MILITARY SPECIFICATION

INDICATOR, HORIZONTAL SITUATION AQU-6/A

1. SCOPE

1.1 This specification covers the requirements for one type of horizontal situation indicator, designated AQU-6/A.

2. APPLICABLE

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

SPECIFICATIONS

Federal
QQ-P-416 Plating, Cadmium (Electrodeposited)
PPP-B-636 Box, Fiberboard

Military
MIL-P-116 Preservation, Methods of
MIL-E-5400 Electronic Equipment, Aircraft, General Specification for
MIL-C-5541 Chemical Films and Chemical Film Materials for Aluminum and
MIL-I-6181 Aluminum Alloys
MIL-S-7742 Interference Control Requirements, Aircraft Equipment
MIL-A-8625 Screw Threads, Standard, Optimum Selected Series: General
MIL-C-14806 Specification for
MIL-P-26514 Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-L-27160 Coating, Reflection Reducing, for Instrument Cover Glasses
MIL-B-27497 and Lighting Wedges

STANDARDS

Federal
FED-STD-595 Colors
Military

MIL-STD-100 Engineering Drawing Practices
MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129 Marking for Shipment and Storage
MIL-STD-130 Identification Marking of U.S. Military Property
MIL-STD-143 Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-454 Standard General Requirements for Electronic Equipment
MIL-STD-471 Maintainability Demonstration
MIL-STD-704 Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-781 Reliability Tests Exponential Distribution
MIL-STD-794 Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-810 Environmental Test Methods
MIL-STD-831 Test Reports, Preparation of
MIL-STD-838 Lubrication of Military Equipment
MIL-STD-889 Dissimilar Metals
NS17322 Meter, Time Totalizing Miniature, Digital, 115 Volt 400 Cycle
NS33558 Numerals and Letters, Aircraft Instrument Dial, Standard Form of

(Copies of documents required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Qualification. The indicators furnished under this specification shall be products which are qualified for listing on the applicable Qualified Products List at the time set for opening of bids (see 4.4 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 spray, 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 in MIL-STD-889.

3.2.6 **Corrosive fumes.** The materials as installed in the indicator and under the service conditions specified herein shall not liberate deleterious fumes.

3.2.7 **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. Steel parts within such enclosures shall be cadmium plated in accordance with type I, class 3 of QQ-P-416.

3.2.8 **Protective treatment.** When materials are used in the construction of the indicator 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.

3.3 **Selection of standards and specifications.** Standards and specifications for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143.

3.4 **Design and construction**

3.4.1 **Design.** The indicator shall be designed to present the following information:

a. Stabilized magnetic compass heading (within 1/2°) provided from the master directional reference

b. Command heading information (within 1/2°) provided from a remote source or desired heading, set in manually

c. Command course (within 1/2°) provided from a remote source or desired course set in manually and 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. Two independent pointers displaying bearing to selected stations or targets (within 1/2°)

i. Reciprocal bearing pointers for item h

j. Power failure.

3.4.1.1 Reliability. The indicator shall have a minimum acceptable mean-time-between-failures (MTBF) of 1,000 hours at a confidence level of 90 percent.

3.4.1.2 Longevity. Equipment longevity, as defined in MIL-STD-781, shall be 5,000 hours before wearout failures occur or the equipment consistently fails to meet the specified MTBF requirements.

3.4.1.3 Maintainability. Maintainability shall be in accordance with MIL-STD-471 and as specified in 3.4.1.3.1 and 3.4.1.3.2.

3.4.1.3.1 The following qualitative requirements shall be considered in the design of the indicator:

a. Minimization of complexity of maintenance tasks (for example: calibration, adjustments, inspection, et cetera) by maximum use of simple design which includes optimum interchangeability and use of standardized equipment or commercial items

b. Rapid and positive recognition of equipment malfunction or marginal performance

c. Rapid and positive identification of the replaceable defective part, assembly, or component

d. Maximum number and types of tools and test equipment (special and standard) needed to perform maintenance

e. Optimum accessibility in all components requiring maintenance, inspections, removal, or replacement.

3.4.1.3.2 The mean corrective maintenance downtime ($\bar{M}_{ct}$) shall be 100 minutes less the time required to unseal and then hermetically seal the instrument after repair. The maximum corrective maintenance downtime ($M_{maxct}$) shall be no greater than 300 minutes less the time required to unseal and hermetically seal the case.
3.4.2 **Construction.** The indicator 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 The indicator 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.

3.5 **Performance.** The indicator shall meet all requirements specified herein after exposure to the following conditions:

a. Operating temperatures ranging from $-54^\circ$ to $+71^\circ$C and storage temperatures ranging from $-62^\circ$ to $+85^\circ$C

b. Altitudes from sea level to 70,000 feet

c. Relative humidity up to 95 percent

d. Rainfall of 4 ±1 inches each hour

e. Fungus growth as encountered in tropical climates

f. Exposure to salt-laden atmosphere

g. Sand and dust particles as encountered in desert areas

h. Thermal shock forces as encountered during rapid changes of extreme temperature

i. Vibration incident to service use

j. Acceleration force of 20g nonoperating and 5g operating

k. Application of 250V dc for 10 seconds

l. Alternate immersions in water at $85^\circ ±5^\circ$ and $5^\circ ±4^\circ$C for 8 cycles with not more than 5 seconds between immersions.

3.5.1 **Radio noise interference.** The indicator shall meet the radio noise interference requirements of MIL-I-6181.

3.5.2 **Attitude.** The indicator shall be capable of operating satisfactorily while in any attitude.
3.5.3 **Friction error.** Not more than 1/4° of error shall be introduced into the readings as a result of friction between moving parts.

3.5.4 **Magnetic effect.** When the indicator is held in various positions magnetically east or west of and not more than 12 inches from the center of a free magnet in a magnetic field having a horizontal intensity of 0.18 ±0.01 oersted, deflection of the magnet shall not exceed 5°.

3.5.5 **Fogging.** There shall be no evidence of moisture or oil fogging of the coverglass, wedge, or display when the indicator is subjected to 71° ±2°C for 1 hour and the coverglass then rubbed with ice for 1 to 2 minutes.

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.** Electronic requirements shall be in accordance with MIL-E-5400 except as specified herein.

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 **Amplifiers.** Five d-c amplifiers shall be provided and shall be integral with the indicator 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, with reduced performance, should partial failure of the amplifier occur.

3.9 **Case.** The indicator 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 **Hermetic sealing.** The case shall be hermetically sealed and so designed that the internal mechanism may be removed, replaced, and the case resealed without the use of special tools and fixtures unless they are approved by the
FIGURE 1. Case Dimensions

DIMENSIONS IN INCHES,
UNLESS OTHERWISE SPECIFIED,
TOLERANCES:
FRACTIONS: ± 1/64
DECIMALS: ± .005
ANGLES: ± 2°
A. DIGITAL DISTANCE READOUT
B. BEARING POINTER NO. 1
C. COMPASS CARD SCALE
D. COURSE POINTER
E. BEARING POINTER NO. 2
F. HEADING MARKER
G. DIGITAL COURSE READ OUT
H. COURSE DEVIATION BAR
J. POWER OFF FLAG
K. FIXED MARKER
L. ELAPSED TIME INDICATOR
M. COURSE SET KNOB
N. RECIPROCAL BEARING POINTER NO. 1
O. RECIPROCAL BEARING POINTER NO. 2
P. RECIPROCAL COURSE POINTER
Q. AIRCRAFT SYMBOL
R. HEADING SET KNOB
S. COURSE DEVIATION DOTS
T. COURSE DEVIATION WARNING FLAG
U. LUBBER LINE
V. TO ARROW
W. FROM ARROW

FIGURE 2. Dial
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 meet the necessary pressure requirements when tested for leaks by means of a mass-spectrometer-type helium leak detector.

3.9.2.1 Filling medium. The filling medium shall be of least 98 percent purity, free of dust particles, and 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 a mixture of 88 to 92 percent nitrogen and the remainder helium. The absolute pressure of the filling medium in the case shall be 12 to 14.7 psi.

3.9.2.2 Leakage. The indicator shall be so sealed that the leak rate at a pressure differential of 12 to 14.7 psi will not exceed 0.1 micron cubic foot per hour.

3.10 Reflective surfaces. All reflective glass surfaces shall be provided with a reflection reducing coating which shall meet the requirements of MIL-C-14806 in addition to withstanding the environmental conditions specified herein.

3.11 Indicator display. The indicator 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 ± 0.5 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 bearing pointer No. 2 shall be 0.03 to 0.04 inch forward of plane A; the forward face of bearing pointer No. 1 shall be 0.04 to 0.05 inch forward of plane A; the lubber line shall be 0.07 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 flags shall be not more than 0.025 inch behind plane A. The dimensions given are design center values.

3.11.1 Visibility. All markings, course counter, distance readout, compass card graduations, heading marker, and bearing pointers shall be clearly visible and readable when viewed at a distance of 2 feet from the front of the indicator at an elevation angle of 30° from the top of the coverglass and 4 inches to the right or left of the instrument 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° to the right or left of the sides of the coverglass and 4 inches above or below the instrument centerline.
LETTERS: 1.100 R TO BOTTOM EDGE; .250 HIGH OVERALL; .040 LINE WIDTH.
NUMERALS: 1.100 R TO BOTTOM EDGE; .188 HIGH OVERALL; .030 LINE WIDTH.
10° LINES: .031 LINE WIDTH, LENGTH .125.
2° AND 8° LINES: .010 LINE WIDTH, LENGTH .062.
4° AND 6° LINES: .010 LINE WIDTH, LENGTH .100.
NUMERALS AND LETTERS SHALL CONFORM TO MS33558.
DIMENSIONS IN INCHES: TOLERANCES: DECIMALS ± .010, FRACTIONS: ±1/16, ANGLES ±2°.
LUBBER LINE TOUCHING COMPASS CARD EDGE, NOT OVER.
COURSE POINTER TOUCHING MINOR INDICES.
NUMBER 1 AND 2 ON BEARING POINTERS TO BE 3/32 HIGH, SAME STYLE AS ON CARD.
INDICES ON BEARING POINTERS TO BE .070 LONG AND .031 WIDE; COLOR, BLACK.

FIGURE 3. Display Component Dimensions
3.12 **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° to 360° dial clamped to the rotor of the synchro shall be settable, rotatable, and readable through 360° of rotation to 6 minutes of arc. The following procedure shall be used to calibrate the test synchro:

3.12.1 The rotor leads shall be designated as H and C and one stator lead designated as Z and connected to C. When 26V is applied to H and C (C being ground) the dial shall be positioned on 0° 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.

3.13 **Presentation.** The presentation shall be in accordance with figure 2.

3.14 **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.

3.14.1 **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 3.12. Any CT with the same general impedance of the stator windings as a type EP AY500-5 may be utilized.

3.14.2 **Azimuth ring servo system.** The servo followup system, consisting of a CT, d-c torquer motor, 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° and 60° per second without hunting. There shall be no appreciable hunting or oscillating 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 ±1/2° of the position of a calibrated synchro. The design of the azimuth card loop shall result in operation such as would be achieved in the system shown on figure 4. The functional design shall be as shown in the block diagram on figure 4, except that d-c torquers and position feedback shall be used.
FIGURE 4. Functional Schematic Diagram
3.14.3 Azimuth card control transformer zero. The azimuth card CT shall be zeroed with a positive rotation reference at an index reference of 270°. 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 BB:

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

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' of the CT shall be in phase with the excitation voltage C to H.

3.15 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 d-c torquer servo system when excited by a remote device similar to the standard test transmitter specified in 3.12 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 7 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 1/4°.

3.15.1 Heading marker servo system. A d-c torquer servo system similar to that described in 3.14.2 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° and 60° 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 ±1/2° of the position of the test synchro, the function design of the heading marker loop shall be as shown on figure 4.

The heading marker servo shall conform to the electrical connector and pin wiring shown on figure 4.

3.15.2 Heading marker signal input. The heading synchro device shall be a Clifton precision transolver CDSH-10-AS-4, or electrical equivalent.
3.15.3 Heading datum control transformer. The heading datum CT shall be a Clifton Precision CTC-8-A-4 CT, or equal, and shall operate as shown on figure 4. Electronic circuitry may be utilized to obtain the datum CT function when approved by the procuring activity.

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

3.15.4.1 The standard test transmitter shall be positioned to zero indication on its dial and locked, connected to the heading command and heading datum CT's in accordance with the XYZ notation indicated on figure 4, and excited with 26V, 400 Hz.

3.15.4.2 The heading marker shall be positioned to 0° (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.

3.15.4.3 When 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° (north) to 180°, null at 180° (south) and shall be in the same phase sense as voltage C to H of the standard test transmitter from 180° (south) to 0° (north).

3.15.4.4 When the heading marker is set on 0° (north) on the azimuth dial and the rotor of the standard test transmitter 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° in the same phase as the excitation voltage C to H from 0° to 180°, null at 180°, and opposite to the phase sense of C to H from 180° to 0°.

3.15.4.5 When the transmitter winding of the heading 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 heading marker is set on 0° (north), then voltage X to Z and Y to Z will be in phase with C to H and voltage X to Y null. When the heading marker is rotated cw to east, the voltage X to Z will increase before decreasing.

3.15.5 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:

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

3.15.5.2 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).

3.15.5.3 When 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.

3.16 **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 3.12, 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 rotate in synchronism with 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 the 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 7 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 indicator.

3.16.1 **Course marker servo system.** A d-c torquer servo system, similar to that described in 3.14.2 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° and 60° 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 ±1/2° 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.
3.16.2 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 3.12. The synchro device shall be a Clifton Precision transolver CDSH-10-AS-4, or equivalent, which shall be capable of operating as a CT and a transmitter as shown on figure 4.

3.16.3 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. Electronic circuitry may be utilized to obtain the course datum function when approved by the procuring activity.

3.16.4 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°. Both synchros can be zeroed in the same manner as the heading command CT and heading datum CT specified in 3.15.4 through 3.15.4.4 with course marker substituted for heading marker and with all references made to the course servo system (the course servo system shall not be excited with power).

3.16.5 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:

3.16.5.1 The course marker shall position to 0° (north) on the azimuth ring when the dial of the standard test transmitter is at 0°.

3.16.5.2 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).

3.16.5.3 When the dial of the test transmitter synchro is rotated in an increasing heading indication (ccw), 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.

3.16.5.4 When 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° (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.

3.16.5.5 Course resolver. A resolver of any size with electrical characteristics of the type EP AY221-5-5, 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° and an index reference of 300°.
3.16.6 Rotor windings

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

3.16.6.2 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.

3.16.6.3 When the course marker is rotated 300° 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°), respectively. The resolver rotator shaft shall be locked to scale and the scale rotated 90° in a positive direction to 30° against the azimuth card. Voltage A to C of RW-1 shall be removed and applied to B to C of 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 of 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.

3.16.6.4 The scale reading shall be set at 300° 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 of RW-2.

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

3.16.6.6 The course selector resolver shall have proper characteristics or additional provisions as required to permit use with VOR systems requiring 30-Hz Omni Range Zero (ORZ). Proper ORZ at 30 Hz shall be obtained when the resolver is electrically zeroed with 400-Hz excitation at 300°. 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 PTIH-24-61P, or equal (see 3.25). The VOR phase shifting component shall be connected to pin A, as shown on figure 4, on connector PTIH-24-61P, or equal.

3.17 Course 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.
3.17.1 **Course 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 bar shall be 11/16 ±1/32 inch in both directions measured from the center of the instrument. A movement of 5/8 inch from center shall require 150 microampere (ua) nominal. A d-c polarity of '+' and '-' indicated as pins on figure 4 shall cause a deflection on the right when course arrow is on top. The course bar sensitivity shall be 75 ua per dot and range of displacement shall be ±2 dots. The course bar mechanism shall have a resistance of 1,000 ohms ±3 percent. The test limits at standard conditions for the course bar mechanism shall be as follows:

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

3.17.1.1 **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 output to input will not decrease by more than 3 decibels (db) at 0.2 Hz.

3.17.2 **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 as 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.

3.18 **TO-FROM arrow.** A TO-FROM arrow shall be incorporated as shown on figure 2 and shall operate from a meter movement having a resistance of 200 ohms ±15 percent. The sensing shall be such that with no signal applied, the arrow will not be visible. A signal with polarity as shown on figure 3 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; and a signal not greater than 225 ua shall cause the TO-FROM arrow to reach full displacement.

3.19 **Display movement.** The central portion of the display, including the course arrow, course bar, 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 motions listed.

3.20 **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.
3.21 **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.

3.22 **Bearing markers.** Bearing marker d-c torquer servo systems shall be incorporated for positioning the bearing pointers shown on figure 2 from remote sources similar to a standard test transmitter synchro. The servo systems shall be similar to the d-c torquer servo that drives the azimuth ring. The servos shall receive changes in bearing between 0° and 60° per second without hunting. There shall be no appreciable hunting or oscillating in the servo systems and they shall position the bearing pointers around the azimuth ring to within ±1/2° of the test synchro position. The servo systems shall be connected as specified on figure 3.

3.22.1 **Bearing pointer signal input.** Each bearing pointer servo system shall receive its input signal from a transmitting synchro device similar to the test transmitter described in 3.12. The bearing pointer CT shall be a type EP AY500-5, or equal. Any CT with the same general impedance of the stator windings as a type EP AY500-5, or equal, may be used.

3.22.2 **Bearing pointer control transformer zero.** Each bearing pointer CT shall be zeroed at a scale reference of 180° (under the lubber line at the bottom of the display) and at an index reference of 90°.

3.22.2.1 With the standard test transmitter connected in accordance with the XYZ notation on figure 3 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. The following conditions shall apply:

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

b. Rotation of the card on the test transmitting 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.

3.23 **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 a 1:1 ratio. The units
display shall have 1-mile and 1/2-mile index lines. The numerals shall be centered each 36° 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.

3.23.1 **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°, the 0 shall be in position on the distance dial of each receiver synchro.

b. Rotation of the test transmitter synchro to 36° 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° of the transmitter synchro rotation.

3.23.2 **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.

3.24 **Power.** The indicator shall be capable of operating on power supplied from an aircraft infinite bus source at 115V, 400-Hz single phase in accordance with MIL-STD-704. The indicator shall also comply with the requirements of MIL-STD-704 for utilization equipment, except when a 28V d-c source, infinite or limited, is connected to any indicator 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 five servo systems shall be excited with 115V, 400 Hz on the specific connector and pins shown on figure 4. In addition, for operation of the integral lighting, 5V a-c power shall be supplied to the proper connector and pins shown on figure 4.

3.24.1 **Voltage and frequency variation.** The indicator shall operate properly and continuously when the voltage and frequency are varied from 103 to 127V and 320 and 480 Hz, respectively, or any combination thereof.

3.24.2 **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 115V power to the bearing and azimuth circuit is interrupted or when there is a failure of the bearing and 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.
3.24.3 **Time totaling meter.** A time totaling meter conforming to MS17322 shall be provided to record the running time of the indicator when power is applied to the azimuth and bearing servo. It shall be located in the lower right-hand corner of the indicator 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.

3.25 **Connector.** An electrical connector shall be supplied on the indicator as shown on figure 1. The connector shall be Bendix part No. PTIH-24-61P, or equal. All electrical connections shall be in accordance with figure 4. The connector shall be protected during shipment and storage by a moisture-proof cap and gasket.

3.26 **Integral lighting.** The indicator shall be integrally lighted as shown on figure 4. The lighting system shall be in accordance with MIL-L-27160. Lighting shall be subject to the approval of the procuring activity.

3.26.1 The integral lighting shall be comparable to and shall balance in brightness with a prime standard. The prime standard shall be an indicator conforming to this specification or a lighted mockup. The prime standard shall have applied to its lighting circuit the specific voltage which the procuring activity has established as being necessary to assure equality or 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.

3.27 **Weight.** The weight of the indicator shall not exceed 8 pounds.

3.28 **Screw threads.** Unless otherwise specified, the threads of all machine screws shall conform to MIL-S-7742.

3.29 **Lubrication.** The indicator shall be lubricated in accordance with MIL-STD-838.

3.30 **Jewel bearings.** Jewel bearings shall be in accordance with MIL-B-27497.

3.31 **Finishes and protective coatings**

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

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

3.31.1.2 Aluminum alloys which do not anodize satisfactorily shall be coated with a chemical film in accordance with MIL-C-5541.
3.31.1.3 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.

3.31.1.4 Castings containing nonaluminum-alloy integral inserts may be treated with a chemical film in accordance with MIL-C-5541 in lieu of anodizing.

3.31.1.5 When abrasion resistance is a factor, chemical film in accordance with MIL-C-5541 shall not be used in lieu of anodizing.

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

3.33 Installation

3.33.1 Mounting screws. The contractor shall furnish sufficient mounting screws for installing the indicator. 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 3/16-inch thick. Screw threads shall be size .190-32 UNF-2A.

3.33.2 Envelope. An envelope containing the mounting screws shall be furnished with each indicator. The following information shall be printed on the face of the envelope:

IMPORTANT
THIS ENVELOPE CONTAINS
MOUNTING SCREWS

3.34 Workmanship. The indicator, 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.

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

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

3.34.3 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 indicator, they shall be held or limited accordingly.

3.34.4 Soldering. Soldering shall be accomplished in accordance with MIL-STD-454, requirement 5.