ARMY AVIATION BOARD

AVIATION BOARD

UNITED STATES ARMY AVIATION BOARD
Fort Rucker, Alabama

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REPORT OF TEST

PROJECT NO. AVN 1162

EVALUATION OF RYANAV IV DOPPLER NAVIGATION SYSTEM

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1. AUTHORITY. Under the provisions of paragraph 5n, USCONARC Pamphlet No. 705-1, "Materiel Developments Program, Fiscal Year 1963," Headquarters, USCONARC, June 1962, this Board has conducted an evaluation of the RYANAV IV Doppler navigation system to determine whether this equipment has sufficient military value to warrant further Army interest.

2. REFERENCES. A list of references is contained in appendix D.

3. BACKGROUND.

a. Paragraph 533c(6), Combat Development Objectives Guide, revised 1 May 1962, contains the Qualitative Materiel Requirement (QMR) for a Navigator, Lightweight, Self-Contained. This QMR is classified CONFIDENTIAL. Military Characteristics for Lightweight Self-Contained Navigator, classified CONFIDENTIAL, have been approved (reference 2). A QMR for a specific type self-contained navigator is also listed in CDOG, Paragraph 533c(5), and is classified CONFIDENTIAL: Military Characteristics based on this paragraph do not exist.

b. Ryan Electronics, Division of Ryan Aeronautical Company, San Diego, California, offered this Board a RYANAV IV Doppler navigation system on consignment for evaluation.

c. The equipment was received on 15 October 1961, and installation was completed 12 December 1961. Due to calibrations and adjustments of the RYANAV IV and maintenance requirements of the airplane, flight tests did not commence until February 1962. A maintenance package was not received.

d. The RYANAV IV is the first Doppler navigator tested by this Board. This evaluation afforded personnel of the Board the opportunity to become familiar with Doppler navigation operation and maintain association with research efforts in Doppler navigation equipment.

4. DESCRIPTION OF MATERIEL.

a. The RYANAV IV Doppler navigation system contains:

(1) Receiver-transmitter unit.

(2) Converter computer unit.

(3) High-voltage power supply.

(4) Ground/wind velocity indicator (G/WVI) control.

(5) Groundspeed/drift-angle, windspeed/wind-direction indicator.

(6) Bearing-to, ground-track, and range indicator.

(7) Computer/indicator group.

(8) Plotting board.

(9) Wiring harness.

b. Equipment required to furnish inputs to the RYANAV IV but not considered part of the navigation system include:

(1) Vertical gyro system.

(2) Compass system.

(3) True airspeed transducer.

(4) Inverter of 750-v.a. capacity.

c. Transmitter frequency is 13,300 (± 5) megacycles, continuous wave.

d. Ryan Electronics states that the system will accommodate all altitudes from zero to 70,000 feet; drift velocities from zero to plus or minus 300 knots; ground velocities from minus 50 knots to plus 2,000 knots; ground track to 360 degrees; and vertical velocities to 60,000 feet per minute.

e. Electrical outputs are heading velocity, drift velocity, vertical velocity, groundspeed, ground track, drift angle, true heading, and east-west north-south distance traveled.

f. Visual displays include the navigation indicator showing groundspeed and drift angle, or windspeed and wind direction, bearing-to, ground-track and range indicator; automatic plotting board for visual two-dimension aircraft-position indication and the control indicator.

g. Navigation with the RYANAV IV is accomplished by determining one or more destinations from a known base in terms of nautical miles north/south and east/west, setting these destinations in the computer indicator and thereby obtaining a bearing and range to the destination on the range-bearing indicator. By then centering the bearing indicator, the airplane can be flown in a straight line, in terms of true north, to the destination that is set in the computer indicator. The computer indicator is capable of accepting two destinations and these destinations could be changed in flight. The primary control on the computer indicator, when changed to Base, would provide, as a read-out on the range-bearing indicator, the range and bearing to the Base.

5. SUMMARY OF TESTS. The RYANAV IV was installed in an R4D and flight tested for approximately 73 hours during the period February-May 1962 within the normal flight envelope of the R4D.

a. Installation presented no unusual difficulties except that the size of the antenna precluded flush-mounting in any standard US Army aircraft. However, informal information indicates that Ryan Electronics has designed a smaller antenna which can be satisfactorily installed in Army aircraft.

b. The RYANAV IV was a hand-built engineering prototype model, and, as a result, many failures occurred, and misadjustments resulted in large and erratic navigational errors. However, as the evaluation progressed, errors were reduced to an acceptable percentage, and the equipment became more reliable. The accuracy of this set when operating properly was extremely close to accuracies outlined in the QMR (reference 1). Accuracy of navigation with the equipment, however, was dependent upon the human navigator and the accuracy of the charts used to obtain the geographical coordinates.

c. Reading and interpretation of the indicators were extremely difficult. Some of the controls were difficult to operate during flight.

d. No special skills were required for the operation of the RYANAV IV. Approximately six hours of formal training and six hours of supervised on-the-job training would be required to train an Electronic Equipment Mechanic, MOS 284.1, to perform organizational maintenance.

e. Trouble-shooting and repairs of the RYANAV IV were simplified because of the modular type of assembly and test features provided.

f. Deficiencies and shortcomings noted are contained in appendix B.

6. <u>DISCUSSION.</u>

a. The RYANAV IV Doppler navigation system was the first such successful system evaluated by the US Army Aviation Board. Many problems have been revealed concerning the method of navigation required for use with Doppler navigation systems and the presentation of visual read-outs best suited to this type of navigation. Board personnel were not aware of many of these problem areas prior to this evaluation.

b. Ryan Electronics states that the RYANAV IV can be utilized for navigation when installed in a helicopter.

c. Other manufacturers of Doppler navigators have offered this Board, on consignment, Doppler navigation systems similar to the RYANAV IV for evaluation. Each of these systems requires a different method of navigation be utilized, and each offers a different visual read-out presentation. These systems are available now or expected to be available in the near future.

d. Military Characteristics for a Doppler navigation system do not exist.

7. CONCLUSIONS.

a. The RYANAV IV Doppler navigation system is not suitable in its present configuration for Army use.

b. The RYANAV IV has sufficient value to warrant further Army interest.

JOHN L. ROWAN
Lt Colonel, Artillery
Acting President

APPENDIX A

DETAILS OF TEST

APPENDIX A

DETAILS OF TEST

I. SCOPE. The RYANAV IV Doppler Navigation System was tested during the period February to May 1962 at altitudes and speed ranges commensurate with the operational characteristics of an R4D airplane. A total of 10,191 nautical miles were flown while the equipment was operated. Total flight time was 72.7 hours. Flights were conducted day and night at absolute altitudes ranging from 0 to 10,500 over land and water during VFR and IFR conditions, through light and heavy rain and snow. Bank attitudes of the aircraft varied from 0 degrees to 60 degrees, and pitch attitudes varied from 0 degrees to plus or minus 10 degrees. Two calibration courses of 140 and 147 nautical miles in length were utilized to determine accuracies and adjust the equipment. These calibration courses were flown a total of 16 times during the evaluation. Maintenance was accomplished in coordination with the US Army Signal Aviation Test and Support Activity.

II. TESTS.

1. Physical Characteristics.

a. Installation Requirements. The RYANAV IV antenna could not be flush-mounted in any standard US Army aircraft (figures 1 and 2). The antenna installation in the R4D was a major modification to the aircraft requiring design of the antenna mounting and Navy airworthiness certification. A cut-out of 26 inches x 30 inches was required in the underside of the R4D fuselage and the depth of the antenna required that it extend below the fuselage approximately three inches. The receiver-transmitter and hi-voltage power supply of the RYANAV IV were installed in the right underside of the R4D fuselage beneath the cargo floor. All other components of the system were installed on the test bench in the airplane and required only normal shock mounting or instrument panel installation. Details of the installation are contained in appendix C.

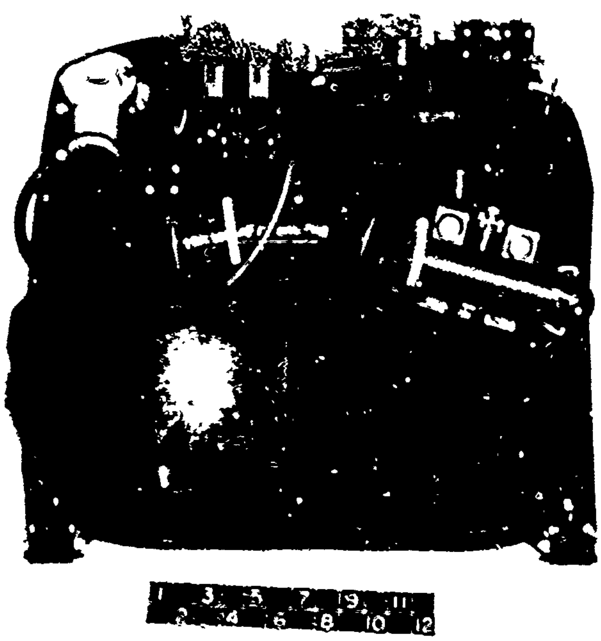


Figure 1. RYANAV IV receiver/ transmitter

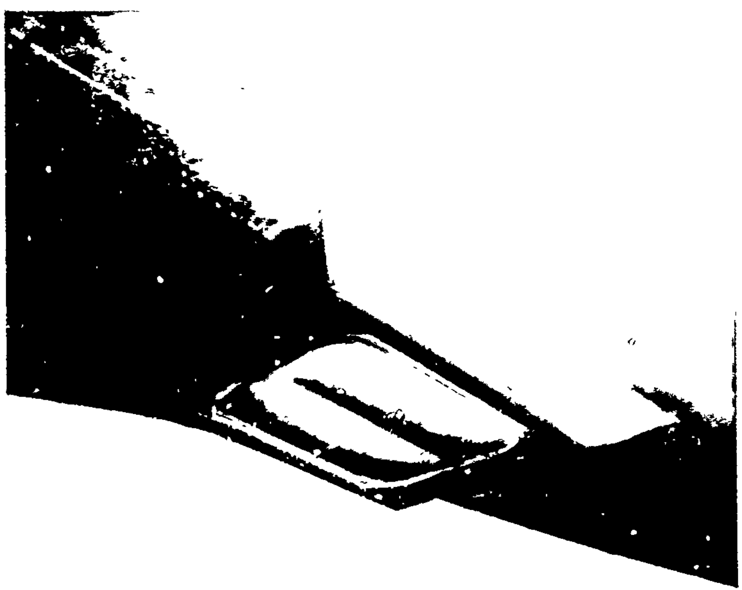


Figure 2. Receiver/ transmitter installed in the R4D

b. Size and Weight.

	Size (Inches)			Weight	
	Length	Height	Width	Pounds/Ounces	
Receiver/transmitter	27	17	24	28	8
Converter-computer	24 3/4	6 1/2	10 1/8	37	8
High-voltage power supply with mount	14 9/16	6	7 3/8	8	14 1/2
G/WVI control	4 3/4	3 3/4	5 3/4	1	10 1/2
Groundspeed/drift-angle, windspeed/wind-direction indicator	5 1/4	3 (dia)		0	13 1/2
Bearing-to, ground-track, and range indicator	3 1/4	3 (dia.)		1	6
Computer indicator	4 3/4	5 3/4	5 3/4	7	14
Plotting board	9 1/2	5 1/4	9 1/2	9	5
Wiring harness				20	0
	TOTAL WEIGHT			115	15 1/2

c. Electrical Requirements. Electrical requirements were 115-v.a., 400 c.p.s., 569 v.a. maximum.

d. Adequacy of Presentation.

(1) All information required for Doppler navigation was presented in the form of visual read-outs. One of the read-outs, drift angle, was not considered necessary in this installation since by centering the "bearing-to-indicator", drift, if any, was automatically compensated for. However, if the equipment was utilized with SLAR or IR not equipped with automatic antenna slewing, the drift angle read-out would be required.

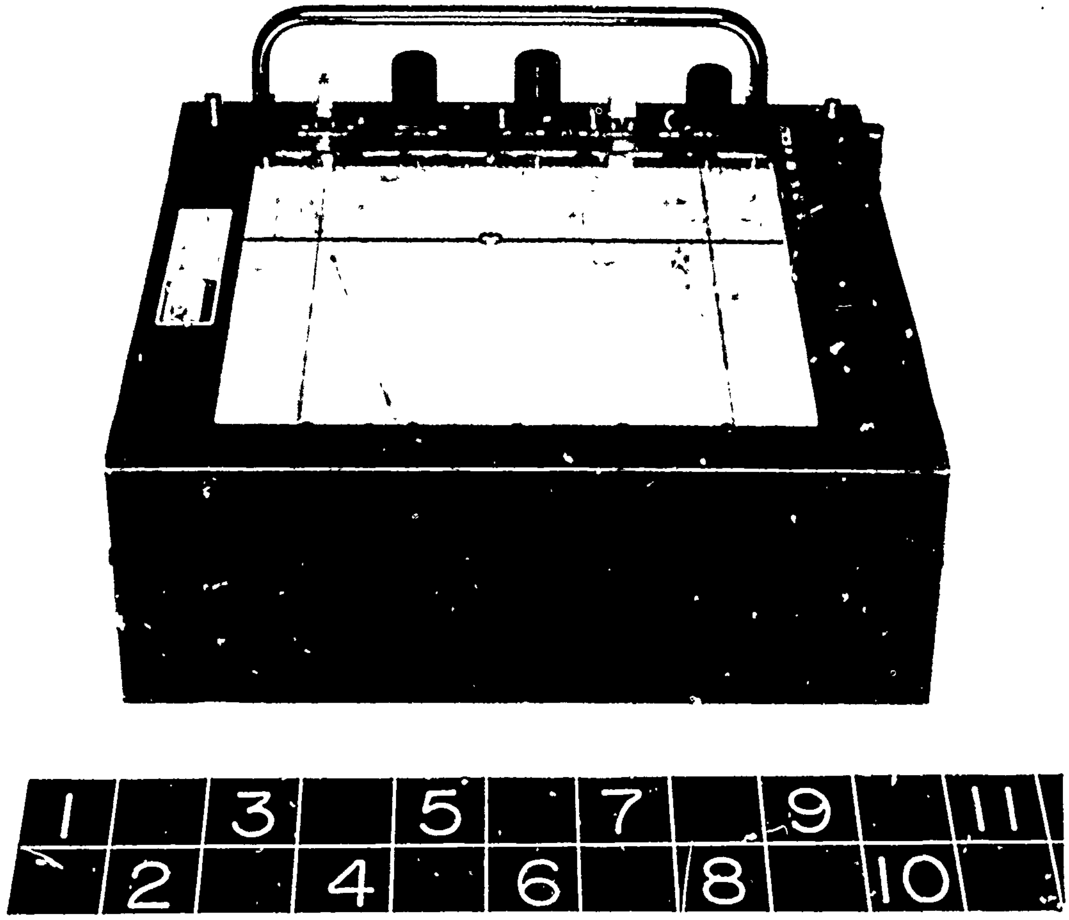


Figure 3. AFC plotting board

(2) The plotting board (see figure 3) had limited application in this configuration. Templates used in the plotting board covered 40-nautical-mile square areas for charts of 1/500,000 and 80-nautical-mile square for charts of 1/1,000,000. At an average airspeed of 140 knots on a generally straight-line mission, it was necessary to change templates every 17 minutes for the 1/500,000 charts and every 34 minutes for the 1/1,000,000 charts.

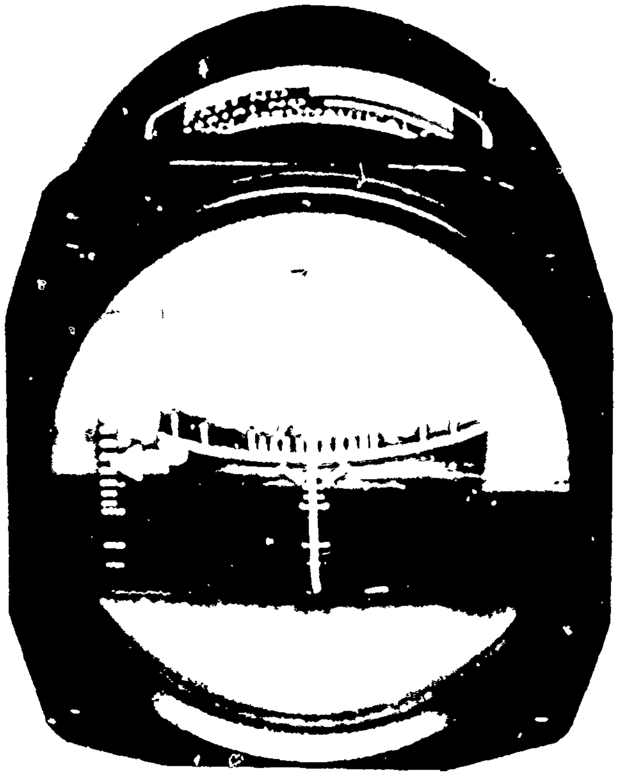


Figure 4. Hover indicator

(3) For helicopter operations, where missions would be short and a return to base would complete the mission, the plotting board could be of great value; however, it will be necessary to determine this in subsequent evaluations of self-contained navigators. If the RYANAV IV were to be utilized in helicopters, a hover indicator (3 1/4 inches x 3-inch diameter and weighing 12 ounces), which is available, could be incorporated (see figure 4).

c. Development Status. The equipment installed for this evaluation was an engineering prototype model, and for the most part was hand built and did not incorporate the quality control normally expected in operational equipment. For this reason, there were many module failures and crossed wires that, in some cases were corrected when the module was returned to Ryan Company in San Diego, California, for repair, and in some other cases were found and corrected "in the field" by isolating an obvious error in navigation results. Details and frequencies of these failures are contained in section III, appendix C.

2. Operational Characteristics.

a. General.

(1) The RYANAV IV was capable of accepting a base (usually 000-000 and the point of departure) and two destinations shown in nautical miles east or west and miles north or south, and furnished continuous visual read-out of:

(a) Range (Upon selection, this digital read-out indicated computed miles to destination number One, Two, or Base)

(b) Bearing-to (Upon selection, this steering needle indicated true bearing to destination number One, Two, or Base)

(c) Ground-track

(d) Groundspeed

(e) Windspeed

(f) Wind-direction

Destinations One, Two, or the Base could be reset while the equipment was operating. Readily available controls were provided to permit changing of these values while in flight. Controls were provided for selection of destination One, Two, or Base and manual selection of magnetic variation; switching was provided to change the sensitivity of the Doppler sensors when the equipment was being operated over land or over water.

(2) Destinations utilized during the evaluation were determined by direct reading of geographical coordinates from

Sectional and World Aeronautical Charts, computing a mid latitude correction factor, and applying these factors to a formula utilized for this purpose. An example of the computations necessary to determine a destination is attached to this report as appendix C. Time necessary to compute a destination was approximately seven minutes.

b. Accuracy. At the start of the evaluation, the navigation errors were very large and erratic. As the evaluation progressed, the errors became smaller and less erratic as required repairs and adjustments were made. During the latter part of the evaluation (2986 nautical miles of flight) the closure errors were well within two percent, the greatest error being a right cross track of 1.8 percent. Errors were computed in percentage cross-track error and percentage along-track error in terms of "miles off" versus "miles flown." Errors were determined from a set base, and navigation courses used during the evaluation varied from 10 to 600 nautical miles in length. The track error between check points varied from 0 to 19 percent, but it is suspected that the largest errors stem from misplacement of points used as check points on the World and Sectional Aeronautical Charts. Track errors between check points for the entire evaluation averaged 1.5 percent left cross-track and 0.7 percent long along-track. Closures averaged 0.5 percent left and 0.4 percent long. Errors have been tabulated and are presented in appendix C.

c. Ease of Interpretation of the Indicators.

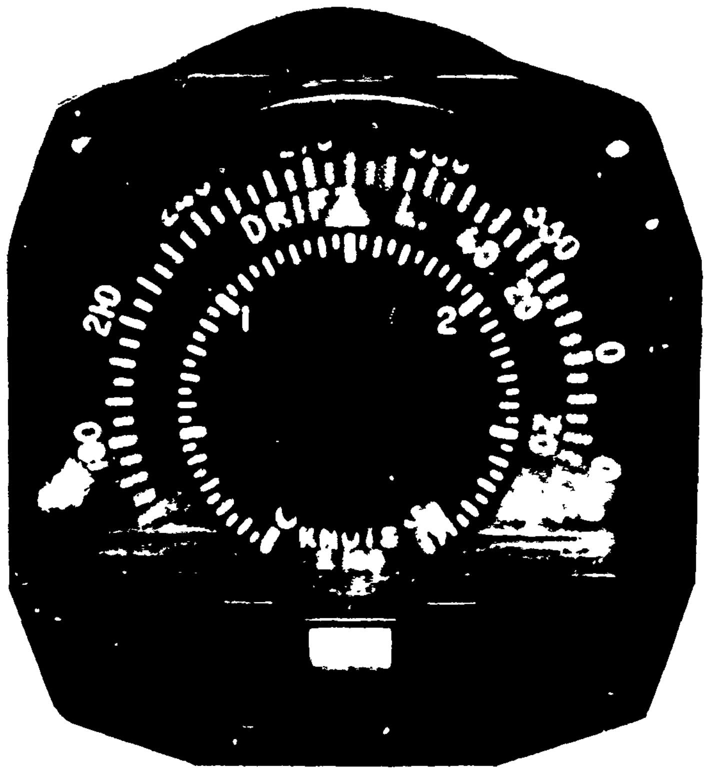
(1) The groundspeed/drift-angle, windspeed/wind-direction indicator (figure 5) was difficult to read and differed from normal instrument presentation in that:

(a) One index served for both wind direction and drift angle, but used two sets of numbers for read-out. The wind direction was shown on a compass card with the numbers on the outside of the card; the drift angle was shown as "Left" or "Right" with the numbers nearer the center of the instruments.

(b) When switching from groundspeed/drift-angle to windspeed/wind-direction, the "knots x 100" pointer oscillated wildly for 5 to 10 seconds before stabilizing.

(c) The outside compass card of the instrument accepted and displayed instantaneous Doppler information without

Figure 5. Groundspeed/drift-angle, windspeed/wind-direction indicator



damping, thus jerking and jumping at intervals of from one to five seconds in increments of five to fifteen degrees. The groundspeed and windspeed pointer varied constantly but in much smoother and smaller increments.

(2) At the beginning of the test, the ground-track, bearing-to, and range indicator displayed ground track on a compass card that had the heading numbers on the outside of the card and the degree increments on the inside (figure 6). This was later reversed (figure 7), enabling easier interpretation. The numbers on the digital range read-out were too small for normal operation and were hidden by the center of the instrument when viewed at an angle from above.

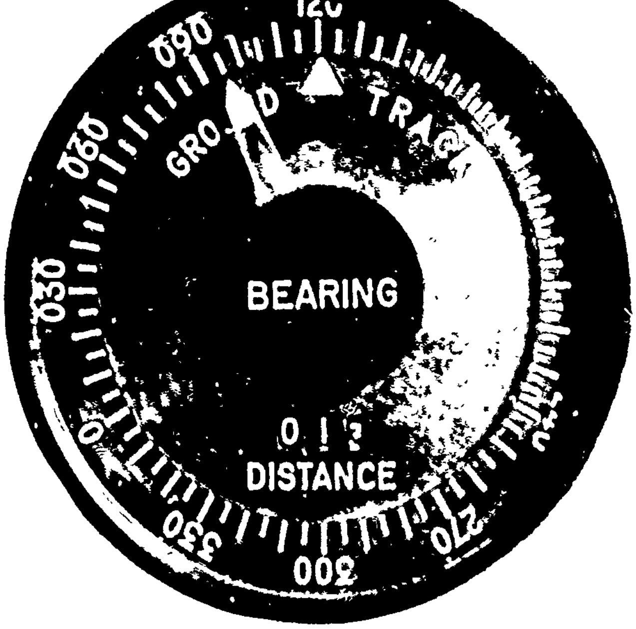


Figure 6. Original configuration of the bearing-to, ground track, and range indicator

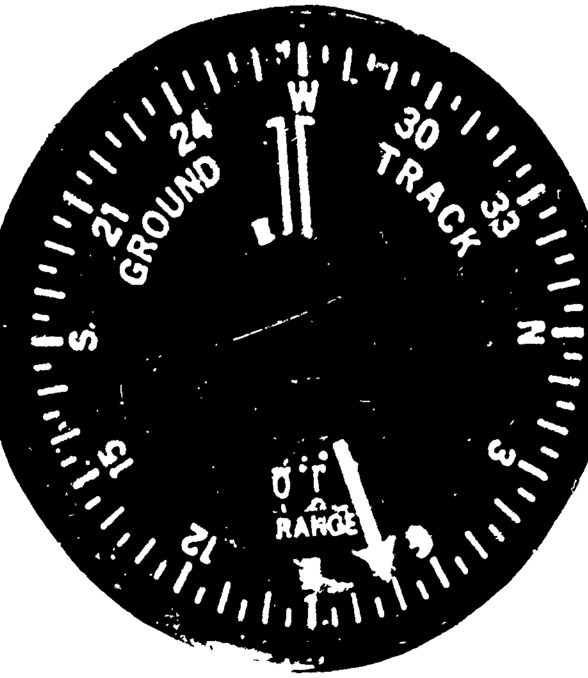


Figure 7. Indicator shown in figure 6 as changed during test

Figure 8. The G/WVI control

e. Ease of Operation of Controls and Indicator.

(1) The G/WVI control (figure 8) was easy to operate in that the switches and control knobs were readily available and lettering was easily readable. The two switches controlling wind speed and direction and the switch controlling the wind/ground reading seemed fragile. At one time one of the switches was bent, but still usable. No failures occurred during the evaluation.

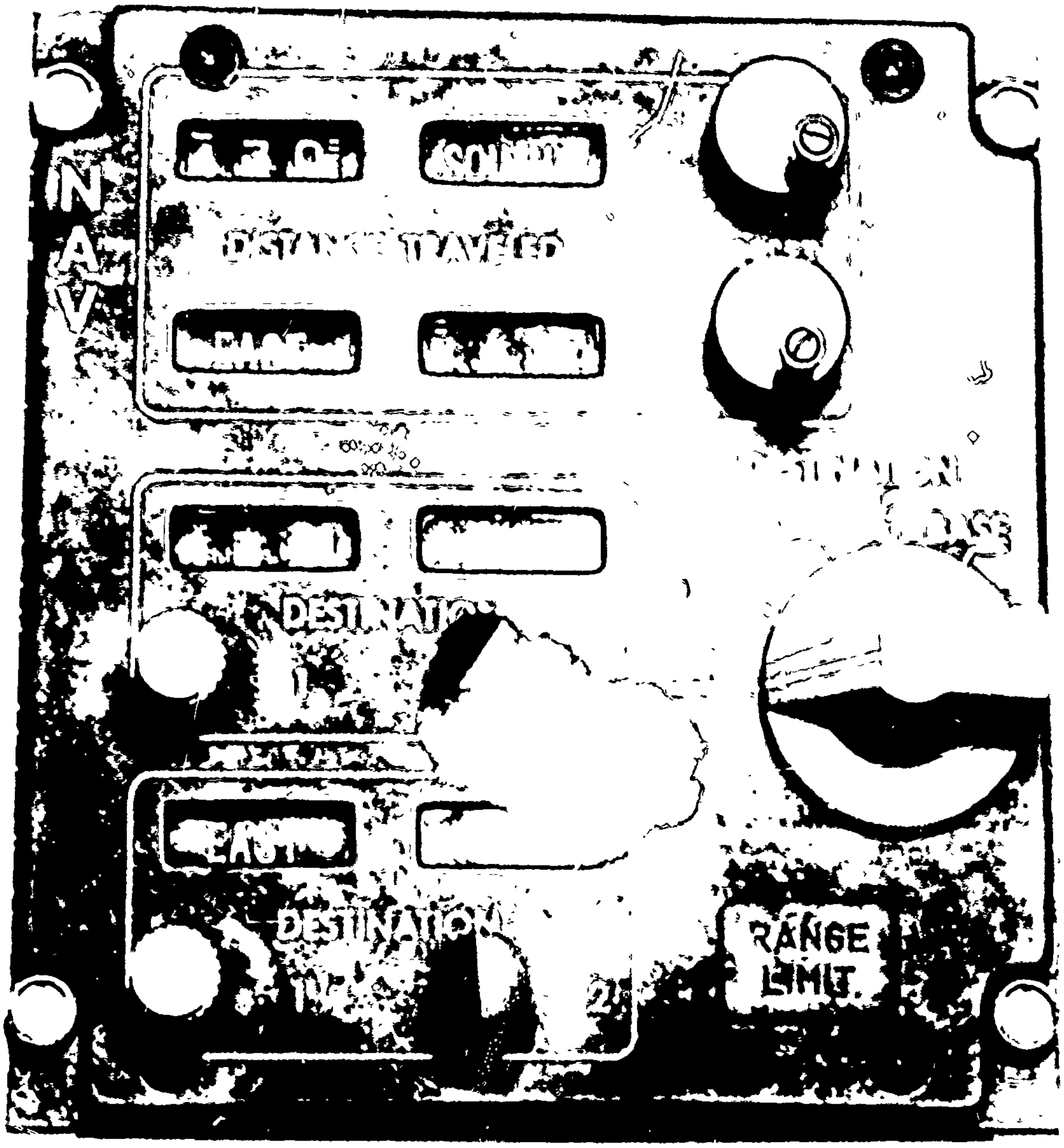


Figure 9. Computer indicator group

(2) The computer indicator (figure 9) was very difficult to operate in that the controls necessary to set destinations were overly sensitive, and it was extremely difficult to set the desired destination.

f. Suitability of Illumination. The internal red lighting used in the equipment was adequate for night operation.

3. Limitations.

a. Occurrence of Doppler loss (insufficient Doppler signal return) generated a Doppler loss output signal which caused the navigation set to operate automatically in a "memory" mode until the Doppler signal was regained. In the memory mode, computations and readouts furnished by the navigation set were calculated from the last computed Doppler-derived wind, combined with the true airspeed. The equipment will go into "memory" operation when over water that has a sea state of Beaufort 1 or less. (Beaufort 1 is that sea condition where a wind speed exists of from one to three miles per hour.)

b. It is suspected that heavy rain will adversely affect the accuracy of the equipment; however, due to the limited amount of heavy rain encountered during the flight test portion of this project, the magnitude of this error could not be determined.

4. Personnel.

a. Operator. No special skills were required for the operation of the RYANAV IV. The operator must have the ability to navigate by dead reckoning, to determine geographical coordinates from maps or charts, and to determine natural cosine functions either by use of a slide rule or from published tables. Training required for operation of the RYANAV IV consisted of teaching personnel the method of determining destinations east/west and north/south.

b. Maintenance.

(1) Approximately six hours of formal training and six hours of supervised on-the-job training are required to train an Electronic Equipment Mechanic, MOS 284.1, to perform organizational maintenance.

(2) Extensive formal training would be required to train an Electronic Equipment Repairman, MOS 284.2, to perform field maintenance. USASATSA and this Board have no knowledge of any established course of instruction, either military or civilian, on this equipment. If the system is adopted for Army use, it is assumed that a course of instruction will be established.

c. Adequacy of Operating and Maintenance Instructions.

(1) Operating. Operating instructions for the RYANAV IV were contained in a Ryan Electronics report (reference 9). These instructions, though adequate, were not in the standard military form used for operating instructions and did not present a method for determining the east/west or north/south legs necessary to set in the destinations used for Doppler navigation.

(2) Maintenance. Published maintenance instructions were not provided.

5. Tactical Suitability.

a. The calibration courses noted in section I (Scope) were used to simulate tactical missions having a fixed base for departure and return. These courses were flown at absolute altitudes from 500 feet to 1700 feet. The 500-foot level was considered to be the lowest practical altitude for the R4D from the standpoint of maneuverability and safety, and at altitudes above 1700 feet it was difficult to determine visually if a target was being over-flown directly so that a "mark" could be taken. Doppler navigation can be compared favorably with radio navigation, i.e. an indicator needle on the instrument panel furnished destination information. The primary difference in the Doppler navigation method is that the bearing-to indicator needle is a steering needle and is furnishing track information eliminating the need for wind drift considerations. Accuracy of this method of navigation, assuming the equipment is furnishing accurate data within its own capability, is dependent upon the human navigator who has determined the destination by means of geographical coordinates and manual computations, and the accuracy of the charts used to obtain the geographical coordinates. Utilizing the bearing-to indicator for steering information is much the same as ADF or omni tracking--when the aircraft is nearing the destination (station) the steering needle (bearing-to indicator) must be ignored and heading maintained because of the large needle swings that take place during this time. Destination passage is indicated by the 180-degree needle swing of the bearing-to indicator and a read-out of 000 on the range indicator.

b. This equipment, or other self-contained navigators of this type, will permit point-to-point navigation from a known base to any number of destinations without the use of ground-based navigation aids or visual reference to the ground. Successful completion of the mission, however, is dependent upon accuracy of the navigation set, its allied equipment, the human navigator, and available maps.

6. Maintenance. Installation and maintenance were accomplished in coordination with the US Army Signal Test and Support Activity and the manufacturer's representatives. Installation drawings, maintenance instructions, and technical assistance were provided by the Ryan representative present during the test period.

a. Time and Frequency of Maintenance. Time and frequency of maintenance were not determined because the system utilized was not new when received.

b. Ease-of-Maintenance.

(1) Because of the modular type of assembly and test features provided, troubleshooting and repair were simplified.

(2) The replacement of modules could be readily accomplished at third echelon. However, the sub-miniaturization and high-density packaging of the modules precluded repair below fourth echelon.

c. Parts Standardization. The RYANAV IV is a prototype system of recent design. Percentage of components and parts available through normal Signal supply channels was not determined. All parts and components required during test were made available through the manufacturer.

d. Tools.

(1) The TE-41 Tool Equipment Set was adequate for organizational maintenance.

(2) The TK-87/U and TK-88/U Tool Equipment Sets would be adequate for field maintenance, if supplemented by a printed circuit repair kit.

e. Parts Replacement. All parts replacement was accomplished by trained Ryan personnel with no major difficulties. However, owing to the sub-miniaturization and extreme high-density packaging of the equipment, extreme caution must be exercised to prevent damage to adjacent parts and components.

f. Test Equipment. Standard organizational test equipment was adequate for organizational maintenance and could be utilized in field maintenance of the RYANAV IV. However, special test and support equipment furnished and utilized during test greatly enchanced ease of troubleshooting and maintenance.

g. Repair Operations. A detailed list of component failures and repair operations is contained in section III of appendix C.

APPENDIX B

FINDINGS

APPENDIX B

FINDINGS

This appendix includes all deficiencies and those shortcomings which are considered significant enough to warrant corrective action.

SECTION I.

This section contains deficiencies requiring elimination in order to make the item acceptable for use on a minimum basis.

DEFICIENCY	SUGGESTED CORRECTIVE ACTION	REMARKS
1. Antenna is too large for flush-mount installation in Army aircraft.	Redesign antenna to a smaller size for installation in Army aircraft.	Informal information indicates this has already been accomplished by the manufacturer.
2. Presentation of the groundspeed/drift-angle, windspeed/wind-direction indicator is too complicated and information was displayed erratically and with oscillations.	Redesign indicator with damping incorporated taking into consideration engineering factors with regard to readability and simplicity of the instrument face.	
3. Bearing-to, ground-track, and range indicator has numbers in the digital range read-out which are too small for normal operation and are hidden by the center of the instrument when viewed at an angle from above.	Redesign the digital readout so that the digits are large enough for normal operation, and relocate the readout so that it is readily readable from all normal observing angles.	The manufacturer has partially corrected this by enlarging the digits. However, the digital read-out has not been relocated.

DEFICIENCY	SUGGESTED CORRECTIVE ACTION	REMARKS
4. The computer indicator was very difficult to operate in that the controls necessary to set destinations were overly sensitive.	Damp and gear the controls so that they are less sensitive and are not jerky.	

SECTION II

This section lists shortcomings which are desired to be corrected as practicable, either concurrent with elimination of the deficiencies in section I, in production engineering or by product improvement.

SHORTCOMINGS	SUGGESTED CORRECTIVE ACTION	REMARKS
The three toggle switches on the G/WVI control are too fragile.	Install more rugged switches.	

APPENDIX C

TEST DATA

APPENDIX C

SECTION I

RYANAV IV DOPPLER NAVIGATION

TO TRAVEL FROM OZR (BASE) TO ATL (DESTINATION 1)

1. Determine from Aeronautical Chart latitude (lat.) and longitude (long.) of present location (Base).

OZR

Lat. 31 degrees 16.4' N
Long. 85 degrees 42.9' W

2. Determine from Aeronautical Chart latitude and longitude of desired destination.

ATL

Lat. 33 degrees 31.0'N
Long. 84 degrees 29.2'W

3. Determine the difference between the latitude of the Base (OZR) and the latitude of the destination (ATL).

ATL 33 degrees 31.0'N
OZR 31 degrees 16.4'N
DIFF 2 degrees 14.6'

1 degree of lat. = .60 NM
ATL is 134.6 NM North of OZR

4. Determine the difference between the longitude of the Base (OZR) and the longitude of the destination (ATL).

OZR 85 degrees 42.6' N
ATL 84 degrees 29.2' W
DIFF 1 degree 13.4'

Since 1 degree of long. = 60 NM, 1 degree 13.4' = 73.4 NM. But this is not the true E/W Distance. To get the true E/W Distance, this number (73.4 NM) must be multiplied by a mid latitude correction factor.

5. Determine the mid latitude correction factor. Divide the difference obtained in step 3 (2 degrees 14.6') by 2.

$$\frac{\text{2 degrees 14.6'}}{2} = \text{1 degree 7.3'}$$

Add this amount (1 degree 7.3') to the smaller lat. (31 degrees 16.4')

31 degrees 16.4'
1 degree 7.3'
32 degrees 23.7'

Determine the cosine of this number (32 degrees 23.7')

Cosine 32 degrees 23.7' = .8443

This is the mid latitude correction factor (.8443).

6. Determine the true E/W distance. Multiply the figure obtained in step 4(73.4 NM) by the mid latitude correction factor (.8443).

73.4 NM x .8443 = 61.8 NM
ATL is 61.8 NM East of OZR

SECTION II

SYSTEM ACCURACY

(Errors are stated as percent)

	Feb 62	Mar 16-17, 62	Mar 21-23, 62	Mar 23-25, 62	May 7-8, 62	May 9, 62	May 9-18, 62	Total Miles and Average Errors
REMARKS		SEE NOTE 1	SEE NOTE 2	SEE NOTE 3	SEE NOTE 4	SEE NOTE 5	SEE NOTE 6	SEE NOTE 7
MILES FLOWN	1520	897	1305	2851	386	146	2986	10,191
BETWEEN CHECK POINTS								
Average cross-track error (CTE)	0.4Right	4.2Right	1.0Left	0.5 Right	5.4 Left	3.2 Left	0.3 Left	1.5 Left
Average along-track error (ATE)	1.2 Short	4.0 Short	1.6 Long	1.7 Long	0.7 Long	1.2 Long	.0 Long	0.7 Long
Greatest right CTE	13.6	38.8	9.8	6.9	.0	.0	19.0	
Greatest left CTE	8.1	21.4	17.7	5.8	14.5	8.0	16.9	
Greatest short ATE	6.6	11.5	10.1	11.1	4.4	1.7	2.8	
Greatest long ATE	1.4	7.2	9.7	8.7	5.6	9.7	9.7	
CLOSURE AT BASE								
Average CTE	1.6 Left	13.6 Right	0.7 Left	0.2 Left	0.2 Left	0.1 Left	0.4 Left	0.5 Left
Average ATE	0.4 Left	0.4 Left	1.4 Left	0.2 Short	0.1 Long	0.2 Long	0.2 Long	0.4 Long
Greatest right CTE	.0	13.6	.0	1.3	.0	.0	1.8	
Greatest left CTE	1.8	.0	1.6	3.0	0.2	0.1	0.4	
Greatest short ATE	0.7	.0	0.7	1.6	.0	.0	.0	
Greatest long ATE	1.4	0.4	3.0	3.2	0.1	0.2	1.2	

NOTE 1. Determined at end of this flight that the drift angle section of the computer was wired in reverse. This was corrected This flight was not considered valid for test results.

NOTE 2. Determined, after six runs on the calibration course, that the MA-1 compass was two degrees in error on westerly headings, and the Doppler computer was integrating approximately two percent fast. Both these errors, according to Ryan, were corrected.

NOTE 3. Determined that the Doppler computer is still integrating too fast. The computer was returned to San Diego for complete check-out and adjustment which was completed on 4 May 1962. Flux valve in MA-1 compass system changed five degrees.

NOTE 4. Computer integrating scale factor reduced two percent.

NOTE 5. Two-degree magnetic variation correction incorporated in RYANAV IV computer section.

NOTE 6. These flights included 126 nautical miles over water from 500 feet M.S.L. to 10,500 feet M.S.L. No change in errors noted.

NOTE 7. Flight on 16-17 March 62 not included in these averages.

SECTION III

INSTALLATION REQUIREMENTS AND COMPONENT FAILURES

1. DETAILS OF INSTALLATION.

a. Installation was accomplished in USAAVNBD R4D Airplane, BuNo 99848, during the period from 26 October 1961 to 12 December 1961 by USASATSA personnel. Sheetmetal support was provided by US Army Transportation Aircraft Test and Support Activity. Installation drawings and wiring diagrams were supplied by Ryan Electronics. Approximately 2300 man-hours were expended in accomplishing the complete installation. A breakdown of man-hours expended is as follows:

Airframe rework to accommodate system antenna (Includes engineering and preparation of structural drawings by Ryan engineers, and structural rework.)	1200
Installation of RYANAV IV wiring and equipment (Includes planning, preparation of drawings, sheetmetal requirements and fabrication of wiring.)	500
Installation of associated systems (Includes planning, preparation of drawings, sheetmetal requirements, fabrication of wiring, etc. Associated systems are listed in paragraph 1c below.)	550
System's operational check-out	50

b. The RYANAV IV receiver-transmitter was installed on the right underside of the airplane fuselage between Stations 390.5 and 429.5. The high voltage power supply was located just forward of the receiver-transmitter at Station 385.0. The remainder of the system was installed on a test bench located just aft of the forward cargo bulkhead, Station 177.5.

c. In addition, the equipments listed below were installed concurrently with the RYANAV IV to provide all necessary external inputs required.

(1) Type MA-1 Directional Gyro System

(2) Type MD-1 Vertical Gyro

(3) T-349/APA570 Airspeed Transmitter

(4) F-138-2 Inverter (115VAC, 3 phase, 1500VA)

2. COMPONENT FAILURES AND REPAIR OPERATIONS.

a. All repairs required during test were accomplished by the manufacturer. USASATSA monitored all repair action taken and accumulated necessary maintenance data. A complete breakdown of maintenance operations during 195.6 hours of in-flight and ground operations during the test follows:

Sys. Hours	Date	Discrepancy	Corrective Action	Man-Hours	Comment
1	13Dec61	Doppler would not come out of standby.	Replaced defective transister in high-voltage power supply.	4.0	Defective unit returned to the manufacturer where repairs were accomplished. Analysis indicated that the current was too great for reliable operation of the transistor. A zener diode was added to the circuitry to alleviate future recurrence of this problem.
3	13Dec61	RYANAV IV inoperative	Replaced defective transistor (MPN Q-16) in low-voltage power supply module. Replaced servo motor (MPN MG-202) in wind-memory computer module.	2.0	Converter computer chasis returned to the manufacturer for repair. A shorted winding in the servo motor (MG-202) directly responsible for the transistor failure in the low-voltage power supply.

Sys. Hours	Date	Discrepancy	Corrective Action	Man-Hours	Comment
60	9Jan62	Plotting board inoperative.	Replaced plotting board. Corrected wiring to plotting board.	.5	Failure caused by incorrect wiring made during initial installation of system.
62	4Feb62	Doppler operated continuously in the memory mode.	Replaced defective regulator in high-voltage power supply.	5.0	Defective unit returned to manufacturer where repairs were accomplished.
65	13Feb62	Ground speed readout flipped 180 degrees intermittently.	Repaired broken wire on Relay K-4 in navigation computer module	2.0	
70	26Feb62	Manual wind speed slew function inoperative.	Replaced wind slew servo motor (B-207) in navigation computer module.	6.0	Defective module, returned to the manufacturer where repairs were accomplished.
90	7 Mar62	North-south distance-traveled readout rotates continuously.	Replaced servo motor(MG-XI)	4.0	
90	7Mar62	Navigation information unreliable in memory operation.	Repaired broken wire on Doppler loss relay (K-208) in navigation computer module.	.2.0	

Sys. Hours	Date	Discrepancy	Corrective Action	Man-Hours	Comment
102	15Mar62	Excessive memory operation noted during flight.	Adjusted Doppler loss settings.	.3	
108	20Mar62	Drift angle readout reversed (read left when drifting right and vice-versa).	Reversed phase of ground track, magnetic heading, and east-west distance-traveled synchro outputs.	1.0	
127	24Mar62	Displayed magnetic variation unreliable.	Adjusted magnetic variation control setting.	.2	
127	24Mar62	Range to destination readout off 4 nautical miles.	Readjusted range zero pot.	.2	
166	11May62	Systems inoperative	Replaced Q-15 power transistor in low-voltage power module.	1.0	
166	12May62	Transmitter inoperative.	Replaced high-voltage regulator in high-voltage power supply.	5.0	Defective unit returned to Ryan Electronics where repairs were accomplished.

Sys. Hours	Date	Discrepancy	Corrective Action	Man-Hours	Comment
178	16May62	System would not come out of standby	Replaced relay (K-2) in control indicator.	2.0	
		System requires excessive warmup period (approx. 8 minutes) when outside air temperature is in the vicinity of 20 degrees to 45 degrees Fahrenheit.	A thermistor was added to compensate for circuitry effected by temperature variation.	0	This condition existed during the early stages of testing. Ryan Electronics was aware of this problem and engineering correction was in progress. The modified Tracker Module was forwarded on 7 Mar 62. No recurrence was noted.
Not applicable		Excessive oscillation noted in distance-setting readout(computer indicator)	Circuit changes were accomplished in the gain of the servo amplifier (MPN A1A and A1B)		This condition existed during early stages of testing. The computer indicator was returned to Ryan Electronics where the engineering correction was accomplished.

APPENDIX D

LIST OF REFERENCES

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1. Paragraph 533c(5) and (6), Combat Development Objectives Guide, revised 1 May 1962.

2. Memorandum 216FM/EL-TNR(SCTC), Department of Army, Office of the Chief Signal Officer, 6 July 1961, subject: "Recording of Approved Military Characteristics for Lightweight, Self-contained Navigator (U)."

3. Letter, File No. 981/0214 mag, Ryan Electronics, 27 February 1961, subject: "RYANAV IV," with one inclosure.

4. Letter, ATBG-DGAV, US Army Aviation Board, 28 April 1961, subject: "Model 504 Doppler Navigation Sets," with one inclosure.

5. Letter, File No. 987/4163/0517/JOH:bh, Ryan Electronics, 18 May 1961, subject: "Model 504 Doppler Navigation Sets (RYANAV)."

6. Disposition Form, ATBG-AVAB AVN 1162, 28 September 1961, subject: "Evaluation of the RYANAV IV Doppler Navigation Set."

7. Letter, ATBG-AVAB, US Army Aviation Board, 27 October 1961, subject: "Flight Worthiness Certification for RYANAV IV Doppler Navigation Set Receiver/Transmitter Unit Installed in R4D Airplane S/N 44-99846" with 14 inclosures.

8. Message, DERBEPD 381, 14 November 1961, Navy BUWEPS to President USAAVNBD, subject: "Airworthiness Certification for RYANAV IV R/T Unit Installation."

9. Brochure, Ryan Report No. 50464-1, Ryan Electronics, August 1961, subject: "Brief Operating Instruction for Navigation Set, Radar RYANAV IV-A and Accessory Group RYANAV V-P."

10. Letter, ATBG-AVAB, US Army Aviation Board, 26 June 1962, subject: "Doppler Navigation Principles, Concepts, and Problems related to Doppler Navigational Systems for the US Army."