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MILITARY SPECIFICATION

INDICATOR, HORIZONTAL SITUATION AQU-4/A

This specification is approved for use by the Department of the Air Force and is available for use by all Departments and Agencies of the Department of Defense.

1 SCOPE

1.1 Scope This specification covers the requirements for one type of horizontal situation indicator, designated AQU-4/A

2 APPLICABLE DOCUMENTS

2 1 Government documents

2 1 1 Specifications, standards and handbooks The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

PPP-B-601	Boxes, Wood, Cleated Plywood
PPP-B-636	Box, Shipping, Fiberboard

MILITARY

MIL-P-116	Preservation, Methods Of
MIL-C-675	Coating Of Glass Optical Elements (Antireflection)
MIL-E-5400	Electronic Equipment, Aircraft, General Specification For
MIL-C-5541	Chemical Conversion Coatings On Aluminum And Aluminum Alloys
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification For
MIL-A-8625	Anodic Coatings, For Aluminum And Aluminum Alloys
MIL-L-25467	Lighting, Integral, Red, Aircraft Instrument, General Specification For

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Oklahoma City Air Logistics center/TICLA, Tinker AFB OK 73145-5990 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter

AMSC N/A FSC 6605

MIL-L-27160	Lighting, Instrument, Integral, White, General Specification For
MIL-C-83488	Coating, Aluminum, ION Vapor Deposited

STANDARDS

FEDERAL

FED-STD-595	Colors

MILITARY

MIL-STD-100	Engineering Drawing Practices
MIL-STD-129	Marking For Shipment And Storage
MIL-STD-130	Identification Marking Of US Military Property
MIL-STD-461	Electromagnetic Emission And Susceptibility Requirement For The Control Of Electromagnetic Interference
MIL-STD-704	Aircraft, Electric Power, Characteristics
MIL-STD-781	Reliability Testing For Engineering Development, Qualification & Production
MIL-STD-810C	Environmental Test Methods & Engineering Guidelines
MIL-STD-838	Lubrication Of Military Equipment
MIL-STD-889	Dissimilar Metals
MIL-STD-970	Standards And Specification, Order Of Preference For The Selection Of
MIL-STD-2073-1	DOD Material Procedures For Development & Application Of Packaging
MS33558	Numerals And Letters, Aircraft Instrument Dial, Standard Form Of

(Unless otherwise indicated, copies of federal and military specification, standards, and handbooks are available from Standardization Document Order Desk, Bldg 4D, 700 Robbins Ave, Philadelphia, PA 19111-5099)

2.2 Non-Government publications The following document(s) form a part of this document to the extent specified herein Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2)

American Society For Testing And Materials (ASTM)

ASTM D3951 Packaging, Commercial

(Application for copies should be address to. ASTM, 1916 Race St, Philadelphia, PA 19103.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2 3 Order of precedence In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained

3 REQUIREMENTS

3 1 Qualification The indicator, horizontal situation AQU-4/A furnished under this specification shall be a product which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.3 and 6.4)

3 2 Materials

3 2.1 Fungus-proof materials Materials that are nutrients for fungi shall not be used where it is practical to avoid them Where used and not hermetically sealed, they shall be treated with a fungicidal agent acceptable to the procuring activity However, if they will be used in a hermetically sealed enclosure, fungicidal treatment will not be necessary

3.2.2 Nonmagnetic materials Nonmagnetic materials shall be used for all parts except where magnetic materials are essential

3 2.3 Nonferrous materials Nonferrous materials shall be used for all parts except where ferrous materials are essential.

3.2 4 Metals Metals shall be of the corrosion-resistant type or suitably treated to resist corrosion due to fuels, salt fog, or atmospheric conditions likely to be met in storage or normal service

3 2.5 Dissimilar metals. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other Dissimilar metals are defined on MIL-STD-889

3.2.6 Hermetic seal. Nonferrous materials contained within hermetically sealed enclosures (see 6 3.2) shall be considered suitably protected from corrosion. Requirements specified for fungicidal and corrosion protective treatment and anodizing of aluminum-alloy parts shall not be applicable for parts within hermetically sealed enclosures

3 2 7 Protective treatment When materials are used in the construction of HSI that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage, they shall be protected against such deterioration in a manner that will in no way prevent compliance with the performance requirements of this specification. The use of any protective coating that will crack, chip, or scale with age or extremes of climatic and environmental conditions shall be avoided.

3.2.8 Recycled and reclaimed materials. Recycled and reclaimed materials shall be encouraged to the maximum extent possible without jeopardizing the intended end use of the item.

3 2 9 Steel parts Steel parts shall be coated with ion vapor deposited aluminum, where practical, in accordance with MIL-C-83488, type I or II as applicable, and of a class that is adequate to achieve the degree of protection required Other protective coating, in lieu of MIL-C-83488, may be used if demonstrated to be satisfactory and approved by the cognizant government engineering activity. Cadmium plating must be avoided when satisfactory alternative processes can be used

3 3 Selection of specifications and standards Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-970

3 4 Design and construction

3 4 1 Design The HSI shall be designed to present the following information.

(a) Stabilized magnetic compass heading (within 1 degree) provided from the master directional reference

(b) Command heading information (within 1 degree) provided from a remote source or desired heading, set in manually

(c) Command course (within 1 degree) provided from a remote source or desired course, set in manually, displayed by a pointer and a numerical indication

(d) Displacement of the aircraft from a manually or automatically selected track as indicated by a course bar

(e) Invalidity of course deviation data as indicated by a course-deviation alarm flag

(f) Numerical indication of distance to a transmitting radio source or target

(g) To-from indication for a selected radio facility

(h) Bearing to selected station or target (within 1 degree)

(i) Reciprocal bearing to selected station or target.

(j) Power failure

3 4.2 Construction The HSI shall be so constructed that no parts will work loose in service. It shall be built to withstand the strains, jars, vibrations, and other conditions incident to shipping, storage, installation, and service.

3 4 2.1 Overhaul parts. The HSI shall be so constructed that overhaul, including replacement of worn parts, adjustment balance, and calibration may be accomplished by instrument and electronic repairmen provided with simplified tools and equipment, and trained in the repair of electronic equipment.

3 4.3 Compatibility. The HSI must be designed and built to be compatible with all of the interfacing equipment. This equipment includes but is not limited to the TACAN sets, ILS sets, INS, and FDCs in use at the time of qualification The HSI must operate with the above equipment in both single and dual HSI installations. In the dual installation the HSI must operate properly as the master or as the slave.

3.5 Performance The HSI shall conform to all requirements specified herein after exposure to the following conditions:

(a) Operating temperatures ranging from -54° to +71°C and storage temperatures ranging from - 65° to +85° C

(b) Altitudes from sea level to 100,000 feet

(c) Relative humidity up to 100 percent.

(d) Fungus growth as encountered in tropical climates.

(e) Exposure to salt-laden atmosphere

(f) Sand and dust particles as encountered in desert areas.

(g) Thermal shock forces as encountered during rapid changes of extreme temperatures

(h) Vibration force incident to service use.

(i) Immersion in water and leak test conducted with an approved helium leak detector

(j) Acceleration forces as encountered in high-performance aircraft.

(k) The application of 250V DC for 10 seconds

3 5 1 Radio interference The HSI shall not be a source of radio interference and shall meet the requirements of MIL-STD-461

3 5.2 Attitude The HSI shall be capable of operating satisfactorily while in any attitude.

3.5.3 Friction error Not more than 0.25 degree of error shall be introduced in the readings as a result of friction between moving parts.

3 5 4 Magnetic effect The HSI shall not cause excessive error in the indication of panel-mounted directional magnetic compasses

3.5.5 Life. The HSI shall be capable of meeting the performance requirements for 1,000 hours of operation during actual service usage

3.5 5.1 Reliability The HSI shall have a mean-time-between-failure (MTBF) of not less than 775 hours (θo) at a confidence factor of 90 percent and a discrimination ratio of 2. Testing to verify this requirement shall be in accordance with MIL-STD-781, Test Plan III C.

3.6 Part numbering of interchangeable parts. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable. The item identification and part number requirements of MIL-STD-100 shall govern the manufacturer's part numbers and changes thereto.

3 7 Electronic requirements. The requirements specified in MIL-E-5400 are applicable as electronic requirements of this specification. Additional requirement shall be as specified herein In the event the requirements of MIL-E-5400 and this specification conflict, this specification shall govern

3 8 Miniaturization Modern techniques of miniaturization, potting, and hermetic sealing shall be exploited to the greatest extent practicable without sacrificing ruggedness, reliability, and service life.

3 8 1 Transistorized or magnetic amplifier circuits Four transistorized or magnetic servo amplifier shall be provided and shall be integral with the HSI mechanism within the case The amplifiers shall feature module plug-in capability, if possible Each amplifier module shall be designed with partial redundant circuits so that the servos will continue to operate, though with reduced performance, should partial failure of the amplifier occur

3 9 Case The HSI case shall be in accordance with FIGURE 1 It shall be metal, uniform in texture, shall have a smooth surface, and shall be entirely covered with a durable finish The inside of the case around the electrical connector shall be of sufficient strength to prevent damage to the case when the electrical connector is tightened during installation

3 9.1 Control knobs Control knobs as shown on FIGURE 2 shall be provided. A minimum of 2 ounce-inches and a maximum of 10 ounce-inches shall be required to turn the knobs The knobs shall be medium gray, color No 36231 of FED-STD-595, except the ends shall be black with white lettering. Block-type lettering shall be used

3 9.2 Coverglass The coverglass shall be hermetically sealed within the HSI case and shall be mounted from the inside of the case The coverglass shall be from 0.16 to 0.25 inch in thickness. It shall be flat and free from discolorations, except as induced by glare-reducing coating, scratches, and striae which interfere with reading of the instrument. The coverglass aperture shall be as shown on FIGURE 2

3 9 3 Reflective surfaces All reflecting glass surfaces shall be provided with a reflection-reducing coating which meets the requirements of MIL-C-675, in addition to withstanding the environmental conditions specified herein, except that the reflectance tolerances indicated in TABLE I shall apply

3 9 4 Hermetic sealing The case shall be hermetically sealed The case shall be so designed that the internal mechanism may be removed, replaced, and the case resealed This shall be accomplished without the use of special tools and fixtures unless they are approved by the procuring activity. Hermetic sealing shall be such that the sealing will not be affected by the action of any atmosphere to which the component may be subjected. The case shall met the necessary pressure requirements when tested for leaks by means of a mass-spectrometer-type of helium leak detector

3 9 4 1 Filling medium The filling medium shall be of at least 98 percent purity, free of dust particles, land shall contain not more than 0.006 milligram of water vapor per liter (dewpoint -65° C) at the filling pressure The filling medium shall be either 100 percent helium or a mixture of 88 to 92 percent nitrogen and the remainder helium. The absolute pressure of the filling medium in the case shall be approximately 1 atmosphere. Where practicable, the 100 percent helium filling medium shall be utilized.

TABLE I. Reflective Tolerances

Angel of Incidence	Wavelength Millimicrons	Percent Reflectance
0 degree	450 to 675	0.6 maximum
0 degree	425 to 700	0.5 average
30 degrees	450 to 625	1.0 maximum
30 degrees	425 to 700	0 5 average

3 9.4.2 Leakage rate. The indicator shall be so sealed that the initial maximum leakage rate at a pressure differential of approximately 1 atmosphere will not permit more than 10 percent loss of the total filling medium after 1,000 hours

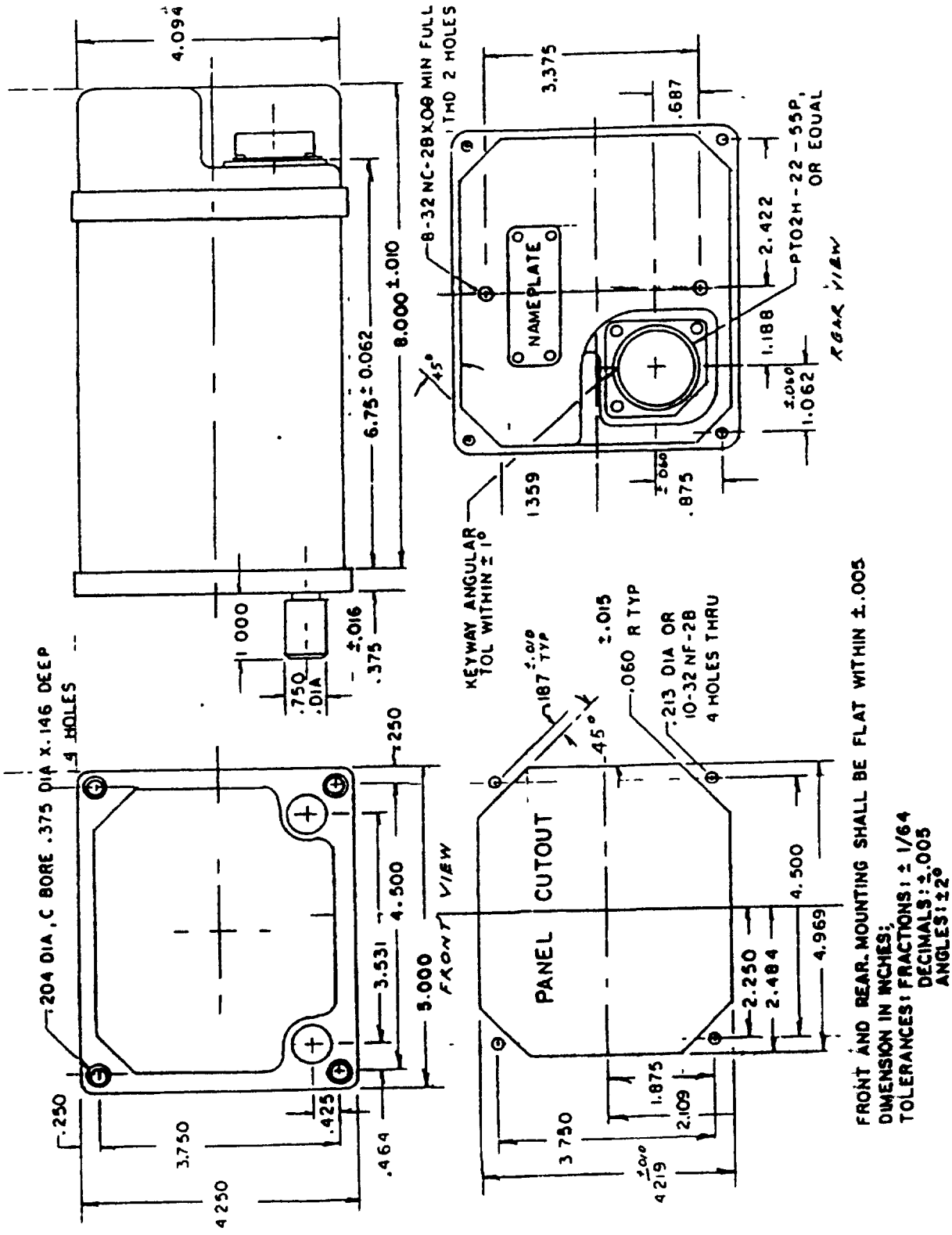
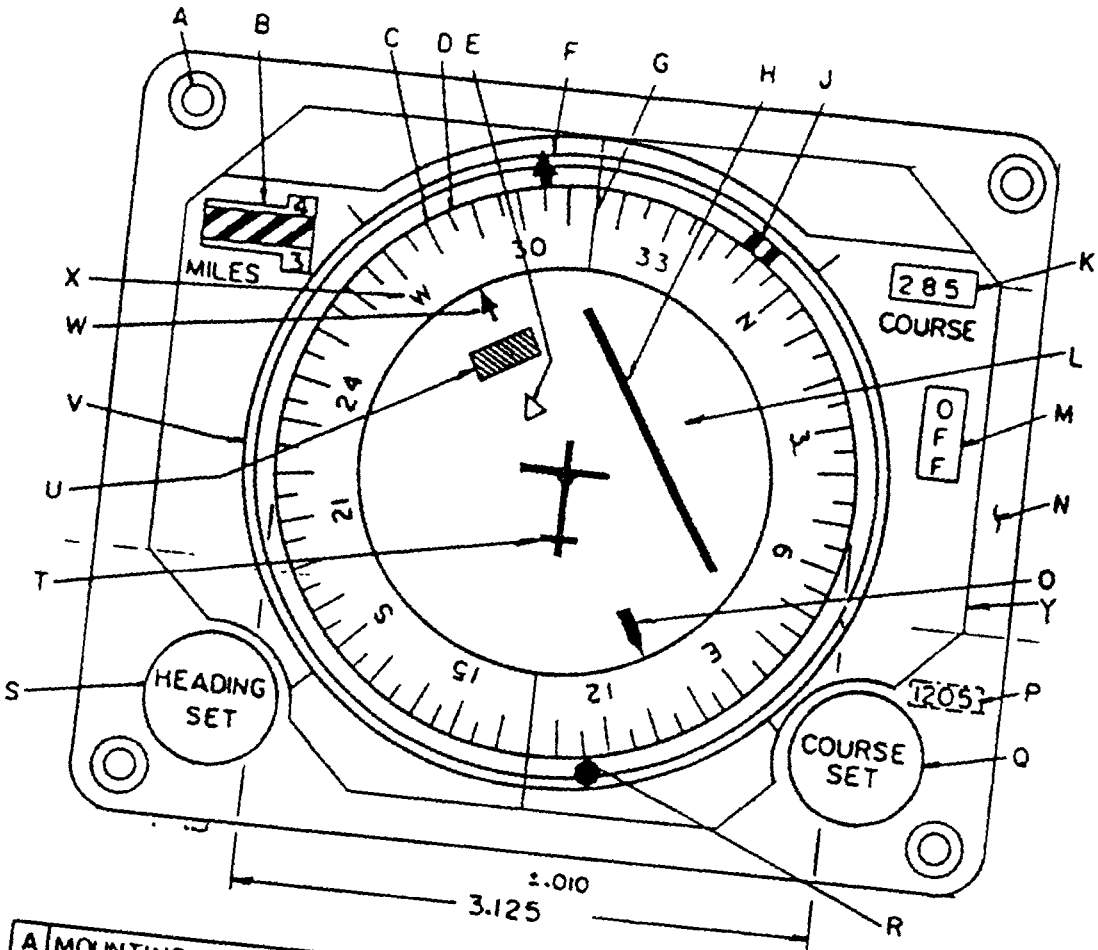


FIGURE 1 Case dimensions



A	MOUNTING HOLE
B	DIGITAL DISTANCE DISPLAY
C	10° INCREMENTAL MARKS
D	5° INCREMENTAL MARKS
E	TO - FROM ARROW
F	BEARING POINTER
G	LUBBER LINE
H	COURSE DEVIATION BAR
J	HEADING MARKER
K	DIGITAL COURSE DISPLAY
L	COURSE DEVIATION DOTS
M	POWER OFF FLAG
N	CASE FLANGE
O	RECIPROCAL COURSE INDEX
P	ELAPSED TIME INDICATOR
Q	COURSE SET KNOB
R	RECIPROCAL BEARING MARKER
S	HEADING SET KNOBS
T	AIR PLANE SYMBOL
U	DEVIATION BAR ALARM FLAG
V	FIXED MARKER
W	COURSE ARROW
X	CARDINAL MARKINGS
Y	COVERGLASS APERTURE

FIGURE 2 Dial.

3 10 HSI display The display detail dimensions shall conform to one of the following design criteria options

3 10.1 Option A The HSI display shall conform to FIGURES 2 and 3. All sizes of the pointers, azimuth card, deviation bar, numerals, and letters shall conform to the size and width listed on FIGURES 2 and 3 The azimuth card, center section of the display, and main mask of the display shall lie in one plane, designated plane A, and shall be 0 7 ± 0 05 inch from the forward edge of the coverglass. The forward edge of the heading marker shall be 0.01 inch forward of plane A; the forward face of the bearing pointer shall be 0.03 inch forward of plane A; the lubber line shall be 0 05 inch forward of plane A, the forward face of the course arrow and deviation bar shall be 0.18 inch forward of plane A, and the fixed airplane reference shall be 0 25 inch forward of plane A The first set of deviation dots shall be 0.11 inch forward of plane A and the second set shall be 0.03 inch forward of plane A. The forward face of the TO-FROM pointer and deviation alarm flag shall be not more than 0.025 inch behind plane A The dimensions as given are design center values.
3
3 10.2 Option B The HSI display shall conform to figures 2 and 3. All sizes of display components and letters shall conform to FIGURES 2 and 3. The azimuth card, main mask of the display, course arrow, and deviation bar shall all lie on the same plane, designated plane A, and shall be 0.5± 0.05 inch from the forward edge of the coverglass The airplane and lubber line shall be 0 05 inch forward of plane A The forward face of the bearing pointer shall be 0.03 inch forward of plane A. The forward face of the heading shall be 0.01 inch forward of plane A The first set of deviation dots shall be 0.04 inch back of plane A The forward face of the TO-FROM pointer and deviation-bar alarm flag shall be 0.12 inch back of plan A. The second set of deviation dots shall be 0.13 inch back of plane A The deepest point of any visible portion of the display shall be 0 17 inch from plane A The dimensions as given are design center values

3.10.3 Visibility All markings, the curse counter, distance readout, compass card graduations, heading marker and bearing pointers shall be clearly visible and readable when viewed at the distance of 2 feet from the indicator at an elevation angel of 30 degrees from the top of the coverglass and 4 inches to the right or left of the indicator centerline. The units digit of the course counter and the hundreds digit of the distance readout shall be visible when viewed at a distance of 2 feet in front of the indicator at an angle of 20 degrees to the right or left of the sides of the coverglass and 4 inches above or below the indicator centerline

3 11 Standard synchro test transmitter. A standard calibrated synchro with minimum and known errors shall be provided and shall be an Eclipse-Pioneer type AY201-1, or equal, high-precision transmitting synchro. A 0 degree to 360 degrees dial clamped to the rotor or the synchro shall be settable, rotatable, and readable through 360 degrees of rotation to 6 minutes of arc. The following procedure shall be used to calibrate the test synchro.

3.11.1 Rotor leads The rotor leads shall be designated as H and C and one stator lead designated as Z and connected C. When 26V AC, 400HZ is applied to H and C (C being ground) the dial shall be positioned on 0 degree and clamped to the rotor when:

(a) The voltage across H and Y is maximum.

(b) The voltage across the remaining two stator leads (X and Y) is minimum

(c) The voltage across X and Z increases before it decreases for increasing heading indication of the dial. The voltage X to Z and Y to Z shall be in phase with the excitation voltage C to H when the dial reading is zero. For increasing heading indication of the dial, the voltage X to Y shall increase and be in phase with the excitation voltage C to H The test transmitter will be set at an index reference of zero to a positive rotation reference XYZ

3 12 Presentation The presentation shall be in accordance with FIGURE 2

3 13 Aircraft heading The aircraft heading shall be displayed on the azimuth ring and shall be read under the fixed lubber line located at the top of the indicator face as shown on FIGURE 2

3 13 1 Azimuth ring signal input The input synchro control transformer (CT) shall be a high impedance type EP AY500-5, or equal, which shall receive an input from a synchro device similar to the test transmitter described in 3 11 A size 8 synchro CT, with the same general impedance of the stator windings as a type EP AY500-5, may be utilized

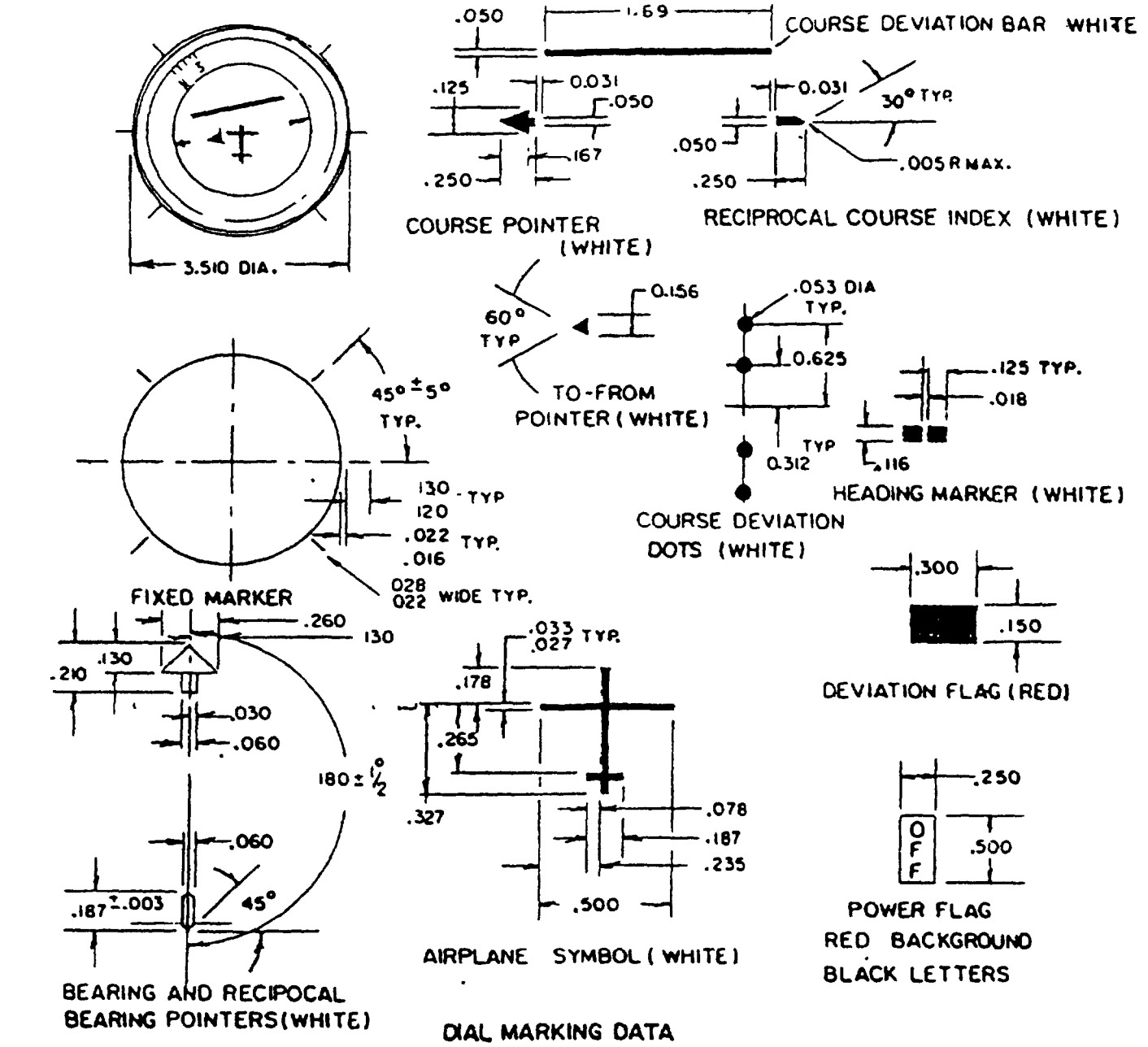
3 13.2 Azimuth ring servo system A servo follow-up system consisting of a CT, motor, rate generator feedback, and amplifier shall drive the azimuth card and rotor or the input CT to a null It shall be capable of receiving a change of heading at any rate between 0 degree and 60 degrees per second without hunting There shall be no appreciable hunting or oscillation in the servo system while the input compass signal is changing or stationary The servo system shall position the heading indication under the lubber line to within ±1 degree of the position of a calibrated synchro. The design of the azimuth card gearing shall result in operation such as would be achieved in the system shown on FIGURE 4 The electrical pin connections of the azimuth card servo system shall be in accordance with FIGURE 4

3 13 3 Azimuth card control transformer zero The azimuth card CT shall be zeroed with a positive rotation reference at an index reference of 270 degrees With the XYZ leads of the azimuth card CT as specified on FIGURE 4 and the excitation voltage of the test transmitter C to H in phase with the power input pin AA to pin B.

(a) The azimuth ring shall position at 0 degree (north) when the rotor of the test transmitter dial is at 0 degree.

(b) If the dial on the rotor of the test transmitter is continuously rotated so that its heading indication increases, the azimuth ring heading shall increase (counterclockwise (ccw) rotation) accordingly and the voltage C to H prime (') of the CT shall be in phase with the excitation voltage C to H

3 14 Command heading. A means of selecting a desired heading both automatically and manually shall be provided A heading marker as shown on FIGURE 2, which can rotate around the azimuth ring, shall be driven by a servo system when excited by a remote device similar to the standard test transmitter specified in 3.11 and manually by a knob at the lower left corner of the instrument. There shall be no visible interaction between the knob and the servo motor so that when the remote synchro device is driving the servo system, turning the knob will have no lasting effect on the heading marker position. The heading marker shall rotate in synchronism with the azimuth ring after it is set. The heading selection knob shall be connected with the heading marker in such manner that clockwise (cw) rotation of the knob produces cw rotation of the heading marker, and vice versa. The turning ratio between the knob and the heading marker shall be between 8 and 10 to 1 The azimuth scale reading indicated under the heading marker shall be the desired heading. The heading set knob shall be as shown on FIGURE 1. The maximum backlash between the command heading marker and the azimuth card shall be 0.25 degree



DIAL MARKING DATA

LETTERS: 1.155 R TO BOTTOM EDGE; .250 HIGH OVERALL; 032-.040 LINE WIDTH.
NUMERALS: 1.217 R TO BOTTOM EDGE; .188 HIGH OVERALL; .024-.030 LINE WIDTH.
10° LINES: 1.433 R TO INNER END AND EXTENDING WITHIN .005 OF OD OF PART; .016 - .020 LINE WITH, LENGTH .125 (REF).
5° LINES: 1.495 R TO INNER END EXTENDING TO WITHIN .005 OF O.D. PART: 008 - 010 LINE WIDTH, LENGTH .062 (REF)
NUMERALS AND LETTERS SHALL CONFORM TO MS33558.
DIMENSIONS IN INCHES TOLERANCES: DECIMALS ± 010, FRACTIONS: ± 1/16, ANGLES ± 2°.

FIGURE 3 Display component dimensions.

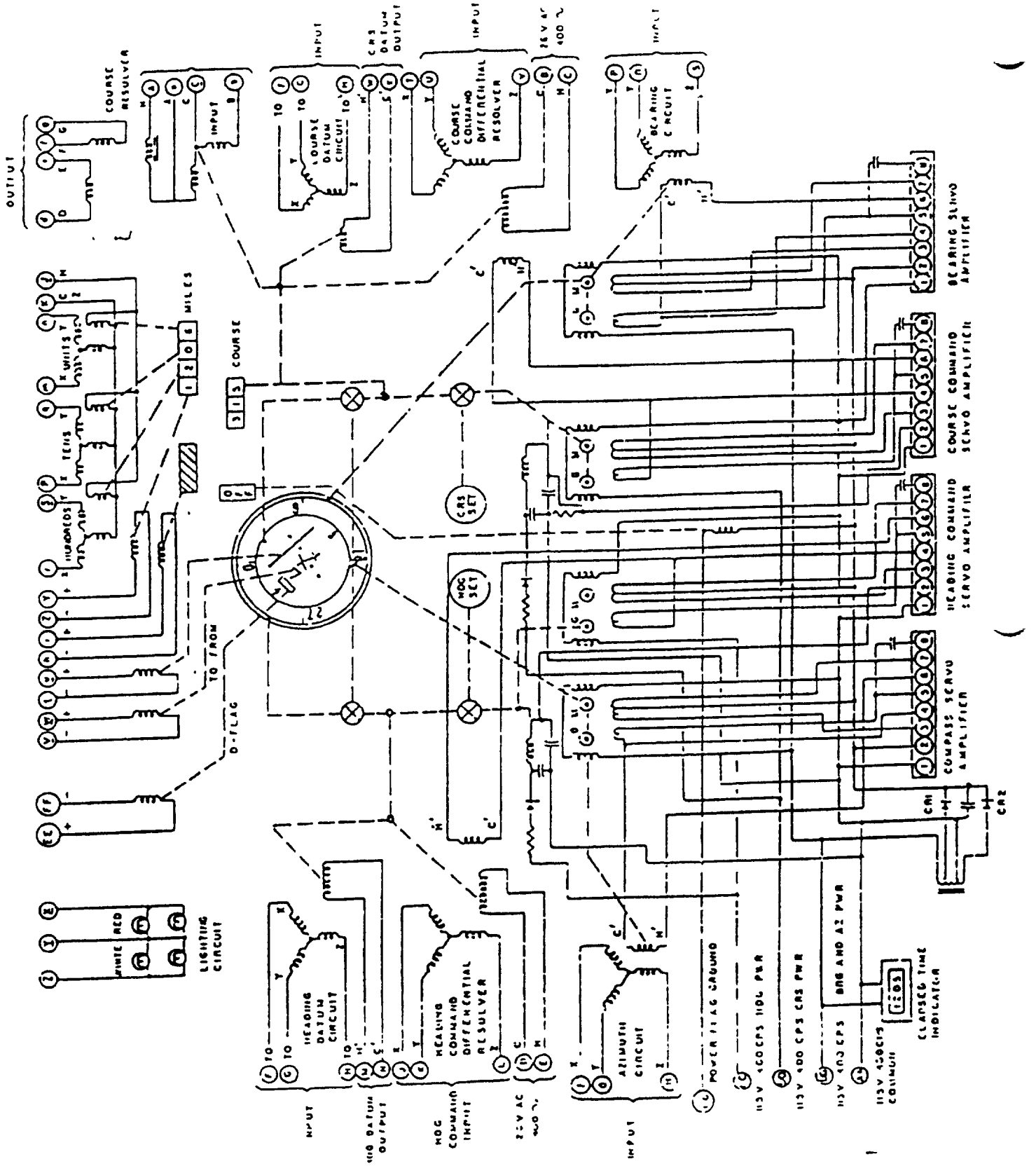


FIGURE 4 Schematic diagram

3 14 1 Heading marker servo system. A servo system similar to that described in 3 13.2 for driving the azimuth ring shall be employed for positioning the heading marker in response to a remote input signal. The servo shall receive a change of command heading at any rate between 0 degree and 60 degrees per second without hunting There shall be no appreciable hunt or oscillation in the servo system and it shall position the heading marker around the azimuth ring to within ±1 degree of the position of the test synchro The design of the differential gearing shall be such as to result in operation of the heading marker with respect to the azimuth ring, remote synchro command input, and knob command input as shown on FIGURE 4 The heading marker servo shall conform to the electrical connector and point wiring shown on FIGURE 4

3 14 2 Heading marker signal input. The heading synchro device shall be a Clifton Precision transolver CDSH-10-AS-4, or equivalent, capable of operating as a CT and a transmitter as shown on FIGURE 4

3 14 3 Heading datum control transformer The heading datum CT shall be a Clifton Precision CTC-8-A-4 CT, or equal, and shall operate as sown on FIGURE 4

3.14 4 Heading command and heading datum control transformer zero. Both the heading command and the heading datum CT's shall be zeroed with positive rotation referenced at an index reference of 270 degrees Both synchros shall be zeroed in the following manner.

3 14 4 1 Standard test transmitter The standard test transmitter shall be positioned to zero indication of its dial and locked, connected to the heading command and heading datum CT's in accordance with XYZ notation indicated on FIGURE 4, and excited with 26V, 400 cycles per second (cps).

3.14.4.2 Heading marker. The heading marker shall be positioned to 0 degree (north) on the azimuth card and the voltage C to H' of the heading command CT rotor and heading datum CT rotor as shown on FIGURE 4 shall be null

3.14.4.3 Voltage C to H. If the heading marker is rotated cw around the azimuth ring, voltage C to H' of the heading command CT rotor and heading datum CT rotor shall be in the opposite phase sense as the voltage C to H of the standard test transmitter from 0 degree (north) to 180 degrees, null at 180 degrees (south) and shall be in the same phase sense as voltage C to H of the standard test transmitter from 180 (south) to 0 degree (north)

3 14.4 4 Dial If the heading marker is set on 0 degree (north) on the azimuth dial and if the rotor of the standard test transmitter is rotated to indicate an increasing heading (dial ccw), the voltage C to H' of the heading command CT and the heading datum CT shall be null at 0 degree, in the same phase sense as the excitation voltage C to H from 0 degree to 180 degrees null at 180 degrees, and opposite to the phase sense of C to H from 180 degrees to 0 degree

3.14.4.5 Transmitter winding. If the transmitter winding of the heading command CT is excited with 26 V ac so that the voltage C to H is in phase with power excitation ground to phase and the heading marker is set on 0 degree (north), then voltage X to Z and Y to Z will be in phase with C to H and voltage X to Y null. If the heading marker is rotated sw to east, the voltage X to Z will increase before decreasing.

3 14.5 Heading marker servo zero. The heading command control transformer shall be connected to its servo system. The standard test transmitter shall be connected to the heading command CT in accordance with XYZ notation on FIGURE 4. The excitation voltage of the test transmitter C to H shall be in phase with the servo power excitation voltage, pin AA to pin CC The following conditions shall be satisfied

(a) The heading marker shall position to 0 degree (north) on the azimuth ring when the dial of the standard test transmitter is at 0 degree

(b) The heading marker shall rotate in an increasing heading indication on the azimuth ring (cw) when the dial of the test transmitter synchro is rotated in an increasing heading indication (dial ccw).

(c) If the dial of the standard test transmitter is rotated in the increasing heading indication, the voltage C to H' of the heading command CT shall be in the same phase sense with the voltage C to H of the standard test transmitter

3.15 Command course A means of selecting a desired course, both automatically and manually, shall be provided A course arrow, as shown on FIGURE 2, that can rotate around the inside edge of the azimuth ring shall be driven by a servo system when excited by a remote device similar to the standard test transmitter specified in 3 11, and shall be manually turned by a knob at the lower right corner of the instrument. As in the heading marker servo system, turning of the course knob shall have no lasting effect on the course arrow when the servo is being driven by a remote device The course marker shall rotated in synchronism wit in the azimuth ring after it is set. The scale reading on the azimuth ring at the tip of the course arrow shall be the selected course or track The course selection knob shall be connected with course arrow in such manner that cw rotation of the knob will produce cw rotation of the course arrow, and vice versa The turning ratio between the knob and the course marker shall be between 8 and 10 to 1 The course set knob shall be as shown on FIGURE 2 A digital-type counter shall present the selected course in a window on the right side of the HSI

3 15 1 Course marker servo system A servo system, similar to that described in 3.13.2 for driving the azimuth ring, shall be employed for positioning the course marker in response to a remote input signal. The servo shall be capable of receiving a change of command course at any rate between 0 degree and 60 degrees per second without hunting. There shall be no appreciable hunt or oscillation in the servo system during steady-state dynamic operation and it shall position the course around the inside edge of the azimuth ring to within ±1 degree of the position of the test synchro The design of the differential gearing shall be such as to result in operation of the course marker with respect to the azimuth ring, remote synchro command input, and knob command input as shown on FIGURE 4. The course marker servo shall conform to the electrical connector and pin wiring shown on FIGURE 4.

3.15.2 Course marker signal input. The course marker servo system shall receive its input signal from a transmitting synchro device similar to the test transmitter described in 3 11. The synchro device shall be a Clifton Precision transolver CDSH-10-AS-4, or equivalent, capable of operating as a CT and a transmitter as shown on FIGURE 4

3.15.3 Course datum control transformer The course datum CT shall be Clifton Precision CTC-8-A-4, or equivalent, and shall operate as shown on FIGURE 4

3.15.4 Course command and course datum control transformer zero Both the course command and course datum CT's shall be zeroed as a standard test transmitter at an index reference of 270 degrees. Both synchros can be zeroed in the same manner as the heading command CT and heading datum CT specified in 3.14 4 through 3.14.4 4 with course marker substituted for heading marker and with all references made to the course servo system (the course servo system should not be excited with power)

3 15.5 Course marker servo zero. The course command CT shall be connected to the standard test transmitter in accordance with the XYZ notation given on FIGURE 4 The excitation voltage of the test transmitter C to H shall be in phase with the servo power excitation voltage pin AA to pin DD. The following conditions shall be satisfied

3 15 5.1 Course marker The course marker shall position to 0 degree (north) on the azimuth ring when the dial of the standard test transmitter is at 0 degree

3 15 5.2 Course marker rotate. The course marker shall rotate in an increasing heading indication on the azimuth ring (cw) when the dial of the test transmitter synchro is rotated in an increasing heading indication (ccw)

3 15.5.3 Transmitter synchro. When the dial of the test transmitter synchro is rotated in an increasing heading indication (ccs), the voltage C to H' of the course command CT shall be in phase with the voltage from C to H of the standard test transmitter.

3 15 5 4 Course pointer. If the transmitter winding of the course command CT is excited with 26V AC so that the voltage C to H is in phase with power excitation ground to phase and the course pointer is set on 0 degree (north), then voltage X to Z and Y to Z will be in phase with C to H and voltage X to Y null If the course pointer is rotated cw to east, voltage X to Z shall increase before decreasing

3.15.5.5 Course resolver. A resolver of any size with electrical characteristics of type EP AY221-5-B, or equal, shall be connected to the course gear train to function as shown on FIGURE 4 and zeroed at a scale reference of 0 degree and an index reference of 300 degrees

3.15 6 Rotor windings.

3 15 6 1 Rotor winding number 1. Rotor winding number 1 (RW-1) is defined as the leading winding which mechanically leads rotor winding number 2 (RW-2) by 90 degrees in the direction of higher dial numbers with respect to the azimuth card. At the index reference point 300 degrees, when properly zeroed, stator winding 1 (SW-1) and RW-1 are directly coupled and stator winding Z (SW-Z) and RW-2 are directly coupled

3 15.6.2 Common pin. The common pin of the rotor windings is designated as pin C. The two leads of a stator winding are arbitrarily labeled D and E and this stator winding is called SW-1.

3.15 6 3 Rotor lead. When the course marker is rotated 300 degrees against the azimuth card, a rotor lead shall be chosen and labeled A. This rotor winding shall be excited (C being the common ground) with 10V, 400 Hz ac and the resolver rotator shaft adjusted (with scale locked at 300 degrees), respectively. The resolver rotor shaft shall be locked to scale and the scale rotated 90 degrees in a positive direction to 30 degrees against the azimuth card. Voltage A to C or RW-1 shall be removed and applied to B to C or RW-2 The voltage as read across D to E of SW-1 should be maximum and in phase with applied voltage B to C or RW-2. If the voltage is out of phase, labeling A and B of the rotor leads shall be reversed and the above zeroing procedure repeated

3 15.6 4 Scale reading. The scale reading shall be set to 300 degrees against the azimuth card and leads B and C of RW-2 excited Letters F and G shall be assigned to stator winding SW-2 so that the voltage measured from F to G is in phase with voltage B to C or RW-2

3.15.6.5 Fine zeroing. Fine zeroing can be accomplished by exciting leads B to C or RW-2 and nulling the voltage D to E of SW-1 by rotating resolver rotor shaft when the scale reading is 300 degrees against the azimuth card

3.15.6.6 Course selector resolver. The course selector resolver shall have proper characteristics or additional provisions as required to permit use with COR systems requiring 30 cps Omni Range Zero (ORZ). Proper ORZ at 30 cps shall obtained when the resolver is electrically zeroed with 400 Hz excitation at 300 degrees. The ORZ leads shall be designated as H and C. The leads designated as A to G shall be connected to the pins, specified on FIGURE 4, on connector PT02H-22-55P, or equal (see 3.24) The VOR phase shifting component shall be connected to pin A, as shown on FIGURE 4, on connector PT02H-22-55P, or equal.

3.16 Course deviation bar An indication of the displacement of the aircraft to the right or left of the selected course shall be provided by means of a course bar and dots in accordance with FIGURE 2.

3 16 1 Course deviation bar mechanism Direct current deflection signals shall cause the course bar to move across the face of the instrument. The total movement of the course deviation bar shall be 0.69 ± 0.03 inch in both directions measured from the center of the instrument. A movement of 0.62 inch from center shall require 150 microampere (ua) nominal. A dc polarity of "+" and "-" indicated as pins on FIGURE 4 shall cause a deflection on the right when course arrow is on top. The course deviation bar sensitivity shall be 75 ua per dot and range of displacement shall be ±2 dots The course deviation bar mechanism shall have a resistance of 1,000 ohms ±3 percent The test limits at standard conditions for the course deviation bar mechanism shall be as follows

±1 dot deflection ±75 ua ±6 ua
±2 dots deflection ±150 ua ±12 ua

3.16 1.1 Dynamic response. The course bar mechanism shall have a damping ratio of not less than 1 The frequency response shall be such that the amplitude ratio of input will not decrease by more than 3 decibels (db) at 0.2 Hz

3.16.2 Deviation bar alarm flag. A deviation bar alarm flag shall be incorporated as shown on FIGURE 2 The flag shall be operated by a suppressed zero-type mechanism which, in the absence of current or when the current is below 180 (ua), shall hold the flag against a stop in the position shown on FIGURE 2. Upon application of 180 ua, with the polarity shown on figure 4, the flag shall leave its stop and shall disappear completely (black background showing) with the application of 245 ua A consecutive application of 500 ua as a step function shall not damage the mechanism The meter movement resistance shall be 1,000 ohms ±3 percent.

3.17 TO-FROM arrow A TO-FROM arrow shall be incorporated as shown on FIGURE 2 The TO-FROM arrow shall operate from a meter movement having a resistance of 200 ohms ±15 percent. The sensing will be such that with no signal applied, the arrow will not be visible. A signal with polarity as shown on FIGURE 4 shall cause the TO-FROM arrow to appear on the same side as the course arrow A signal with opposite polarity shall cause the TO-FROM arrow to appear on the tail side of the course arrow A signal not greater than 225 ua shall cause the TO-FROM arrow to reach full displacement

3 18 Display movement. The central portion of the display, including the course arrow, course bar, the deviation bar alarm flag, TO-FROM arrow, and course deviation dots, shall rotate as a unit turning with the azimuth ring as the airplane's heading changes, in addition to the individual motion listed.

3.19 Meter movement bearings and pivots Meter movements shall turn on hardened ground and highly polished pivot bearings, highly polished first quality sapphire bearings, or other materials that meet the performance requirements of this specification

3.20 Balancing The meter movements shall be balanced by an approved means (threaded nut or splice nuts, or a wire helix moving along a crown arm and counterweight arm) with easily accessible means for rebalancing. The use of solder, shellac, or similar means of holding balance weights will not be acceptable.

3.21 Bearing marker. A bearing marker servo system shall be incorporated for positioning the bearing pointer shown on FIGURE 2 from a remote source similar to a standard test transmitter synchro. The servo system shall be similar to the servo that drives the azimuth ring. The servo shall receive a change in bearing between 0 degree to 60 degrees per second without hunting. There shall be no appreciable hunt or oscillation in the servo system and it shall position the bearing pointer around the azimuth ring to within ±1 degree of the position of the test synchro. The servo system shall be connected as specified on FIGURE 4

3.21.1 Bearing pointer signal input. The bearing pointer servo system shall receive its input signal from a transmitting synchro device similar to the test transmitter described in 3.11. The bearing pointer CT shall be a type EP AY-500-5, or equal A size 8 synchro CT with the same general impedance of the stator windings as a type EP AY-500-5, or equal may be utilized

3 21.2 Bearing pointer control transformer zero The bearing pointer CT shall be zeroed at a scale reference of 180 degrees (under the lubber line at the bottom of the display) and at an index reference of 90 degrees

3 21.2.1 Transmitter connected. With the standard test transmitter connected in accordance with the XYZ notation on FIGURE 4 and excited with voltage from C to H in phase with the servo excitation pins AA to BB, the transmitter dial shall be positioned to zero

(a) The bearing pointer shall position under the lubber line at the bottom of the display

(b) Rotation of the card on the test transmuting synchro to an increasing heading indication shall cause the bearing pointer to rotate cw

(c) If the rotor of the test transmitter synchro is rotated to an increasing heading indication voltage C to H' of the bearing, CT shall be in the same phase sense as voltage C to H of the standard test transmitter.

3.22 Distance display A digital-type distance display shall be provided at the upper left of the instrument as specified on FIGURE 2. The range of the display shall be 000 to 1,999 miles. The hundreds, tens, and units numerals shall be individually driven by receiver synchros with 1:1 ratio. The units display shall have 1-mile and 0.50 mile index lines. The numerals shall be centered each 36 degrees of synchro shaft rotation. The receiver synchro shall be Clifton CRC-8-A-1, or equal. The thousand digit shall be driven by a shutter showing black when normally unexcited and 1 when excited with 27V DC

3.22.1 Distance synchro electrical zero. With a standard test transmitter connected in accordance with the XYZ common with C notation, and C to H of both the receiver synchros and transmitter synchro excited, the three synchros shall be zeroed as follows:

(a) With the test transmitter rotor position set on 0 degree, the 0 shall be in position on the distance dial of each receiver synchro

(b) Rotation of the test transmitter synchro to 36 degrees shall result in 1 being positioned on the distance dial.

(c) Increasing numerical dial readings on the receiver synchros shall be indicated for each 36 degrees of the transmitter synchro rotation.

3.22.2 Distance shutter mechanism A red and white (diagonally striped) masked shutter shall be provided for obscuring the distance display The shutter mechanism shall be excited by 28V DC. voltage excitation shall cause the shutter to disappear from view The units digit shall be only partially masked by the shutter

3.23 Power The HSI shall be capable of operating on power supplied from an aircraft infinite bus source at 115VAC, 400-Hz single phase in accordance with MIL-STD-704 The HSI shall also comply with the requirements of MIL-STD-704 for utilization equipment, except when a 28V DC source, infinite or limited, is connected to any HSI coil, disconnecting the circuit by any normally utilized aircraft switch shall not produce positive or negative transients in the system exceeding 40V maximum Each of the four servo systems shall be excited with 115VAC, 400 Hz on the specific connector and pins specified on FIGURE 4 In addition, for operation of the integral lighting, 5V AC power shall be supplied to the proper connector and pins shown on FIGURE 4

3.23 1 Electrical power variation The indications shall operate properly and continuously when the ac voltage supplied to the indicator connector is in a range between 103 and 127V and at any frequency between 320 and 480 Hz, or any combination thereof, in addition to transient variation specified in MIL-STD-704.

3.23.2 Power-off flag. A power-off flag as shown on FIGURE 2 shall be incorporated It shall be red with black letters and so mechanized that it will appear when 115VAC, 400 Hz power to the bearing and azimuth circuit is interrupted or when there is a failure of the bearing an azimuth B+ voltage The flag shall disappear (black background showing) when both voltages are present and pin GG is externally grounded. If pin GG is not grounded, the flag shall not disappear even though both voltages are present.

3 23 3 Elapsed time indicator A Haydon K19203 elapsed time indicator, or equal, shall be provided to record the running time of the HSI when power is applied to the azimuth and bearing servo It shall be located in the lower right-hand corner of the indictor face, behind the coverglass, and just above the course set knob, and shall be visible only when viewed from above and slightly in front of the coverglass When viewed as specified, the numerals shall be easily distinguishable.

3 24 HSI connector An electrical connector shall be supplied on the HSI as shown on FIGURE 1 The connector shall be Bendix part No PT02H-22-55P, or equal, and shall mate with Bendix part No PT06A-22-55S, or equal All electrical connections shall be in accordance with FIGURE 4

a. The electrical connector shall be protected from water vapors by the application of a cap and gasket conforming to Bendix part no 10-123094-221, or equal

3.25 Integral lighting The HSI shall be integrally lighted with two parallel lighting circuits (a white lighting circuit and a red lighting circuit) as shown on FIGURE 4 The red lighting system design shall be in accordance with MIL-L-25467 and the white lighting system design shall be in accordance with MIL-L-27160. The lighting shall be subject to the approval of the procuring activity

a. The integral lighting shall be comparable to and shall balance in brightness with a prime standard HSI. The prime standard shall be a HSI conforming to this specification or a lighted mockup of the HSI. The prime standard shall have applied to its lighting circuits the specific voltage which the procuring activity has established as being necessary to assure equality of presentation (from a lighting standpoint) with adjacent but dissimilar instruments. The contractor shall submit to the procuring activity for approval the test procedure for determining compliance with this requirement.

3.26 Weight. The weight of the HSI shall not exceed 9.5 pounds

3.27 Screw threads. Unless otherwise specified, the threads of all machine screws 0 060 or larger in diameter shall conform to MIL-S-7742

3.28 Lubrication. The HSI shall be lubricated in accordance with MIL-STD-838

3.29 Finishes and protective coatings

3.29.1 Aluminum-alloy parts Aluminum parts shall be covered with an anodic film conforming to MIL-A-8625, except as follows

a. Dials, small holes, and case inserts need not be anodized.

b Aluminum alloys which do not anodize satisfactorily shall be coated with a chemical film in accordance with MIL-C-5541.

c Where the primary purpose of the treatment is to afford a suitable paint base, chemical treatments in accordance with MIL-C-5541 may be used in lieu of anodizing

d Castings containing nonaluminum-alloy integral inserts may be treated with a chemical film in accordance with MIL-C-5541 shall not be used in lieu of anodizing.

3.29.2 Aluminum deposited coating Aluminum ion vapor coating of steel parts shall be in accordance with MIL-C-83488, type I or II as applicable. Alternative processes shall be demonstrated satisfactory and submitted for approval (see 3 2.10)

3 30 Identification of product. Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130

3.31 Installation

3 31 1 Mounting screws The contractor shall furnish sufficient mounting screws for installing the HSI They shall be round-head, brass machine screws and shall have a durable dull-black finish Length shall be sufficient to permit mounting on a panel 0.187-inch thick. Screw threads shall be size 10-32NC-2A

3.31.2 Envelope An envelope containing the mounting screws shall be furnished with each HSI The following information shall be printed on the face of the envelope·

IMPORTANT
THIS ENVELOPE CONTAINS
MOUNTING SCREWS

3.32 Workmanship. The HSI, including all parts and accessories, shall be so fabricated and finished as to assure freedom from blemishes, defects, burrs, and sharp edges, accuracy of dimensions, radii of fillets, and marking of parts and assemblies; thoroughness of soldering, welding, brazing, painting, wiring, and riveting; alignment of parts and tightness of assembly screws and bolts.

3.32.1 Riveting Riveting operations shall be carefully performed to insure that the rivets are tight and satisfactorily headed.

3.32.2 Cleaning. The HSI shall be thoroughly cleaned and loose, spattered, or excess solder, metal chips, and other foreign materials removed during and after final assembly

3 32.3 Dimensions and tolerances Dimensions and tolerances not specified shall be as close as is consistent with the best shop practices Where dimensions and tolerances may affect the interchangeability, operation, or performance of the HSI, they shall be held or limited accordingly

3.32.4 Screw assemblies. Assembly screws and bolts shall be tight The word tight means that the screw or bolt cannot be appreciably tightened further without damage or injury to the screw, bolt, or threads

4 QUALITY ASSURANCE PROVISIONS

4 1 Responsibility for inspection Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements

4 1 1 Responsibility for compliance All items shall meet all requirements of sections 3 and 5 The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, no does it commit the Government to accept defective material

4.2 Classification of inspection The examination and testing of the HSI shall be classified as follows.

a Qualification inspections (4 3)
b Quality conformance inspections (4.4)

4.3 Qualification inspections

4.3 1 Test samples. The test samples shall consist of three (3) HSI's representative of the product equipment. The samples shall be identified with the manufacturer's own part number and such other information as required by the procuring activity

4.3 2 Inspections Qualification inspections consist of all the tests specified within (a) and (b)

a. Contractor inspections (4.3.2 1)
b. Government inspections (4.3.2.2)

4.3.2.1 Contractor inspections. The Contractor qualification tests shall consist of the Contractor performing all the tests specified under 4.7, except 4.7.31 Each of the tests shall be performed on all three HSI test samples

4.3.2.2 Government inspection The Government qualification test will consist of the Government performing the test specified in 4.7.31 This test will be performed on all three HSI test samples

4.3 3 Inspections The qualification inspections shall consist of al the inspections specified under 4.7

4 4 Quality conformance inspections Quality conformance inspections shall consist of individual inspections and sampling plans A and B inspections

4 4 1 Individual inspections. Each HSI shall be subjected to the following inspections as described under 4 7.

(a)	Examination of product	(4.7.1)
(b)	Synchro and receiver zero	(4.7.2)
(c)	Servo operation	(4 7.3)
(d)	Power-off flag	(4 7.4)
(e)	Course bar mechanism	(4.7.5)
(f)	TO-FROM arrow	(4 7.6)
(g)	Deviation alarm flag	(4 7.7)
(h)	Distance display	(4 7 8)
(i)	Shutter	(4 7.9)
(j)	Leakage rate	(4.7.10)
(k)	Lighting	(4 7 11)
(l)	Fogging	(4 7.12)
(m)	Control knobs	(4.7.13)
(n)	Early failure detection	(4.7 14)

4.4.2 Sampling plans and inspections

4 4.2 1 Sampling plan A. HSI's, selected at random in accordance with the following schedule as specified, shall be subjected to the inspections listed, as described under 4.7.

Schedule

Number of items	Quantity of items to be tested
First 10	1
Next 90	2
Each additional 100	1

(a)	Individual inspections	(4.4.1)
(b)	Power consumption	(4.7.15)
(c)	Voltage variation	(4 7.15.1)
(d)	Magnetic effect	(4.7.16)
(e)	Acceleration	(4 7.17)
(f)	Dielectric	(4.7 18)
(g)	Vibration error	(4 7.19)
(h)	Oscillation and variation	(4.7.20)
(j)	Low-temperature operation	(4.7.21)
(k)	High-temperature operation	(4 7.22)
(l)	Course bar mechanism	(4.7.23)
(m)	Coatings	(4.7.24)

4 4 2 2 Sampling plan B Unless otherwise specified, 3 HSI's shall be selected at random from the first 15 items on the contract or order and subjected to the following tests in accordance with the schedule specified and as described in 4 7

(a)	Sampling plan A tests	(4 4.2 1)
(b)	Radio Noise interference	(4 7.25)
(c)	High-temperature exposure	(4 7.26 1)
(d)	High altitude - low temperature	(4 7.26.2)
(e)	Temperature shock	(4 7 26.3)
(f)	Humidity	(4.7.26 4)
(g)	Fungus	(4 7.26.5)
(h)	Salt fog	(4 7.26 6)
(I)	Dust (fine sand)	(4 7.26 7)
(j)	Vibration failure	(4 7.26 8)
(k)	Acceleration	(4 7.27)
(l)	Life	(4 7 30)
(m)	Sealing thermal shock	(4 7 28)
(n)	Abrasion	(4 7.29)

4 4 3 Options At the option of the contractor, the tests may be divided into three groups as shown in TABLE II, to be performed on three sets of three HSI's, if a need exists to expedite tests Each HSI shall met the requirements of all the individual tests after completing the group of specific tests to which submitted At the option of the procuring activity, group II testing may be conducted on empty cases which have all external parts installed or attached, as on a complete HSI case.

4.5 Rejection and retest When one HSI selected from a production run fails to meet the specification, no HSI's still on hand or later produced shall be accepted until the extent and cause of failure are determined After corrections have been made, all necessary tests shall be repeated

4 5 1 Individual tests may continue. For operational and production reasons, individual tests may be continued pending the investigation of a sampling test failure But final acceptance of HSI's on hand or later produced shall not be made until hit is determined that the HSI's meet all the requirements of the specification.

4.5.2 Defects in items already accepted. The investigation of a test failure could indicate that defects may exist in HSI's already accepted If so, the contractor shall fully advise the procuring activity of all defects likely to be found and methods of correcting them

4 6 Inspection conditions Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in paragraph 4.6 1 in the specification

4.6.1 Standard atmospheric conditions. Whenever the pressure and temperature existing at the time of the test are not specified definitely, it is understood that the test is to be made at atmospheric pressure (approximately 29.92 inches Hq) and at room temperature (approximately +25° C).

4 6.2 Voltage input Unless otherwise specified, the HSI shall be tested with 115VAC, 400Hz (nominal) single-phase power, connected to the specific pins of the indicator connector.

4.6 3 Proper connection. When the HSI is referred to as being properly connected, it shall be understood that it is connected to a test fixture that provides a lighting circuit voltage variable from 5 to approximately 1 volt and that it provides:

(a) Synchro signals for remote inputs to the servo systems
(b) Variable current dc signals with reversible polarity to meter movements
(c) 27VDC for shutter excitation
(d) Ac power as required for operation of the servo system

TABLE II. Groups and inspections

Groups	Inspections	Paragraphs
I	Radio noise interference	4 7.25
	High-temperature exposure	4 7.26.1
	Low-temperature operation	4.7.21
	Temperature shock	4 7.26 3
II	Humidity	4.7.26 4
	Fungus	4.7.26.5
	Salt fog	4.7.26.6
	Dust (fine sand)	4 7.26 7
	Sealing thermal shock	4 7.28
	Abrasion	4 7.29
III	Vibration failure	4 7.26 8
	Acceleration	4.7.27
	Life	4 7.30

4 6 3.1 Sealing The test specified in 4 7 3 may be performed, at the contractor's option, prior to final sealing of the indicator

4 6 4 Visual observation Unless otherwise specified, all visual observations of HSI performance shall be made at a distance of 2 feet.

4 7 Inspection methods

4.7.1 Examinations of product. The HSI shall be examined to determine compliance with the requirements specified herein with respect to materials, workmanship, marking, and visibility of the display components

4.7.2 Synchro and resolver zero The CT receiver synchro and resolver shall be checked for zero by the method specified in section 3.

4 7.3 Servo operation. The synchro shall be properly connected and the rotor of the calibrated synchro rotated at constant speeds of 1.50 and 60 degrees per second. All four servos shall be tested The azimuth heading, bearing, and course indications shall not differ from the calibrated synchro indication by more than ±5 degrees at 60 degrees per second. This test shall be conducted in both cw and ccw directions

4.7.3.1 Hunting and jumping There shall be no noticeable hunting or jumping when the standard calibrated synchro shaft is not rotated Under dynamic conditions, the peak-to-peak amplitude of hunting and jumping shall not exceed 0.25 degree. The error signal shall be measured and shall not vary more than 0 1V peak-to-peak for any 0 5 second time frame for either of the rate tests specified in 4 7 3 This test shall be performed before the indicator is installed in the case

4 7.3 2 Servo sensitivity and friction error The HSI shall be properly connected The rotor of the calibrated synchro shall be rotated 1 degree and there shall be a perceptible movement in each of the pointers and dial as their respective CT's are excited Friction error shall not exceed 0.25 degree

4 7 3.3 Scale error The HSI shall be properly connected, the standard calibrated synchro set on zero, and the heading indication read and recorded. The calibrated synchro connected to the azimuth card shall be turned successively to headings of 30 degrees, 60 degrees, 90 degrees, 120 degrees, 150 degrees, 180 degrees, 210 degrees, 240 degrees, 270 degrees, 300 degrees, 330 degrees, and 360 degrees and the readings under the lubber line recorded No one reading shall differ from the corresponding synchro heading by more than ±1 degree An identical procedure shall also be followed for the bearing pointer, except that the test transmitter will be set at 180 degrees (bearing pointer will position at the top lubber line) and readings taken relative to this zero

4 7.3.3 1 Heading marker datum output (error output) With the azimuth signal input at electrical zero, the heading marker shall be set to each azimuth card position listed in TABLE III The heading datum voltage output shall be as specified therein

TABLE III Azimuth card position and voltage error

Azimuth Card Position	Degrees	Voltage Error
5	185	2 0 ± 0 8
10	190	3 9 ± 0.8
15	195	5.8 ± 0.8
30	210	11.2 ± 0 7
45	225	15 9 ± 0 6
135	315	15 9 ± 0.6
150	330	11.2 ± 0.7
165	345	5.8 ± 0.8
170	350	3.9 ± 0.8
175	355	2.0 ± 0.8

4 7.3 3.2 Course marker datum output (error output) With the azimuth signal input at electrical zero, the course marker shall be set to each azimuth card position listed in TABLE III The course datum voltage output shall be as specified therein

4.7.3.4 Servo follow-up rate and damping. The HSI shall be properly connected The calibrated synchro connected to the azimuth card shall be deenergized and its rotor rotated 90 degrees and reenergized. The time required for the azimuth ring to rotate between 5 degrees and 85 degrees of its original displacement from the calibrated synchro shall not exceed 1.5 seconds, and the total time before the azimuth ring comes to rest shall not exceed 2 seconds An identical test shall be performed on each of the other servo systems

4.7.4 Power-off flag. With the HSI properly connected but no power applied, the flag shall be in full view. Power shall be applied and the flag shall immediately despair The connection between pin "GG" and ground shall be broken and the flag shall appear. Pin "GG" shall then be grounded and the flag shall disappear Power shall be removed and the flag shall immediately reappear

4 7.5 Course bar mechanism The course bar mechanism shall operate with the polarity and sensitivity specified in 3 16.1.

4 7.5.1 Balance A static balance test with the normal 1 g force of gravity acting successively along each mutually perpendicular axis of the case shall not cause the bar to deviate from it center position more than on-half bar width.

4 7.5.2 Accuracy An accuracy test with ±dc polarity applied to the proper terminals shall result in the following

±1 dot deflection ±75 ± 6 ua.
±2 dots deflection ±150 ±12 ua

Tolerances applicable to the tests specified in 4 7.21, 4.7.22, 4.7.26.1, 4.7.26.2, and 4 7.30 shall be as follows:

±1 dot deflection ±75 ±10 ua.
±2 dots deflection ±150 ±17 ua.

4 7.5.3 Stop Twice normal current shall be applied in each direction and slowly reduced. The pointer shall not stick.

4 7 6 TO-FROM arrow The sensitivity of the TO-FROM arrow shall be checked by applying current in each direction as specified in 3.17 Double voltage shall be applied in both directions and slowly reduced. There shall be no sticking.

4 7.7 Deviation alarm flag The sensitivity of the deviation alarm flag shall be checked by applying voltage in the proper polarity as specified in 3.17 Double voltage shall be applied and lowly reduced; there shall be no sticking.

4.7.8 Distance display. Standard test transmitter synchros shall be applied to each receiver synchro. A scale error test shall be conducted for each numeral of the units, tens, and hundreds counter Each numeral shall center on consecutive 36-degree ±4-degree increments of the test transmitter as specified in 3.22.1. A voltage of 27V DC shall be applied to the thousand shutter and the thousand digit shall appear. Counter motion shall be smooth with no sticking

4 7 9 Shutter Proper polarity of 28V DC shall be applied to the shutter mechanism The shutter shall disappear from view

4 7 10 Leakage rate The HSI shall be tested for leakage by means of a mass-spectrometer-type helium leak detector. The initial maximum detected leak rate at a pressure differential of 1 atmosphere shall not permit more than 10 percent loss of the total filling medium after 1,000 hours

4 7.11 Lighting Each lighting circuit shall be properly connected individually and tested to show compliance with 3.25.

4 7.12 Fogging The HSI shall be properly connected with power applied and placed in a 71° ±2° C controlled ambient for a minimum period of 1 hour. Upon completion of this period and while still at the specified temperature, an ice cube shall be rubbed on the HSI coverglass for a period of from 1 to 2 minutes. The glass shall be carefully wiped dry (compressed air shall not be used) and the HSI inspected for evidence of water or oil fog on the coverglass, wedge, or display. Evidence of fogging shall be cause for rejection

4 7 13 Control knobs. The torque required to rotate the course and heading set knobs shall be measured throughout one revolution of the course arrow and the heading marker in both cw and ccw directions and shall be within 2 to 10 ounce-inches

4 7 14 Early failure detection Following final assembly of the HSI and the completion of the preceding individual tests, the HSI shall be properly connected with power applied to each of the four servo systems and the lighting circuits. The four servos and three distance counters shall be operated at 10 degrees per second for approximately 720 degrees and then alternated in the opposite direction The course bar, TO-FROM arrow, and deviation alarm flag and shall be driven through their full range on time per minute The heading and course knobs shall be rotated for five revolutions in each direction every hour with the remote transmitting synchro source unexcited The test shall be conducted fro a minimum of 10 hours No failure shall occur during this test

4 7 15 Power consumption The power consumption of the HSI shall be measured with suitable meters The ac consumption shall not exceed 50 va (volt amperes)

4 7.15 1 Voltage variation The HSI shall be properly connected and the ac voltage reduced to 103V, 320 cps. The indicator shall then meet all individual tests, except the scale error accuracy may be increased from 1 degree to 2 degrees and servo operation may be decreased from 10 to 20 percent in the 320- to 380-Hz range

4 7.15.2 Voltage transient test. THE HSI shall be connected to an aircraft-type power supply and all HSI coil circuits tested for compliance with 3.23 A switch shall be used in the test circuit which has essentially point contacts and no built-in arc suppression capabilities. Adequate recording equipment, subject to the approval of the procuring activity, shall be used to read and record the resulting voltage transients

4.7 16 Magnetic effect This test shall be made first with no power applied to the HSI and then repeated with the HSI operating on rated power The HSI shall be held in various potions magnetically east or west of and 12 inches from the center of a free magnet approximately 1.50 inches long in a magnetic field with horizontal intensity of 0 18 ±0 01 oersted The maximum deflection of the magnet shall not exceed 5 degrees. An aircraft compass with the compensating magnets removed may be used as the free magnet for this test

4 7.17 Acceleration The HSI shall be properly connected and power applied to the servos and meter movements. The HSI shall be accelerated with a force of 5g along each axis. The servoed pointer and azimuth card shall not vary more than 1 degree from the initial indication and the deviation bar shall not vary more than one bar width from its initial position The TO-FROM arrow with no power applied shall not appear.

4 7 18 Dielectric A potential of 250V DC shall be applied between isolated pins and between pins and the case for a period of 10 seconds There shall be no breakdown of insulation

4 7 19 Vibration error The indicator shall be mounted in its normal operating position on a vibration fixture and properly connected for operation While being operated, the indicator shall be vibrated with circular motion in a plane inclined 45 degrees to the horizontal with a total vibration amplitude between 0.003 and 0.005 inch The frequency of applied vibration shall be varied slowly from 5 to 50 cycles per second. While being vibrated, the indicator shall meet the following requirements

4 7.19.1 Amplitude of the pointer The maximum total amplitude of pointer oscillation, azimuth card oscillation, and course bar oscillation shall not exceed 0 50 degree in pointer and azimuth card or 0.50 deviation bar width.

4.7.19.2 Variation of the pointers. The maximum variation of the pointers, azimuth card, and course bar, during vibration from the original indication before vibration throughout the frequency range, shall be noted and shall not exceed 0.50 degree in pointer and azimuth card or 0.50 of the deviation bar width

4 7 19 3 Oscillation and variation Oscillation and variation tests may be conducted at any indication

4 7.20 Servo null position shift. The four servos shall be properly connected to standard test transmitters set at the zero indication The input voltage and frequency shall be varied within the following limits and combinations thereof

Frequency	320 to 480 Hz
Ac voltage	103 to 127V

The zero indication of the servoed pointers and azimuth card shall not shift more than 1 degree from the normal null position.

4.7.21 Low-temperature operation. The HSI shall be properly connected, with no power applied, and subjected to a temperature of -54° ±21° C for a period of 4 hours. At the end of this period and while still at the low temperature, power shall be applied. There shall be no sticking of movable component parts, and pointers shall move throughout their range of travel without sticking No failure shall result from this test There shall be a 5-minute warm-up period after the application of power before data are taken The HSI shall pass the tests specified in 4 7.3 through 4.7.10, except that an additional 15 percent will be permitted on all tolerances except those specified in 4.7.5.2.

4.7.22 High-temperature operation. With power applied, the HSI shall be properly connected, placed in a chamber, and maintained at a temperature of +72° to ±2° C for a period of 4 hours There shall be no sticking of movable component parts, pointers shall move throughout their range of travel without sticking, and there shall be no failure as a result of this test. The HSI shall pass the tests specified in 4.7.3 through 4.7.10, except that an additional 15 percent shall be permitted on all tolerances except those specified in 4.7.5.2

4.7.23 Course bar mechanism. The course bar mechanism shall conform to the dynamic response characteristics specified in 3.16.1.

4.7.24 Coatings The coated sample required in 3.25.a shall be evaluated to determine transmittance and reflectance of light from a 2,854° K (Color temperature) source The values shall not exceed those specified in SECTION 3.

4.7 25 Radio noise interference The radio noise interference test shall be conducted in accordance with MIL-STD-461.

4 7.26 Environmental tests The HSI shall be subjected to the following environmental tests, performed in accordance with the applicable procedures of MIL-C-810C and as specified herein

4 7.26.1 High-temperature exposure. The HSI shall be properly connected and subjected to a high-temperature test in accordance with Procedure II or a period of 24 hours, except that no power shall be applied At the end of the 24-hour period and while still at the high temperature, the HSI shall pass the tests specified in 4.7.3 through 4 7.10, except an additional 15 percent tolerance shall be permitted on all tolerances except those specified in 4.7.5.2.

4.7.26.2 Low-temperature - high altitude. The low-temperature test shall be conducted in accordance with equipment category 6 except that examination shall be performed only at the end of the 72-hour period. The HSI shall be properly connected, but no power shall be applied. At the end of the 72-hour period, the pressure in the chamber shall be reduced to the equivalent of 80,000 ±500 feet and power applied There shall be no binding or sticking at any indication. After the HSI has returned to room temperature, it shall pass all individual tests. Before data is taken, there shall be a 5-minute warm-up period after the application of power.

4 7.26 3 Temperature shock The temperature shock test shall be performed in accordance with Procedure I After the test, the HSI shall pass all individual tests.

4 7.26.4 Humidity The humidity test shall be in accordance with Procedure I. The HSI and amplifier shall then pass the tests specified in 4.7.3.4 through 4.7.10 There shall be no deterioration that would adversely affect subsequent operation

4 7.26.5 Fungus The fungus test shall be performed in accordance with Procedure I.

4 7.26.6 Salt fog The salt fog test shall be performed as specified in method 509 1 Procedure I At the end of the 50-hour period, the HSI shall pass the tests specified in 4 7.3 4 through 4 7.10 No damage that would adversely affect subsequent operation shall result from this test, and the tolerances specified under the individual tests shall apply

4.7.26 7 Dust (fine sand) The dust (fine sand) test shall be as specified in method 510.1 Procedure I. At the end of this test, the HSI shall be removed from the test chamber and allowed to cool at room temperature. The HSI shall then pass the tests specified in 4 7 3 4 through 4 7.10.

4.7.26.8 Vibration failure The indicator shall be subjected to a vibration type failure test as follows The indicator shall be mounted on the vibration apparatus in its normal operating position. While being operated, it shall be vibrated with circular motion of 0.018 to 0.020 inch diameter in a plane inclined 45 degrees to the horizontal plane, and the frequency of vibration shall be varied uniformly from 5 to 50 cycles per second and return once each hour for a 3-hour period Following the vibration test, the HSI shall meet the requirements specified in 4 7.3.4 through 4 7.10 No looseness in the mechanism nor damage to any part of the HSI shall result from this test.

4 7.27 Acceleration. The HSI, nonoperating, shall be mounted in its normal operating position and accelerated first along its vertical axis and then along each of two axes that are perpendicular to the vertical axis and to each other. The HSI shall be subjected to an acceleration of 20g in each axis for a period of 1 minute. At the tend of this acceleration, the HSI shall pass the individual tests No damage to the HSI shall result from this test

4.7.28 Sealing thermal shock The HSI shall be immersed alternately in tap-water maintained at 85° ±5° C and 5° ±4° C for a total of 8 cycles The length of time for each batch immersion shall be 30 minutes and not more than 5 seconds shall elapse between bath immersions No damage to the hermetic seal shall result due to this test Following the immersions, the HSI shall be tested for leaks by means of a mass-spectrometer-type helium leak detector The initial maximum detector leak rate at a pressure differential of one atmosphere shall not permit more than 10 percent loss of the total filling medium after 1,000 hours

4 7.29 Abrasion. An abrasive pad shall be pressed firmly against and pulled across the coverglass in two different directions in the form of a cross. The glass shall be scratched once in each direction. Pressure shall be applied gradually within the case until a 20-psi differential exists This pressure shall be maintained for 30 minutes. There shall be no damage to the coverglass as a result of this test The abrasive pad shall be 600-grit sandpaper, 0.75 inch wide by 3 inches long mounted on a wooden base.

4.7.30 Life. The HSI shall be subjected to a life test for 1,000 hours. The HSI shall be properly connected and power supplied to each of the 4 servos and 3 distance counters shall be operated at 10 degrees per second for approximately 720 degrees and then alternately in the opposite direction. The course bar, TO-FROM pointer, and deviation alarm flag shall be driven through their ranges five times per minute. The distance shutter shall be operated for 30 minutes for every 1-hour period. The heading and course knobs shall be rotated for 10 revolutions in each direction every 30 minutes with the remote transmitting synchro source unexcited At the end of 250, 500, 750 and 1,000 hours, the HSI shall pass the individual tests, except the tolerances shall be as specified in 4.7.5.2. Test failures shall be limited in accordance with 4.7.30.1

4 7.30 1 MTBF Equipment on-time accumulated during sampling/life tests shall be used in computation of MTBF Accept/reject criteria shall be as specified in MIL-STD-781, Test Plan III C

4 7.31 Compatibility Flight testing, as required, will be performed by the Government for the purpose of demonstrating successful fulfillment of the requirements specified in paragraph 3 4.3

4.8 Inspection of packaging The inspection of the preservation and interior package marking shall be in accordance with group A and B quality conformance inspection requirements, section 4 of MIL-P-116 The sampling and inspection of the packing and marking for shipment and storage shall be in accordance with the quality assurance provisions of applicable container specifications and the marking requirements of MIL-STD-129

5 PACKAGING

5 1 Preservation Preservation shall be level A, C, or industrial, IAW MIL-STD-2073-1, as specified (see 6.2)

5 1 1 Level A

5 1 1 1 Cleaning Indicator shall be cleaned in accordance with process C-1 or MIL-P-116

5 1 1 2 Drying Indicator shall be dried in accordance with process D-4 of MIL-P-116

5.1 1 3 Preservation application Preservative shall not be used

5.1.1.4 Unit packaging Unless otherwise specified by the contracting activity, each indicator shall be packaged in quantity unit packs of one each in accordance with Method IIC of MIL-P-116 Each indicator shall be placed in a PPP-B-636 Fiberboard container weather resistant, with sufficient cushioning material between bag and unit container of a type, density, and thickness to insure shock transmission does not exceed peak values in G's established for the indicator when completed packs are subjected to the right handling drop tests of MIL-P-116

5.1.2 Level C. Each indicator shall be clean, dry, and individually packaged in a manner that will afford adequate protection against corrosion, deterioration, and physical damage during shipment from supply course to the first receiving activity

5 1.3 Industrial The industrial preservation of indicator shall be in accordance with ASTM D3951

5 2 Packing Packing shall be level A, B, C or Industrial as specified (see 6.2).

5.2.1 Level A. Indicator packaged as specified in 5.1.1 shall be packed in shipping containers conforming to PPP-B-601, Styles A or B Class overseas, unless otherwise specified by the contracting activity. Insofar as practical, exterior shipping container shall be of uniform shape, size, minimum tare and cube consistent with the protection required

5.2.2 Level B Indicator packaged as specified in 5 1.1 shall be packed in shipping containers conforming to PPP-B-636, class weather-resistant, unless otherwise specified by the contracting activity Other requirements as specified in 5.2 1 apply

5 2 3 Level C Packing shall be applied which affords adequate protection during domestic shipment from the supply source to the first receiving activity for immediate use This level shall conform to applicable carrier rules and regulations

5.2.4 Industrial. The packaged indicator shall be packed in accordance with ASTM D3951

5 3 Marking In addition to any other markings required by the contract or order (see 6.2), interior and exterior containers shall be marked in accordance with MIL-STD-129

6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6 1 Intended use The AQU-4/A HSI covered by this specification is intended for use in high performance aircraft with an integrated panel The display will be controlled by reference and remote command sources providing transmitter synchro output signals and dc master movement signals

6 2 Acquisition requirements Acquisition documents must specify the following

(a) Title, number, and date of the specification
(b) Whether or not sampling plan B is to be omitted (see 4 4.2.2)
(c) Applicable levels of packaging and packing and markings as specified in SECTION 5
(d) Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2 1)

6 3 Definitions

6.3.1 Index reference position. The index reference position of a synchro is that position specified in terms of dial reading where the voltage XY is zero and the stator voltage XZ and YZ is 180 degrees out of phase with the rotor voltage HC. When the synchro is in this position, the voltage between H and X will be the sum of the rotor and stator voltages. The index reference position of the standard test transmitter is 0 degree, of the distance counter receiver synchros 0 degree, of the CT's in course and heading 270 degrees, and the bearing pointer CT 90 degrees

6 3.2 Hermetic seal. A hermetic seal is a perfectly closed and airtight seal made between vitric, metallic, elastomeric and resinous materials To meet the specified leak rate requirements, combinations of these materials may be used in areas approved by the procuring activity A hermetic seal is not intended to include seals accomplished by gaskets

6 4 Qualification With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in the applicable Qualified Products List, whether or not such products have actually been so listed by that date The attention of the supplies is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be award contracts for orders for the products covered by this specification. The activity responsible for the Qualified Products List is Oklahoma City Air Logistics Center/TICLA, 3001 Staff Drive, Tinker AFB, OK 73145-5990, and information pertaining to qualification of product may be obtained from that activity

6 5 Subject term (key word) listing

Connector - Female - PT06A-22-SSS
115V/400 Hz single phase

6 6 International standardization agreements Certain provisions of this specification are the subject of NAT-STD-3741 and ASCC Air Std 10/45 When amendment, revision or cancellation of the specification is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels including departmental standardization offices to change the agreement or make other appropriate accommodations

6 7 Changes from previous issue Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes

Custodians
AIR FORCE - 99
Army - AV
Navy - AS

Preparing activity
AIR FORCE - 71

Project No
6605-0401

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1 The preparing activity must complete blocks 1, 2, 3, and 8 In block 1, both the document number and revision letter should be given

2 The submitter of this form must complete blocks 4, 5, 6, and 7

3 The preparing activity must provide a reply within 30 days from receipt of the form

NOTE This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements

I RECOMMEND A CHANGE:	1 DOCUMENT NUMBER	2 DOCUMENT DATE (YYMMDD)
	MIL-I-27848	5 NOVEMBER 1994

3. DOCUMENT TITLE INDICATOR, HORIZONTAL SITUATION AQU-4A

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible Attach extra sheets as needed)*

5 REASON FOR RECOMMENDATION

6. SUBMITTER		
a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY	
a NAME HARLENA EDWARDS	b TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON 336-5960
c ADDRESS (Include Zip Code) OC-ALC/TICLA 3001 Staff Drive Tinker AFB, OK 73145-5990	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340