MILITARY SPECIFICATION

DISPLAY, HEAD-UP, GENERAL SPECIFICATION FOR

This specification has been approved by the Naval Air Systems Command, Department of the Navy

1. SCOPE

1.1 Scope - This specification covers the general design, performance, and test requirements for procurement of all fixed wing aircraft Head-Up Displays.

1.2 Classification - The equipment covered by this specification shall consist of the following items:

Item	Type Designation	Applicable Paragraph
Pilot's Display Unit (PDU)	(1)	3.5.2
Electronics Unit (EU)	(1)	3.5.3
Control Panel (Optional) (CP)	(1)	3.3.4
Display Unit Mount (DUM)	(1)	3.5.5

1.3 Associated equipment - This equipment shall operate with the associated equipment listed in 6.8.

2. APPLICABLE DOCUMENTS

2.1 General - The following documents of the issue in effect on the date of invitation for bids form a part of this specification to the extent specified herein:

(1) To be designated by the detailed specification for the individual aircraft Head-Up Display, AN/AVQ-( ).

SPECIFICATIONS

Military

MIL-C-172	Cases; Bases, Mounting, and Mounts, Vibration (for use with Electronic Equipment in Aircraft)
MIL-W-5088	Wiring, Aircraft, Installation of
MIL-E-5400	Electronic Equipment, Aircraft, General Specification for
MIL-C-6781	Control Panel; Aircraft Equipment, Rack or Console Mounted
MIL-M-7793	Meter, Time Totalizing
MIL-O-13830	Optical Components for Fire Control Instruments; General Specification Governing the Manufacture, Assembly, and Inspection of
MIL-C-14806	Coating, Reflection Reducing, for Instrument Cover Glasses and Lighting Wedges
MIL-E-17555	Electronic and Electrical Equipment and Associated Repair Parts, Preparation for Delivery of
MIL-T-18303	Test Procedures; Preproduction Acceptance, and Life for Aircraft Electronic Equipment, Format for
MIL-N-18307	Nomenclature and Nameplates for Aeronautical Electronic and Associated Equipment
MIL-T-23103	Thermal Performance Evaluation, Airborne Electronic Equipment, General Requirements for

SPECIFICATIONS (Cont'd)

MIL-C-25050	Colors, Aeronautical Lights and Lighting Equipment, General Requirements for
MIL-C-25516	Connectors, Electrical, Miniature Coaxial, Environment Resisting Type, General Specification for
MIL-C-26482	Connectors, Electric, Circular Miniature, Quick Disconnect, Environment Resisting
MIL-I-81219	Indicator, Elapsed Time, Electrochemical

Naval Air Systems Command

AR-5	Microelectronic Devices Used in Avionics Equipment, Procedures for Selection and Approval of
AR-8	Versatile Avionic Shop Test System, Avionic System Compatibility, General Requirements for
AR-9	VAST Test Programs, General Requirements for
AR-10	Maintainability of Avionics Equipment and Systems, General Requirements for
AR-34	Failure Classification for Reliability Testing, General Requirements for

STANDARDS

Military

MIL-STD-203	Aircrew Station Controls and Displays for Fixed Wing Aircraft
MIL-STD-210	Climate Extremes for Military Equipment
MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment

STANDARDS (Cont'd)

MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-781	Reliability Tests, Exponential Distribution
MIL-STD-785	Reliability Program for System and Equipment Development and Production
MIL-STD-794	Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-810	Environmental Test Methods
MIL-STD-1333	Aircrew Station Geometry for Military Aircraft
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MS 3311	Indicator, Elapsed Time, Electrochemical (Mercury Indicating Cell)
MS 17321	Meter, Time Totalizing, 28v dc, Miniature Digital
MS 17322	Meter, Time Totalizing, 115 Volt, 400-Cycle

2.1.1 Availability of documents - When requesting specifications, standards, drawings, and publications, refer to both title and number. Copies of this specification and applicable specifications required by contractors in connection with specific procurement functions may be obtained upon application to the Commanding Officer, Publications and Forms Center, Code 105, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

3. REQUIREMENTS

3.1 Preproduction - This specification makes provision for preproduction testing.

3.2 Parts and materials - In the selection of parts and materials, fulfillment of major design objectives shall be the prime consideration. In so doing, the following shall govern:

(1) Microelectronic technology shall be considered and microelectronic items shall conform to requirements specified herein.

(2) Other parts and materials requirements shall conform to MIL-E-5400.

(3) Nonrepairable subassemblies shall be used in accordance with AR-10 and as outlined in MIL-E-5400.

(4) When previously produced models of this equipment did not use nonrepairable subassemblies, the design shall not be changed to employ nonrepairable assemblies without the approval of the procuring activity.

3.2.1 Nonstandard parts and materials approval - Approval for the use of nonstandard parts and materials (including electron tubes, transistors and diodes) other than microelectronic devices shall be obtained as outlined in MIL-E-5400. Microelectronic devices shall be approved as outlined in AR-5.

3.2.2 Microelectronic modular assemblies - When used, microelectronic modular assemblies shall meet the requirements of AR-5. Conformal coatings, encapsulants, embedments or potting materials used with modular assemblies containing integrated circuits and discrete parts shall be easily removable without damage to the assembly.

3.2.3 Modules - The electronic portions of the equipment shall be functionally modularized in accordance with AR-10.

3.2.4 Vacuum electronic tubes - Vacuum electronic tubes shall not be utilized except for the cathode ray tube or laser.

3.3 Design and construction - The equipment shall conform with all the applicable requirements of MIL-E-5400 for design, construction and workmanship, except as otherwise specified herein.

3.3.1 Total weight - The total weight of the equipment excluding cables, shall be a minimum consistent with good design and shall not exceed seventy (70) pounds.

3.3.2 Reliability - The contractor shall conduct a reliability program using MIL-STD-785 as a guide. On a reorder from a supplier who has previously produced the equipment, the program previously used may be continued unless otherwise indicated in the contract or order.

3.3.2.1 Operational stability - The equipment shall operate with satisfactory performance, continuously or intermittently for a period of at least 500 hours without the necessity for readjustment of any controls which are inaccessible to the operator during normal use.

3.3.2.2 Operating life - The equipment shall have a total operating life of 10,000 hours or ten years with reasonable servicing and replacement of parts. Parts requiring scheduled replacement shall be specified by the contractor.

3.3.2.3 Reliability in mean time between failure (MTBF) - The equipment, excluding the cathode ray tube, shall have at least 1,000 hours of mean (operating) time between failures when tested and accepted as outlined under the requirements of 4.4.3. The cathode ray tube shall have at least 500 hours of mean (operating) time between failures when tested and accepted as outlined under the requirements of 4.4.3.

3.3.2.4 Time totalizing meter - The following units shall contain time totalizing meters in accordance with MIL-M-7793 or MIL-I-81219.

Unit	Type of Meter
Pilot's Display Unit	MS 17321, MS 17322 or MS 3311 as applicable
Electronics Unit	MS 17321, MS 17322 or MS 3311 as applicable

3.3.3 Cabling and Connections -

3.3.3.1 Cables and connectors - The equipment shall provide for the use of cables and connectors in accordance with MIL-E-5400.

3.3.3.2 Interconnection cabling - The equipment shall be capable of satisfactory operation using external wiring in accordance with the applicable requirements of MIL-W-5088 and the connectors shall be in accordance with MIL-C-26482, or for coaxial connectors MIL-C-25516, as applicable. The

external wiring shall be unshielded except that a minimum number of the individual wires may be shielded when demonstrated as necessary to meet interference control requirements and provided the assembly of the cable to its plugs may be easily accomplished. External cables and that portion of the connectors attached to the cables shall not be supplied as part of the equipment.

3.3.4 Control panels - The HUD may or may not have its own control panel. If the HUD has a control panel, the requirements for the Control Panel Unit shall be designated by the detailed specification for the individual aircraft HUD. All rack or console mounted control panels shall conform to the applicable requirements of MIL-C-6781. The configuration of all control panels must be approved by the procuring activity prior to preproduction testing.

3.3.5 Interchangeability - The equipment shall meet the interchangeability requirements of MIL-E-5400.

3.3.6 Interference control - The generation of radio interference by the equipment and the vulnerability of the equipment to radio interference shall meet the requirements of MIL-STD-461.

3.3.7 Provisions for maintainability - The Maintainability Program, built-in test features, construction and packaging, provisions for test points, and other maintainability parameters shall be as specified in AR-10.

3.3.7.1 Compatibility with VAST - The equipment shall be compatible with the Versatile Avionic Shop Test System (VAST) and shall meet the requirements of AR-5. When required by contract, VAST Test programs shall be furnished in accordance with AR-9. If VAST Test Programs exist for the equipment, and changes to the equipment are made which affect the fault diagnosis procedure, changes to the existing Test Program shall be prepared as part of the equipment changes in accordance with AR-9.

3.3.8 Nomenclature, nameplates and identification marking - Nomenclature and serial number assignment, nameplate approval and identification marking shall be in accordance with MIL-N-18307.

3.3.9 Standard conditions - Unless otherwise specified, the following conditions shall be used to establish normal performance characteristics and for making laboratory bench tests.

Temperature	Room ambient (25° C ± 5° C)
Altitude	Normal ground
Vibration	None

Humidity	Room ambient up to 90% relative humidity
Input Power Voltage	115/200 ± 1.0 V AC and/or 27.5 ± 0.5 V DC 5.0 ± 0.1 V AC or DC
Ambient Lighting	50 to 100 foot candles (538 to 1076 lumens/meter^2 or lux)

3.3.10 Service conditions - The equipment shall operate satisfactorily under any of the environmental service conditions or reasonable combination of these conditions as specified in MIL-E-5400, Class 2 or 2X equipment, except as modified herein.

3.3.11 Warm-up time - The time required for the equipment to warm-up prior to operation shall be kept to a minimum and shall not exceed two minutes at temperatures down to -54° C.

3.3.12 Input electrical power -

3.3.12.1 Operating power - The equipment shall meet all applicable requirements of MIL-STD-704 and shall give specified performance when energized from the following power sources having characteristics and limits as defined in MIL-STD-704. The power required shall not exceed the specified amounts.

(1) AC Power (Single or Three-Phase), 115/200V, Category B, 300 VA.

(2) DC Power, 28V, Category B, 84 Watts.

3.3.12.2 Other power -

3.3.12.2.1 Standby reticle power - The standby reticle lamp shall have a power input separate from any other HUD power input.

3.3.12.2.2 HUD control panel lighting power - Input power for lighting of a HUD control panel shall require not more than 1 amp at 5 volts.

3.3.12.3 Degraded performance - Degraded performance will be permitted for voltage transients not exceeding 0.5 second during normal electric system operation. Operation shall return to normal with no resulting damage to the equipment.

3.3.12.4 Electrical overload protection - The HUD shall contain overload protection devices for all internal power supplies. The protection device shall reset automatically when overload conditions cease to exist.

3.3.13 Cooling -

3.3.13.1 Thermal design - Thermal design shall be in accordance with MIL-E-5400. The Electronics Unit may be forced-air cooled.

3.3.13.2 Operating temperature check point - Each weapons replaceable assembly (WRA) shall have a point accessible on the outer surface of the equipment for monitoring the temperature(s) of the most critical part(s) inside. The operating temperatures of the part(s) selected for the check point shall be determined from the evaluation made in accordance with MIL-T-23103. This check point shall be clearly marked. The installation instruction shall be such that the temperature of the check point shall be maintained within ±6° C. The thermal evaluation shall be in accordance with MIL-T-23103.

3.3.13.2.1 Thermal overload indicator - The HUD shall contain provisions for thermal overload circuits in the PDU and EU which shall indicate to the pilot that a thermal overload exists.

3.3.13.3 Emergency cooling air failure - The entire Head-Up Display system shall continue to operate and meet its specified performance in the event of an airplane air conditioning failure. A mean-time-between-failure time degradation of 50% will be allowed during operation under these conditions.

3.4 Performance - Unless otherwise specified, values set forth to establish the requirements for satisfactory performance apply to performance under both standard and extreme service conditions. When reduced performance under the extreme conditions is acceptable, tolerances or values setting forth acceptable variations from the performance under the standard conditions will be specified.

3.4.1 Operation - The Head-Up Display (HUD) receives computed weapon delivery, navigation, terrain following and landing input data from a central tactical or general purpose computer, airplane performance data from airplane flight sensors, discrete signals from various airplane systems, and electrical power from the aircraft AC and DC busses. The data is processed by the HUD. The HUD uses the processed data to generate animated symbol images which represent essential aircraft performance, command, and situation information. The symbol images are transmitted by optics to a semi-transparent mirror or lens where the symbol images are focused at infinity and superimposed over real world objects.

3.4.1.1 Total system error - The symbol images when viewed from the design eye position defined in MIL-STD-1333 shall not be in error by more than 1.0 milliradians in the central 12° field of view, more than 2.0 milliradians for 12° to 24° annular field of view, or more than 3.0 milliradians for greater than 24° annular field of view.

3.4.2 Storage life - The HUD shall be capable of meeting the requirements of this specification after two years of storage under any combination of climate conditions specified in MIL-STD-210.

3.4.3 Magnetic susceptability - Within the limits set forth in this specification the HUD shall meet operational requirements when exposed to any magnetic field from neutral to two gauss (2×10^{-4} tesla) and from zero fluctuation to 400 Hz.

3.4.4 Certificate of alignment and calibration - A certificate shall be packed with each display unit, electronics unit, and control panel citing the degree of alignment, calibration and compatibility with other units of the same manufacture or of the same military designation. This certificate shall be signed by an officer of the manufacturer and shall include the date of signature. The manufacturer shall maintain a duplicate certificate for at least ten years from date of signature.

3.4.5 Acoustic noise - Unless otherwise specified, the equipment shall be capable of meeting the requirements of this specification when subjected to ambient noise levels up to 130 db (reference 0.0002 dynes/centimeter^2) through a frequency of 20 to 10,000 Hz.

3.4.6 Hermetic sealing - If a repairable portion of the HUD system is hermetically sealed, it shall be so constructed that it may be opened, the contents removed, replaced, and the case resealed. The sealing of the case shall not be dependent upon any material which will be adversely affected by any environment to which it may be subjected in normal use in military aircraft.

3.4.7 Filling medium - If the unit is hermetically sealed, the filling medium shall contain not more than 0.006 milligram of water vapor per liter (dew point -65° C) at the filling pressure. The absolute pressure of the filling medium in the case shall be 1 ± 0.1 atmosphere.

3.4.8 Pressurized units - If a unit of the HUD system is pressurized, it shall be fitted with an automotive type valve fitting, or other type valve approved by the procuring activity. A plug or other device shall be provided to allow for purging. Provision shall also be made for a pressure type of go-no-go gage or desiccant, and a suitable gage or desiccant shall be provided.

3.4.9 Desiccant or pressure-indicator - When necessary, units other than hermetically sealed units shall include an indicator type desiccant or pressure-indicator that can readily be seen, and replenished in the case of a desiccator. If a pressure-indicator is used, it shall be go-no-go type changing indication when the internal atmospheric pressure changes drastically.

3.5 Detail requirements -

3.5.1 Symbology - Symbology for the HUD shall be governed by the constraints imposed by Figures 1 through 36 and as otherwise specified in this specification.

3.5.1.1 Display modes - The Display Unit visual image presentations through the combiner shall be in the format of sets of symbol images called display modes. The display modes shall be:

(a) Takeoff/Navigation (See Figure 24)

(b) Terrain Following (See Figure 25)

(c) Bombing (See Figure 26)

(d) Boresight Weapons (See Figure 27)

(e) Guided Weapons (See Figure 28)

(f) Landing (See Figure 29)

(g) Test (No Figure)

(h) Boresight (See Figure 30)

(i) Standby (See Figure 31)

The symbols to be presented in each of these modes are specified in Table I and Figures 24 through 31.

3.5.1.1.1 Submodes - Modes such as Bombing, Boresight Weapons, and Non-Boresight Missiles may have submodes which shall be designated by the detailed specification of the HUD for a particular aircraft. For example, the Boresight Weapons mode may have a guns submode and a rockets submode.

3.5.1.1.1.1 Group A symbols - The Group A symbols shall be the velocity vector, flight director, target, aiming reticle, runway, and angle of attack error symbols.

3.5.1.1.1.2 Group B symbols - The Group B symbols shall be the bomb fall line, first optimum weapon release cue, second optimum weapon release cue, pull up anticipation cue, and pitch and horizon lines symbols.

TABLE I

SYMBOL TYPE CLASSIFICATION FOR EACH MODE

Group	SYMBOL \ MODE	Takeoff/ Navigation	Terrain Following	Bombing	Boresight Weapons	Guided Weapons	Landing	Boresight	Test	Standby
A	Velocity Vector	1	1	1	1	1	1			
A	Flight Director	1	1	1	1	1				
	Breakaway	1	1	1	1	1	1			
	Warning Indicator	1	1	1	1	1	1			
B	Horizon Line	1	1	1	1	1	1			
B	Pitch Lines (Attitude)	2		2	2	2	2			
	Heading	2	2	2	2	2	2			
	Vertical Velocity	2,3	2,3	2,3	2,3	2,3	2,3			
	Airspeed	2,3	2,3	2,3	2,3	2,3	2,3			
	Mach Number	2,3	2,3	2,3	2,3	2,3	2,3			
	Altitude, Barometric	2,4	2,4	2,4			2,4			
	Altitude, Radar	2,4	2,4	2,4			2,4			
	Closure Rate				2	2				
	Range				2	2				
	Target Designate	1		1	1					
B	Bomb Fall Line			1						
B	First Optimum Weapon Release Cue			1						
B	Second Optimum Weapon Release Cue			1						
B	Pull-Up Anticipation Cue			1						
	Terrain Carpet		1							
	Ordnance Type & No.		1		1	1		1		
A	Aiming Reticle				1					
	Missile Target					1				
A	Angle of Attack Error						1			
A	Runway						1			
	Aircraft Reticle	1								
	Armament Datum Line							1		
	Test Pattern								1	
	Standby Reticle									1

Symbol Type Display Options

Type 1 - Pilot has no option to delete Type 1 symbols.
Type 2 - Pilot has an option to delete all Type 2 symbols at one time.
Type 3 - Pilot has choice of displaying Vertical Velocity, Airspeed, or Mach Number.
Type 4 - Pilot has choice of displaying either Barometric or Radar Altitude.

3.5.1.1.1.3 Scales on submode - When the Scales signal indicates scales on, the tape symbols shall appear and Group A and B symbols shall be able to appear in Region I of the field of view (See Figure 34). When any of the Group A symbols is beyond the boundary of Region I in either one of the cartesian coordinates of the field of view, the symbol shall be positioned along that coordinate next to the boundary and shall flash four times a second. The on and off portions of the flash cycle shall be of approximately equal duration.

3.5.1.1.1.4 Scales off submode - When the Scales signal indicates scales off, the tape symbols shall disappear and Groups A and B symbols shall be able to appear in both Regions I and II of the field of view (See Figure 34). When any of the Group A symbols is beyond the outer boundary of Region II in either one of the cartesian coordinates of the field of view, the symbol shall be positioned along that coordinate next to the boundary and shall flash four times a second. The on and off portions of the flash cycle shall be of approximately equal duration.

3.5.1.1.2 Modes required for each general type of aircraft - The Modes which are required and optional for each general type of fixed winged aircraft shall be as shown in Table II.

TABLE II

Required and Optional Display Modes for Each General Type of Fixed Wing Aircraft

MODE / AIRCRAFT	NAV/TAKEOFF	TERRAIN FOLLOWING	BOMBING	BORESIGHT WEAPONS	GUIDED WEAPONS	LANDING	TEST	BORESIGHT	STANDBY
Attack	R	O	R	R	O	R	R	R	R
Fighter	R	O	O	R	R	R	R	R	R
ASW*	R					R	R	R	O
Reconnaissance	R					R	R	R	O
Transport	R					R	R	R	O
AEW**	R					R	R	R	O

*ASW - Anti-submarine warfare
**AEW - Aircraft early warning

R - Required Mode
O - Optional Mode

3.5.1.2 Symbol size and shape, general requirements - The size and shape of individual symbols shall be as shown in Figures 1 through 23.

3.5.1.2.1 Symbol dimension determination - Unless otherwise indicated, each dimension of each symbol (as shown in the respective figures) is the angle subtended by the symbol and measured at the design eye position defined in MIL-STD-1333.

3.5.1.2.2 Fixed location symbols - The positions of fixed location symbols are shown in Figure 33.

3.5.1.2.3 Symbol linewidth - Symbol linewidth shall be 1.0 ± 0.2 milliradians (2σ) on a black background.

3.5.1.2.4 Alphanumerics - The shape of the alphanumerics which are incorporated as part of other symbology shall be as shown in Figure 13. Unless otherwise specified, each character shall be 1/2° high and 1/3° wide and character spacing shall be 1/6° for this size character.

3.5.1.3 Symbols, individual requirements -

3.5.1.3.1 Velocity vector - The velocity vector shall portray the aircraft's vector velocity by displaying the aircraft flight path direction relative to the outside world. The symbol shall be positioned laterally and vertically with respect to the aircraft's flight reference line and shall not rotate in roll with respect to the airframe. The symbol shall not overlie the tape symbols. In the bombing mode after weapon release the velocity vector shall flash for three seconds at the rate of four times per second. The on and off portions of the flash cycle shall be of approximately equal duration (See Figure 1).

3.5.1.3.2 Flight director - The flight director shall be a fly-to steering command symbol while the aircraft is in the air (and shall be a turn-to steering command while the aircraft is under ground control). When the flight director is centered in the aperture of the velocity vector, the steering command is satisfied. In the Take-off/NAV mode during take-off the flight director symbol shall be located in the center of the horizon line until the aircraft reaches rotation airspeed. When the aircraft reaches rotation airspeed the flight director symbol shall rise to the command angle of rotation of the aircraft. The flight director symbol shall disappear when the airspeed is greater than the rotation airspeed plus 50 knots. In the Take-off/NAV mode the flight director symbol shall show navigation fly-to information when the airspeed is greater than the rotation airspeed plus 50 knots (See Figure 2).

3.5.1.3.3 Breakaway - The breakaway symbol, an "X", shall indicate need for immediate pull-up of the aircraft. Upon data input command, the symbol shall appear and commence blinking at a rate of four flashes per second with a duty cycle of 0.5 (See Figure 16).

3.5.1.3.4 Warning indicator - The warning indicator shall display a warning of critical airplane conditions in all modes. The indicator shall be controlled by a minimum of five parallel sensor inputs (discretes). The inputs shall be:

1. Designated by the detailed specification for the individual aircraft HUD.
2. Hydraulic pressure warning.
3. Oil pressure warning.
4. Engine temperature warning.
5. Fire warning.

The warning indicator shall be a "W" flashing four times a second with a duty time of 0.5 (See Figure 17).

3.5.1.3.5 Horizon line - The horizon line shall represent the true horizon. Movement of the horizon line shall be in a direct one-to-one correspondence with the roll and pitch of the aircraft. The horizon line shall not overlie any part of the tape symbols (See Figure 4).

3.5.1.3.6 Pitch lines - The pitch lines shall represent the aircraft attitude and shall move in a direct one-to-one correspondence with the pitch and roll of the aircraft. The pitch lines shall be parallel to the horizon line and shall be spaced at 5° intervals from the horizon line up to +90° and down to -90°. The pitch degree number of the pitch line shall be written at the extreme ends of the pitch lines every ten degrees starting at -90°. The pitch lines shall not overlie the tape symbols (See Figure 4).

3.5.1.3.7 Tape symbology on the left, right, and top - The tape symbology (i.e. Vertical Velocity, Airspeed, Mach Number, Heading, Barometric Altitude, Radar Altitude and Closure) on the left, right, and top of the field of view shall have the same method of display. Each group of symbols shall consist of a moving tape scale. The actual flight parameter indicator shall be a fixed line segment which points to the center of the tape. The command flight parameter indicator shall be a pointer which points to the tape. The command flight parameter indicator shall remain in view within one degree of the scale when the

command parameter is beyond the range of the tape. When the command flight parameter indicator is centered in the pointer of the actual flight parameter indicator, the command flight parameter is satisfied.

3.5.1.3.7.1 Heading - The heading symbols shall show magnetic heading and command magnetic heading on a moving tape scale at the top of the field of view. The scale shall be in five degree increments. Every ten degree increment shall be numbered with the last digit zero omitted. The scale shall be continuous, i.e. 0° shall follow 355° on the scale (See Figure 5).

3.5.1.3.7.2 Vertical velocity - The vertical velocity symbols shall show vertical velocity and command vertical velocity from -10,000 ft/min to +10,000 ft/min on a moving tape scale on the left side of the observer's field of view. The tape shall be divided into 100 ft/min increments. The 500 ft/min increments shall be numbered with the last two zero digits omitted (See Figure 7).

3.5.1.3.7.3 Airspeed - The airspeed symbols shall show airspeed and command airspeed from 0 to 600 knots on a moving tape scale on the left side of the field of view. The tape shall be divided into ten knot increments. Every 50 knot increment shall be numbered with the last zero digit omitted (See Figure 7).

3.5.1.3.7.4 Mach number - The mach number symbols shall show mach number and command mach number from 0 to 4 on a moving tape scale on the left side of the field of view. The tape shall be divided into 0.1 mach increments. Every 0.5 mach increment shall be numbered (See Figure 7).

3.5.1.3.7.5 Altitude - The altitude symbols shall show barometric or radar altitude and command altitude on a moving tape scale on the right side of the field of view. Barometric altitude shall be shown from (minus) -1000 feet to an altitude to be designated by the detailed specification of the Head-Up Display for a particular aircraft. Radar altitude shall be shown from 0 feet to a radar altitude to be designated by the detailed specification of the Head-Up Display for a particular aircraft. The tape shall be divided into 100 foot increments. Every 500 foot increment shall be numbered with the last two zero digits omitted (See Figure 8).

3.5.1.3.7.6 Closure rate - The closure rate symbols shall give closure of the selected missile target from +1000 knots to -1000 knots. The symbology shall consist of an electronically displayed moving tape on the right of the field of view. The line segments on the tape shall consist of 20 knot increments. Every 100 knot increment shall be numbered starting at -1000 knots with the last zero digit omitted (See Figure 19).

3.5.1.3.8 Range - The range symbology shall display range to target in the Guns, Rockets, and Boresight Missiles and Missile Modes. The range symbology

shall be a non-moving tape scale on the bottom of the display. The range symbology shall appear only when a target has been locked on by sensors. Two stationary pointers shall appear on the top of the tape. The right pointer shall indicate maximum weapon release range and the left pointer shall indicate minimum weapon release range. A moving line segment shall indicate the actual distance of the target. The range scale for air-to-air boresight weapons shall be in thousand-foot increments. The total range of the scale shall be ten thousand feet or more. The range scale for air-to-air guided weapons shall be in nautical miles. The total range of the scale shall be the range of the individual aircraft's sensor. If there is more than one target, the range shall indicate the selected target (See Figure 6).

3.5.1.3.9 Bombing - The bombing symbology shall consist of the following symbols:

1. Target Designate (Also used for attack and navigation)
2. Bomb Fall Line
3. First Optimum Weapon Release Cue
4. Second Optimum Weapon Release Cue
5. Pull-up Anticipation Cue.

3.5.1.3.9.1 Target designate - The target designate symbol shall be provided to enable the pilot to locate and track a target during the bombing or weapons modes or to obtain a fixed point reference in the navigation mode. The symbol shall be slaved to and track the target (See Figure 10).

3.5.1.3.9.2 Bomb fall line - The bomb fall line shall command the pilot's steering in azimuth for a derived impact as the weapon system generates a weapon delivery solution. The bomb fall line shall pass through the target reticle prior to the designation or location of the target in the weapons computer. After designation the steering line displacement from the path marker shall represent azimuth steering error. A straight bomb fall line shall be limited in tilt to an angle θ_1 with the local vertical during low drag deliveries and an angle θ_2 during the delivery of high drag stores, both angles to be designated by the detailed specification for the individual aircraft HUD (See Figure 18).

3.5.1.3.9.3 First optimum weapon release cue - The first optimum weapon release cue shall represent the maximum range throw and the lower solution of a bomb delivery and also the air-to-ground boresight missile solution. It shall be presented on the bomb fall line so that as a solution is approached the first optimum release cue moves down the bomb fall line. As the first optimum

release cue passes the center of the flight path marker, a release will occur. The angular difference between the velocity vector and first optimum weapon release cue shall be scaled such that one degree of difference displayed on the HUD represents five degrees in real world measurement (See Figure 14).

3.5.1.3.9.4 Second optimum weapon release cue - The second optimum weapon release cue shall represent the upper solution of a bomb delivery. Scaling of this cue shall be the same as the first optimum weapon release cue. The upper solution is used in hi-loft and over-the-shoulder weapons deliveries (See Figure 14).

3.5.1.3.9.5 Pull-up anticipation cue - The pull-up anticipation cue shall be used to indicate an approaching pull-up requirement. (See Figure 15).

3.5.1.3.10 Terrain carpet - The terrain carpet shall be a perspective rendition of the topography in front of the aircraft. The terrain carpet shall indicate the elevation angles to peak terrain elements with five range gates. Each range gate or elevation line shall be positioned vertically in the field of view at the highest elevation angle for the terrain within the five range increments, 0 to 1 nautical miles (nmi), 1 to 2 nmi, 3 to 4.3 nmi, and 4.3 to 6 nmi. The connection of these five elevation lines with the side lines results in the perspective representation of the terrain. When one or several range gates are in the shadow of closer terrain, they shall be blanked (See Figure 12).

3.5.1.3.11 Ordnance type and number - The ordnance type and number shall consist of one or two letters to identify the particular missile, or guns, or rockets. Underneath these identification letters shall be a one or two digit number which shall show, in the missile modes, the number of missiles which are ready or number of rounds in the hundreds in the gun submode, or number of rockets in the tens in the rocket submode. A small flashing X over the ordnance type and number alphanumerics shall indicate that the Master Arm Switch has not been activated. The X shall flash four times a second. The on and off portions of the flash cycle shall be approximately equal duration (See Figure 23).

3.5.1.3.12 Aiming reticle - The aiming reticle shall be movable and shall designate the computed weapon impact point at target range in any position in the field of view (See Figure 22).

3.5.1.3.12.1 Armament datum line (boresight) - The armament datum line shall be fixed at HUD boresight in the boresight mode, and boresight weapons mode, which will allow the symbol to be used to align the HUD in the aircraft. Preferably, the boresight would be within a four degree angle measured on a vertical arc through the center of the field of the optics. The letters BS shall appear in the weapon ID area of the field of view when the movable reticle is fixed at boresight (See Figure 30).

3.5.1.3.13 Missile target - The missile target symbols shall be provided to enable the pilot to locate and track a target. The symbol shall be slaved to and track the target. If the aircraft is capable of simultaneous multi-missile delivery, "tails" shall appear on each diamond when each target is in range, and the ID number of the missile assigned to each individual target shall appear to the left of the diamond when the missile is locked in and ready (See Figure 21).

3.5.1.3.14 Angle of attack error - The angle of attack error shall be a fly-to command symbol. When the left wing of the velocity vector is centered in the middle of the "C", the command angle of attack is satisfied. The distance from the top line of the "C" to the bottom line of the "C" shall represent four angle of attack units. The "C" shall move in a path perpendicular to the left "wing" of the velocity vector (See Figure 3).

3.5.1.3.15 Runway - The runway symbol shall represent the center line and aimpoint of a 700 by 70 foot runway with an aimpoint 330 feet from the ramp. The runway shall overlie the actual runway in the outside world. The runway symbol shall show perspective length and width of a runway in a one-to-one correlation to the actual runway at any angle and distance of one nautical mile or closer from the actual runway. At a distance of greater than one nautical mile from the actual runway the runway symbol shall change angular perspective shape, but shall maintain the size of a runway at a distance of one nautical mile (See Figure 9).

3.5.1.3.16 Aircraft reticle - The aircraft reticle symbol shall represent an extension of the fuselage reference line. The aircraft reticle symbol shall indicate the pitch angle of the aircraft fuselage as compared to the pitch lines or to the command angle of rotation of the aircraft (the flight director). The aircraft reticle shall disappear when the airspeed is greater than the rotation airspeed plus 50 knots (See Figure 11).

3.5.1.3.17 Test pattern - A test pattern shall show a fixed design of symbology. The misalignment or absence of parts of this pattern shall show that there is a defect in the HUD.

3.5.1.3.18 Standby reticle image - The standby reticle image shall be as shown in Figure 31.

3.5.2 Pilot's display unit - The Pilot's Display Unit (PDU) shall project virtual images of the symbology which is generated on the face of a cathode ray tube by signals from the electronics unit. The display unit shall also generate and project a virtual image of a standby reticle. The display unit shall sense the brightness of the real world background in the observer's field of view. The display unit shall be capable of recording with a camera the symbology and the real world background.

3.5.2.1 Pilot's display unit components - The Pilot's Display Unit shall consist of a cathode ray tube or a laser, electron beam/light beam deflection circuitry, collimating optics, a combining glass, a standby reticle, a light brightness detector and a film camera and its associated optics.

3.5.2.1.1 Cathode ray tube - The cathode ray tube shall be of a ruggedized type and shall be prealigned and potted in a CRT mounting fixture for ease of alignment in the Display Unit.

3.5.2.1.1.1 Cathode ray tube defects - Spot, blister, stone, knot, bruise, and scale defects on the face of the CRT shall be no larger than 0.007 in. in diameter.

3.5.2.1.2 Optical elements - The combining element and other required optical elements shall be in accordance with MIL-O-13830, as applicable, but shall meet the performance and safety requirements specified herein.

3.5.2.1.2.1 Combining glass - The combining glass or combiner is located between the observer and the windscreen. The combining glass shall be a partial mirror which shall have a trichroic color separation coating with the spectral characteristics shown in Figures 35 and 36. The bandwidth of this trichroic coating "notch" filter shall be no more than 750Å. The notch bandwidth shall be approximately centered at the wavelength of the light of the symbols. The average transmission of the coating excluding the notch wavelength shall be 80% or more. The average reflection of the coating excluding the notch wavelengths shall be 15% or less.

3.5.2.2 Display unit size - The overall size of the display unit shall not exceed 10-1/8"W by 7-5/8"H by 19-7/16"L excluding the combiner, combiner mount, and film camera, and connectors.

3.5.2.3 Display unit volume - The volume of the display unit excluding the combiner, combiner mount, and film camera shall not exceed 1500 cubic inches.

3.5.2.4 Acoustic noise generation - The noise level generated by the Display Unit or its components shall not exceed 85 decibels (reference 0.0002 dynes/centimeter^2) measured at any point one (1) foot from the Display Unit.

3.5.2.5 Mounting orientation - There shall be a mark or part of the Display Unit which shall permanently establish the Display Unit's reference, horizontal or vertical, for bench and boresight alignment.

3.5.2.6 Combiner mount - The combiner mount shall obscure a minimum of the real world field of view.

3.5.2.7 Reflection reducing coating - The windshield side of the combining glass shall be coated with a reflection reducing coating as defined in MIL-C-14806.

3.5.2.8 Field of view - The HUD shall provide an instantaneous, monocular field of view as shown in Figure 33 when measured from the design eye position of the cockpit. The center of the field of view should be near the boresight (armament datum line). The field of view shall allow all symbols of this specification to be used without constraint of symbol movement unless specified in the symbology section (3.5.1). Normal carrier position, and therefore carrier symbol position, on glide path shall be visible in the field of view.

3.5.2.9 Combining glass (real world to observer) displacement error - When objects are viewed through the combining glass, the combining glass shall not cause real world objects to be displaced by more than 0.6 milliradian anywhere within the central 12° field of view, nor more than 1.2 milliradians between 12° and 24° annular field of view, and not more than 2.0 milliradians beyond 24° annular. The displacement error shall be computed as the vector sum of the azimuth and elevation errors.

3.5.2.10 Binocular disparity - When observed from a vertical plane transverse to the fore and aft axis through the design eye position, the vertical disparity of a symbol shall not be greater than one milliradian, the horizontal divergent disparity of the symbol shall not be greater than one milliradian, and the horizontal convergent disparity of a symbol shall not be greater than 2.5 milliradians. The symbols shall be viewed from any two points two and one-half inches apart laterally within a 3-inch high by 5-inch wide range of eye positions in the transverse viewing plane.

3.5.2.11 Cleanliness of exterior optics - Exposed optics shall be so arranged as to minimize the effect of dust or other airborne materials on the observed display. In any event, provision shall be made for adequate, easy access for cleaning. Required cleaning tools shall not exceed camels hair brushes, soft cloths, or conventional optical cleaning material.

3.5.2.12 Glare - Glare and other unwanted visual signals shall be minimized. (See MIL-O-13830).

3.5.2.13 Vulnerability - The vulnerability of the aircraft to external detection because of HUD, such as generated light which is transmitted out of the aircraft, shall be minimized.

3.5.2.14 Fatigue - The HUD Display Unit shall be so oriented to minimize personnel fatigue that might be caused by viewing.

3.5.2.15 Vibration isolators - Vibration isolators shall not be used for mounting the Pilot's Display Unit.

3.5.2.16 Night filter - The HUD shall be provided with a filter for night operations. When a CIE illuminant A (2854°K) is viewed through the filter, the illuminant shall appear no paler or yellower than the illuminant when viewed through an NBS No. 3215 filter. The filter shall transmit a minimum of 15 percent of the incident light provided by a CIE illuminant A (2854°K). Use of the filter shall not affect the operability of the HUD or its controls. The night filter shall be permanently affixed to the projector so that it can be moved out of the path of light from the CRT to the pilot. The filter shall be used for CRT symbols only.

3.5.2.17 Standby reticle - The reticle shall be focused at infinity and be capable of being depressed manually from 0 to minus 210 milliradians in elevation and caged to 0 degrees azimuth. The standby reticle shall be displayed on the combining glass when desired by the pilot. The reticle lamp shall be easily removed and replaced with the projector unit installed in the aircraft. When the lamp is installed, no light shall be visible at the lamp access. The reticle color shall be aviation red in accordance with Specification MIL-C-25050.

3.5.2.17.1 Standby reticle brightness - The reticle line brightness shall be such that the projected images shall be clearly defined when superimposed on a background of 10,000 foot-lamberts (34,260 candela/meter^2) luminance and equivalent color temperature of 5000° to 5500° Kelvin. The average line brightness over the total line area shall be a minimum of 1600 foot-lamberts (5482 candela/meter^2) when viewed through the combining lens. The line brightness shall not vary more than 1 to 1.4.

3.5.2.17.2 Standby reticle line widths - The reticle line and circle widths shall be 1.0 ± 0.2 milliradians (2σ) on a black background.

3.5.2.18 Film camera - The display unit shall contain a film camera and associated optics capable of recording both the HUD symbology and the real world view through the HUD. The camera shall automatically be turned on when the bombing and two attack modes are selected and shall be automatically turned off when other modes are selected. A manual switch shall be provided on the Display Unit to operate the camera in modes other than the bombing and two attack modes (3.5.4.12). The film camera and its associated electronics shall meet the requirements of MIL-E-5400 that pertain to the Display Unit. The film shall be easily removed from the camera and the camera from the Pilot's Display Unit without the need of displacing or removing the display unit from the aircraft or displacing or removing any other equipment of the aircraft.

3.5.2.19 Maximum time to repair (MTTR) - Maximum time to repair the Display Unit at the flight line shall not exceed 30 minutes.

3.5.3 Electronics unit - The electronics unit shall be capable of processing input signals and generating all symbol shape and position signals to the display unit in accordance with Tables I and II and the figures. The overall size of the electronics unit shall not exceed one ATR unit (10-1/2W by 7-5/8H by 19-9/16L inches). The volume of the electronics unit shall not exceed 1500 cubic inches. The electronics unit shall be in accordance with MIL-C-172 and MIL-E-5400.

3.5.3.1 Fault warning - The HUD equipment shall contain circuitry arranged to automatically interrogate itself upon receipt of a malfunction by monitoring circuitry. The display shall automatically provide a warning signal, isolate and identify equipment faults to the Weapons Replaceable Unit portion of the unit. This shall be accomplished without external test equipment, disruption of unrelated equipment or channels, or human intervention. A failure within the HUD shall cause removal of all displayed data controlled by the failed circuit(s). Maximum display capability of non-failed circuits shall be maintained. As a minimum, the following parameters shall be monitored.

High voltage supply voltage
Low voltage supply voltage
Vertical deflection amplifier gain
Horizontal deflection amplifier gain

3.5.3.2 Control of symbols - The control of the HUD symbol position shall be as listed in Table III and as follows:

(a) Digital-controlled symbols - For symbols controlled by a central weapons computer or other digital input source, the symbols shall be displayed on the HUD only when a validity check of each data word is valid. When the validity check is not valid, the symbol shall not be displayed on the HUD.

(b) Analog and discrete-controlled symbols - For symbols controlled by analog and discrete inputs, the performance monitoring circuitry shall cause the respective symbols not to be displayed when a fault is detected in circuits generating or controlling the symbols.

3.5.3.3 Input signal requirements - A list of input signals to the HUD and the specific equipment required to supply the input signals shall be submitted for approval. The input waveform voltage, current, power, impedance, and accuracy required of each signal shall be listed.

3.5.3.4 Maximum time to repair (MTTR) - Maximum time to repair the Electronics Unit at the flight line shall not exceed 30 minutes.

TABLE III - SYMBOL POSITION CONTROLLING SOURCES

Symbol	Controlling Source
Velocity Vector	Central Computer
Flight Director	Central Computer
Angle of Attack Error	Angle of Attack Transducer
Horizon Line	Central Computer
Pitch Lines (Attitude)	Central Computer
Heading	Central Computer
Vertical Velocity	Central Computer
Airspeed	Air Data Computer
Mach Number	Central Computer, CADC
Altitude, Barometric	Central Computer, CADC
Altitude, Radar	Central Computer, Radar Altimeter
Runway	ACLS, ILS, Central Computer
Terrain Carpet	Central Computer
Bombing Symbology	Weapons Computer
Breakaway	ACLS, Radar, Central Computer
Warning Indicator	Master Caution, Weapons Computer
Range, Guns, etc.	Weapons Computer
Range - Missiles	Weapons Computer
Closure Rate	Weapons Computer
Target, Guns, Rockets & Boresight Missile	Weapons Computer
Aiming Reticle	Weapons Computer
Missile Target	Weapons Computer
Ordnance Type & No.	Weapons Computer
Alphanumerics	HUD
Aircraft Reticle	HUD

3.5.4 Manual controls - HUD manual controls shall be provided on the Display Unit on a HUD control panel on the pilot's right hand side of the cockpit and/or elsewhere on the pilot's right hand side of the cockpit. Spacing, shape, and marking for all HUD manual controls shall be in accordance with MIL-C-6781 and the controls section of MIL-STD-1472, and the installed HUD shall be compatible with MIL-STD-203. The manual controls shall be:

(a) Symbol Brightness/OFF

(b) Mode Selection

(c) Submode Selection

(d) HUD Barometric/Radar Altitude Selection

(e) Barometric Altitude Adjustment

(f) VAM Selection

(g) Scales ON/OFF

(h) Filter

(i) Standby Reticle Brightness

(j) Standby Reticle MIL Depression

(k) Standby Reticle Filament Selection

(l) Camera ON/OFF

(m) HUD Control Panel Light's Switch

3.5.4.1 Symbol brightness/OFF control - The symbol brightness/OFF control shall continuously vary the brightness of all symbols and shall cut off all power to the HUD from completely dark to full brightness.

3.5.4.2 Mode selection - The mode selection control(s) shall determine which of the following modes shall be displayed.

(1) Take Off/Navigation

(2) Terrain Following

(3) Bombing (and Camera On)

(4) Boresight Weapons (and Camera On)

(5) Guided Weapons (and Camera On)

(6) Landing

(7) Boresight

(8) Test

(9) Standby Reticle

3.5.4.3 Submode selection control - (Shall be determined in the detailed specification of the HUD of a particular aircraft.)

3.5.4.4 HUD barometric/radar altitude selection control - The HUD barometric/radar altitude selection control shall determine the display of either barometric or radar altitude information on the HUD.

3.5.4.5 Barometric altitude adjustment control - The barometric altitude adjustment control shall continuously vary the displayed barometric altitude at least by plus or minus 1500 feet.

3.5.4.6 Vertical velocity/airspeed/mach number (VAM) selection control - The VAM selection control shall select the display of vertical velocity, airspeed or Mach number information on the HUD.

3.5.4.7 Scales ON/OFF control - The scales ON/OFF control shall add the tape symbology (See 3.5.1.3.7) or remove the tape symbology and allow the "restricted" symbols to be displayed throughout the full field of view of the HUD.

3.5.4.8 Filter control - The filter control shall position a filter into the light beam path of the HUD optics to change the color of the display to red or shall remove the filter from the light beam path of the HUD optics.

3.5.4.9 Standby reticle control brightness control - The standby reticle brightness control shall continuously vary the brightness of the symbol from completely dark to full brightness of the standby reticle.

3.5.4.10 Standby reticle MIL depression control - The standby reticle MIL depression control shall continuously adjust the standby reticle depression angle from 0 to 210 milliradians.

3.5.4.11 Standby reticle filament selection switch-The standby reticle filament selection switch shall allow current to either filament of the two filament reticle bulb.

3.5.4.12 Camera ON/OFF switch-The camera ON/OFF switch shall connect or disconnect electrical power to the camera.

(Note-Selection of the Bombing Boresight Weapons and Guided Weapons Modes shall connect electrical power to the camera.)

3.5.4.13 HUD control panel lights switch-The HUD panel lights switch shall connect or disconnect electrical power to the control panel lights of the HUD and shall dim or brighten the control panel light.

3.5.5 Display Unit Mount (DUM)-The DUM shall be an adjustable, rack-type mount capable of being adjusted in pitch, yaw, and roll for the purposes of boresighting the mount to the Armorment Datum Line of the aircraft. The mount shall contain provisions for a boresighting fixture. The mount shall have ± 1.5 degrees of adjustment in each of the three axis.

3.6 Mounting and Boresighting-The HUD mounting and boresighting requirements shall be as follows:

(a) Display Unit Mount - The Display Unit Mount shall be hard mounted to the aircraft structure and boresighted to the armorment datum line in each aircraft to compensate for individual aircraft structure variations.

(b) Pilot's Display Unit. The Pilot's Display Unit shall be hard mounted on the Display Unit Mount. The PDU and DUM mating surfaces shall be controlled such that any production PDU may be mounted in any aircraft without the necessity of reboresighting. The CRT or CRT assembly of the PDU shall be hard mounted in the PDU, and provisions shall be made for field replacement without the necessity for reboresighting.

(c) Electronics Unit-The Electronics Unit shall be shock mounted.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection-Unless otherwise specified, the supplier is responsible for the performance of all test requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the tests set forth in the specification where such tests are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Classification of tests-Items covered by this specification shall be subjected to the following tests to determine compliance with all applicable requirements.

(1)	Preproduction (First Article) Tests	(4.2)
(2)	Initial Production Tests	(4.3)
(3)	Acceptance Tests	(4.4)
(4)	Life Tests	(4.5)

4.2 Preproduction (first article) tests-Preproduction tests shall be conducted by the contractor on an equipment representative of the production equipments to be supplied under the contract. Preproduction tests shall be accomplished under the approved test procedure of 4.6. The Government inspector and the procuring activity shall be advised when tests are to be conducted so that a Government representative may be designated to witness or supervise the tests when so desired. Contractors not having adequate facilities to conduct all required tests shall obtain the services of a commercial testing laboratory acceptable to the Government.

4.2.1 Preproduction (first article) test data - The contractor shall submit all data collected in conducting these tests to the Naval Air Systems Command, Headquarters, and the procuring agency for review and approval. On first production contracts this data shall include a list of all electrical and electronic parts giving their specified voltage, current, and temperature rating and the applied circuit voltage, current, and ambient and surface temperatures. The ambient and surface temperature shall be obtained under the extreme high temperature operating condition.

4.2.2 Scope of tests - Preproduction tests shall include all tests listed in 4.8 and the Reliability Qualification phase test, 4.4.3.1, and such other tests deemed necessary by the procuring activity to determine that the equipment meets all requirements of this specification, other applicable specifications and the contract.

4.2.3 Preproduction (first article) approval - Approval of the preproduction sample shall be by the procuring activity upon satisfactory completion of all tests. No production equipments shall be delivered prior to the approval of the preproduction sample. Prefabrication of production equipment prior to the approval of the preproduction sample is at the contractor's own risk. The approved preproduction sample shall be retained by the contractor for his use in the fabrication and testing of equipment to be submitted for acceptance. The preproduction sample shall not be considered as one of the equipments under the contract.

4.2.4 Production equipments - Equipments supplied under the contract shall in all respects, including design, construction, workmanship, performance, and quality, be equivalent to the approved preproduction sample. Each equipment shall be capable of successfully passing the same tests as imposed on the preproduction sample. Evidence of non-compliance with the above shall constitute cause for rejection, and for equipment already accepted by the Government, it shall be the obligation of the contractor to make necessary corrections as approved by the procuring activity.

4.3 Initial production tests - One of the first ten production equipments shall be selected and sent at the contractor's expense to a designated Government laboratory for tests. This equipment shall be selected by the procuring activity after the equipment has successfully passed all individual tests. No other tests

shall be conducted on the equipment prior to starting the Initial Production Tests. The preproduction sample shall not be selected for this test.

4.3.1 Scope of tests - This equipment may be subjected to any and all tests the procuring activity deems necessary to assure that the production equipment is equivalent to the previously approved preproduction sample in design, construction, workmanship, performance, and quality and that it meets all applicable requirements. The following tests are considered a minimum.

Vibration	(4.8.10)
Temperature - Altitude	(4.8.11)
Interference Control	(4.8.12)
Equipment Shock	(4.8.13)
Salt Fog	(4.8.17)

4.3.2 Accessory material - In addition to the complete equipment submitted for initial production tests the contractor shall also submit such accessory material and data necessary to test the equipment.

4.3.3 Initial production sample approval - Approval of the initial production sample shall be by the procuring activity upon satisfactory completion of all tests. Any design, material or performance defect made evident during this test shall be corrected by the contractor to the satisfaction of the procuring activity. Failure of the initial production sample to pass any of the tests shall be cause for deliveries of equipment under the contract to cease until proper corrective action is approved and accomplished. Corrective action shall also be accomplished on equipment previously accepted when requested by the procuring activity.

4.3.4 Reconditioning of initial production test sample - On completion of the initial production test the equipment shall be reworked by the contractor by replacing all limited life or damaged items. After reworking, the contractor shall resubmit the equipment for acceptance.

4.4 Acceptance tests - The contractor shall furnish all samples and shall be responsible for accomplishing the acceptance tests. All inspection and testing shall be under the supervision of the Government inspector. Contractors not having adequate facilities for conducting all required tests shall engage the

service of a commercial testing laboratory acceptable to the procuring activity. The contractor shall furnish test reports showing quantitative results for all acceptance tests. Such reports shall be signed by an authorized representative of the contractor or laboratory, as applicable. Acceptance or approval of material during the course of manufacture shall not be construed as a guarantee of the acceptance of the finished product. Acceptance tests shall consist of the following:

(1) Individual Tests

(2) Sampling Tests

(3) Reliability Assurance Tests

(4) Special Tests

4.4.1 Individual tests - Each equipment submitted for acceptance shall be subjected to, and meet, the requirements of the Individual tests. These tests shall be adequate to determine compliance with the requirements of material, workmanship, operational adequacy and reliability. As a minimum, each equipment accepted shall have passed the following tests:

Examination of Product	(4.8.1)
Operational Test	(4.8.2)
Recognition Test	(4.8.3)
Manufacturing Run In Test	(4.8.4)

4.4.2 Sampling tests - Equipments selected for sampling tests shall first have passed the Individual tests. Equipment shall be selected for sampling tests by the Government inspector in accordance with the following:

Quantity of Equipments Offered for Acceptance	Quantity to be Selected for Sampling Test
First 10	1
Next 50	1
Next 75	1
Next 100	1
	1 for each additional 200 or fraction thereof.

One out of the first ten need not be selected and tested if Initial production tests are conducted. Sampling tests are not required when reliability assurance tests are conducted.

4.4.2.1 Scope of tests - As a minimum, each equipment selected for sampling tests shall be subjected to the following tests:

(1) Complete operational test at ambient room conditions, making all necessary measurements to assure that all applicable specification requirements have been met.

(2) Operational test at certain environmental conditions. The conditions may vary for each equipment tested and should be based on results of the Preproduction, Initial production, Individual and Special tests.

(3) Manufacturing run in test specified in 4.8.4 except that the test duration shall be 120 hours with no restriction on the number of failures. However, each failure shall be analyzed as to cause and remedial action necessary to reduce the possibility of its recurrence in future equipment shall be taken.

(4) The following specific tests shall also be conducted, and requirements met, either in the above tests or separately.

(a)	Power Consumption	(4.8.5)
(b)	Dielectric Strength	(4.8.6)
(c)	Voltage and Frequency Variation	(4.8.7)
(d)	Magnetic Properties	(4.8.8)
(e)	Temperature Shock - Pilot's Display Unit	(4.8.9)
(f)	Vibration	(4.8.10)

4.4.3 Reliability assurance tests - Reliability assurance tests shall be conducted using MIL-STD-781. Tests as required by both the qualification phase and production acceptance sampling phase shall be conducted. Classification of failure shall be in accordance with MIL-STD-781 and AR-34. Equipments selected for reliability assurance tests shall first have passed the Individual tests. For purposes of this specification, the reliability shall be calculated separately for the HUD Equipment and the cathode ray tube. The HUD Equipment reliability shall be not less than 1,000 hours MTBF, excluding the cathode ray tube. The cathode ray tube reliability shall be not less than 500 hours. The tests shall be conducted concurrently and respective failures shall be apportioned as outlined in 4.4.3.3.3.

4.4.3.1 Reliability qualification phase - Prior to the acceptance of equipments under the contract or order, a minimum of three (3) equipments shall be tested as outlined in MIL-STD-781, under the section entitled "Qualification Phase of Production Reliability Tests". The maximum number of equipments to be used shall be those listed in Table 5 of MIL-STD-781. For the qualification phase, test level "F" shall be used. The accept-reject criteria for Test Plan I shall be used for the cathode ray tube and Test Plan II for the HUD Equipment.

4.4.3.2 Reliability production acceptance (sampling) phase tests - The equipment, throughout production, shall be tested as outlined in MIL-STD-781 (as modified herein) under the section entitled "Production Acceptance (Sampling)Phase of Production Reliability Tests". Test level F shall be used. The Accept-Reject Criteria for Test Plan II shall be used to determine the length of the tests (until an accept or reject decision is reached).

4.4.3.2.1 All equipment test - Each equipment produced shall be tested as follows: (1) the PDU for 30 hours and (2) the EU for 100 hours. Prior to the 30 hour and 100 hour tests on each equipment, a burn-in period may be used at the option of the contractor. If the burn-in period is to be used, the details thereof must be included in the approved test procedures. To determine whether the MTBF is being met at any time during the contract the operating test hours and the failures thereon (not counting burn-in failures or burn-in operating time) shall be totaled and the results compared with the reject line of Test Plan II of MIL-STD-781. (Extend the line as necessary to accomodate the date.) These totals shall accumlate so that at any one time the experience from the beginning of the contract is included. At the conclusion of each month the test results shall be sent to the procuring activity and to the Naval Air Systems Command, Attention: Avionics Division. At any time that the current totals of test hours and test failures plotted on Test Plan II curves show a reject situation, the procuring activity shall be notified. The procuring activity reserves the right to stop the acceptance of equipment at any time that a reject situation exists pending a review of the contractor's efforts to improve the equipment, the equipment parts, the equipment workmanship, etc., so that the entire compilation will show other than a reject decision.

4.4.3.3 Test details - The test details such as the length of the test cycle, the length of the heat portion of the cycle, the performance characteristics to be measured, special failure criteria, preventative maintenance to be allowed during the test, etc., shall be part of the test procedure to be submitted to and approved by the procuring activity prior to the beginning of the Qualification Test Phase of the Reliability Assurance Tests. The following paragraphs shall be considered as minimum requirements and apply to both phases.

4.4.3.3.1 Duty cycle - In addition to the test level F cycling of MIL-STD-781 the following procedure shall be used:

During each power "ON" period the HUD symbols shall continuously be cycled through the following simulated maneuver, where applicable:

(a) Take Off and Navigation

(b) Terrain Following

(c) Bombing

(d) Boresight Weapons

(e) Guided Weapons

(f) Landing

The time spent in each of these maneuvers shall be in accordance with the intended service use.

4.4.3.3.2 Performance characteristics to be measured - At least once each seven duty cycles the HUD shall be subject to and meet the requirements of 4.8.2 and 4.8.3.

4.4.3.3.3 Failure criteria - In addition to the requirements of MIL-STD-781, the following requirements shall be used to determine when a failure has occurred during the test:

(1) Whenever performance characteristics fall below the accepted requirement (paragraph 4.4.3.3.2) at least one failure has occurred. If subsequent analysis reveals that several parts have deteriorated, each shall be counted as a failure, unless one caused the other parts to fail.

(2) HUD Equipment failures and cathode ray tube failures shall be counted separately as follows:

As HUD Equipment failures -

(a) Any failure not repairable by replacement of the cathode ray tube.

(b) Any failure of a cathode ray tube caused by the HUD equipment.

(c) Every cathode ray tube failure when using cathode ray tubes not meeting the MTBF of 500 hours.

As Cathode ray tube failures -

(a) Any failure of the HUD equipment repairable by replacement of the cathode ray tube with a new cathode ray tube.

(b) Any characteristic of a cathode ray tube outside of cathode ray tube design characteristics.

(3) Manual Reticle failures shall be counted as HUD equipment failures.

4.4.3.4 Preventative maintenance - During the period of the tests, the following preventative maintenance measures may be performed upon the equipment:

Replacement of the cathode ray tube shall be permitted within the limits of 4.4.3.3.3 A replaced tube is considered as a failure(s).

4.4.4 Special tests - Special tests shall be conducted for the purpose of checking the effect of any design or material change on the performance of the equipment and to assure adequate quality control. The equipment selected for special tests may be selected from equipments previously subjected to the sampling or reliability assurance tests.

4.4.4.1 Special test schedule - Selection of equipments for special tests shall be made as follows:

(1) On an early equipment after an engineering or material change.

(2) Whenever failure reports or other information indicate additional tests are required. (This will be determined by the procuring activity.) .

4.4.4.2 Scope of tests - Special tests shall consist of such tests as approved by the procuring activity. Test procedures previously approved for the preproduction tests shall be used where applicable. When not applicable, the contractor shall prepare a test procedure and submit it to the procuring activity for approval prior to conducting the tests.

4.4.5 Equipment failure - Should a failure occur during the sampling, reliability assurance, or special tests, the following action shall be taken:

(1) Determine the cause of failure.

(2) Determine if the failure is an isolated case or design defect.

(3) Submit to the procuring activity for approval, proposed correction action intended to reduce the possibility of the same failure(s) occurring in future tests.

(4) Where practical, include a test in the Individual test to check all equipment for this requirement until reasonable assurance is obtained that the defect has been satisfactorily corrected.

4.5 Life test - The contractor shall furnish all samples and shall be responsible for accomplishing the life tests. The test shall be 1,000 hours duration and shall be conducted on equipments that have passed the Individual tests. The life test shall be performed under the conditions specified in 4.5.1. The life test sample shall be selected by the Government inspector in accordance with the following. (Equipments which have successfully passed the Initial Production Test, Sampling Tests, Reliability Tests, or Special Tests may be selected for life tests.) When reliability tests are conducted, the life test shall be omitted if, during the reliability tests, a quantity of equipments equal to, or more than, that listed below receive at least 1,000 hours each of test time.

Quantity of Equipments Offered for Acceptance	Quantity to be Selected for Life Test
First 25	1
Next 175	1
Next 300	1
	1 for each additional 500 or fraction thereof

4.5.1 Test conditions - The life test shall be conducted under the following simulated service conditions:

Temperature	Normal room
Altitude	Normal ground (0-5000 ft.)
Humidity	Room Ambient
AC Voltage	115/200, Category B, MIL-STD-704
DC Voltage	28; Category B, MIL-STD-704
Lighting Voltage	5.0 ± 0.5 AC or DC

4.5.2 Test periods - The test may be run continuously or intermittently. Any period of operation shall be of sufficient duration to permit the equipment temperature to stabilize. Periodically, the equipment shall be turned on and off several times and put through its various phases of operation.

4.5.3 Performance check - At approximately 8 hour intervals during the test, a limited performance check shall be made. The performance check proposed by the contractor shall be subject to approval by the procuring activity.

4.5.4 Test data - The contractor shall keep a daily record of the performance of the equipment, making particular note of any deficiencies or failures. In the event of part failures, the defective part shall be replaced and the operation resumed for the balance of the test period. A record shall be kept of all failures throughout the test. This record shall indicate the following:

(1) Part type number

(2) The circuit reference symbol number

(3) Part function

(4) Name of manufacturer

(5) Nature of the failure

(6) The number of hours which the part operated prior to failure.

4.5.4.1 Failure report - In the event of a failure, the Government inspector shall be notified immediately. A report shall be submitted to the procuring activity upon completion of test. In this report, the contractor shall propose suitable and adequate design or material corrections for all failures which occurred. The procuring activity will review such proposals and determine if they are acceptable.

4.6 Test procedures - The procedures used for conducting preproduction tests, acceptance tests and life tests shall be prepared by the contractor and submitted to the procuring activity for review and approval. The right is reserved by the procuring activity or the Government inspector to modify the tests or require any additional tests deemed necessary to determine compliance with the requirements of this specification or the contract. Specification MIL-T-18303 shall be used as a guide for preparation of test procedures. When approved test procedures are available from previous contracts, such procedures will be provided and may be used when their use is approved by the procuring activity. However, the right is reserved by the procuring activity to require modification of such procedures, including additional tests, when deemed necessary.

4.7 Test conditions -

4.7.1 Standard conditions - Unless otherwise specified all tests shall be made under the conditions of 3.3.9.

4.7.2 Attitude - Unless otherwise specified the HUD shall be mounted in its normal operating position. However, it shall be possible to maneuver the sight unit against optical references.

4.7.3 Precision mounting fixture - The precision test mounting fixture shall simulate the display unit alignment referenced to the aircraft armament datum with a repeatability of 0.1 milliradian. This fixture is used for boresight alignment.

4.7.4 Coarse mounting fixture - The coarse test mounting fixture shall simulate the display unit alignment referenced to the aircraft's armament datum with a repeatability of one milliradian. This fixture shall provide stable mounting of the pilot's display units on the workbench and under the required environmental conditions. If the HUD display unit configuration permits stable mounting, without hold-down provisions on a level surface. this coarse mounting fixture is not required.

4.7.5 Test data requirements - Error computation shall be made from the recorded raw data. The method of error computation shall be indicated and the errors shown shall be exclusive of those of the test equipment. All significant data, passing as well as failing, shall be recorded for all equipments tested.

4.7.6 Signal simulator - The signal simulator shall be capable of generating the signals required by Table I and the Figures.

4.7.7 Temperature and altitude extremes - The entire HUD system shall be energized as required in the respective test method at the extremes. The system will be checked to assure operation at the extremes. The sight unit shall then be returned to room ambient while the electronics unit remains at the extreme condition. Under these conditions the system shall meet the specified requirements. If the electronics unit is integral with the display unit, it shall be tested as a display unit.

4.7.8 Alignment telescope - The alignment telescope, or other device, shall be capable of determining relative displacement within the display field of view with an accuracy of 0.1 milliradian. This telescope shall also be used with the HUD in conjunction with the Precision Mounting Fixture to determine Boresight position within 0.05 milliradians.

4.7.9 Design eye position - Unless otherwise specified, all measurements shall be made from design eye position, defined in MIL-STD-1333, with monocular viewing.

4.8 Test methods -

4.8.1 Examination of product - Each equipment shall be examined carefully to determine that the material and workmanship requirements, and all other requirements not covered by tests, have been met.

4.8.2 Operational test - The HUD shall be connected to its signal simulator and operated long enough to permit the equipment temperature to stabilize and to check sufficient characteristics and record adequate data as to assure satisfactory equipment operation. The display that appears shall be in accordance with the applicable requirements of this specification, Tables II & III, the Figures and the detail specification. When the controls of the simulator are maneuvered and configured through their ranges, visual inspection of the display symbol position, symbols presented, and symbol ranges shall indicate conformance with the applicable requirements.

4.8.2.1 Line thickness and symbol brightness - Line thickness shall be measured by the alignment telescope and shall conform to 3.5.1.2.3. The manual brightness control may be adjusted once to establish compliance with this specification under a lighting background of 50 to 100 foot-lamberts (171 to 343 candela/meter^2). Throughout all other background levels the line width shall remain within tolerance. In addition to the initial background level of 50 to 100 foot-lamberts (171 to 343 candela/meter^2) tests shall be conducted near zero, 500, 1,000 and 10,000 foot-lamberts (0, 1713, 3426, and 34,260 candela/meter^2) to simulate total darkness to the extreme brightness of a reflective background.

4.8.2.2 Control panel - If a control panel is designated by the detailed specification for the individual aircraft HUD to be part of the HUD system, the Control Panel Unit shall meet the requirements of the same tests as the Electronics Unit of the HUD.

4.8.3 Recognition tests - All symbols shall be tested for conformance with the requirements of Table I and Figures 1 through 31. Symbols shall be easily detected and recognized. The displacement tests shall include compliance with the scale factor requirements of Figures 1 through 34. All symbol displacement shall meet the total system error limits. (See 3.4.1.1). Unless otherwise specified the visually observed persistence of ghosts anywhere within the total system field of view shall be a minimum. The persistence of ghosts, under any conditions, shall not exceed one second of time.

4.8.4 Manufacturing run-in test - Each HUD equipment shall be operated under the conditions specified in 4.7 for a period of 10 hours without failure. The time spent in operation 4.8.2 and 4.8.3 may be counted towards the 10 hours. A failure shall be defined as anything which causes malfunctioning of the equipment. Only those adjustments will be permitted which can be made by using such controls and adjustments that are accessible to the operator during the normal use of the equipment. The equipment shall be vibrated (without vibration isolators) for a period of 10 minutes prior to the beginning of the 10 hour period of operation. Where feasible, the equipment shall be operated during this vibration period for the purpose of detecting flaws and imperfect workmanship. Operation within the specified limits of satisfactory performance is not necessarily required during the vibration period. The direction of vibration should be vertical to the normal mounting plane for 5 minutes and lateral to the plane for 5 minutes. Where it is not feasible to vibrate the equipment in 2 directions, the vertical direction shall be used. During the 10 hour period of operation following the 10 minute vibration period, the equipment shall be mechanically cycled periodically through its various phases of operation. Should a failure occur, it should be repaired and the test started over, except that the 10 minute vibration period need not be repeated when it is certain the failure was not a result of the vibration. Should repetitive failures occur, corrective action shall be taken to eliminate this defect from future equipment. A record shall be kept of all failures. The 10 hour period specified above may be composed of two 5 hour periods to conform with standard working hours. This test is not required if a Reliability Assurance Test is selected which includes a test on each equipment which consumes at least 10 hours of operation.

4.8.5 Power consumption - The HUD system shall be properly connected and power shall be applied for a period of five minutes. The power consumption shall be measured at the end of this time and shall not exceed 300 volt amperes, AC, and 84 Watts DC. The power factor of the AC power circuits shall be within 0.85 lagging to 0.95 leading.

4.8.6 Dielectric strength - Except as otherwise specified, a potential of 500 volt (root mean square) alternating current at 60 cycles per second shall be applied between isolated pins and between pins and the case for a period of 5 seconds. There shall be no breakdown of insulation or any other permanent damage to the HUD equipment as a result of this test. Calculated leakage resistance should be greater than 50 megohoms. Where HUD operating voltages are above 500 volts the dielectric test voltage at those pins shall be twice the HUD operating voltage applied in the manner described above.

4.8.7 Voltage and frequency variation - The HUD equipment shall meet the requirements of 4.8.2 and 4.8.3 herein, when subjected to the range of normal power conditions of Category B of MIL-STD-704. The HUD equipment shall give a usable display under emergency power conditions Category B. Also, as a minimum, the manual reticle shall be capable of full utilization. Upon return to normal power conditions the HUD shall be subjected to and meet the requirements of 4.8.2 and 4.8.3. Operation under other power conditions shall be as detailed in the detail specification.

4.8.8 Magnetic properties - The HUD system shall be tested to ascertain that its magnetic effect, and magnetic susceptability are within the required limits.

4.8.8.1 Magnetic effect - The HUD system shall be properly connected and power applied. Each unit of the HUD system shall separately be revolved about a short bar magnet compass with the nearest part of the unit 5-1/2 inches from the bar magnet. The compass shall have its compensating magnets removed and shall be set up in a uniform magnetic field whose horizontal intensity is between 0.17 and 0.19 oersted. The HUD unit shall be revolved in a horizontal plane which is perpendicular to the axis of the bar magnet. The HUD system shall be held in positions 0, 45, 90, 135, 180, 225, 270 and 315 degrees. At each of these positions the HUD unit shall be rotated 360 degrees about its horizontal axis. The deflection of the compass at any of the specified positions shall not exceed one degree. This test shall be repeated with no power applied. The same tolerance shall apply.

4.8.8.2 Magnetic susceptability - The HUD system shall be tested for compliance with 3.4.3.

4.8.9 Temperature shock-pilot's display unit - This test is intended to ascertain that the internal optics of the system will not be degraded, permanently or temporarily, through formation of fog or condensate in normal service use. The manner of conducting this test will vary with the configuration of the HUD display unit and the manner in which it is sealed. Unless otherwise specified, the test shall be conducted after an evaluation of these factors and shall represent realistic conditions. The following are considered minimum requirements: The unit shall be subjected to Procedure I, Method 503, of MIL-STD-810 except that the relative humidity during the 71°C portion shall be between 80% and 90% and that the internal surface of the optics be observed immediately upon removal from the last -54°C exposure. Contamination of the optics as a result of this test shall be cause for rejection. (Outer optical surfaces may be wiped dry.) The display unit shall operate properly upon return to room temperature.

4.8.10 Vibration - Vibration tests shall be in accordance with Procedure I, Method 514.1 of MIL-STD-810 using Curve Z of Figure 514.1-1 for parts 1, and 2 under standard operating conditions. Upon completion of the vibration tests, the HUD shall be subjected to and meet the requirements of 4.8.2.

4.8.10.1 Pilot's display unit - The PDU mounted on the DUM shall be observed during vibration. Any image change, as viewed on a distant screen from the normal eye position shall be measured and noted. The sight unit itself shall be unaffected and apparent image size change shall be that related solely to the motion of the vibration machine. The screen shall be far enough away to provide a measuring precision of at least 1 percent.

4.8.10.2 Electronics unit - The EU shall be subjected to vibration. The PDU (not vibrating) operating in conjunction with the electronics unit shall be monitored and shall exhibit no deformation or resonance of the images processed through the vibrating electronics unit.

4.8.11 Temperature-altitude - The HUD equipment shall be subjected to Procedure I, Method 504, of MIL-STD-810 for Class 2 equipment. After the temperature-altitude test the HUD equipment shall be subjected to and meet the requirements of 4.8.2. The chamber air velocity shall be designated by the detailed specification for the individual aircraft HUD.

4.8.12 Interference control - Conducted and radiated susceptability and conducted and radiated interference measurements shall be made of the HUD system in accordance with MIL-STD-462. The results shall not exceed the values specified therein.

4.8.13 Equipment shock - The Electronics Unit shall be shock tested in accordance with Procedure I, Method 516.1, Figure 516.1-1 or 516.1-2, amplitude a, duration c, of MIL-STD-810. The identification of the filters shall be designated by the detailed specification for the individual aircraft HUD.

4.8.14 Dust - The HUD equipment shall be subjected to Procedure I, Method 510, of MIL-STD-810 except that the cleaning technique at the end of the exposure shall be in accordance with 3.5.2.11. The display unit shall not have been adversely affected by the dust and shall be subjected to and meet the requirements of 4.8.2. The equipment shall not be operated during the dust test. A second 6-hour test at 63°C (145°F) shall be performed immediately after reaching stabilization of step 2 of Method 510.

4.8.15 Humidity - The HUD equipment shall be connected to simulate aircraft installation. The HUD equipment shall then be subjected to, and meet, the requirements of 10 cycles of Humidity, Procedure I, Method 507 of MIL-STD-810. The specified limits of satisfactory operation referred to in step 7 is subject to compliance with 4.8.2 and 4.8.3. The HUD shall be exposed to high temperature of the temperature-altitude test (4.8.11) prior to the humidity test. Measurements shall be taken at the end of 10 cycles. Moisture on the surface of the optices internal to the HUD, shall be caused for rejection.

4.8.16 Fungus resistance - The HUD equipment shall be subjected to and meet the requirements of Procedure I, Method 508, of MIL-STD-810. The HUD shall not be operated during the test.

4.8.17 Salt fog - The HUD equipment shall be connected to simulate aircraft installation. The HUD equipment shall then be subjected to and meet the requirements of Procedure I, Method 509, of MIL-STD-810. The operation tests conducted upon completion of the salt fog exposure shall be 4.8.2 and 4.8.3. The HUD equipment shall be twice subjected to, and shall twice meet, the requirements of these tests; the first time within 48 hours of removal from the salt fog and the second time within 48 to 72 hours of removal.

4.8.18 Explosion - The HUD system shall be subjected to and meet the requirements of Procedure I, Method 511, of MIL-STD-810.

4.8.19 Mounting (crash safety) - The Pilot's Display Unit, complete with its required cathode ray tube and combining element, shall be mounted to simulate aircraft installation. The unit shall then be subjected to and meet the requirements of Mounting (Crash Safety) of Procedure III, Method 516.1, Figure 516.1-1 or 516.1-2, amplitude a, duration c, of MIL-STD-810. No dummy load shall be used. No loose external fragmentation shall occur as a result of this test. The unit need not be operable after this test. The identification of the filters shall be designated by the detailed HUD specification.

4.9 Reconditioning of tested equipment - Equipment which has been subjected to acceptance and life tests shall be reconditioned by the contractor by replacing all "wear" or damaged items. After reworking the contractor shall resubmit the equipment for acceptance.

4.10 Presubmission testing - No item, part, or complete equipment shall be submitted by the contractor until it has been previously tested and inspected by the contractor and found to comply, to the best of his knowledge and belief, with all applicable requirements.

4.11 Rejection and retest - Equipment which has been rejected may be reworked or have parts replaced to correct the defects, and be resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished the Government inspector.

5. PREPARATION FOR DELIVERY

5.1 General - All major units and parts of the equipment shall be preserved, packaged, packed and marked for the level of shipment specified in the contract or order in accordance with MIL-E-17555 and MIL-STD-794. In the event the equipment is not covered in MIL-E-17555, the method of preservation for Level A shall be determined in accordance with the selection chart in Appendix D of MIL-STD-794.

6. NOTES

6.1 Intended use - The requirements of this specification are general as applicable to Head Up Displays. Deviations from the requirements of this specification may be granted following presentation and approval of substantiating data. This specification is intended for use to incorporate by reference in the equipment detail specification or (when no specification is available) in the equipment control specification or order.

6.1.1 Description - The Head-Up Display is an electronic and optical device that displays, in symbolic form, essential airplane performance information and take-off, navigation, weapon delivery, terrain following, or landing information on one display. Symbols representing airplane altitude, airspeed vertical velocity, mach number, attitude and heading are displayed. In addition, navigation, weapon delivery, or landing symbols are selectively displayed. All information is displayed on a semi-transparent combination aspherical lens and mirror (combiner) located directly in front of the pilot at eye level. The information in the form of symbols, is focused to infinity and superimposed over real world objects in line with the airplane flight path. Certain symbols are

positioned on the combiner to correspond with real world objects in line with the airplane flight path. Certain other symbols are positioned on the combiner to correspond with real world object positions relative to the airplane, even though the real world objects may not be visible. The HUD greatly reduces the need for cockpit instrument scanning and allows the pilot to fly head-up at all times. The HUD consists of the Display Unit, the Electronics Unit, Display Unit Mount, and an optional control panel.

6.2 Detail data for equipment specification - Since this specification covers only the general requirements for parts, materials, processes and design, the detail specification for the equipment should specify the actual requirements for that particular equipment from the multiple choices or exceptions which are available in the following items:

(a) Type of aircraft for which HUD equipment is to be designed and used.

(b) Detail each integration situation requirement.

(c) Adequate test requirements (Section 4).

(d) Preparation for delivery (5.1).

6.2.1 Design Data - Design data shall be submitted in accordance with the requirements of the contract.

6.3 Ordering Data - Purchasers should exercise any desired options offered herein, and procurement documents should specify the following:

(1) Title, number, and date of the equipment detailed specification.

(2) Selection of applicable levels of packaging and packing (see 5.1).

6.4 Precedence of Documents - When the requirements of the contract, this specification, or applicable subsidiary specifications are in conflict, the following precedence shall apply:

(1) Contract - The contract shall have precedence over any specification.

(2) Detailed specification - A detailed Head-Up Display specification shall have precedence over this specification.

(3) Specification - This specification shall have precedence over all applicable subsidiary specifications. Any deviation from this specification, or from subsidiary specifications where applicable, shall be specifically approved in writing by the procuring activity.

(4) Referenced Specifications - Any referenced specification shall have precedence over all applicable subsidiary specifications referenced herein. All referenced specifications shall apply to the extent specified.

6.5 Performance Objectives - Minimum size and weight, simplicity of operation, ease of maintenance, and an improvement in the performance and reliability of the specific functions beyond the requirements of this specification are objectives which shall be considered in the production of this equipment. Where it appears a substantial reduction in size and weight or improvement in simplicity of design, performance, ease of maintenance or reliability will result from the use of materials, parts and processes other than those specified in MIL-E-5400, it is desired their use be investigated. When investigation shows advantages can be realized, a request for approval shall be submitted to the procuring activity for consideration. Each request shall be accompanied by complete supporting information.

6.6 Nonrepairable subassemblies - As a general rule, nonrepairable subassemblies should be encapsulated or hermetically sealed. The number of connections internal to the subassembly should be held to a minimum. Detail parts tolerances and rating should be so selected that the life of the subassembly is greater than that of a similar repairable one. With few exceptions (such as high voltage power supplies), the nonrepairable subassembly should evidence a Mean-Time-To-Failure greater than 5000 hours, and for many applications this figure must be nearer 50,000 hours.

6.7 Type designations - The type designation may be modified by the procuring activity upon application by the contractor for assignment of nomenclature in accordance with 3.3.8. The correct type number shall be used on nameplates, shipping records and instruction books, as applicable.

6.8 Associated equipment - The equipment shall operate with the following associated equipment:

Data Link
Air Data Computer
Aircraft Instrumentation
Aircraft Data Processor
Inertial Navigation System

Accelerometer
Mach Airspeed Indicator
Angle of Attack Indicator
Radar Altimeter
Lateral Accelerometer
Weapon Delivery Computers
Forward Looking Radar
Low Level Light Television
Forward Looking Infrared
Central Computer

6.9 This Specification is under the cognizance of AIR-53372E.

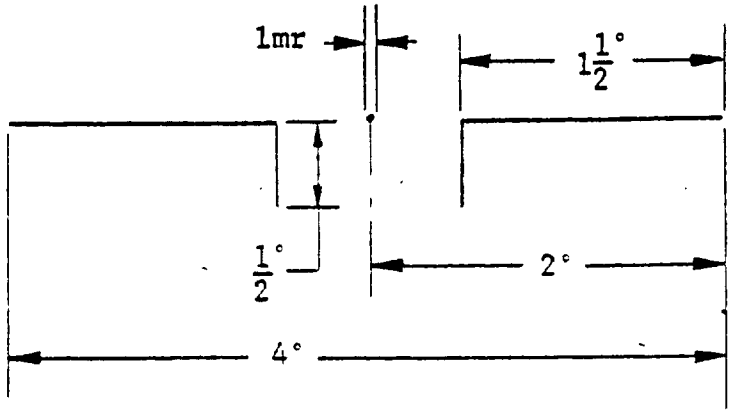


FIGURE 1. VELOCITY VECTOR

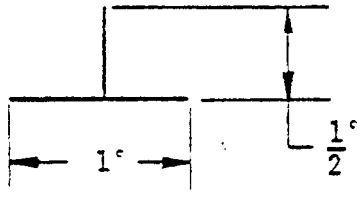


FIGURE 2. FLIGHT DIRECTOR

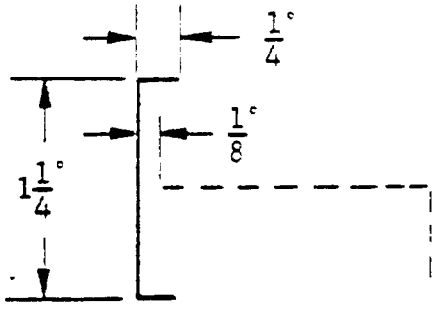


FIGURE 3. ANGLE OF ATTACK ERROR

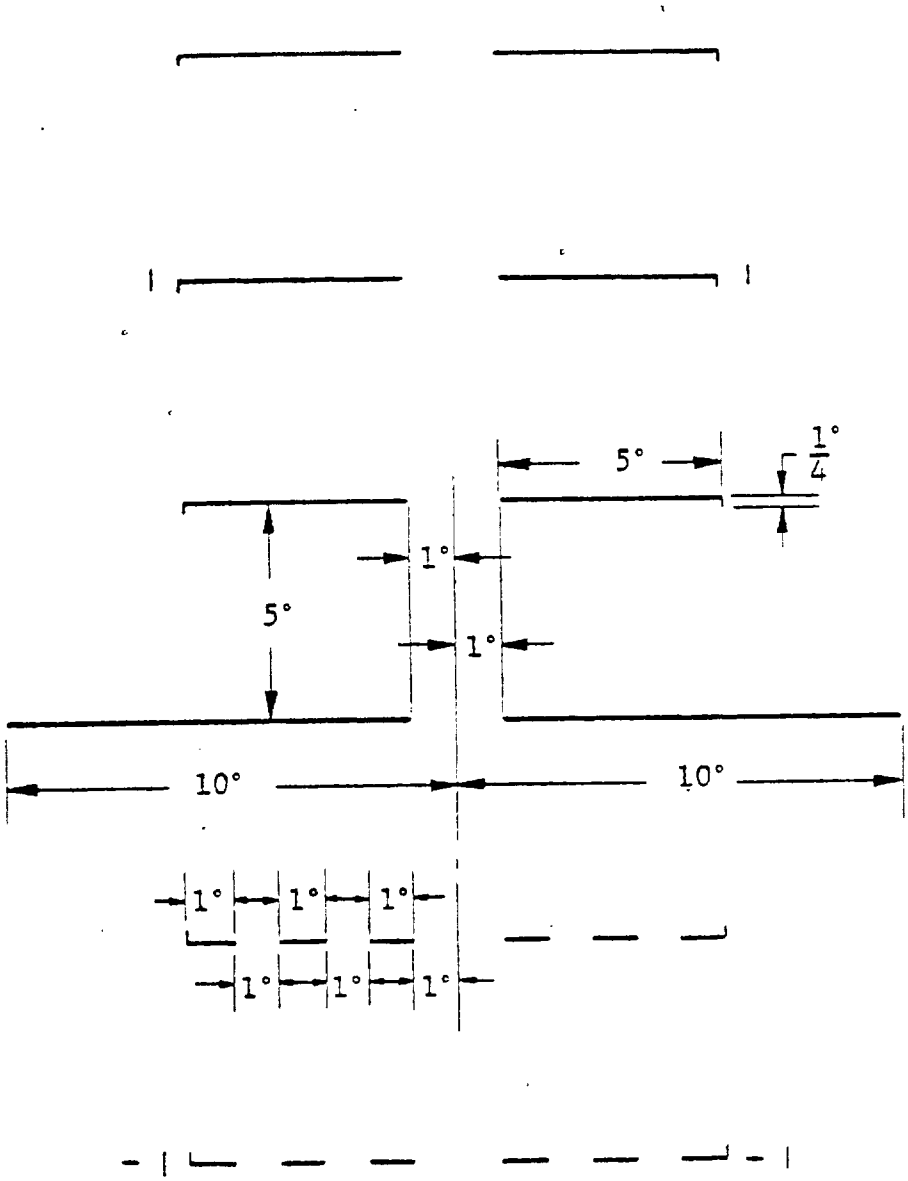


FIGURE 4. PITCH AND HORIZON

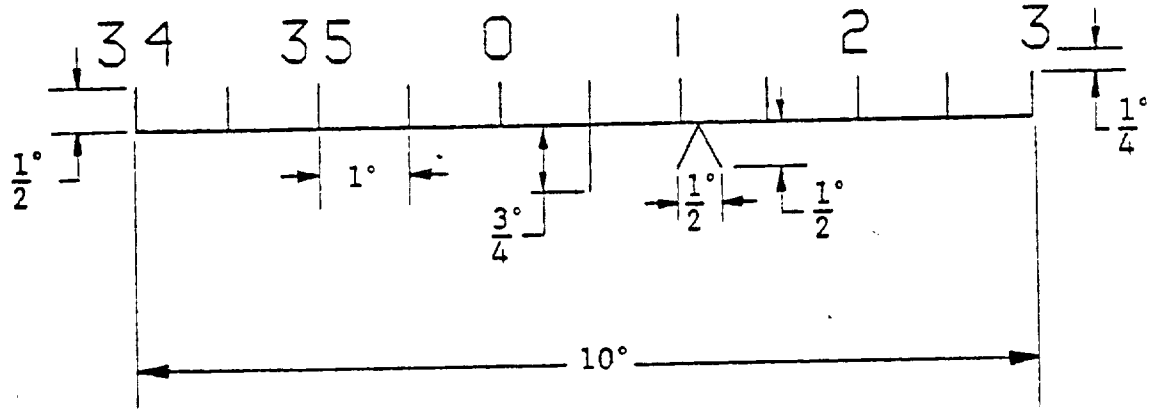


FIGURE 5. HEADING

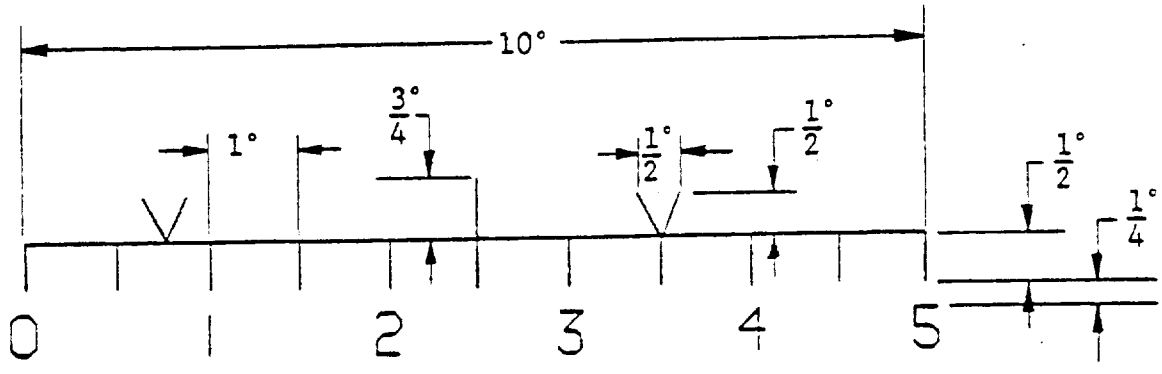


FIGURE 6. RANGE

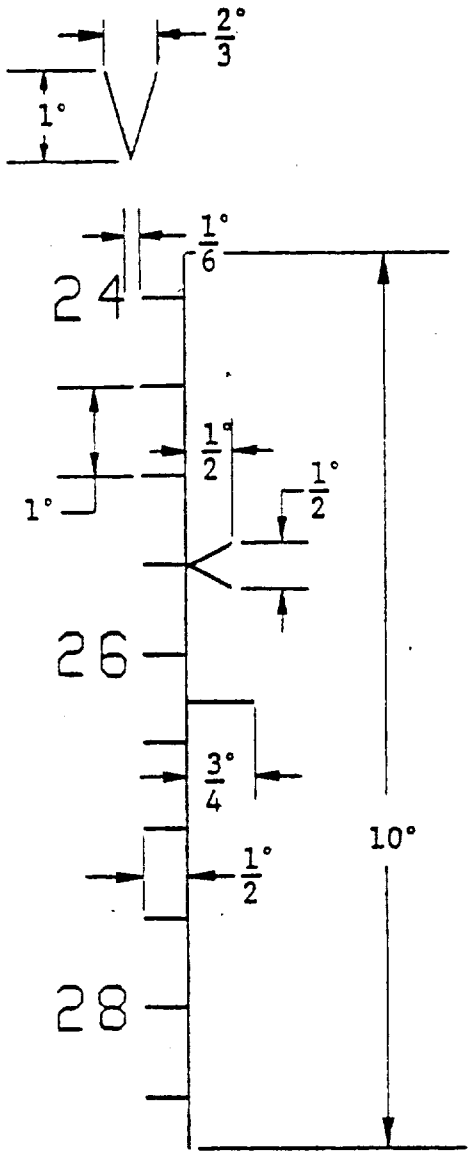


FIGURE 7

VERTICAL VELOCITY (V),
AIRSPEED (A), MACH NUMBER (M)
(VERTICAL VELOCITY SHOWN)

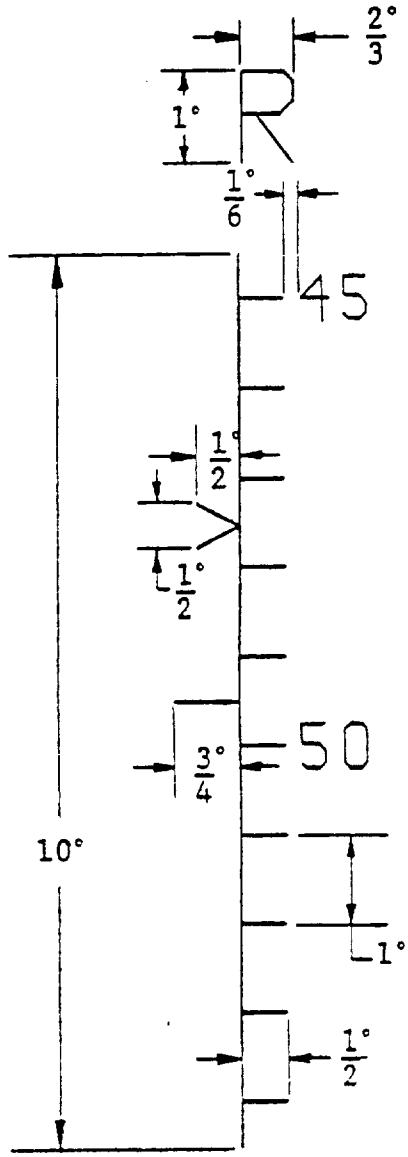


FIGURE 8

ALTITUDE, BAROMETER (B)
OR RADAR (R)
(RADAR SHOWN)

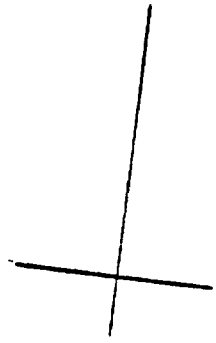
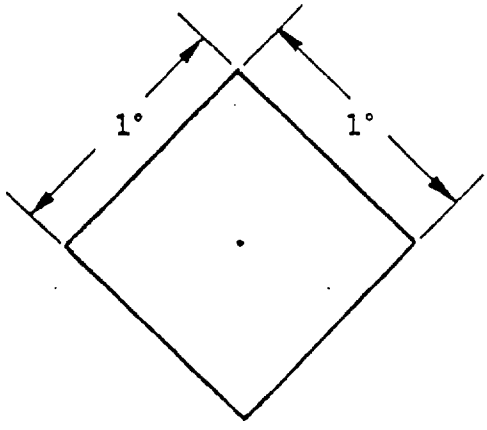


FIGURE 9. RUNWAY



(DOT IN GEOMETRIC CENTER OF SQUARE, 1mr DIAMETER)

FIGURE 10. BOMBING TARGET

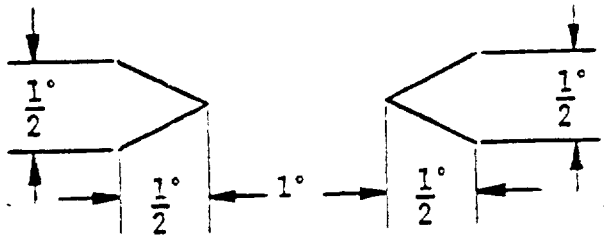


FIGURE 11. AIRCRAFT RETICLE

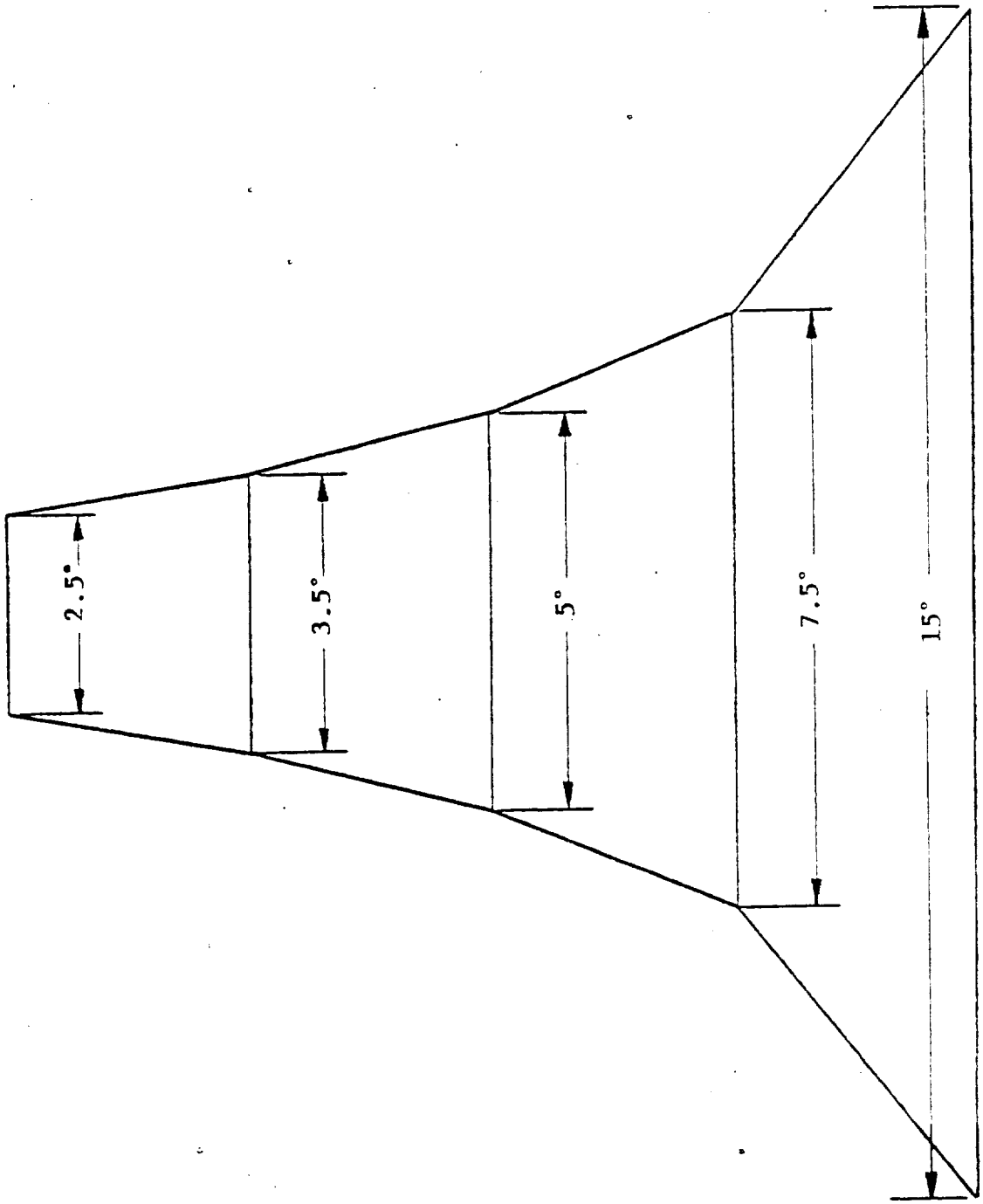


FIGURE 12. TERRAIN CARPET

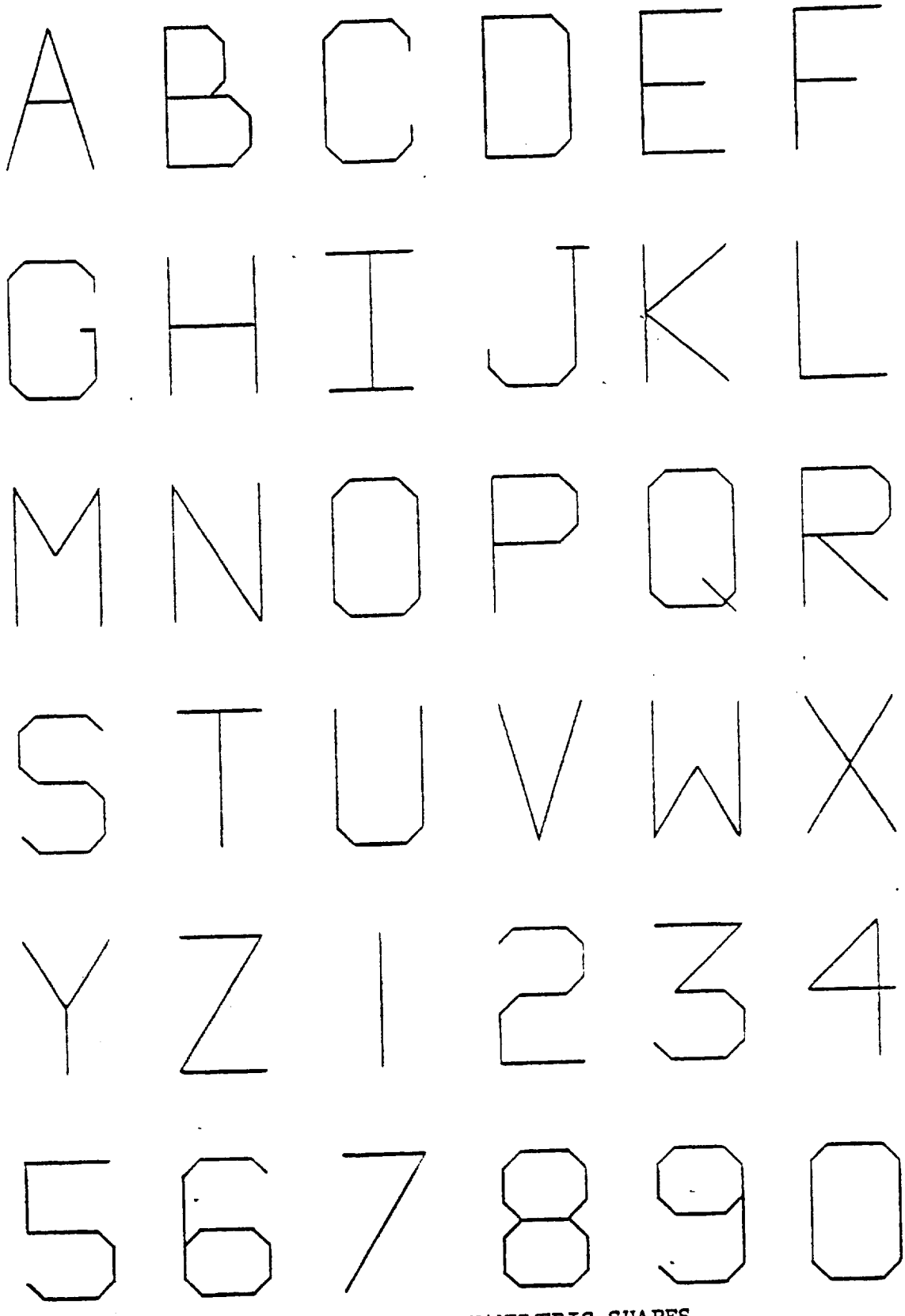
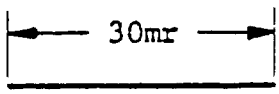
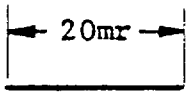


FIGURE 13. ALPHANUMERIC SHAPES



NO. 1



NO. 2

FIGURE 14. OPTIMUM WEAPON RELEASE CUES

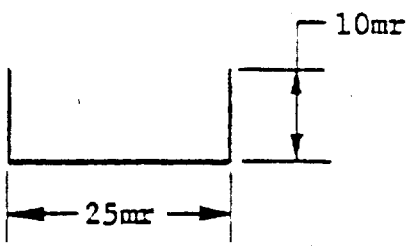


FIGURE 15. PULL UP ANTICIPATION CUE

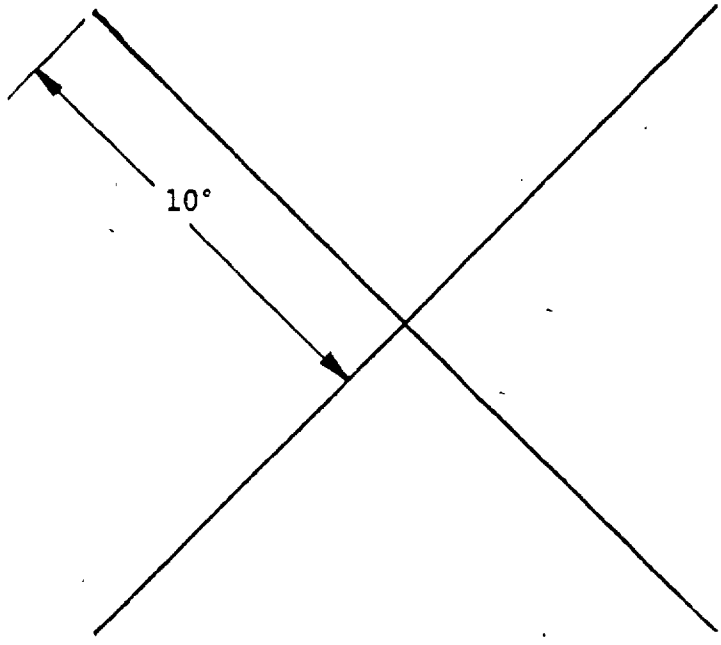


FIGURE 16. BREAKAWAY

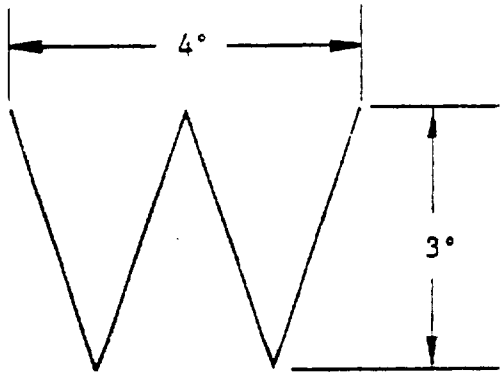


FIGURE 17. WARNING INDICATOR

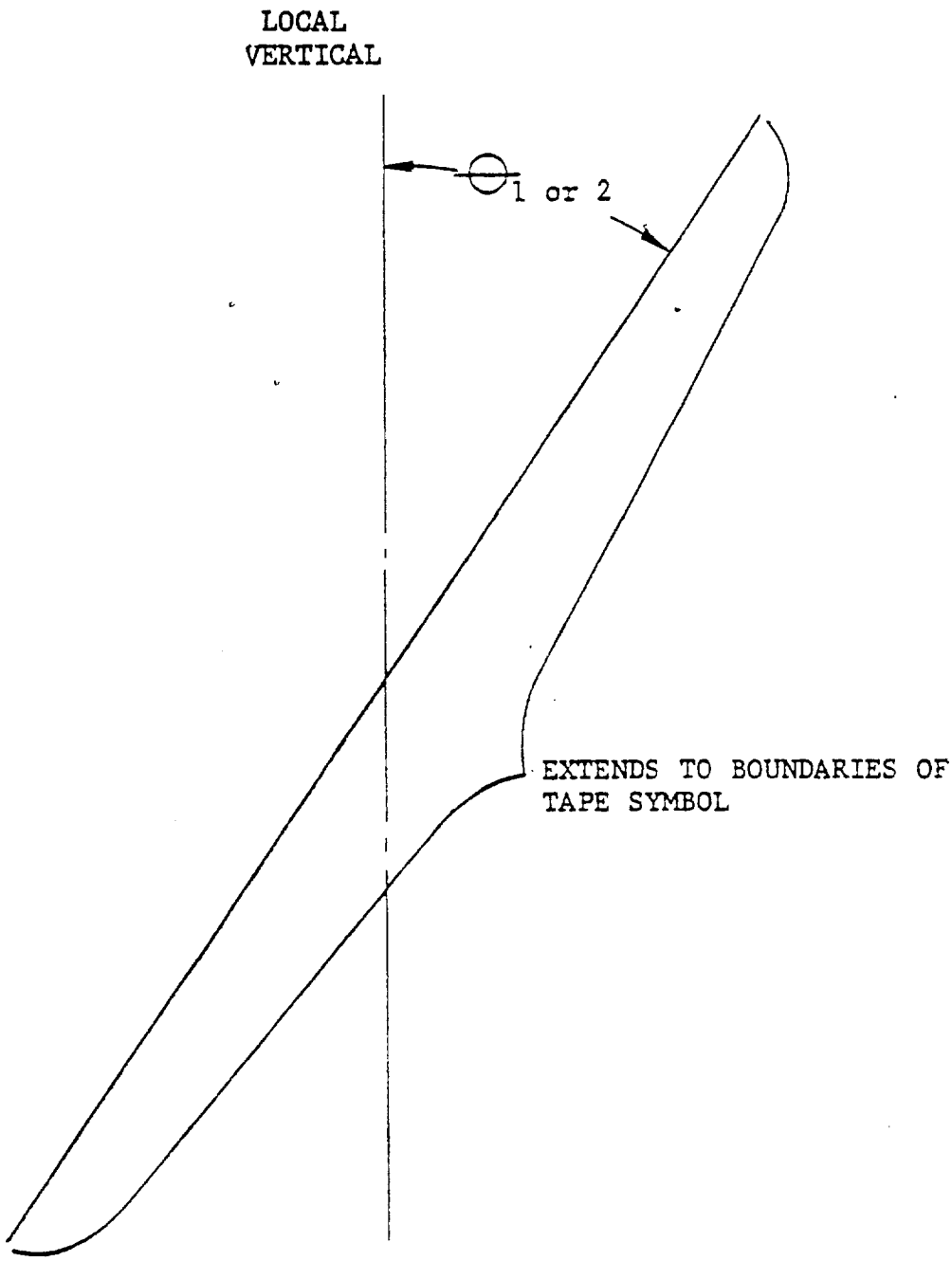


FIGURE 18. BOMB FALL LINE

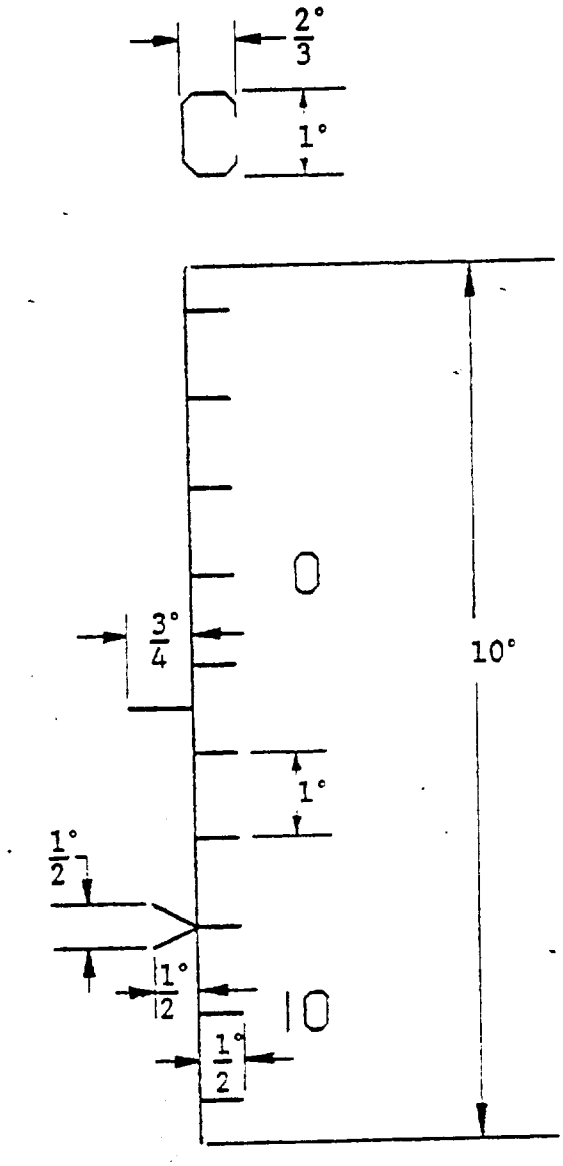


FIGURE 19. CLOSURE RATE

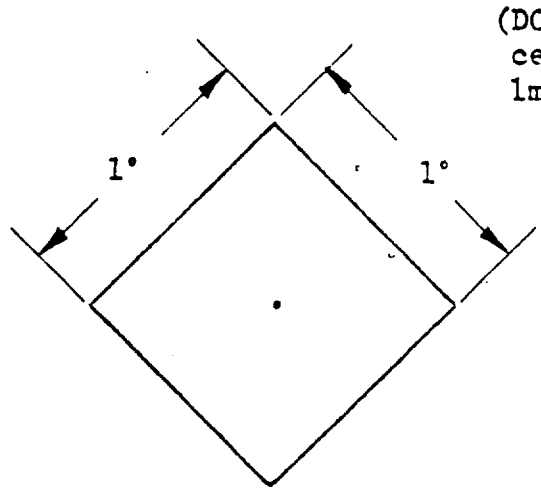


FIGURE 20. TARGET, GUNS, ROCKETS, AND BORESIGHT MISSILES

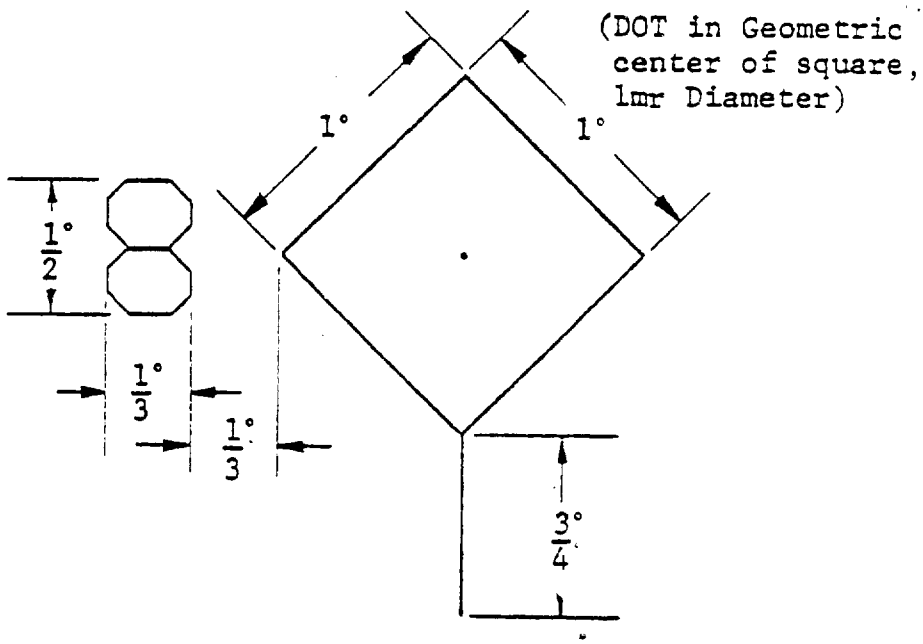


FIGURE 21. MISSILE TARGET

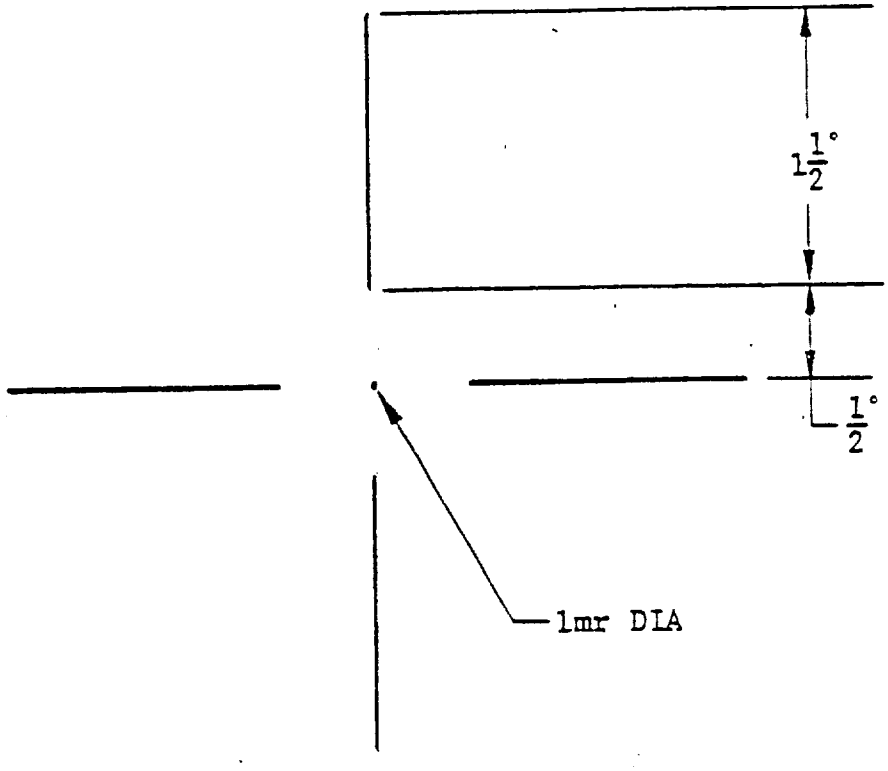


FIGURE 22. AIMING RETICLE

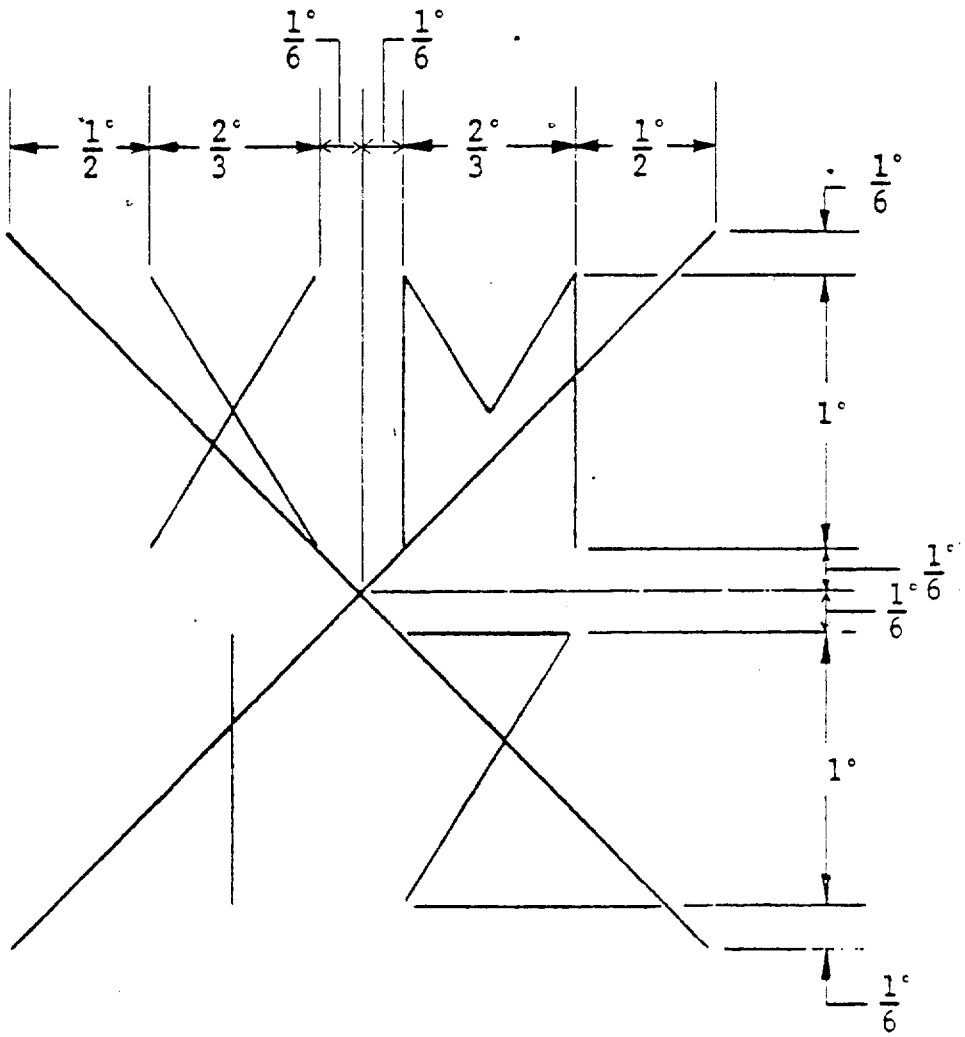


FIGURE 22. ORDNANCE TYPE AND NUMBER

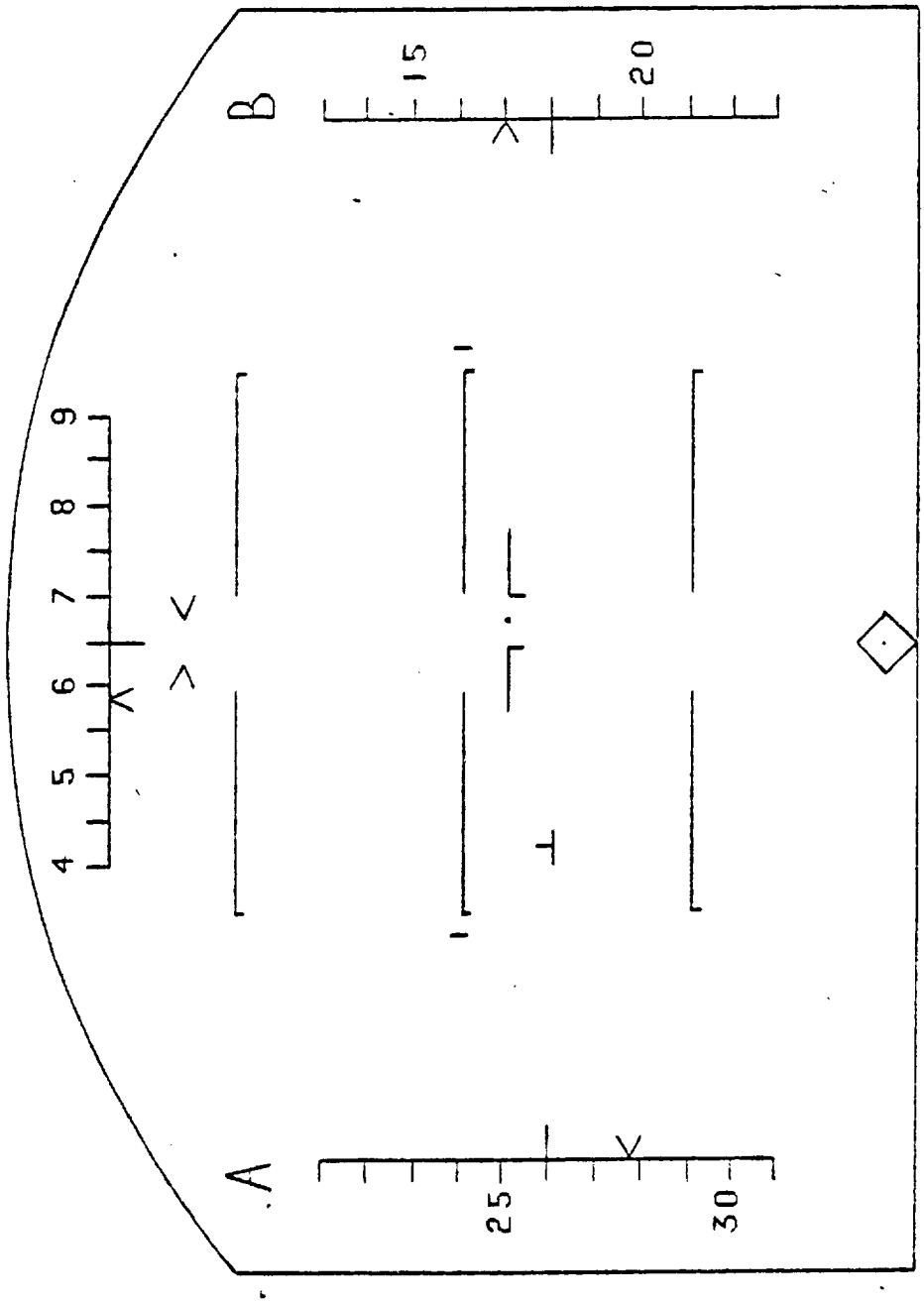


FIGURE 24. TAKE OFF/NAVIGATION MODE

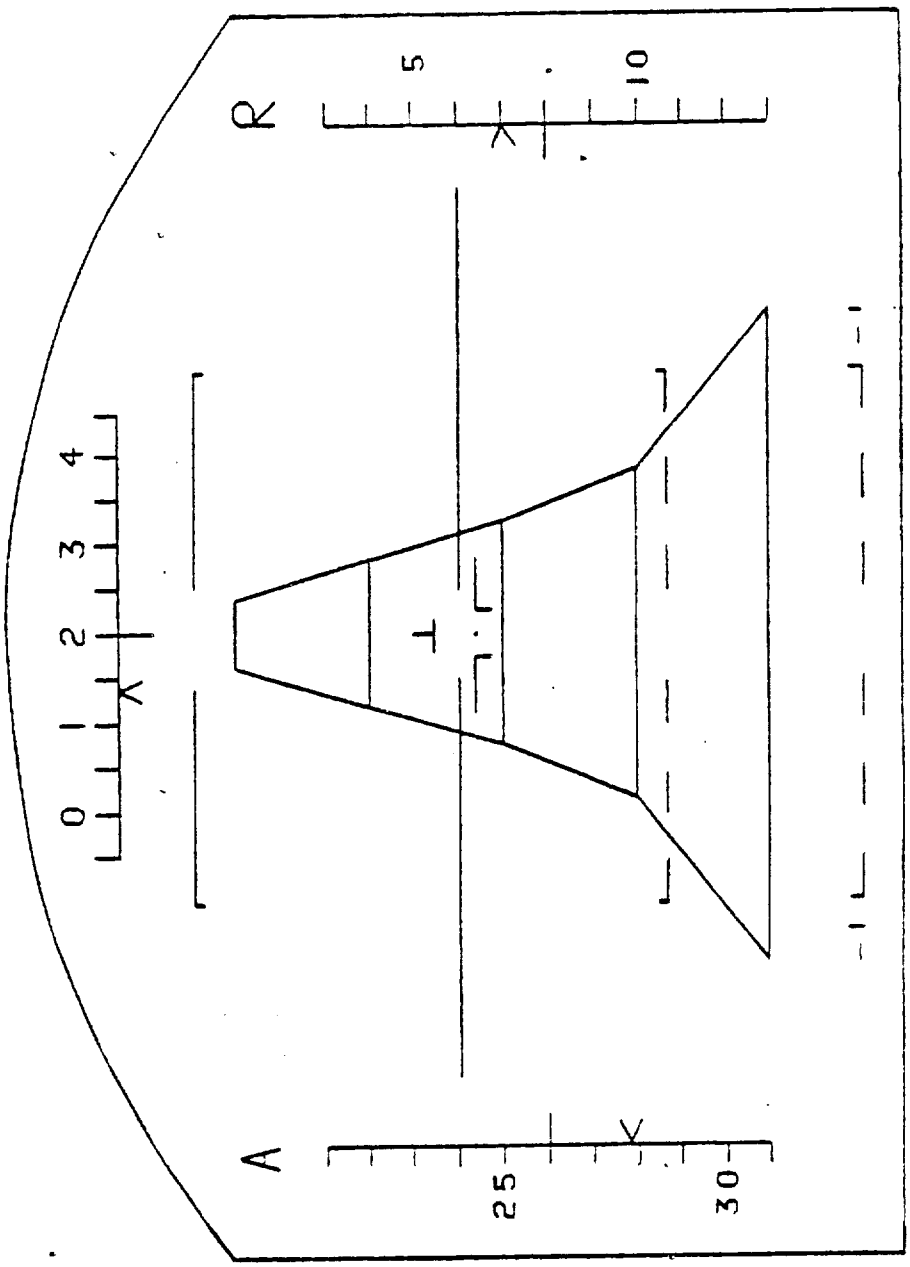


FIGURE 25. TERRAIN FOLLOWING MODE

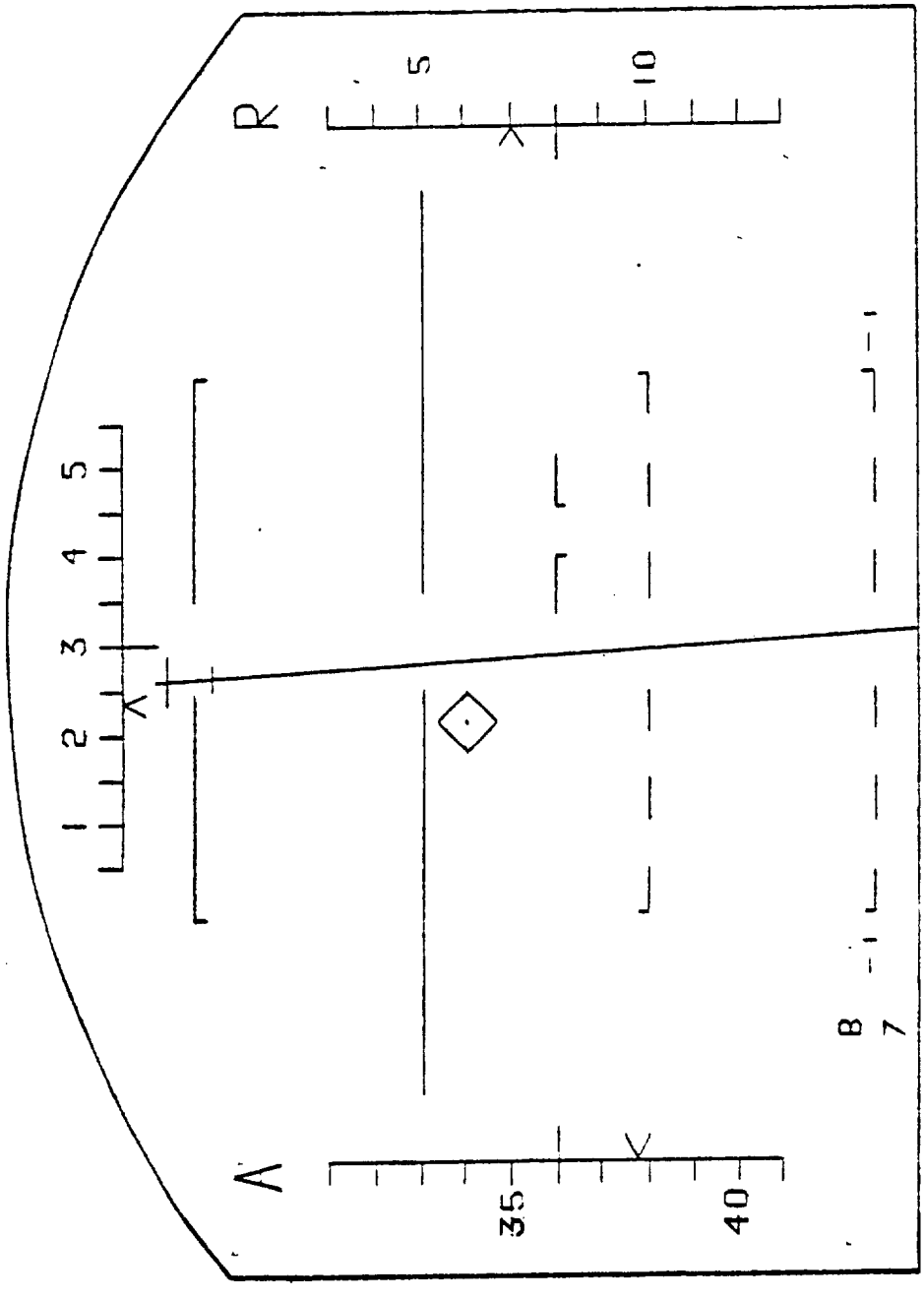


FIGURE 26. BOMBING MODE

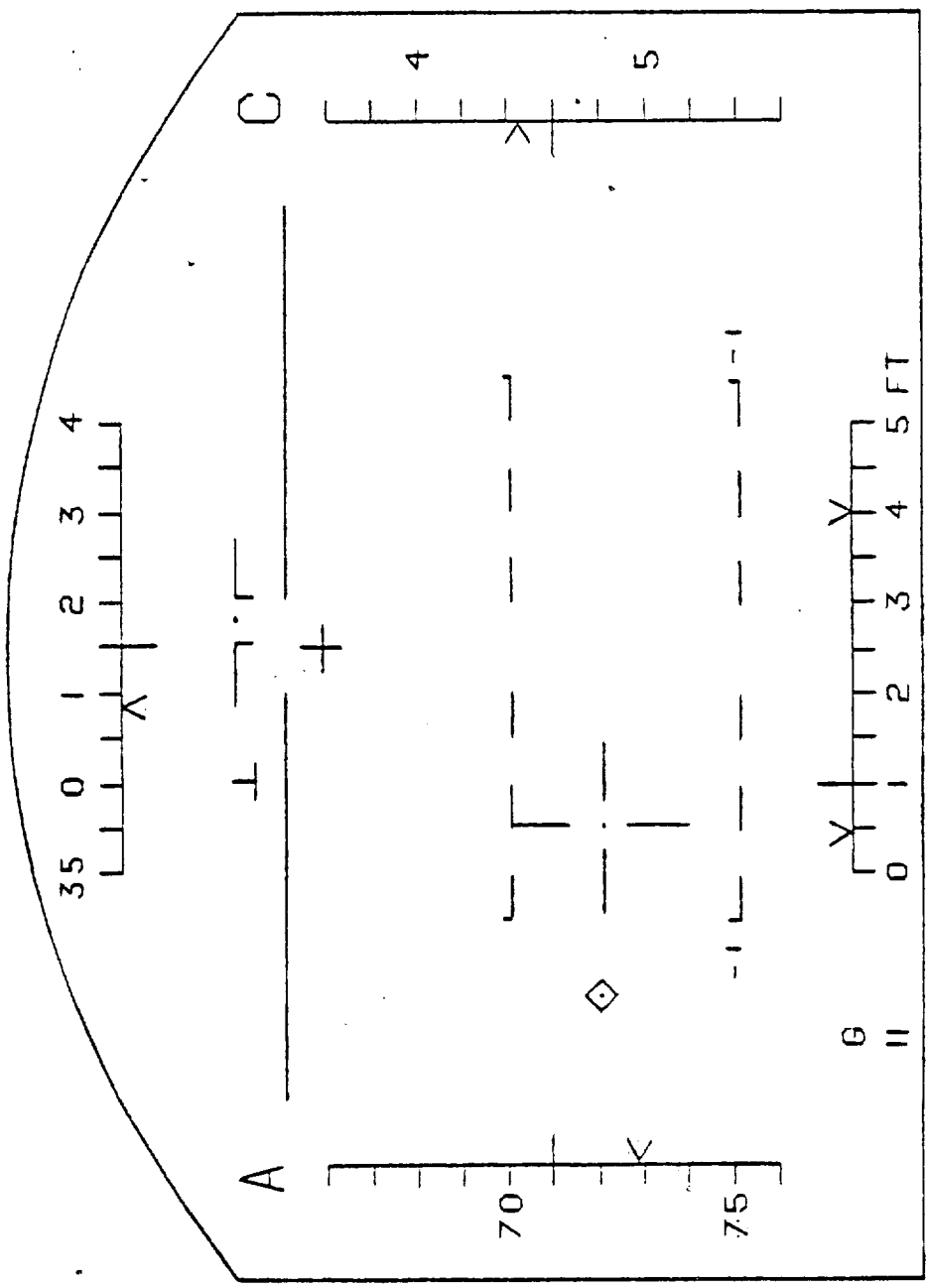


FIGURE 27. BORESIGHT WEAPON MODE

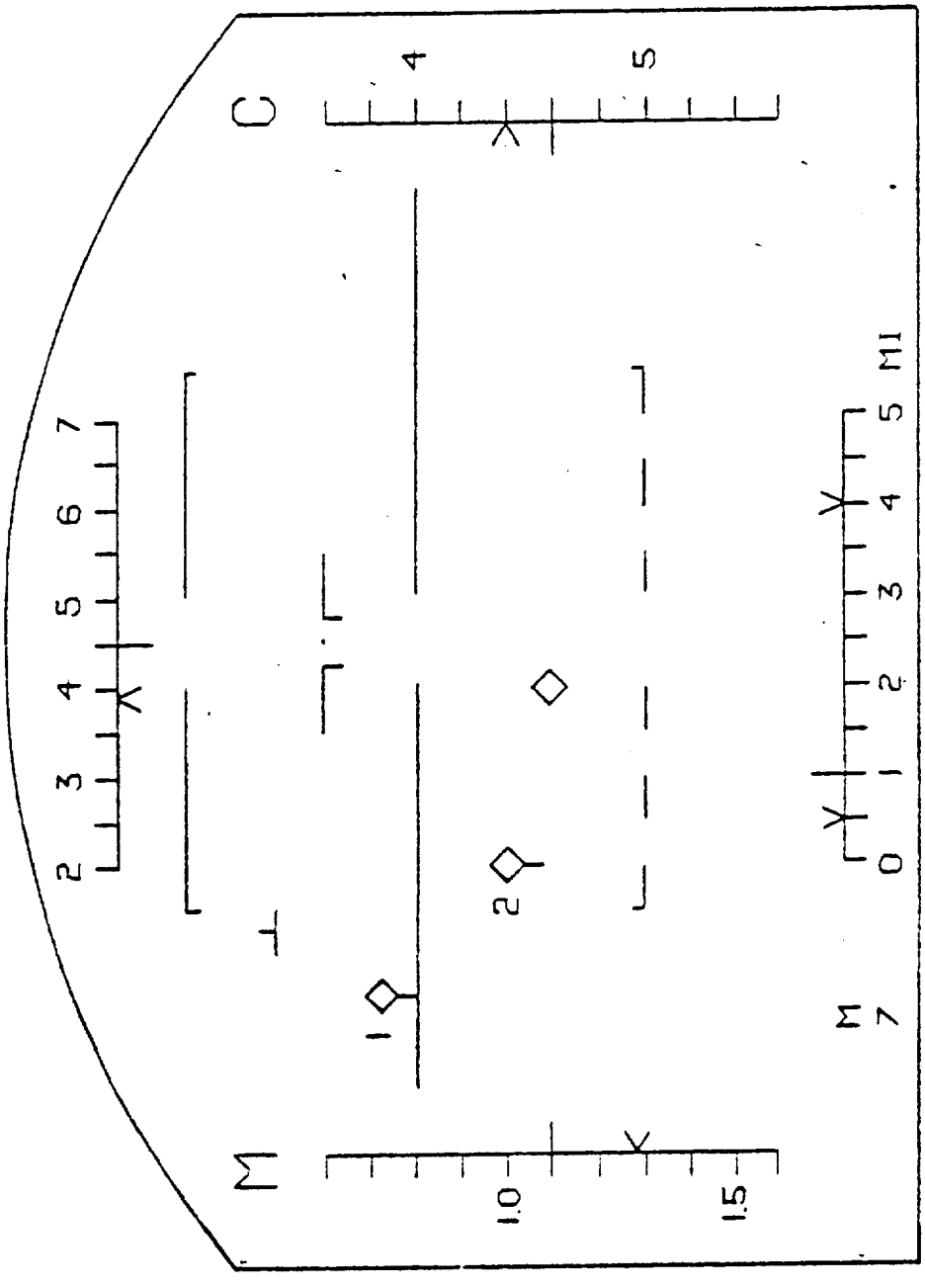


FIGURE 28. GUIDED WEAPONS MODE

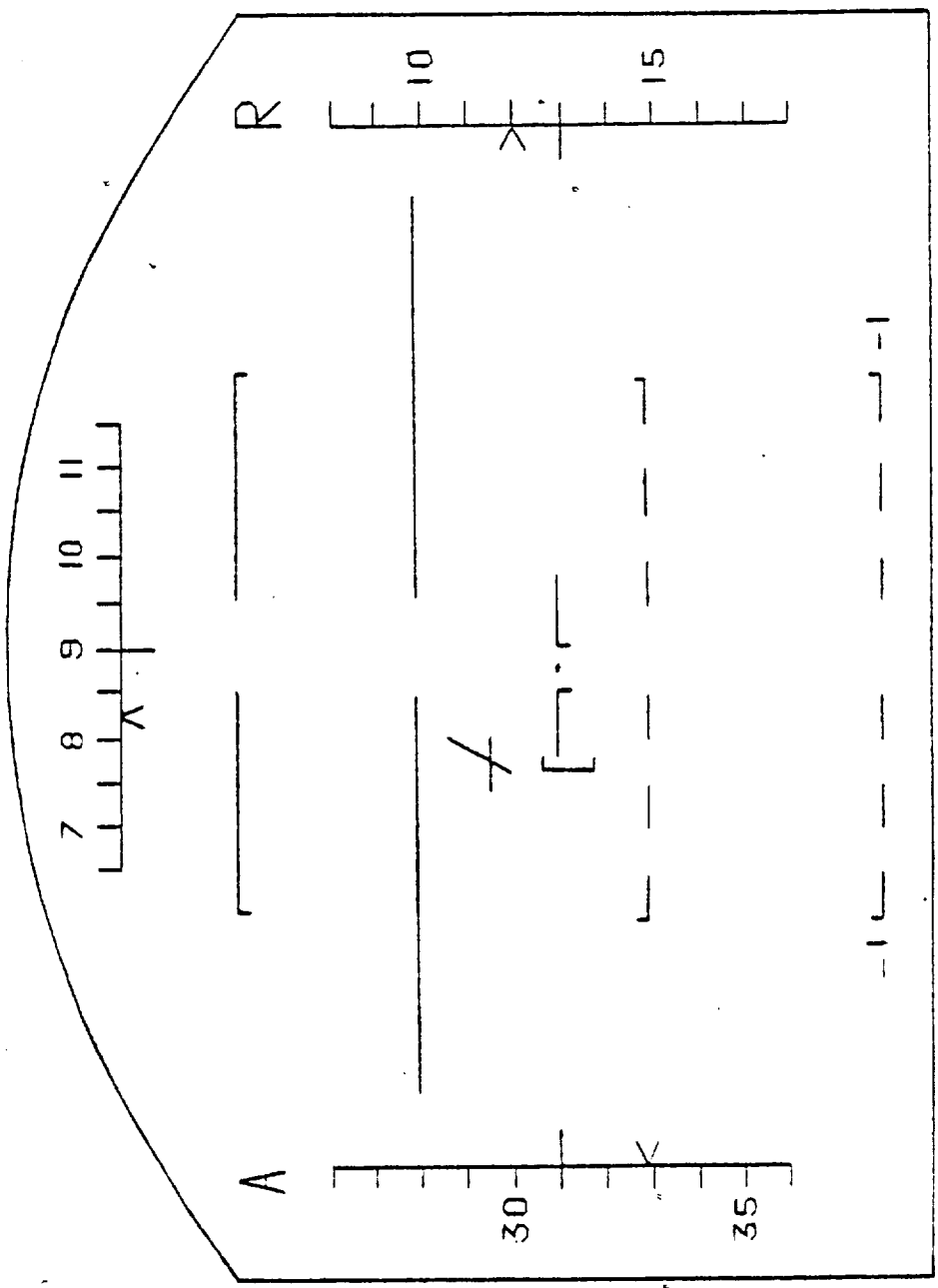


FIGURE 29. LANDING MODE

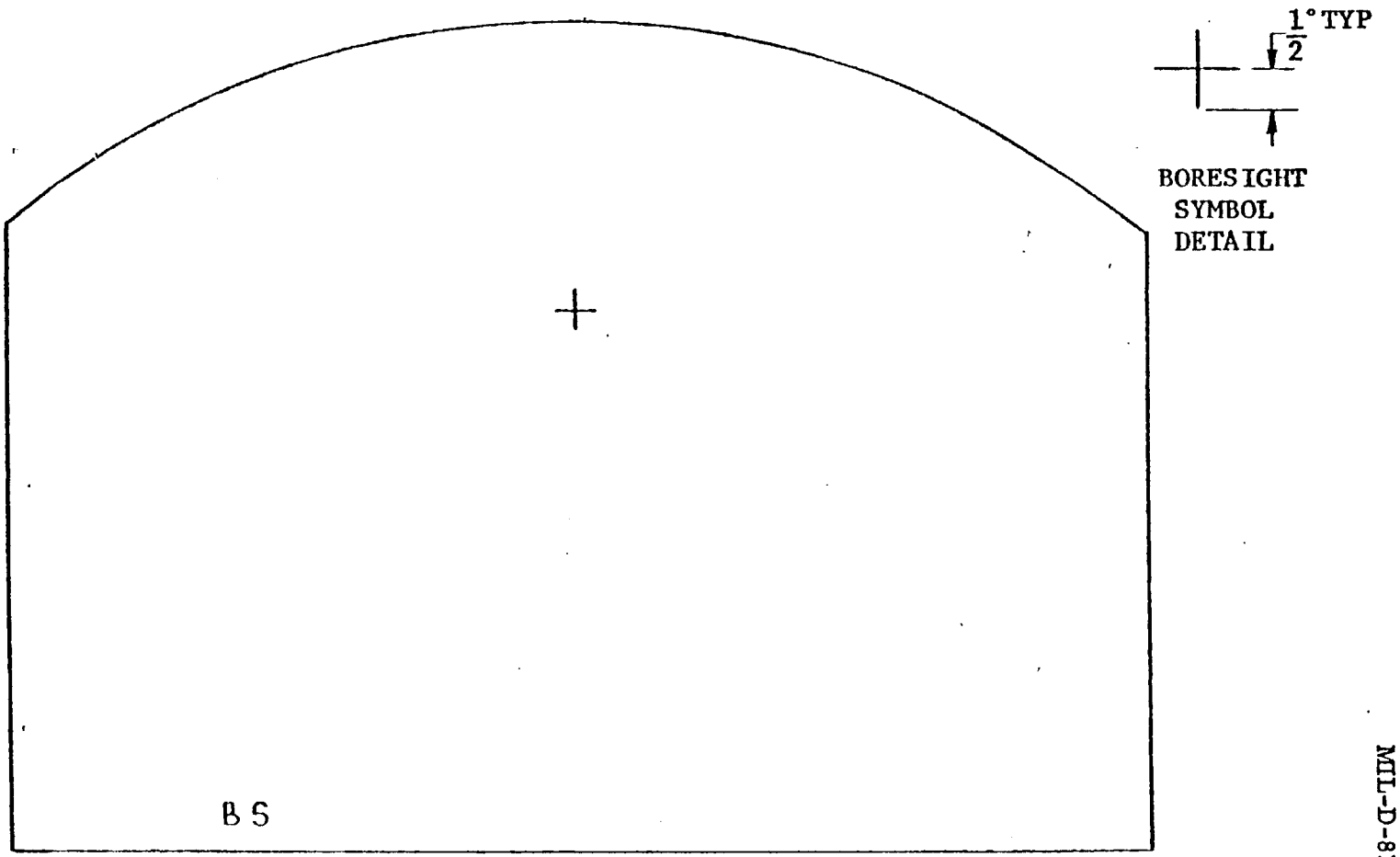
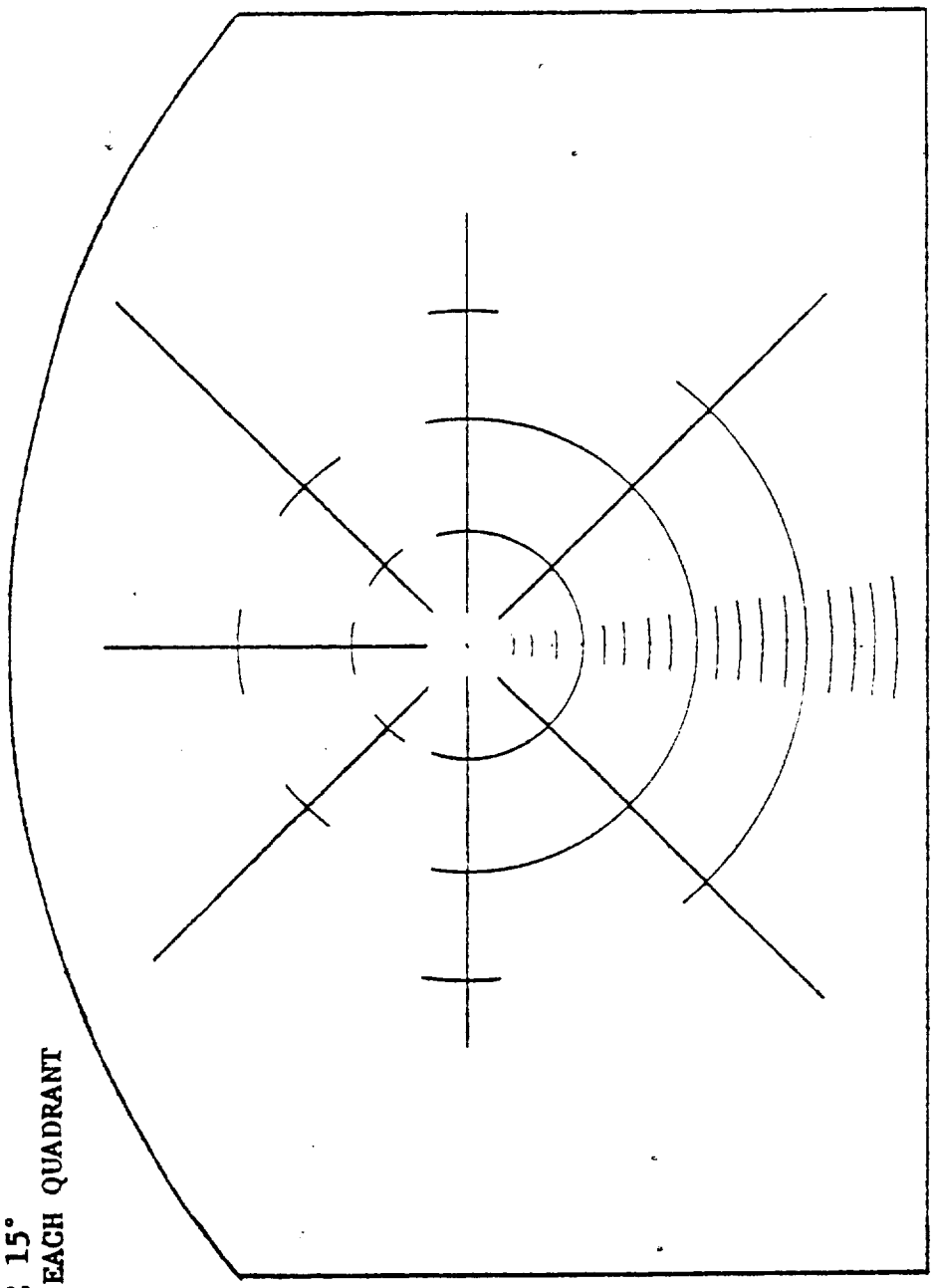


FIGURE 30. BORESIGHT MODE



DETAIL:
SMALL CIRCLE 5°
MIDDLE CIRCLE 10°
LARGE CIRCLE 15°
"X" BISECTS EACH QUADRANT

FIGRUE 31. STANDBY RETICLE MODE

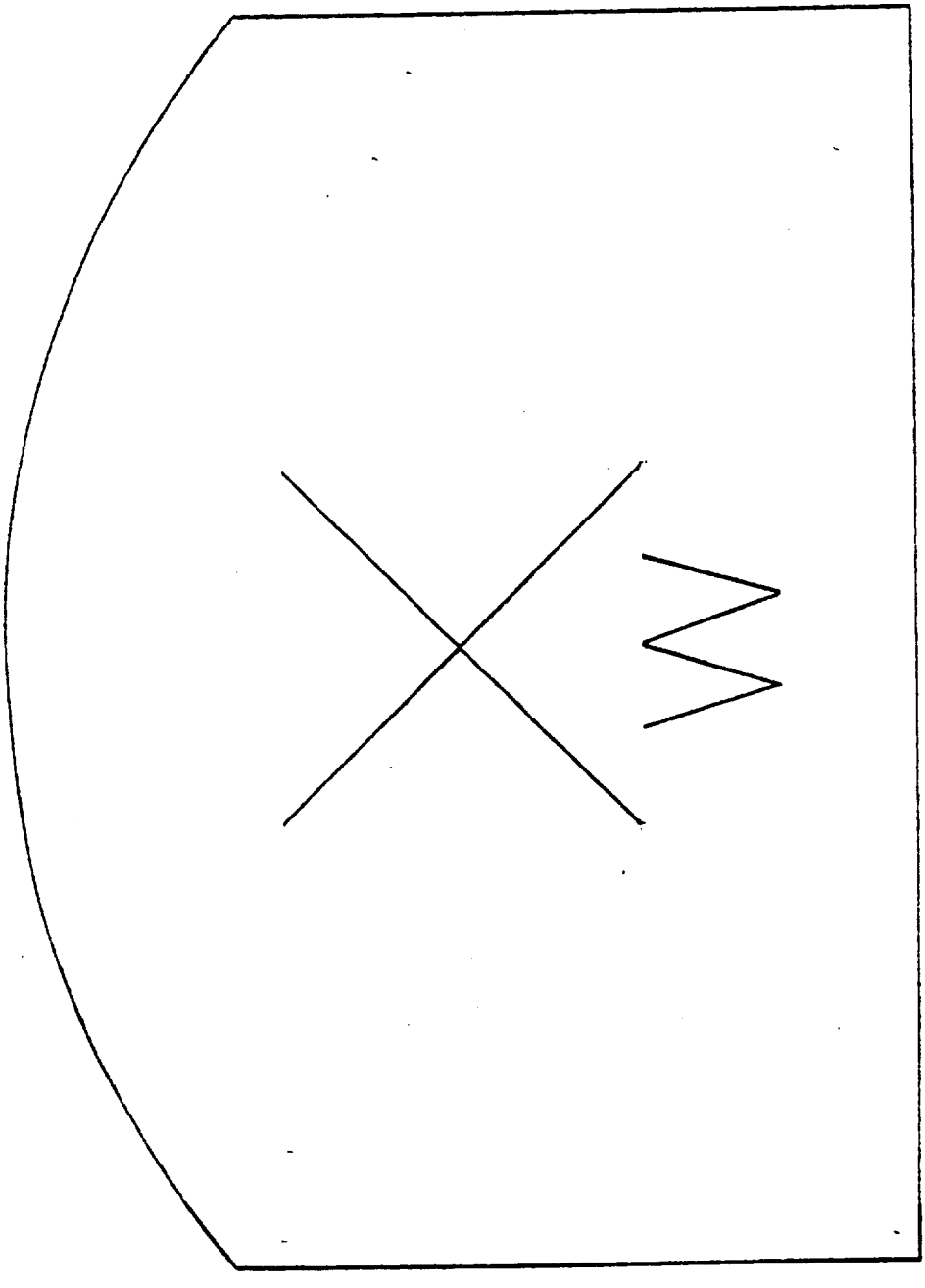


FIGURE 32. GENERAL POSITION OF THE PULL UP AND THE WARNING SYMBOLS IN THE FIELD OF VIEW

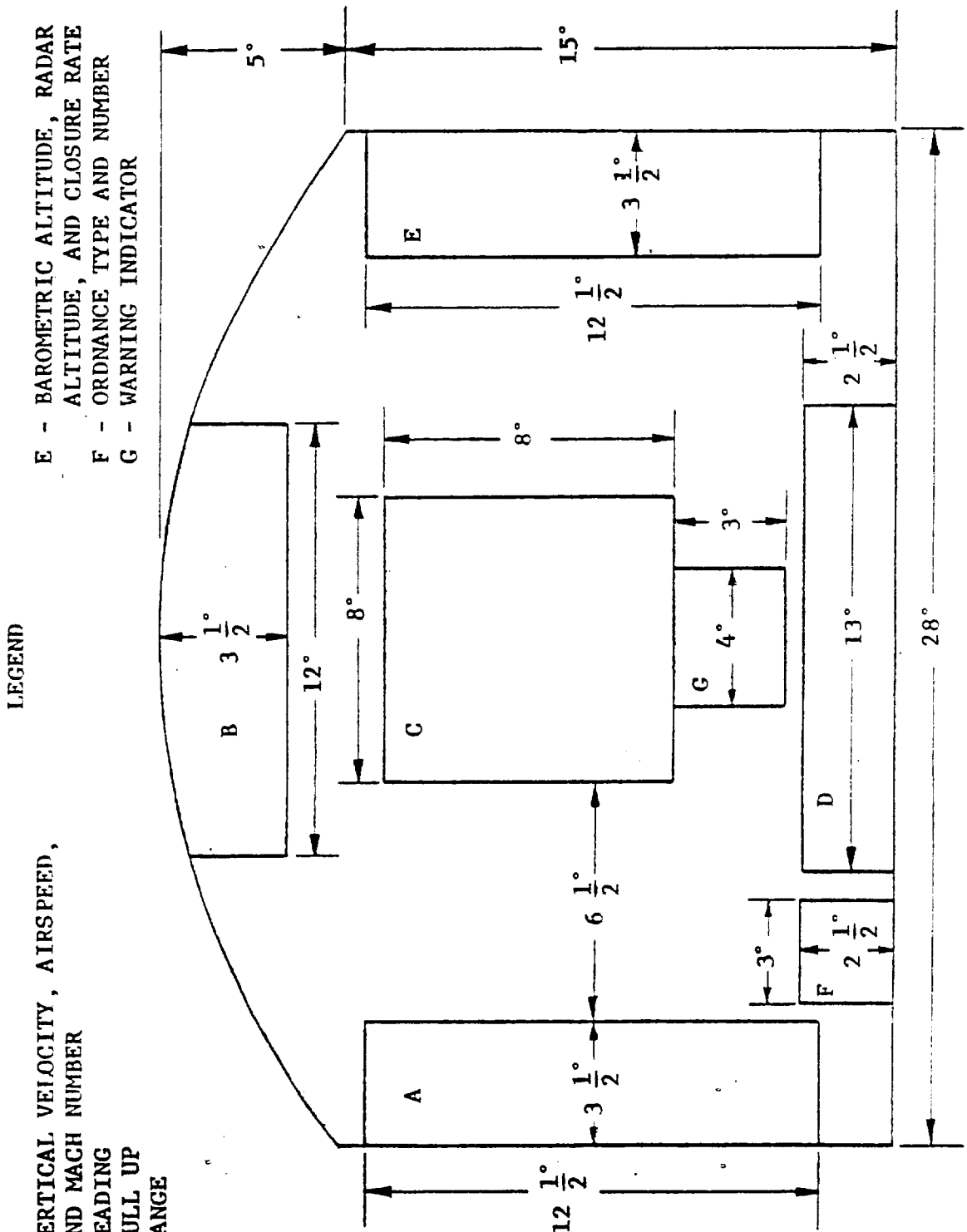


FIGURE 33. FIELD OF VIEW AND FIXED LOCATION SYMBOL POSITIONS

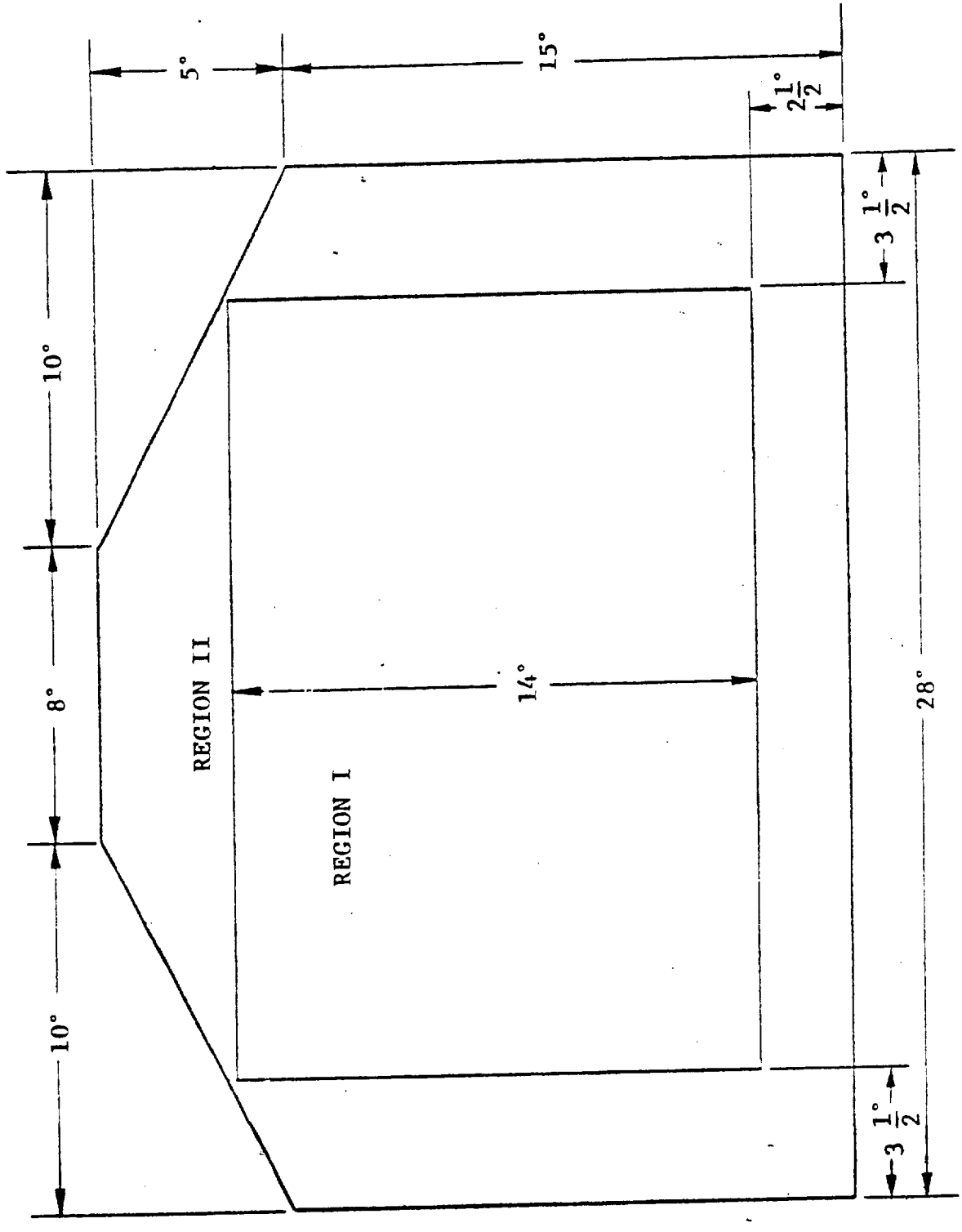
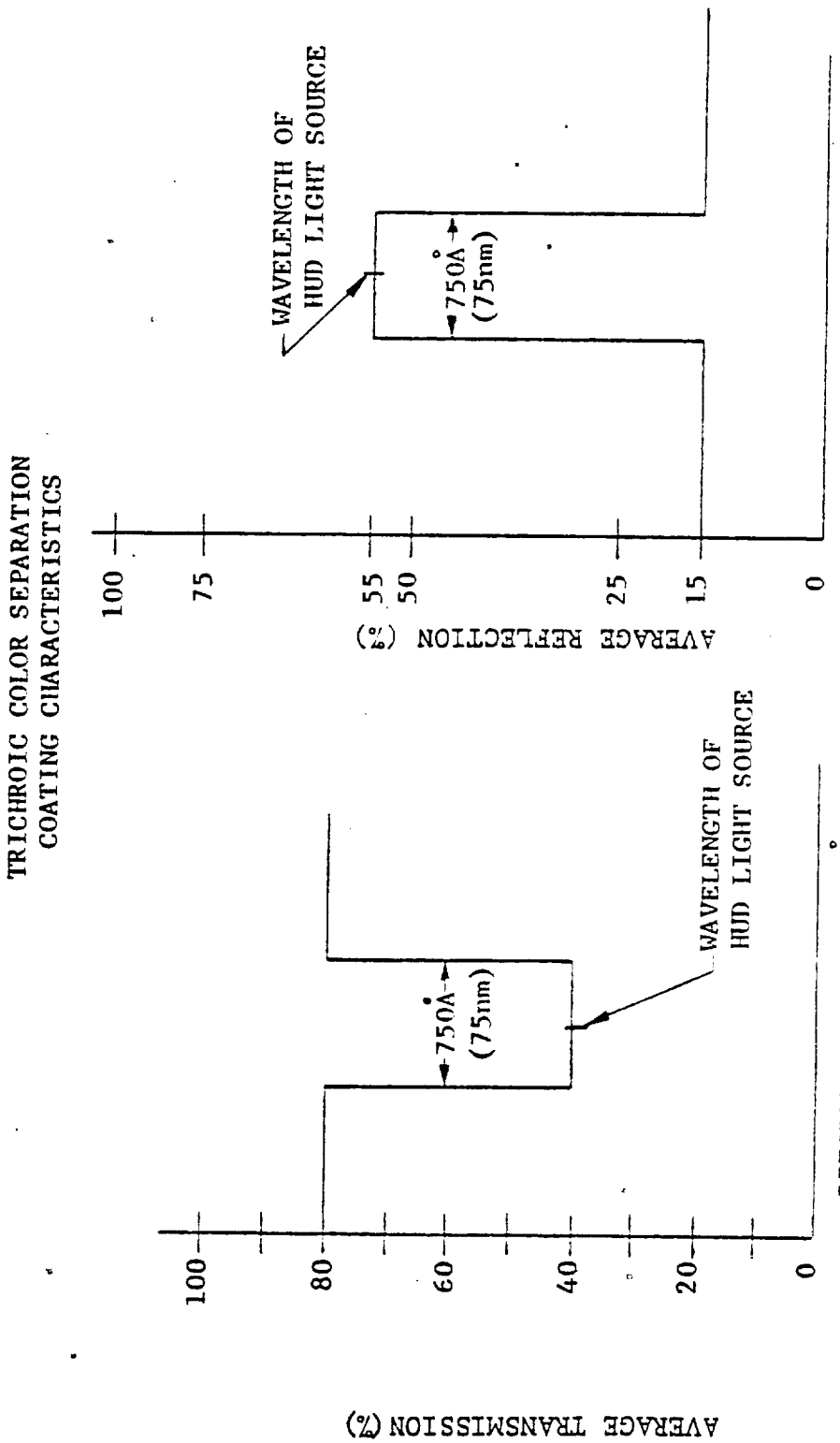


FIGURE 34. REGION I AND REGION II OF THE FIELD OF VIEW



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Index of Specifications and Standards References

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