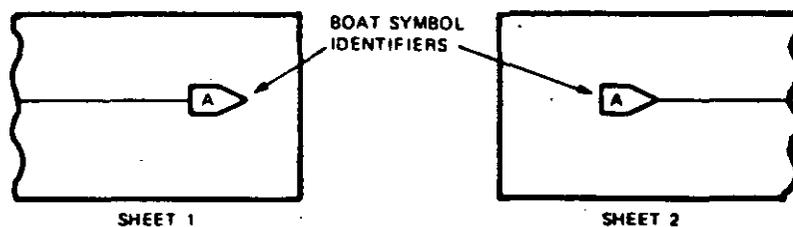
Each signal will be identified adjacent to its breakoff symbols.

The source of signals will be shown at the left edge of diagram.

Only power forms, clock pulses, and other multi-use, minor signals will use the breakoff symbol technique.

(2) Between Sheets of a Diagram

(a) Boat Symbol - use to continue signals from the right edge of one sheet to the left edge of the following sheet within a multi-sheet diagram.



Boat Symbols Used to Continue Signals
Between Adjacent Sheets of a Diagram

Rules for Using Boat Symbols

1. Use for single signals only.
2. Boat symbols will have a unique letter inside the boat.
3. Use to continue signals between adjacent sheets of a diagram only.

(b) Oval Connector - - use to continue signals from one area of a diagram to another. Application is the same as within a single sheet of a diagram. Identification of source and destination areas, the following zoning rules are recommended for multi-sheet diagrams.

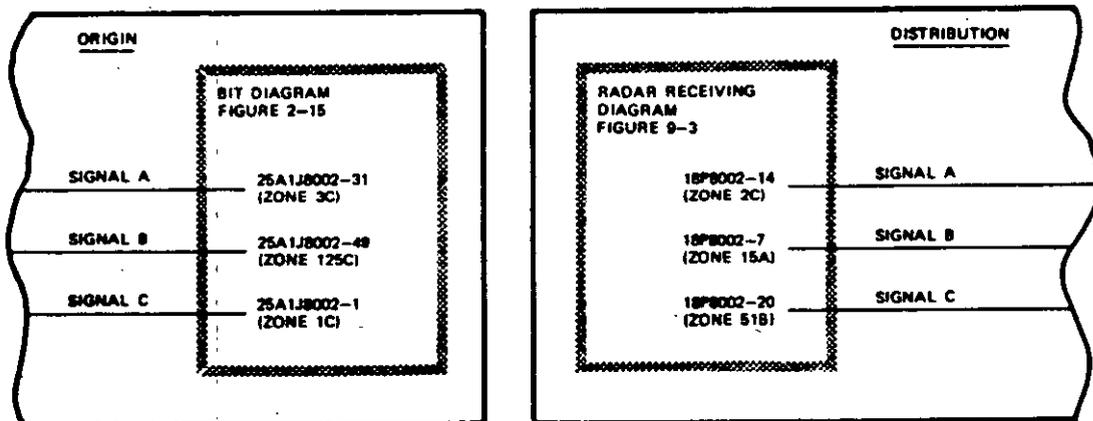
Rules for Zoning Multi-Sheet Diagrams

1. Number vertical zones; letter horizontal zones
2. Limit number of horizontal zones to 10.
3. Always number zones as below, even if all zones are not used on any sheet.

Sheet 1	Starts with Zone 1
Sheet 2	Starts with Zone 11
Sheet 3	Starts with Zone 21, etc

(3) *Between Diagrams* - - Three techniques are available

(a) Block technique.



(Figure 9-3)

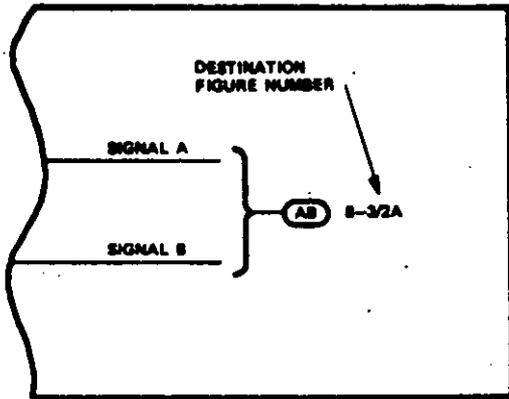
(Figure 2-15)

Block Technique for Continuing Signals Between Diagrams

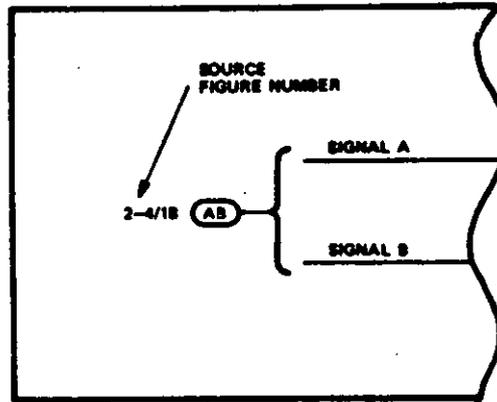
1. Include figure name and number.
2. Include connector and pin numbers.
3. Include zone numbers.

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(b) Oval Connectors - - insert source and destination figure numbers before zone references.



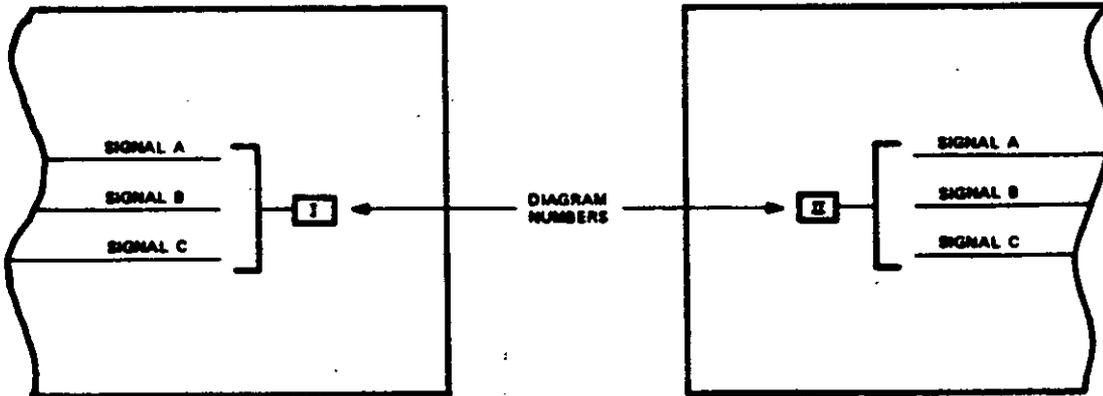
(Figure 2-4)



(Figure 8-3)

Oval Connectors Used to Continue Signals Between Diagrams

(c) Pyramid Diagram



(Diagram 2)

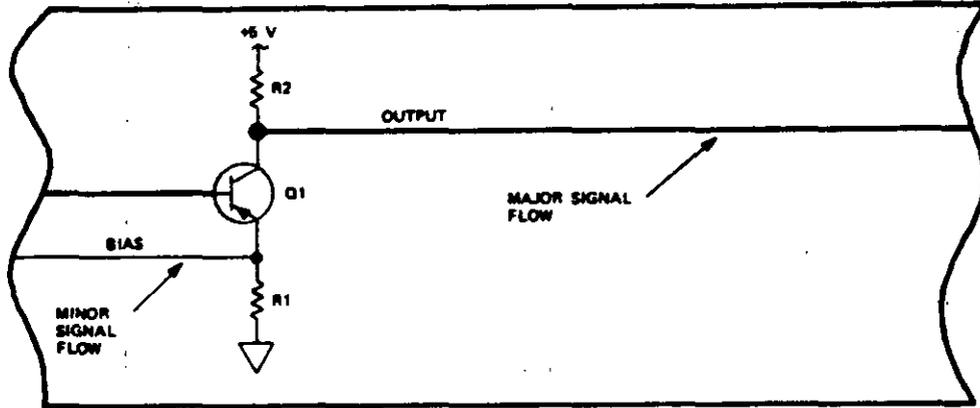
(Diagram 1)

Pyramid Diagrams Interdiagram Signal Continuation

2. Signal Difference

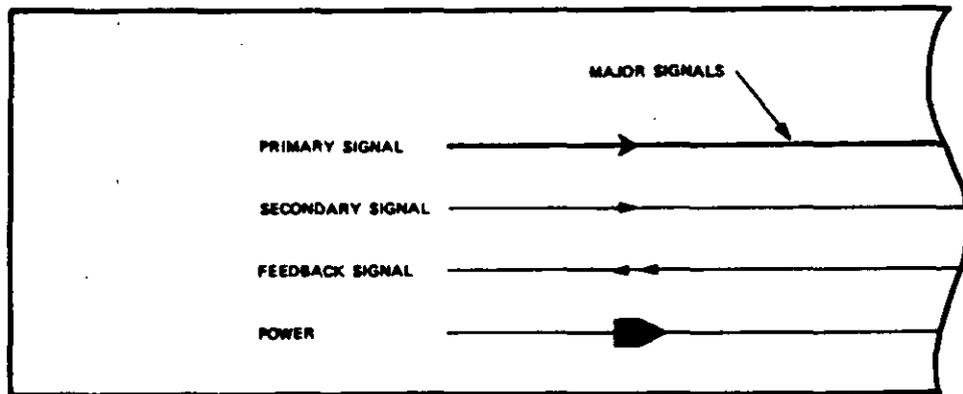
Coded Signal Flow. Various codes are also available to indicate signal importance and type:

- a. Line Width - - use wide lines to represent major signals.



Line Width Code Used to Indicate Signal Importance

- b. Arrowheads - - use special arrowheads to indicate signal types.

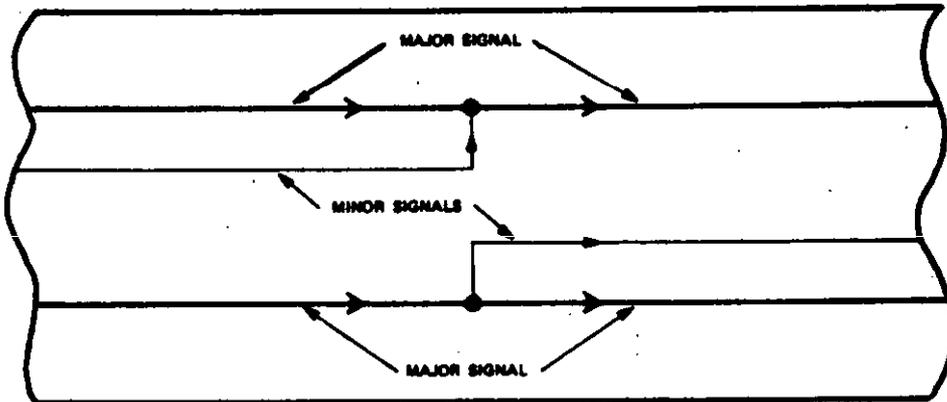


Arrowheads Used to Indicate Signal Types

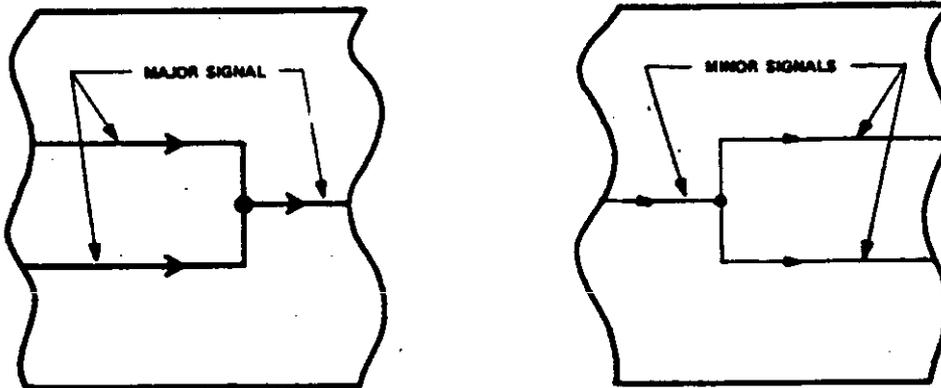
- c. Color - use only if approved by contracting agency.

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3. *Signal Junctions.* The relative importance of signals can also be indicated by the way signal junctions are represented.



Subordinate Junctions Used to Indicate Differences in Signal Importance



Coordinate Junctions Used to Indicate Equality in Signal Importance

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Detailed Methods and Requirements

1. *Conventional.* The essential characteristic of conventional schematic and functional diagrams is that they cover a complete item of hardware--system, subsystem, assembly, or subassembly.

- a. *Schematic.*

<i>Requirements</i>	<i>Methods</i>
<p>Show every maintenance significant functional component.</p>	<p>(1) Directly pick up engineering drawing wherever possible removing nonessential data.</p> <p>(2) Show piece part detail only when replacement is authorized at maintenance level covered or when understanding is required for fault isolation.</p>
<p>For non-repairable assemblies:</p> <p>(1) Show all inputs and outputs.</p> <p>(2) Show enough detail to understand how inputs relate to outputs.</p> <p style="padding-left: 20px;">(a) Show complete details for simple circuits.</p> <p style="padding-left: 20px;">(b) Use symbols for complex circuits.</p>	<p>Functionalize complex assemblies which are nonrepairable.</p>

- b. *Functional.*

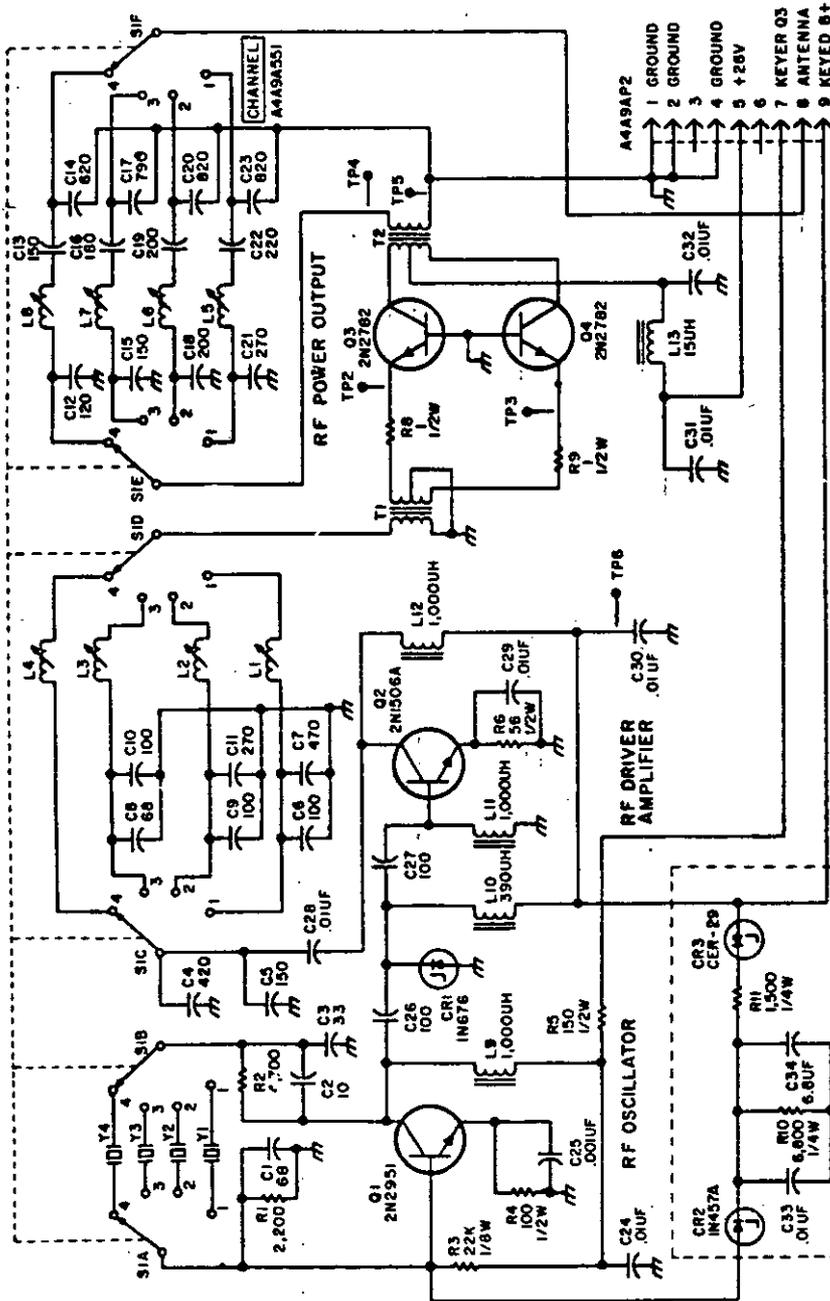
<i>Requirements</i>	<i>Methods</i>
<p>Show complete system or subsystem on one sheet (if possible). (Block functional only.)</p>	<p>Functionalize components; group subfunctions into functions; continue until complete system or subsystem can be shown on one sheet (may be a foldout).</p>
<p>Provide enough details to relate input to output signals.</p>	<p>(1) Use arrowheads to indicate signal flow direction when necessary.</p> <p>(2) Specify signal characteristic/tolerances in pictorial or tabular form.</p>
<p>Account for all maintenance significant components.</p>	<p>Make sure the reader can relate the schematic diagram to the functional diagram; block the components on the schematic to correspond with blocks on the functional or provide a table relating components to functional blocks.</p>

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Show hardware boundaries.

Use solid, dashed, or dotted lines; various weight lines; different types of zip color shades and tints.

- (1) Procuring agency approval required
- (2) Yellow and grey shades preferred
- (3) Use lightest shades where diagram is densest.

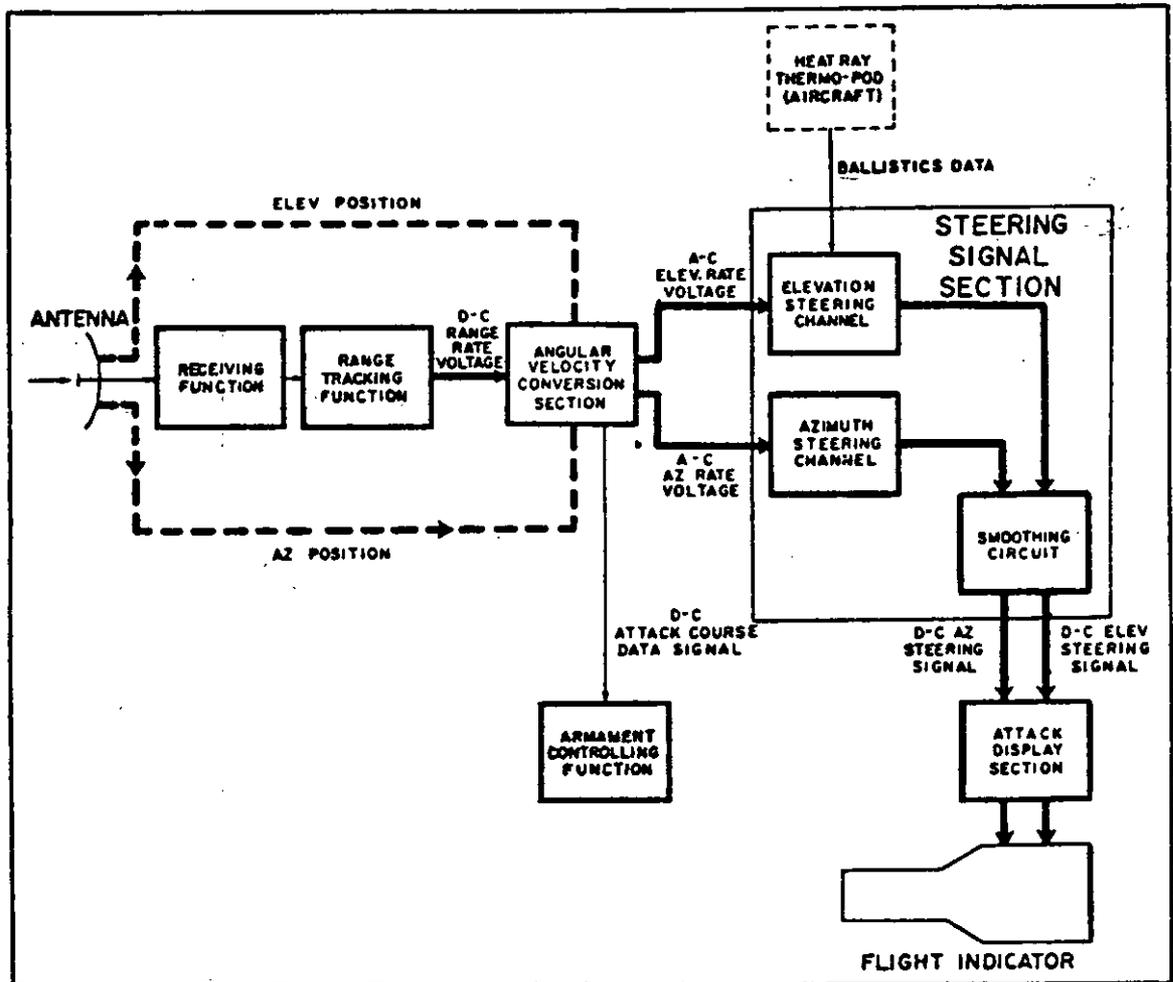


- NOTES:
- 1. UNLESS OTHERWISE SPECIFIED, RESISTANCE VALUES ARE IN OHMS, 1/8W. CAPACITANCE VALUES ARE IN PF. INDUCTANCE VALUES ARE IN UH.
 - 2. PRECEDE OSCILLATOR CONTROL CIRCUIT BOARD ASSEMBLY REFERENCE DESIGNATIONS WITH A449A3. PRECEDE ALL OTHER REFERENCE DESIGNATIONS WITH A449A2 UNLESS OTHERWISE SHOWN.

EL28C001

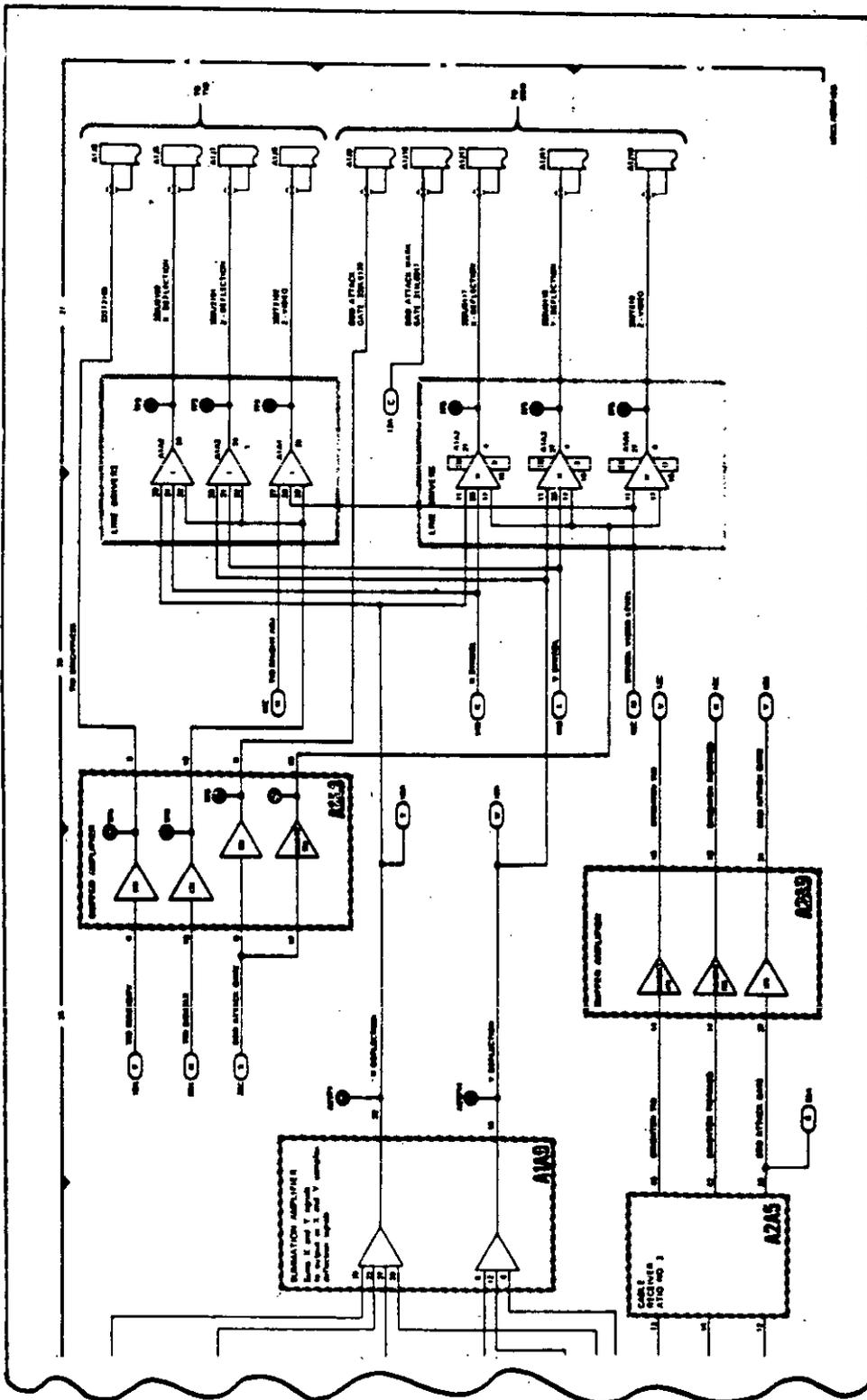
Conventional Schematic Example

MIL-HDBK-63038-1A (TM)

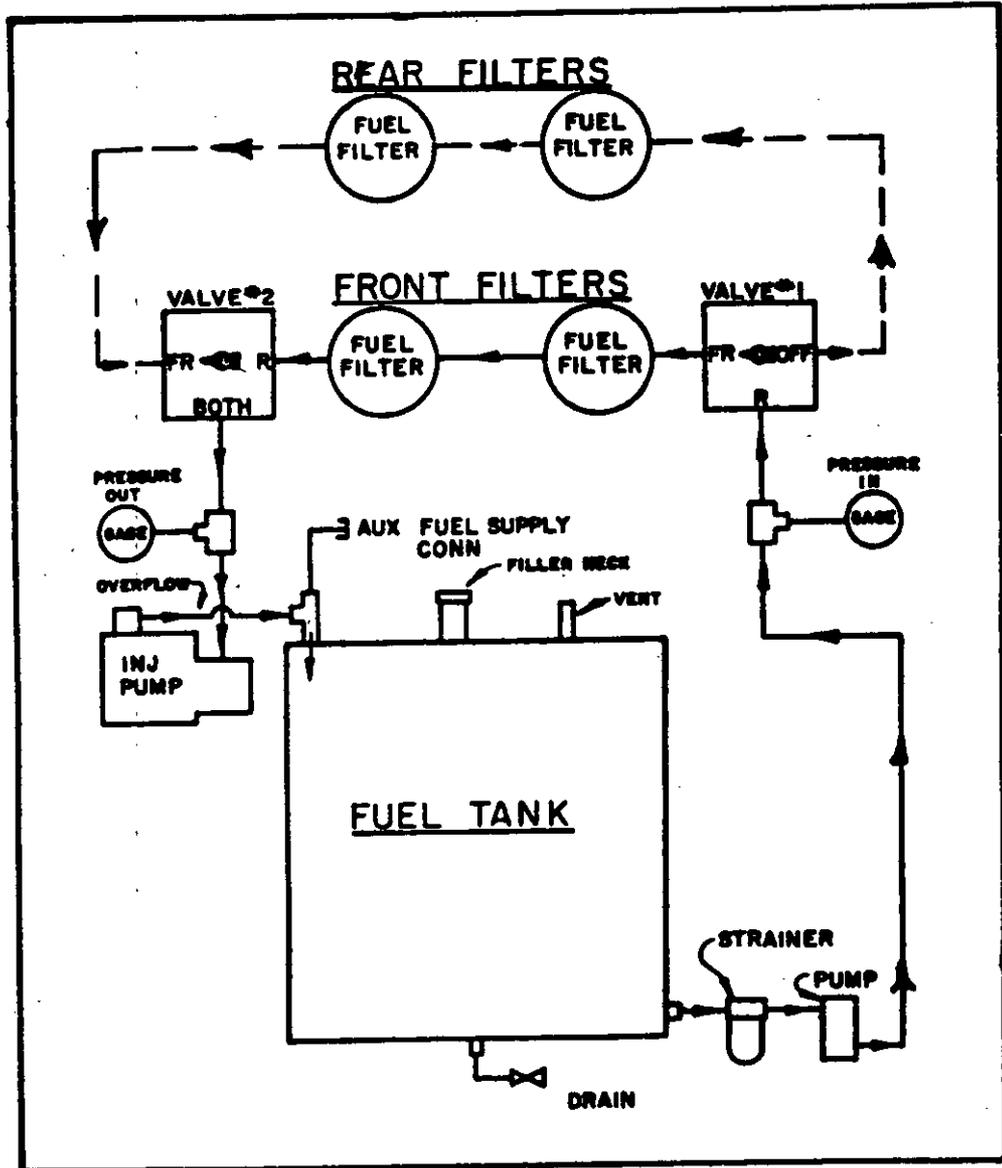


Block Functional Example

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Symbolic Functional Example



Line Drawing Block Example

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2. Pictorial.

Requirements

Show physical view of components; show relative location and size faithfully only when doing so aids understanding of relevant information.

Methods

Use line drawings (trace from photographs when possible) or photographs. (Line drawings are preferred - - halftone photographs usually do not meet the requirements for clarity set forth in the section on Illustration Development.)

NOTE

When necessary to portray position or relative location, other equipment items may be shown in phantom

Identify all maintenance significant functional components.

Use leader lines to identify components.

Show direction of mechanical action or fluid flow.

Use arrowheads to indicate direction.

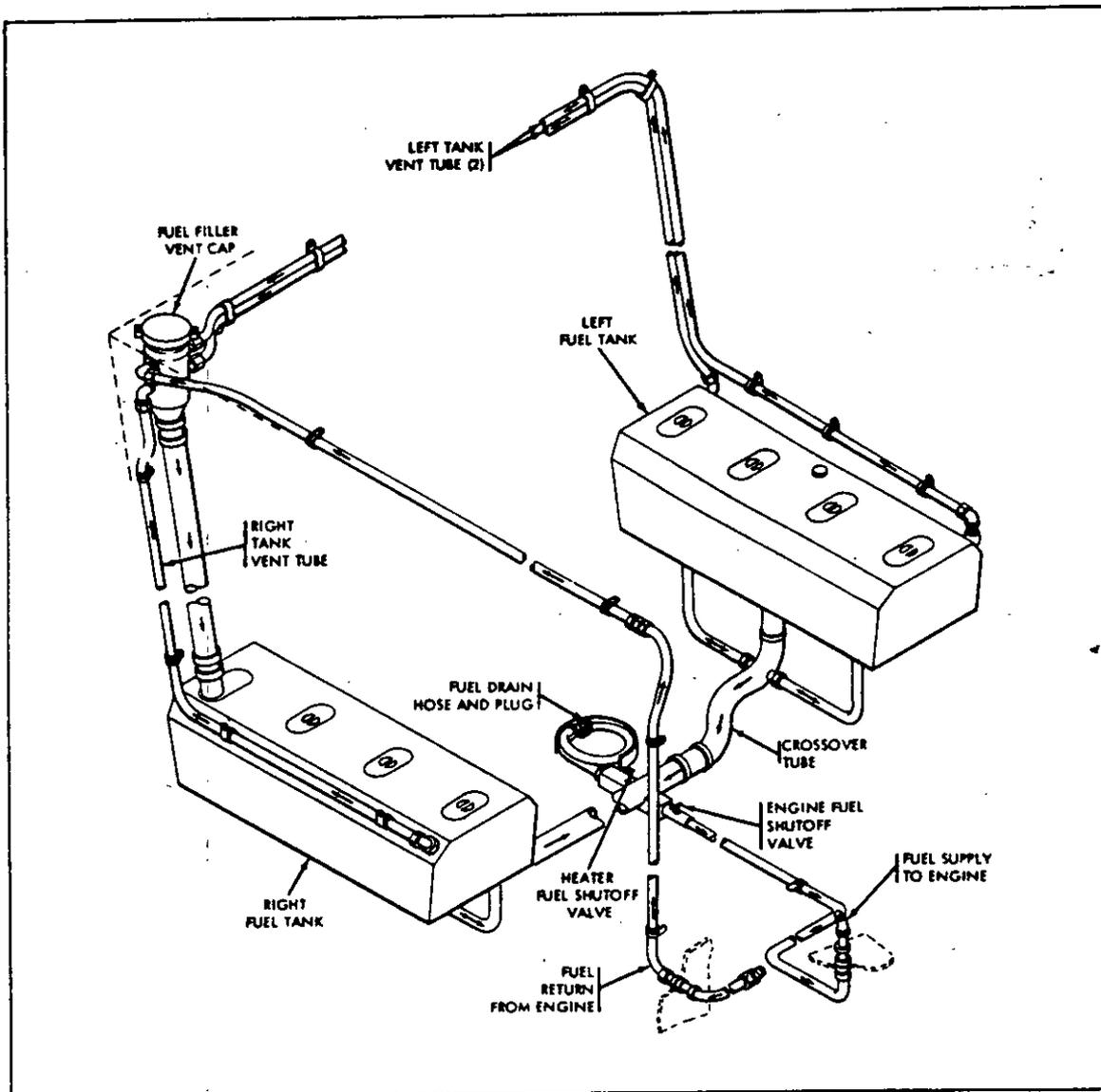
Present data from user's viewpoint.

Use only orientations that are clearly visible to user.

Show waveform data pictorially.

Use photographs and show all necessary data.

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Pictorial Schematic Example

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3. Cutaway.

Requirements

Use only when necessary to show internal functioning or flow.

Identify all fluid flow.

Methods

Use conventional cutaway techniques.

Use different zips to portray different flows; use color only when approved by procuring agency.

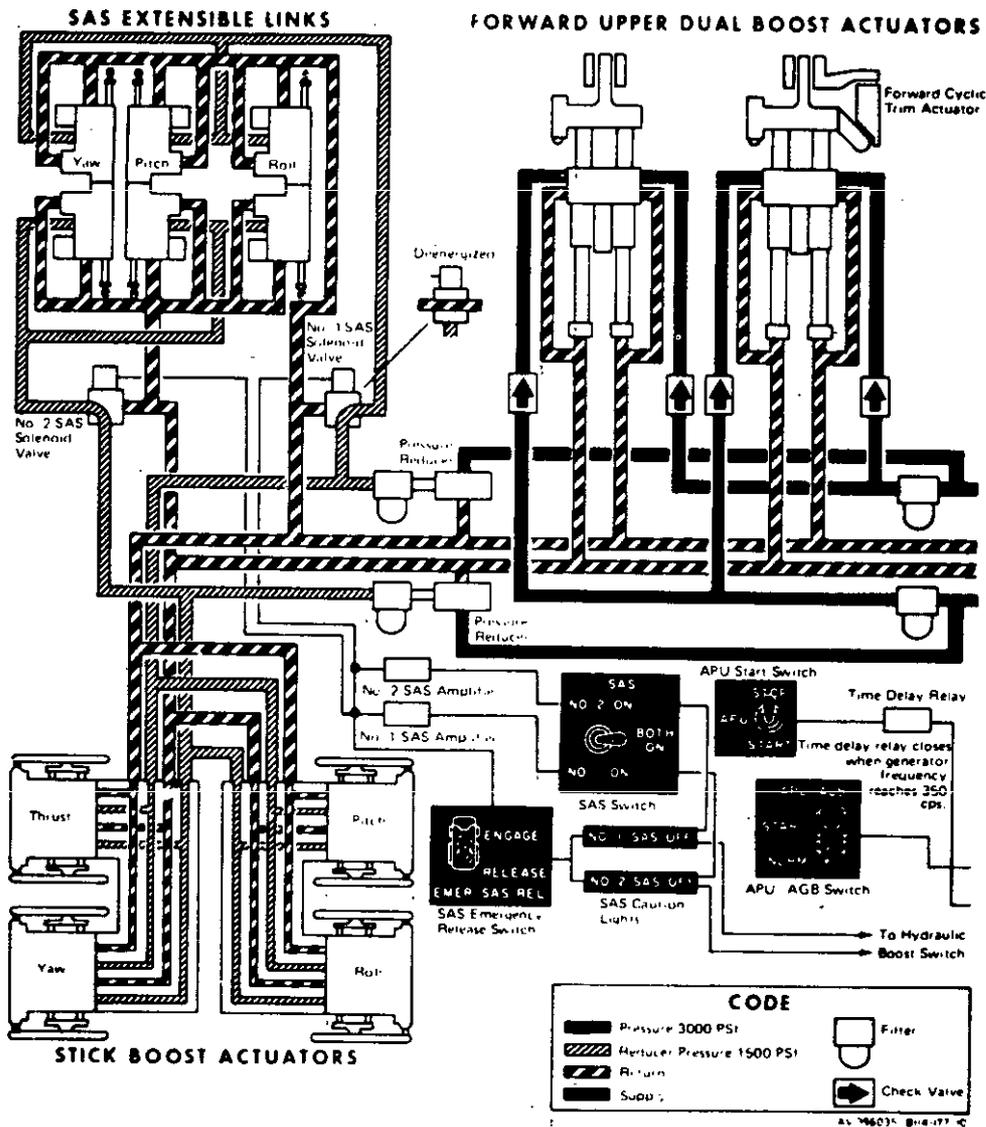


Figure 2-32. Flight control hydraulic system (Sheet 1 of 2)

Cutaway Schematic Example

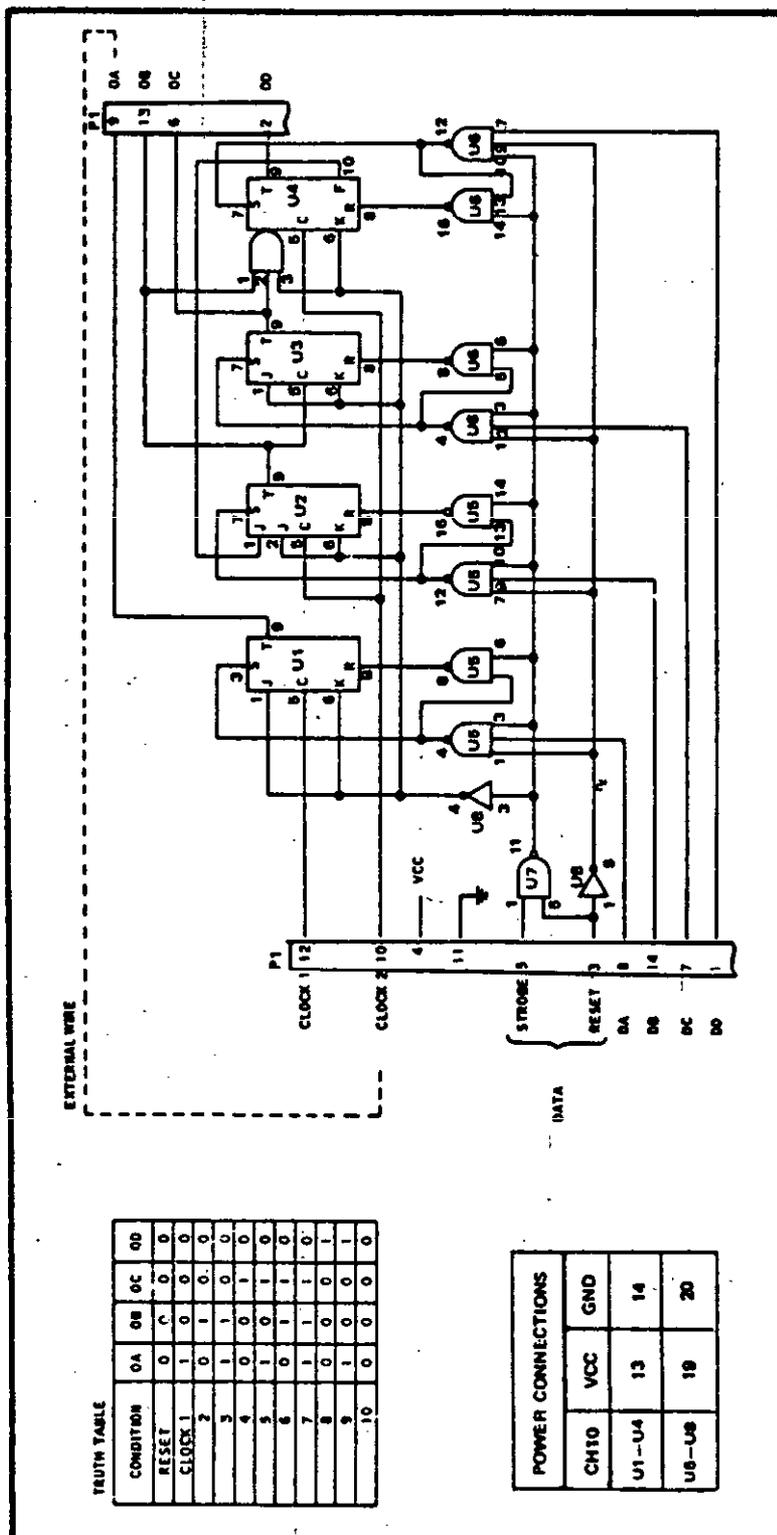
4. Logic.

<i>Requirements</i>	<i>Methods</i>
Show digital circuitry operation.	a. Use graphic symbols from ANSI Y32.14. b. If logic circuit has no specified symbol, identify with rectangle that is labeled to show all circuit functions.
Identify power and clock connections.	Provide truth table (as shown on example) or connect using breakoff signal.
When necessary for clarity, add truth table or timing diagram.	Integrate into diagram - see example for truth table - or reference from diagram - see Text Associated with Illustrations.

NOTE

For logic functions, truth table or timing diagram may be shown inside of block to describe relation of input to output signals.

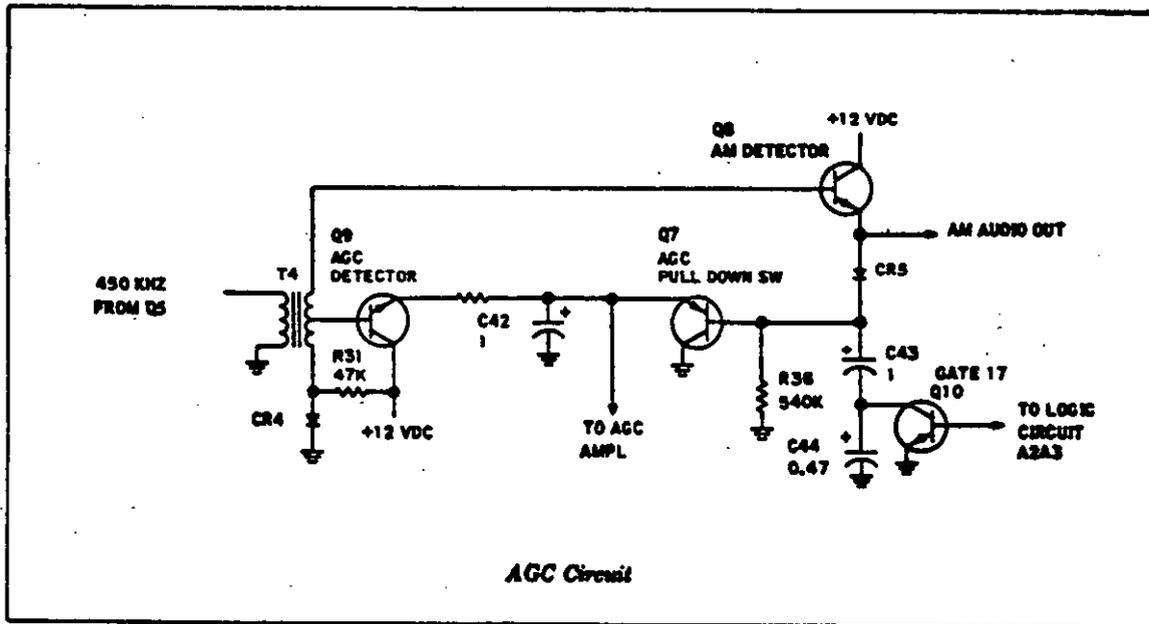
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Logic Schematic Example

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6. *Partial*. Show all circuit details completely - reference all destinations of input or output connections.



Partial Schematic Example

7. *Indicator*.*Requirements*

Show all inputs and controls involved in activating indicator(s).

NOTES

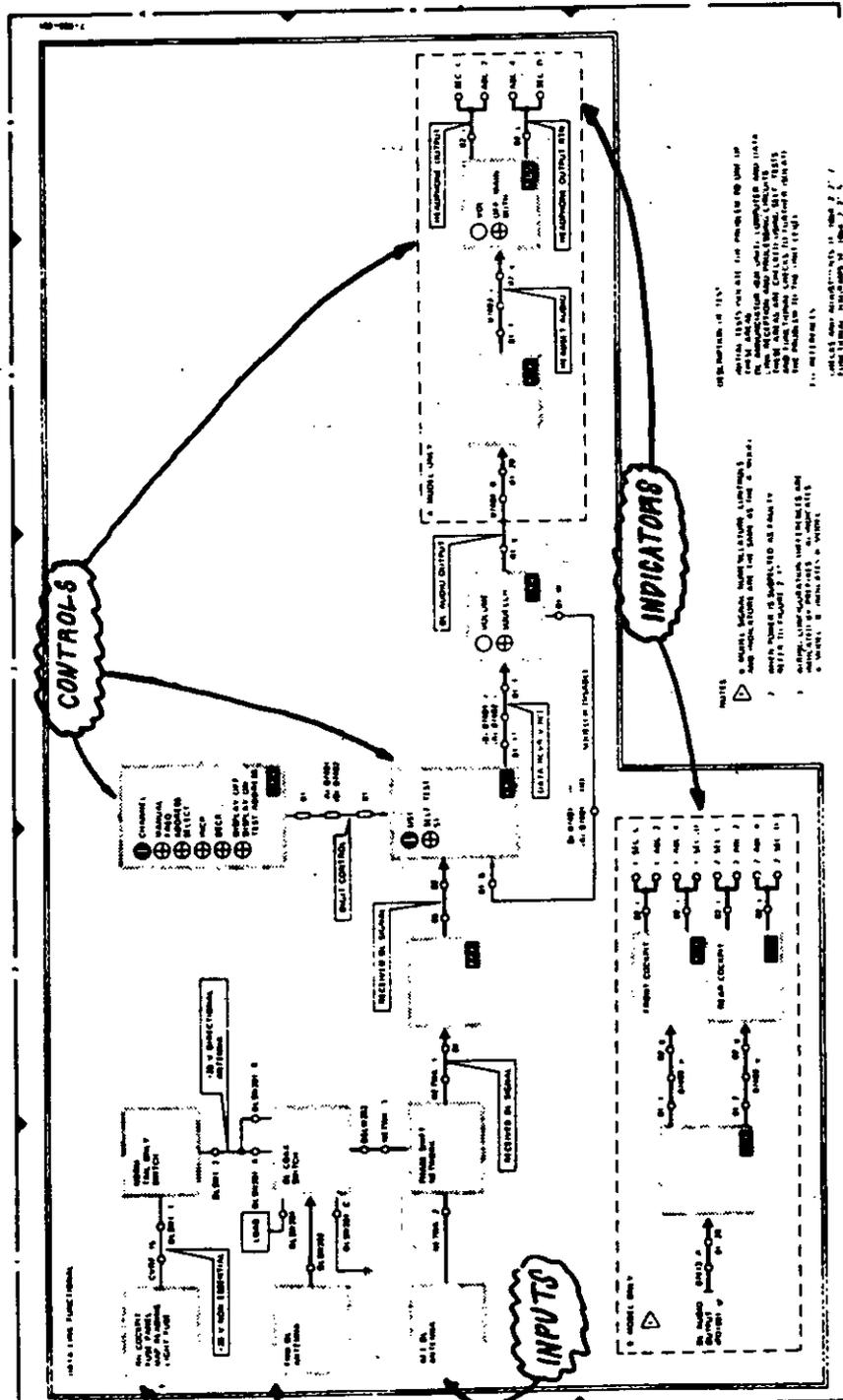
1. B-model signal nomenclature, controls, and indicators are the same as the A-model.
2. When power is suspected as faulty refer to figure 2-17.
3. Wiring configuration differences are indicated by prefixes (a) indicates A-model, (b) indicates B-model.

DESCRIPTION OF TEST

INITIAL tests isolate the problem to one of these areas:

SL annunciator (034 unit), computer and data link reception and processing circuits.

These areas are checked using self-tests and functional checks to further isolate the problem to the unit level.



T.O REFERENCES

- Checks and adjustments IF 106a 2 27 2
- Functional diagrams IF 106A 2 27 5

Indicator Functional Example

MIL-HDBK-63038-1A (TM)

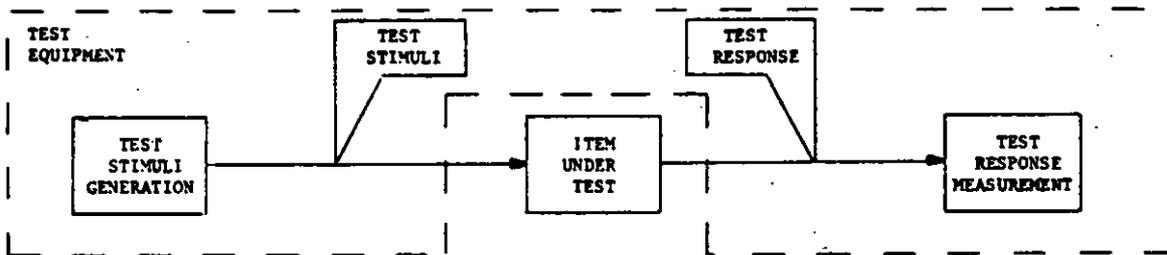
8. Test.

Requirements

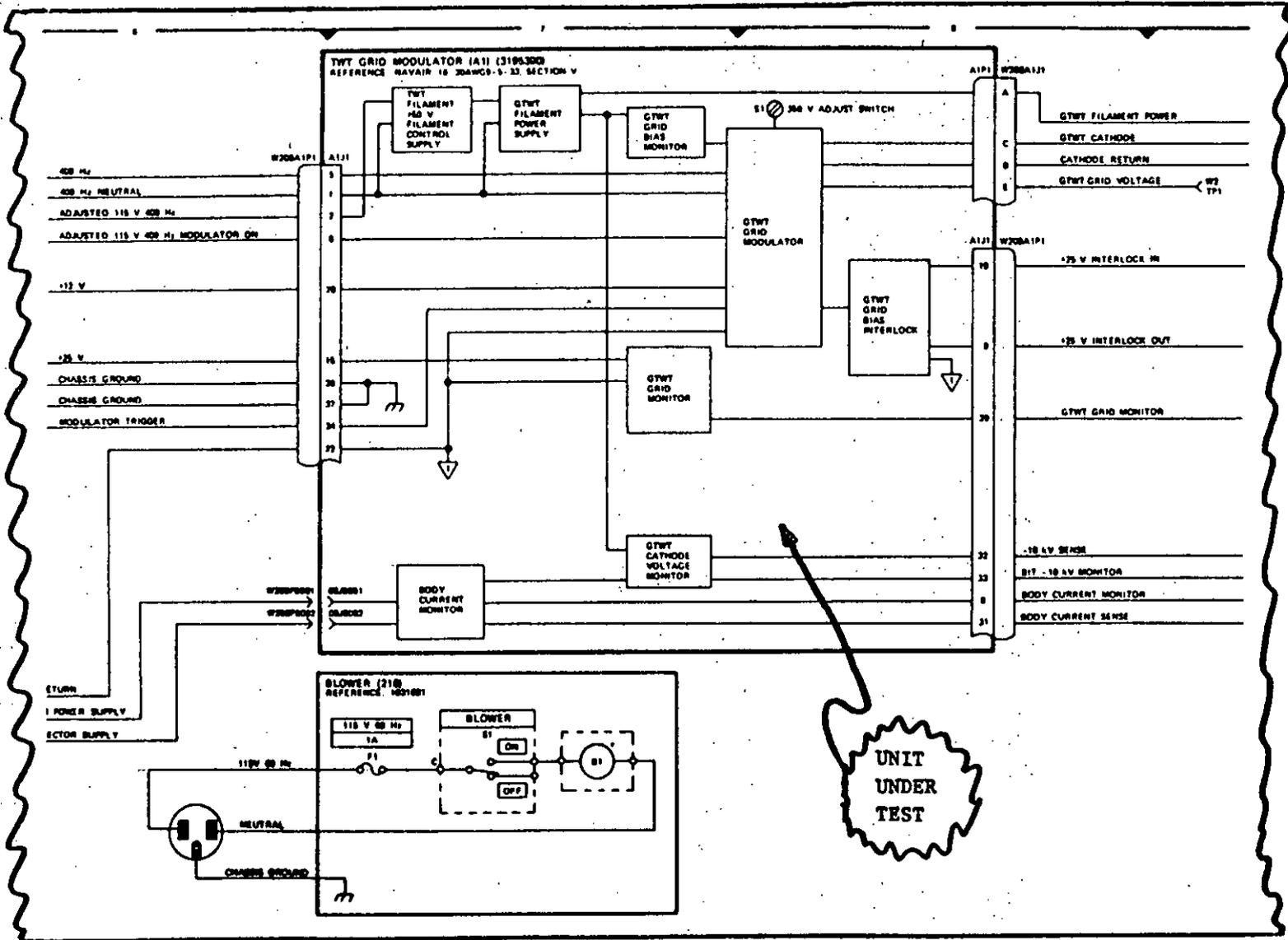
Show test stimuli, item (or circuitry) under test, and test measurement components.

Methods

When diagrams exist for item under test, a block diagram representation may be used (as in example).

**NOTE**

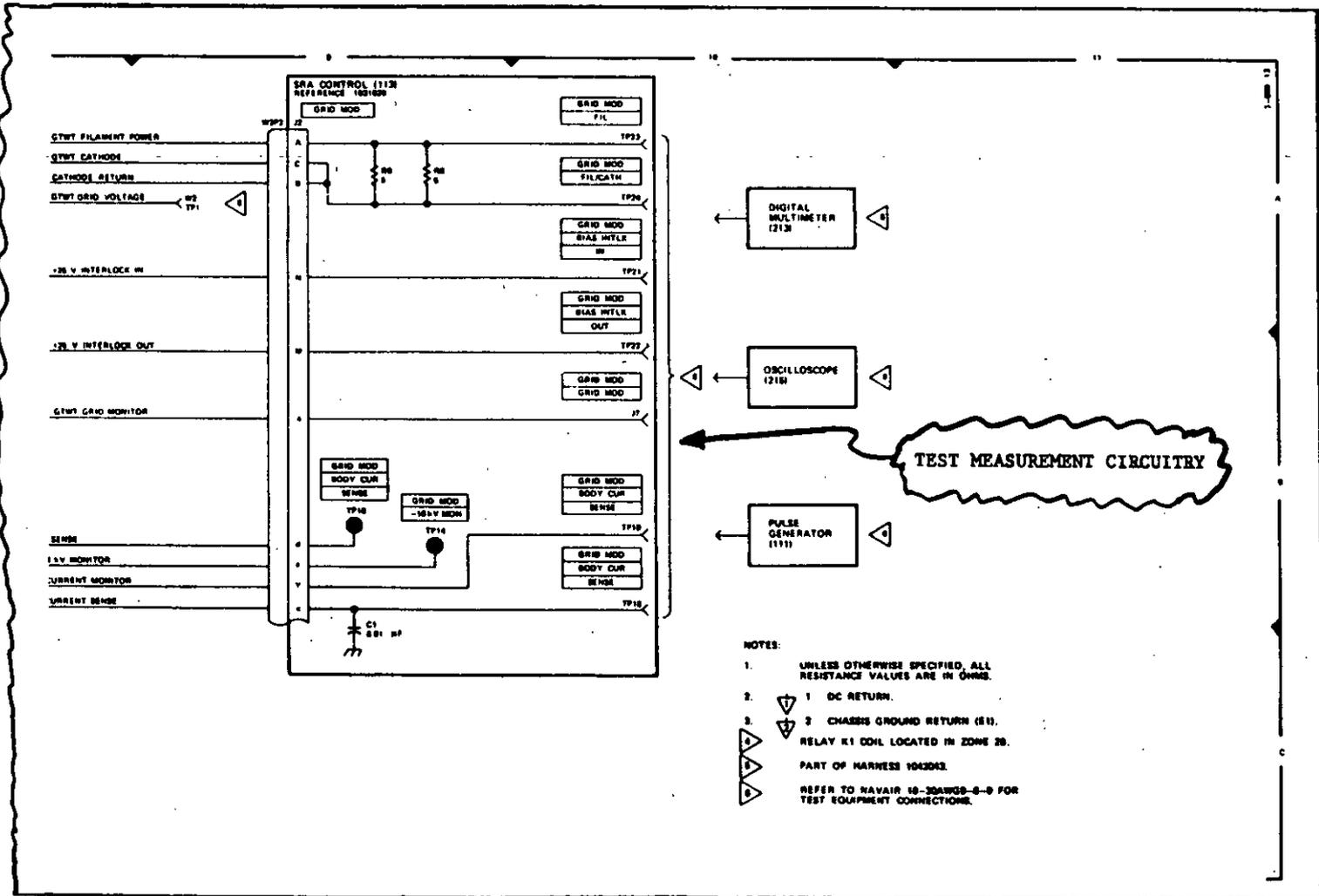
In test manuals, the Item Under Test is emphasized (shown in detail). In test equipment maintenance manuals, the test equipment is emphasized.



Test Example (Sheet 2 of 3)

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UNIT UNDER TEST



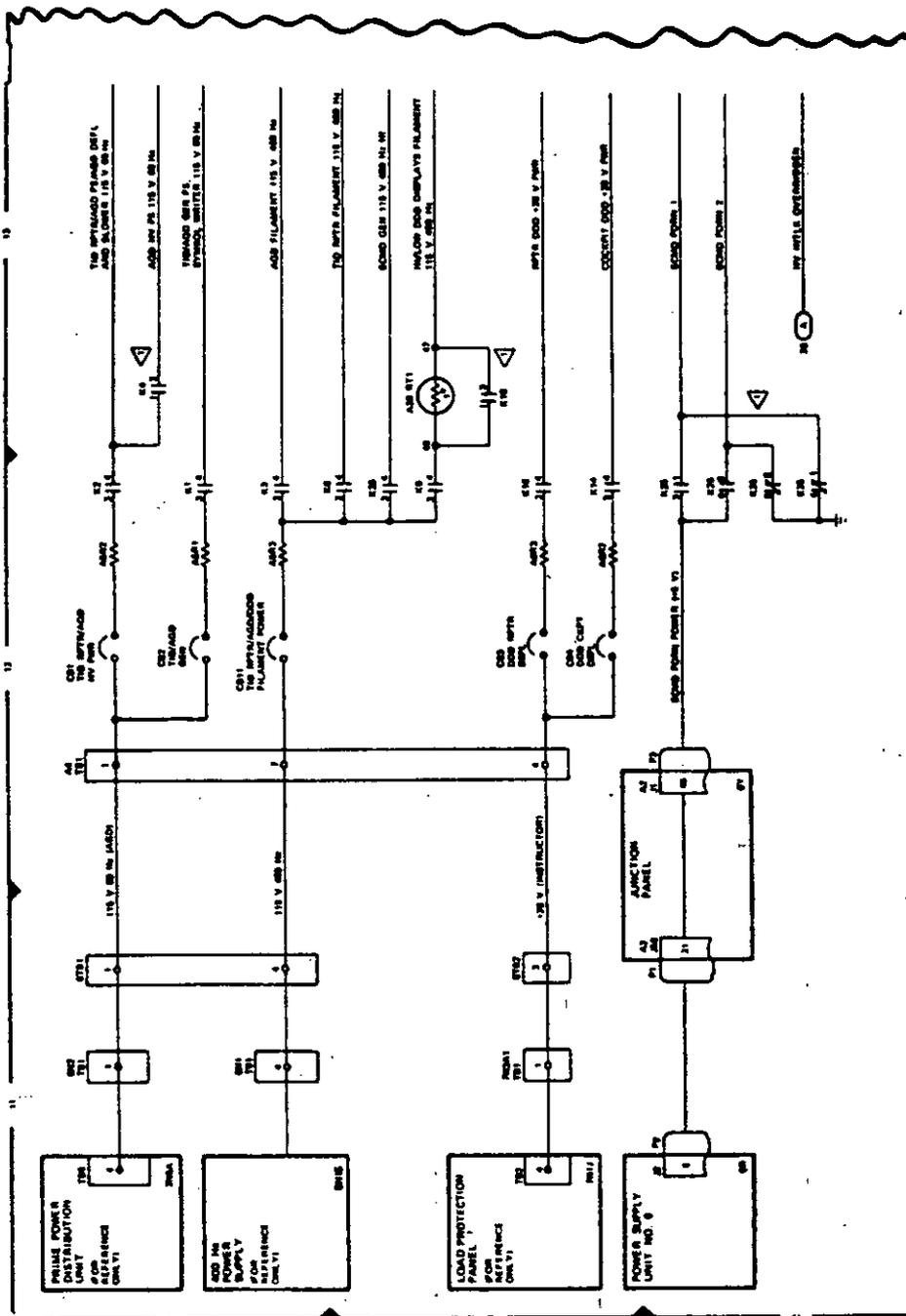
Test Example (Sheet 3 of 3)

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MIL-HDBK-63038-1A (TM)

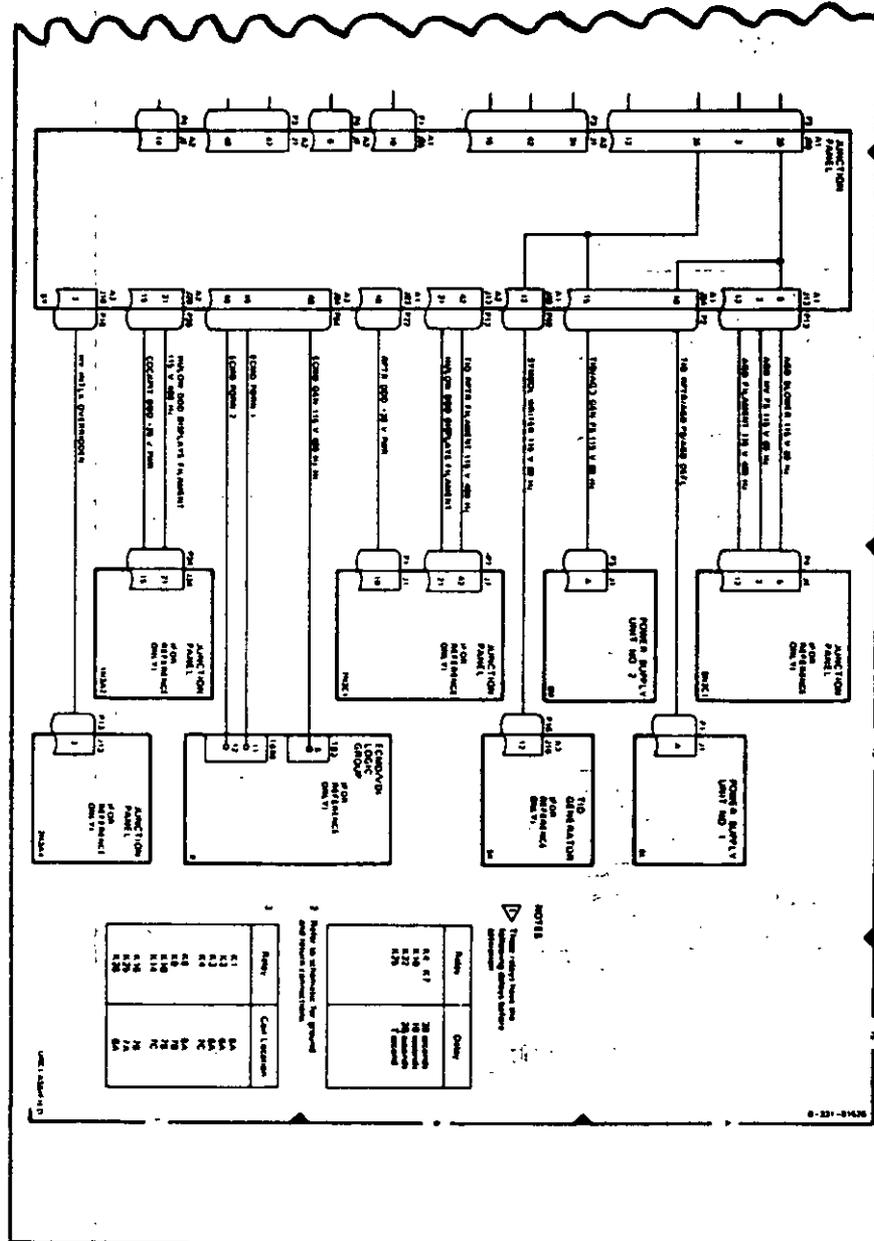
9. Troubleshooting. See section on Troubleshooting.

10. Power Distribution.



Power Distribution Example (Sheet 1 of 2)

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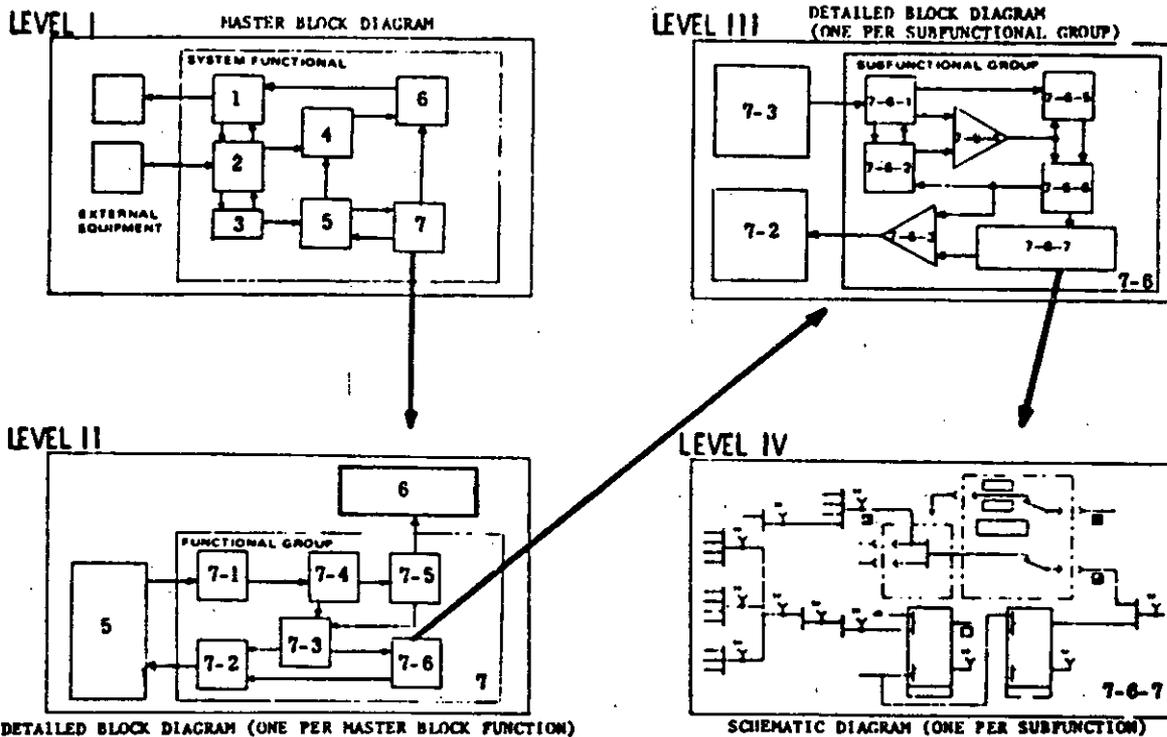
Power Distribution Example (Sheet 2 of 2)

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Pyramid. Pyramid diagrams are a set of interrelated diagrams which consist of:

- a. A master block diagram
- b. Detailed block diagrams
- c. Schematic diagrams

If the equipment covered is complex, several levels of detailed block diagrams may be required.



Interrelation of Pyramid Diagrams

Section 19

WIRING/INTERCONNECTION DATA

	Page		Page
Overview	1	Requirements	1
Methods and Requirements	1	Cable Diagram	1
Objectives and Principles	1	Wiring Diagram	4
		Wire List	6
		Selection Criteria	6

OVERVIEW

Most systems involving electrical or electronic components have some kind of wiring or cabling between those components. Technical manuals supporting systems which have wiring or cabling should include interconnection information in one or more forms. The forms available are:

- a. Cable diagrams
- b. Wiring diagrams
- c. Wire lists

Other useful information can be found in the following sections:

- a. Schematic and Functional Diagrams.
- b. Illustration Development

METHODS AND REQUIREMENTS

Objectives and Principles

All interconnection information should have the following characteristics:

- a. Information keyed to appropriate maintenance level.
- b. User experience level requirements met.
- c. Diagrams simple and straightforward.
- d. Only required data on diagrams.

Requirements

Cable Diagram. Cable diagrams provide all the information necessary to make the electrical

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connection between assemblies, chassis, bays, units, and systems in an easily understood format for:

- a. Installation
- b. Assembly or disassembly
- c. Modification
- d. Service

Each cable diagram consists of an illustration and accompanying table, as shown in the adjacent example

The illustration may be either a composite photograph or a two-dimensional line sketch and shall be in accordance with the following requirements:

- a. View shows all related connectors.
- b. Assembly names and jack numbers given exactly as in list.

The table is essentially a list which meets the following requirements:

- a. Cable entries listed in numerical order or by preferred connection sequence.
- b. Cable origin precedes cable destination
- c. Cable origin and destination include assembly name, assembly jack number, and cable plug number

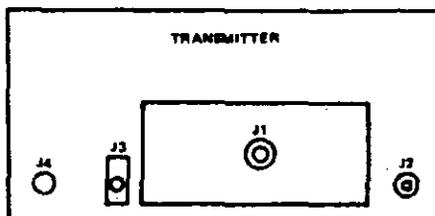
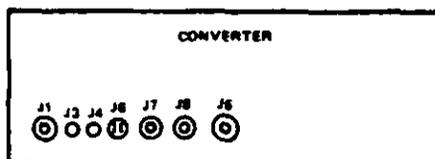
If cable routing is of a special nature, it shall be so noted. For very complex systems, where routing is of great importance, additional diagrams showing desired cable locations may be necessary.

Both list and illustration should appear on the same page. If not feasible, they should be placed on facing pages.

For simple equipment a table may not be needed and pictorial diagram that actually shows the routing may be substituted.

Example of simple cable diagram

CABLE	FROM			TO		
	ASSEMBLY	JACK	CABLE PLUG	ASSEMBLY	JACK	CABLE PLUG
W101	CONVERTER	J1	P1	RECEIVER	J3	P2
W102	CONVERTER	J6	P1	RECEIVER	J1	P2
W103	CONVERTER	J7	P1	TRANSMITTER	J2	P2
W104	CONVERTER	J8	P1	RECEIVER	J2	P2
W106	CONVERTER	J6	P1	TRANSMITTER	J3	P2
W108	CONVERTER	J3	P1	TRANSMITTER	J4	P2
W107	CONVERTER	J4	P1	TRANSMITTER	J1	P2



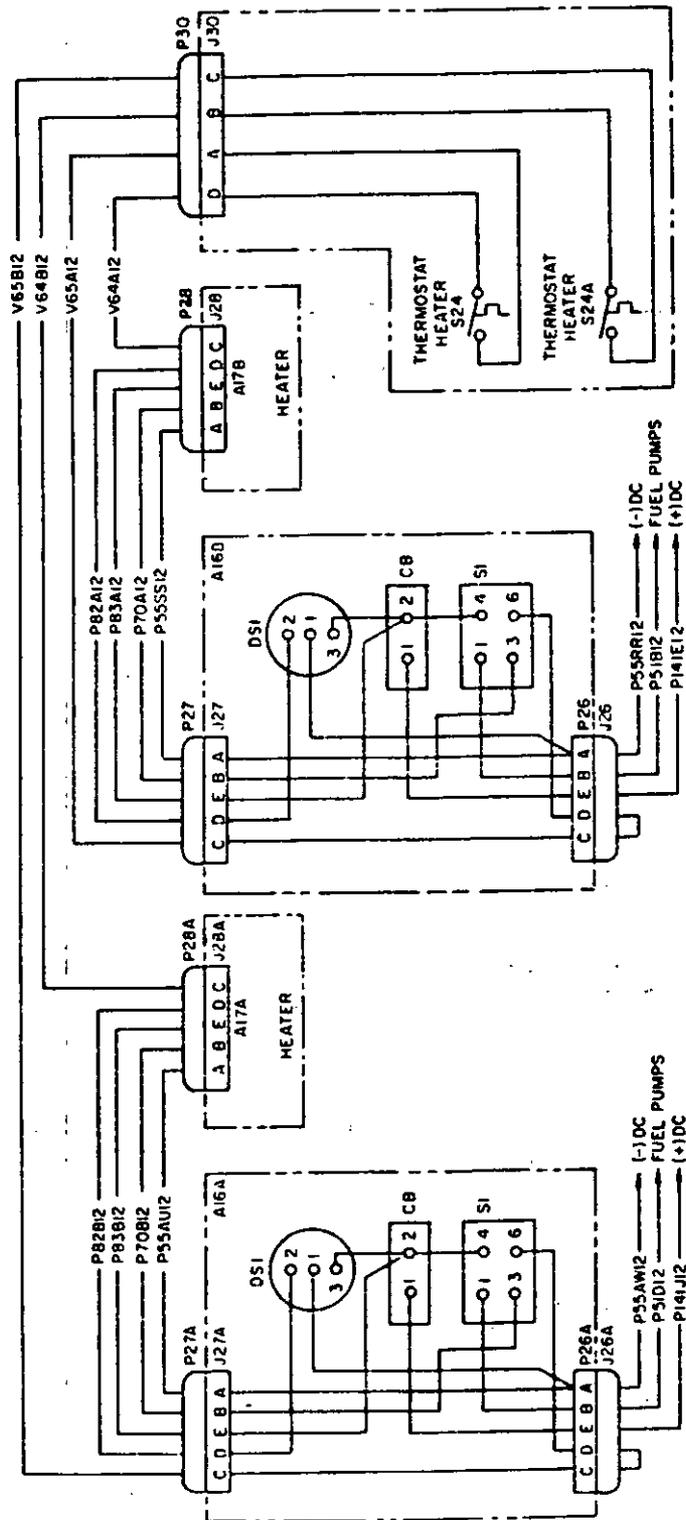
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Wiring Diagram. Wiring diagrams provide an illustration of signal flow. They may also be used to show how to connect wires. Unlike a cable diagram, however, many of the wires in a wiring diagram may be permanently attached by the equipment manufacturer.

For usable wiring diagrams follow these guidelines:

- a. Limit each drawing to an individual system to eliminate overly large foldout illustrations that would be confusing to the user.
- b. Show point-to-point wiring between connectors and terminals.
- c. Show continuity of wiring through junction boxes and other equipment to permit following the wires from their origin to their termination.
- d. Use terminal, connector, and wire identifiers that appear on the hardware.
- e. Assign signal codes to wires to help the user follow signals in equipment that has complex wiring.
- f. Show only the wiring that is appropriate for the level of maintenance for which the manual is written.
- g. Include a list of components giving the reference designation, nomenclature, location, and access cover (as applicable) for every component on each diagram.
- h. Use heavier lines for component outlines than for wires.
- i. Label every wire or wire segment with its wire number.
- j. Minimize crossing lines with a layout that has no more than 20 line intersections in any 4 square inch area.
- k. Avoid landscaping any wiring diagram.
- l. Use a logical, easy to follow technique to show wire continuation onto other diagrams.

Also see ANSI Y14.15.



Example of Wiring Diagram

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Wire List. Wire lists provide wiring data in a tabular format. For usable wiring lists follow guidelines:

- a. Create one table that is in hardware number numerical order.
- b. Create another table that is in signal code numerical order.
- c. List from wire origin to wire destination.
- d. List terminal, connector, and wire identifiers that appear on the hardware.
- e. List only the wiring that is appropriate for the level of maintenance for which the manual is written.

Also see Section 18 and ANSI Y14.15.

Selection Criteria

Cable Diagram. Provide a cabling diagram if the technician must install or remove cables when performing installation, assembly/disassembly, modification or service.

Wiring Diagram. Provide wiring diagrams for medium complexity assemblies in which the technician must fault isolate and repair wiring. If complete coverage of wiring is included in schematic, no special wiring diagrams are required.

Wire List. Provide wire lists for cables and complex wire runs that the technician must fault isolate and repair. Include connector keying diagrams when necessary.

Example of Wire List

Table 4-9. Wiring Data Table - Continued

FROM	SMD GRP	WIRE ID	TO	SMD GRP	ROUTE CODE	FROM	SMD GRP	WIRE ID	TO	SMD GRP	ROUTE CODE
A17 (Cont)						A17 (Cont)					
J2-A		381	A17 J1-A			TB1-8		386H	TB12-8		A-D
J2-B		382	A17 J1-B			TB1-9		389	S6-2		
J2-C		383	A17 J1-C			TB1-9		386J	TB12-9		A-D
J2-D		384	A17 J1-D			TB1-10		380	S7-2		
S1	FS	385	A39	FT		TB1-10		386K	TB12-10		A-D
S1-1		351	A17 TB1-1			TB2		387	TB13		A-D
S1-2		BLK385	A39			TB2-1		376	S2-1		
S1-3		353	A17 TB1-3			TB2-1		387A	TB13-2		A-D
S1-4		352	A17 TB1-2			TB2-2		388	TB13-4	1	A-D
S1-5		RED385	A39			TB2-2		387B	TB13-4	2	A-D
S1-6		354	A17 TB1-4			TB2-3		389	TB13-6		A-D
S2-1		368	A17 S3-1			TB2-3		387C	S8-2		
S2-1		376	A17 TB2-1			TB2-4		361	TB12-11		A-D
S2-2		355	A17 TB1-5			TB2-4		387D	S9-1		
S3-1		368	A17 S2-1			TB2-5		362	TB12-12		A-D
S3-1		369	A17 S4-1			TB2-5		387E	S9-2		
S3-2		356	A17 TB1-6			TB2-6		363	TB12-13		A-D
S4-1		369	A17 S3-1			TB2-6		387F	S9-3		
S4-1		370	A17 S5-1			TB2-7		364	TB12-14		A-D
S4-2		357	A17 TB1-7			TB2-7		387G	S10-1		
S5-1		370	A17 S4-1			TB2-8		365	TB13-12		A-D
S5-1		371	A17 S6-1			TB2-8		387H	S10-2		
S5-2		358	A17 TB1-8			TB2-9		366	TB13-13		A-D
S6-1		371	A17 S5-1			TB2-9		387J	S10-3		
S6-1		372	A17 S7-1			TB2-10		367	TB13-14		A-D
S6-2		359	A17 TB1-9			TB2-10		387K			
S7-1		372	A17 S8-1			A18					
S7-1		373	A17 S8-1			E1		705	STP	FU	
S7-2		360	A17 TB1-10			STP	FU	705	E1		
S8-1		373	A17 S7-1			J1-A		416	P10-A		
S8-1		374	A17 S9-4			J1-A		420	J2-A		
S8-2		361	A17 TB2-4			J1-B		417	P10-B		
S9-1		362	A17 TB2-5			J1-B		421	J2-B		
S9-2		363	A17 TB2-6			J1-C		418	P10-C		
S9-3		364	A17 TB2-7			J1-C		422	J2-C		
S9-4		374	A17 S8-1			J1-D		419	P10-D		
S9-4		375	A17 S10-4			J1-D		423	J2-D		
S10-1		365	A17 TB2-8			J2-A		420	J1-A		
S10-2		366	A17 TB2-9			J2-B		421	J1-B		
S10-3		367	A17 TB2-10			J2-C		422	J1-C		
S10-4		375	A17 S9-4			J2-D		423	J1-D		
TB1		386	TB12		A-D	S1	FU	424	A40		FV
TB1-1		351	A17 S1-1			S1-1		390	A18 TB1-1		
TB1-1		386A	TB12-1		A-D	S1-2		BLK 424	A40		
TB1-2		352	A17 S1-4			S1-3		392	A18 TB1-3		
TB1-2		386B	TB12-2		A-D	S1-4		391	A18 TB1-2		
TB1-3		353	A17 S1-3			S1-5		RED 424	A40		
TB1-3		386C	TB12-3		A-D	S1-6		393	A18 TB1-4		
TB1-4		354	A17 S1-6			S2-1		407	A18 S3-1		
TB1-4		386D	TB12-4		A-D	S2-1		415	A18 TB2-1		
TB1-5		355	A17 S2-2			S2-2		394	A18 TB1-5		
TB1-5		386E	TB12-5		A-D	S3-1		407	A18 S2-1		
TB1-6		356	A17 S3-2			S3-1		406	A18 S4-1		
TB1-6		386F	TB12-6		A-D	S3-2		395	A18 TB1-6		
TB1-7		357	A17 S4-2			S4-1		408	A18 S3-1		
TB1-7		386G	TB12-7		A-D	S4-1		409	A18 S5-1		
TB1-8		358	A17 S5-2			S4-2		396	A18 TB1-7		

Section 20

ERROR REPORTING

	Page		Page
Overview	1	Methods and Requirements (cont)	
Methods and Requirements	1	Objectives and Principles	1
		Requirements	1

OVERVIEW

Any errors in a technical manual should be reported as soon as possible. User reporting of errors is encouraged by:

- a. Inclusion of tear-out DA Form 2028-2 in the back of the technical manual.
- b. Inclusion of a standard Errors Reporting paragraph in the front portion (Table of Contents page) of the technical manual.

METHODS AND REQUIREMENTS

Objectives and Principles

To be effective, error reporting data in the technical manual must:

- a. Get the user's attention.
- b. Be readily available.
- c. Be easy to fill in with minimum effort.
- d. Assure the user that:
 - (1) The information will reach the responsible agency quickly.
 - (2) He will receive prompt feedback.
- e. Encourage user submission.

Requirements

To encourage error reporting by the user, the technical manual shall include:

- a. One filled-out DA Form 2028-2 (see adjacent sample).
- b. Three blank, tear-out DA Forms 2028-2.
- c. The following statement, which should appear on the Table of Contents page in each publication:

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"You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures please let us know. Mail your letter or DA Form 2028 directly to (insert name of proponent). A reply will be furnished to you."

Example of a Tear-out Error Reporting Form

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL MANUALS

SOMETHING WRONG WITH THIS MANUAL?



THEN... JOT DOWN THE DOPE ABOUT IT ON THIS FORM, TEAR IT OUT, FOLD IT AND DROP IT IN THE MAIL!

FROM: (YOUR UNIT'S COMPLETE ADDRESS)
 CDR, Tooele Army Depot
 ATTN: AMXTE-MAE
 Tooele, UT 84074

DATE 14 January 1975

PUBLICATION NUMBER TM 9-1430-560-20P-3		DATE 22 Feb 74	TITLE Data Processing Station, Guided Missile Systems, Semi- trailer Mounted AN/MSQ-79 (XO-1)
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BE EXACT... PIN-POINT WHERE IT IS				IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:
PAGE NO.	PARA-GRAPH	FIGURE NO.	TABLE NO.	
2-290		151		Item 5 is listed as a Screw but should be listed as a Knob.
4-5		1		In bubble J, callout 8 is depicted as a Washer and in bubble G, callout 8 is depicted as a Terminal Board. Recommend that bubble J callout 8 be changed to callout 2.

NOTE TO READER:

Your comments will go directly to the cataloger responsible for this manual, and he will prepare the reply that is returned to you. To help him in his evaluation of your recommendations, please explain the reason for each of your recommendations, unless the reason is obvious.

All comments will be appreciated, and will be given immediate attention. Handwritten comments are acceptable.

For your convenience, blank "tear out" forms, preprinted, addressed, and ready to mail, are included in this manual.

TYPED NAME, GRADE OR TITLE, AND TELEPHONE NUMBER
JAMES M. FOWLER, Autovon 2263
 Ac: Frmn, Mah Comp Rbid Sec, EFC Br

SIGN HERE:


DA FORM 2028-2 (TEST)

P.S.--IF YOUR OFFICE WANTS TO KNOW ABOUT YOUR MANUAL "FIND" MAKE A CARBON COPY OF THIS AND GIVE IT TO YOUR HEADQUARTERS.

Section 21

READABILITY/USABILITY

	Page		Page
Overview	1	Usability Principles	2
Readability Principles	1		

OVERVIEW

This section discusses:

- a. Factors in a technical manual which contribute to easy, practical use of information and instructions.
- b. Principles which a "usable" manual should contain.

READABILITY PRINCIPLES

Where narrative text is concerned, it should be made up of simple words, simple sentences, and simple ideas as much as possible.

- a. Physical characteristics of the words.
 - (1) Minimize the average word length.
 - (2) Minimize the average number of syllables in a word.
 - (3) Avoid using compound and hyphenated words.
- b. Physical combinations of words (sentences).
 - (1) Minimize the average sentence length (*i.e.*, number of words).
 - (2) Reduce the use of modifiers such as adjectives, adverbs, or multiword nouns.
 - (3) Avoid verbal connectives (e.g., and) which result in compound sentences.
- c. Word meaning familiarity.
 - (1) Use words that are frequently used in the general population.
 - (2) Use words that have been tested for comprehensibility of particular educational levels.
 - (3) Use verbs that are commonly used by particular technical populations, and defined as most frequently used by that population.

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(4) Use words of a technical nature with which particular groups of technicians are trained to be familiar.

d. Sentence structure.

(1) Maintain as much as possible a fixed order (subject, verb, object).

(2) Employ simple, active, affirmative, declarative sentences as much as possible.

See MIL-M-38784 for readability standards and sampling.

USABILITY PRINCIPLES

Accessibility

Make it easy to find a particular portion (page) of a manual quickly or determine which page contains the needed information. (Finding the specific bit of information in the portion or on the page is covered under perceptibility on page 21/3.)

Accuracy

Ensure all information is correct and up to date.

Appropriateness of User's Experience Level.

Provide details for the novice; provide highlighted or checklist information for the experienced technician.

Completeness

Provide all necessary or essential information—eliminate the need to get additional information as the job progresses.

Consistency

Use the same names, terminology, style, format, usage, etc., for the same purpose throughout the manual—avoid causing the user to guess the meaning when subtle variations are employed.

Continuity

Provide continuous coverage and easy transition between different types of information—from procedures to troubleshooting, from troubleshooting to diagrams, from diagram to associated theory, etc.

Convenience

Make it easy to handle, store, and hold information—make it easy to use information in the environment.

Familiarity

Use common terms and names—always go from the familiar to the new.

Legibility

Produce and display letters, symbols, and lines on a page so they can be deciphered, recognized, and traced easily because their formation is sufficiently visible. (Obviously, if a word cannot be deciphered, it cannot be read or understood; if a letter or symbol is destroyed by wear in the crack of a folded sheet—or lost in the binding—legibility, and hence usability, suffers. If lines on a schematic are not easily traceable from input to output, the schematic is not easily legible. If too many reproduction processes are used and letters or numbers drop out, legibility and understandability suffer.)

Optimization for Decision-Free Action

Make decisions or do analysis in advance wherever possible—have experts do this once during manual preparation and document their results in the manual. (Some examples are step-by-step, proceduralized troubleshooting, test diagrams, troubleshooting diagrams, and signal code lists.) Including this type of information in the manual both reduces job performance time (the user does not have to make the decision or do the analysis) and reduces errors (the user does not have an opportunity to make mistakes in his decisions or analysis).

Organization

Locate all information required to perform a task close together. Follow logical pattern. Organize for the user—not the writer.

Perceptibility

Make it easy to find a specific bit of information quickly—such as a circuit description, an explanation of a procedural step, the location of a control, etc.—enable the reader to see at a glance the relationship of the information to other facts or thoughts on the page.

Perceptibility includes:

- Effective positioning of information on a page
- Effective pagination
- Spacing—both vertical and horizontal
- Placement of headings
- Use of different type sizes
- Use of blank space

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- Use of attention-getting devices such as—

underlining

italics

boldface type

arrows

leader lines

indenting

special symbols

Pertinence

Exclude unnecessary information—include only essential (but real-world) information for job at hand.

Simplicity

Present material as simply as possible, from the simple to the complex.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL <i>(See Instructions - Reverse Side)</i>	
1. DOCUMENT NUMBER MIL-HDBK-63038-1A (TM)	2. DOCUMENT TITLE Technical Manual Writing Handbook
3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION <i>(Mark one)</i> <input type="checkbox"/> VENDOR <input type="checkbox"/> USER <input type="checkbox"/> MANUFACTURER <input type="checkbox"/> OTHER <i>(Specify):</i> _____
b. ADDRESS <i>(Street, City, State, ZIP Code)</i>	
5. PROBLEM AREAS	
a. Paragraph Number and Wording:	
b. Recommended Wording:	
c. Reason/Rationale for Recommendation:	
6. REMARKS	
7a. NAME OF SUBMITTER <i>(Last, First, MI) - Optional</i>	b. WORK TELEPHONE NUMBER <i>(Include Area Code) - Optional</i>
c. MAILING ADDRESS <i>(Street, City, State, ZIP Code) - Optional</i>	8. DATE OF SUBMISSION (YYMMDD)

(TO DETACH THIS FORM, CUT ALONG THIS LINE)

DD FORM 1426
82 MAR

PREVIOUS EDITION IS OBSOLETE.