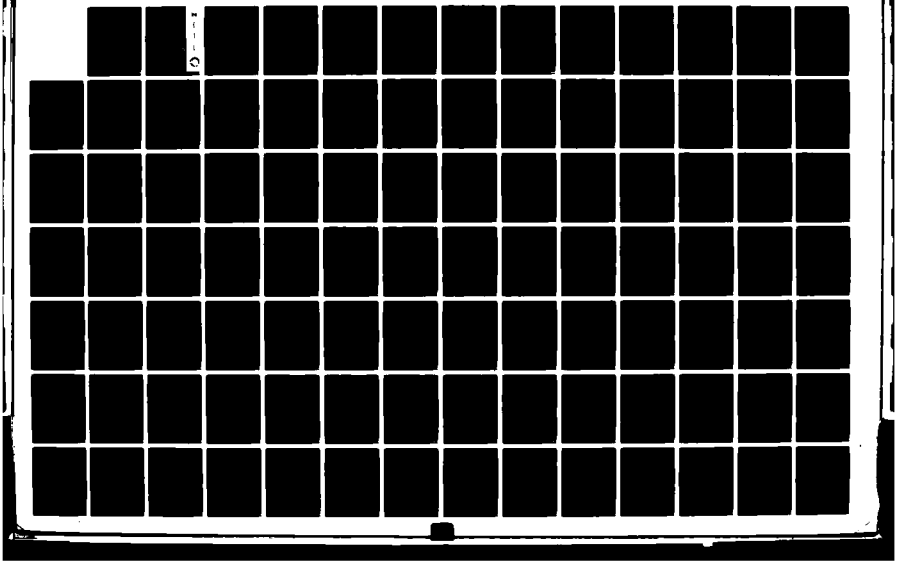

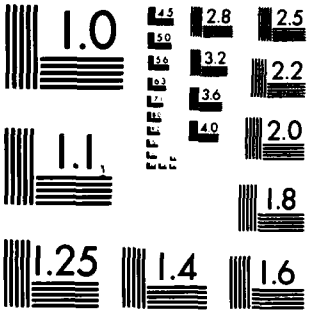

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Circumpolar method for determining azimuth

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March 1983

U.S. ARMY CORPS OF ENGINEERS
ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A new reticle, designed especially for the M2–A2 Aiming Circle, enables an operator to determine north without the need for star tables, timing equipment, or computations. This method uses three circumpolar stars: α Ursae Minoris, δ Ursae Minoris, and 43 Cephei. The reticle has three concentric circles, one for each star. When the aiming circle's telescope is adjusted so that the circles are positioned on their respective stars, the telescope is alined north. The azimuth to a ground object can then be determined with the aiming circle. A similar reticle has been designed for use in the southern hemisphere. This method requires less than 2 minutes, providing an error of less than 2 mils, and only 20 minutes additional training for operators of the M2–A2 Aiming Circle.

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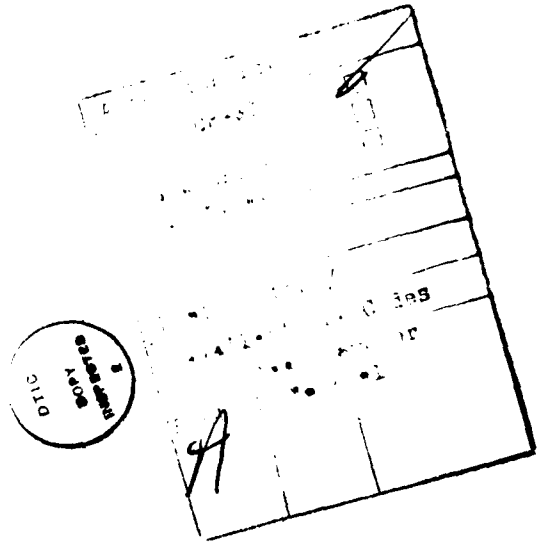
PREFACE

This work unit was performed under DA Project 4A762707A855, Task A, Work Unit 0014.

The work was performed from October 1980 to April 1982 under the supervision of Mr. P. J. Cervarich, II, Chief, Land Navigation Branch; Mr. J. G. Armistead, Chief, Surveying and Navigation Division; and Mr. E. P. Griffin, Director, Topographic Developments Laboratory.

Mr. Michael McDonnell assisted in the development of the idea and contributed to the anlaysis of the plumbline test.

COL Edward K. Wintz, CE, was the Commander and Director and Mr. Robert P. Macchia was Technical Director of the Engineer Topographic Laboratories during the study and report preparation.



CONTENTS

ILLUSTRIATIONS

CIRCUMPOLAR METHOD FOR DETERMINING AZIMUTH

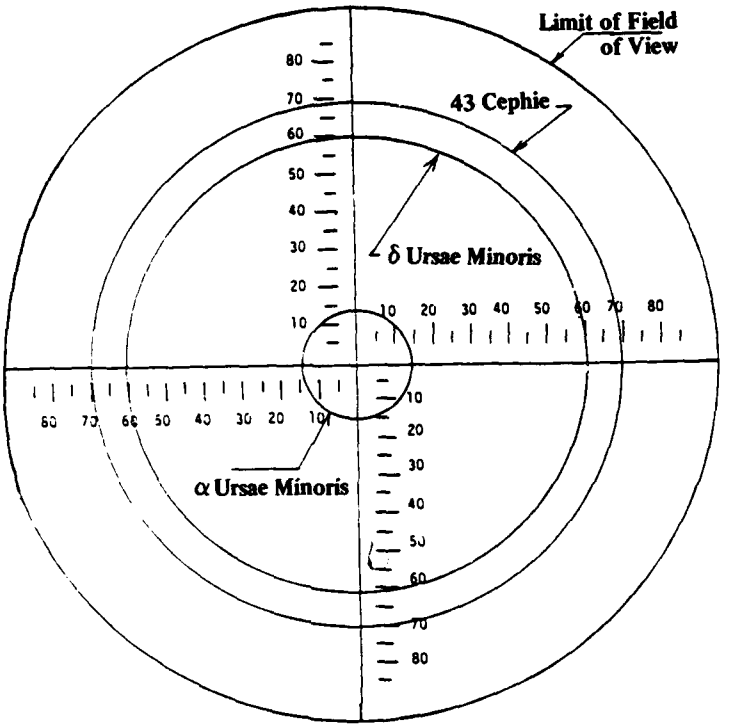
INTRODUCTION

PURPOSE. The purpose of this report is to define the accuracy that can be achieved in laying an astronomic azimuth using a newly designed reticle in an M2A2 Aiming Circle.

BACKGROUND. On 29 April 1980, the U.S. Army Field Artillery School (FAS), Fort Sill, Oklahoma, sent a letter to the U.S. Army Engineer Topographic Laboratories (ETL) asking for an evaluation of the technical feasibility of the Polaris II Method, a new method of determining an astronomic azimuth using the M2A2 Aiming Circle. This method was proposed by Capt. Donald H. Zacherl, Capt. Victor Roeshe and Capt. Rudy Veit because it eliminated the need for star tables, timing equipment, and associated computations and computation forms. As proposed, the Polaris II Method would have required an attachment for the M2A2 with separate lens, reticle, and reticle illumination, plus a modification to the M2A2 Aiming Circle to provide a precision machined surface at the objective end of the telescope to mount the attachment. During the evaluations of the proposed Polaris II Method, which was deemed to be feasible, an improved method was conceived that did not require an attachment and related modifications to the M2A2 Aiming Circle, but required only the substitution of newly designed reticle for the existing reticle. This new reticle and procedure, called the Circumpolar Method, was presented to the Field Artillery School as a simpler, less costly means of determining an astronomic azimuth using the M2A2 Aiming Circle. A work unit for FY81 under Project 4A762707A855 was established and approved. This work unit authorized the expenditure of effort to verify whether the new reticle would meet the objectives of a simple means of establishing and laying an astronomic azimuth for field artillery units.

DESCRIPTION AND OPERATION. The only physical change consists of adding three etched concentric circles to the reticle of the M2A2 Aiming Circle. The radii of these circles are determined by the angles between the celestial pole and the brighter circumpolar stars that have been chosen as sighting points, in combination with the focal length of the objective lens of the M2A2 Aiming Circle. Since the size of these circles is proportional to the focal length of the objective lens, a separate reticle must be designed for each type of instrument with which this method will be used. The radius of each circle in the reticle equals the tangent of the mean declination of the star times the focal length of the objective lens of the instrument used. For a Northern Hemisphere observer using the M2A2 Aiming Circle with a 10^{o} field of view, the three brightest stars within the field of view are α Ursae Minoris, δ Ursae Minoris, and 43 Cephei.

Although three stars give an unambiguous location for the pole, two stars are usually sufficient for locating the pole if it is known which quadrants of the reticle the stars are to be positioned in at the time of observation. A reticle suitable for use in the Northern Hemisphere is diagramed in figure 1. True north may be determined by pointing the aiming circle telescope so that the three stars, α Ursae Minoris, δ Ursae Minoris, and 43 Cephei, are positioned on their reticle circles. It is necessry that at least two stars be visible for the short time (approximately 1 minute) required to sight on these stars. In the Southern Hemisphere, the three stars, δ Octanis, τ Octanis, and x Octanis would be used to determine south. The latter two have practically the same declination; therefore, only two circles are needed for the Southern Hemisphere.



Reticle Design

FIGURE 1. The Northern Hemisphere Circumpolar Reticle.

A step-by-step procedure for the Circumpolar Method of determining an azimuth for artillery weapons is provided as follows:

a. Orient the M2A2 by setting off the declination constant and floating the magnetic needle.

b. Determine your latitude in mils by multiplying your known map latitude by 18. Elevate the M2A2 to this reading. Polaris (α Ursae Minoris) will appear as the brightest star and will be near the center of the field of view.

c. Elevate and traverse the M2A2 to place α Ursae Minoris, δ Ursae Minoris, and 43 Cephei on their respective reticle circles. True north is now at the crosshair center.

d. Depress the M2A2 so that the field of view is within the battery location, and traverse the M2A2 as appropriate to convert true north direction to grid north direction (the relationship between true north direction and grid north direction can be found on a map of the area).

e. Place a lighted aiming stake at a location in line with the crosshair center. The aiming stake can then act as the end of the orienting line, and the battery weapons can be alined by the grid azimuth method without pause.

TEST AND TEST RESULTS

GENERAL. Changes in the direction of the earth's spin axis over a period of years will cause a gradual change in the apparent positions of the circumpolar stars with respect to the celestial pole. If the circles on the reticle are designed to coincide exactly with the apparent positions of the circumpolar stars for a given year, for example 1981, an error in azimuth determinations could occur if this reticle is used prior to, or after, 1981. The apparent positions of the circumpolar stars in the Northern Hemisphere change at a maximum rate of 0.1 mil per year. Therefore, the anticipated maximum error would be $\pm$ 0.5 mil for a reticle that is $\pm$ 5 years out of date. In order to verify this, three reticles were designed using the mean apparent place of the stars for 1965, 1975, and 1985. These reticles were identified as N60-70, N70-80, and N80-90.

The N80-90 reticle was installed in an M2A2 Aiming Circle that had been obtained from the U.S. Army Armament Readiness Command (AARCOM) at Rock Island, IL. The reticle was subjected to preliminary field tests at Fort Belvoir, VA on 17 December 1980 and on 8 January 1981. During this time, laboratory tests of the M2A2 Aiming Circle and the reticles were also performed. The N60-70, N70-80, and N80-90 reticles were installed in aiming circles at Fort Sill, OK and additional field and laboratory tests were performed at Fort Sill in February 1981. As a result of these field tests, the FAS requested that the reticle design be modified slightly by reducing the width of the reticle lines and by removing numbers 10, 60, 70, and 80 from the reticle mil scales (see figure 1).

Three modified N80-90 reticles were procured by ETL, and three additional M2A2 Aiming Circles were obtained from AARCOM. The modified reticles were installed in the aiming circles and subjected to field and laboratory tests at Fort Belvoir, VA and Fort Sill, OK during July through September 1981. A final field test was run at Fort Belvoir by ETL in April 1982, using an instrument that had been carefully adjusted to minimize errors.

FIELD TESTS. All field tests were performed with the procedures outlined earlier in this report. These tests performed at Fort Belvoir, VA used civilian personnel from ETL as operators and recorders. Field tests performed at Fort Sill, OK used military personnel from FAS as operators and recorders. The Fort Sill personnel were familiar with the operation of the M2A2 Aiming Circle, but were not skilled in astronomic observations. All personnel were able to obtain data after approximately 20 minutes of training. The individual field test data sheets are contained in appendix B.

LABORATORY TESTS. A preliminary analysis of field test data indicated that the observed errors could not be attributed only to the reticle being out of date. Laboratory tests were performed to determine the possible contribution of the following sources of error to the error observed in field tests:

- Horizontal circle
- Tangent screw
- Orthogonality/Collimation
- Parallax
- Reticle circle diameter

The procedure used to check for horizontal circle error was to mount and carefully level the aiming circle on top of a precision ultradex table, aline the aiming circle telescope by sighting on a collimator at zero degree elevation, and setting the horizontal circle to read zero. The ultradex table was rotated 2951 mils (166 degrees). The telescope of the aiming circle was then rotated until it was again centered on the collimator, and the horizontal circle was read. The accuracy of the ultradex was 0.001 mil (See figure 2 for test results).

Ultradex (degree)	M2A2 (mils)	Ultradex (degrees)	M2A2 (mils)
0.0	6399.5	166.0	2950.9
0.0	6399.5	166.0	2950.8
0.0	6399.5	166.0	2950.8
0.0	6399.5	166.0	2950.9
0.0	6399.5	166.0	2950.9
0.0	6399.4	166.0	2950.9
0.0	6399.5	166.0	2950.9
0.0	6399.7	166.0	2950.9
0.0	6399.5	166.0	2950.9
0.0	6399.5	166.0	2950.8
Mean =	6399.50 mils	Mean =	2950.87 mils

Mean Measured Angle = 2951.37
True Measured Angle = 2951.11
Error = 0.26 = 0.3 mil

True Measured Angle = $\frac{166}{360}$ X 6400 = 2951.11 mils

FIGURE 2. Horizontal Circle Test Data.

The method for testing the tangent screw was to carefully level the aiming circle, aline the telescope on a collimator at zero degree elevation, and set the tangent screw to zero. The tangent screw was used to aline the five-mil graduation of the reticle mil scale on the collimator and the tangent screw was read. The telescope was then recentered on the collimator, and the tangent screw was set to read five mils. The tangent screw was again used to aline the five-mil graduation of the reticle scale on the collimator and the tangent screw was read. This procedure was repeated until the whole tangent screw was measured at five-mil intervals. The difference between the tangent screw readings and the five-mil-scale interval is an indication of the accuracy of each five-mil interval of the tangent screw (See figure 3 for test results).

A precision collimator stand was used at ETL to measure the combined effect of orthogonality error and collimation error. The procedure was to carefully level the aiming circle on the stand, aline the aiming circle telescope on a collimator mounted at 30 degrees elevation, read the horizontal circle, realine the telescope on a collimator at zero degree elevation, and read the horizontal circle again. The difference in horizontal circle readings is the orthogonality/collimation error. A collimator stand was not available at Fort Sill. A stand was improvised by using a Wild T2 theodolite to aline two Wild T16 theodolites, one above the other, at elevation angles of zero degree and 30 degrees. The test procedure at Fort Sill was the same as the procedure at ETL. Four aiming circles were tested at ETL (figure 4). Fourteen were tested at Fort Sill, three of which were tested with the standard reticle and after the circumpolar reticle had been installed (figure 5).

Tangent Screw Setting With Telescope Centered (mils)	Tangent Screw Reading At 5 Mil Graduation (mils)	Scale Interval (mils)	Difference (mils)
0.0	4.9	5.0	-0.1
5.0	10.0	5.0	0.0
10.0	14.9	5.0	-0.1
15.0	19.9	5.0	-0.1
20.0	25.0	5.0	0.0
25.0	29.9	5.0	-0.1
30.0	35.0	5.0	0.0
35.0	40.0	5.0	0.0
40.0	44.9	5.0	-0.1
45.0	50.0	5.0	0.0
50.0	55.0	5.0	0.0
55.0	60.1	5.0	+0.1
60.0	65.0	5.0	0.0
65.0	70.1	5.0	+0.1
70.0	75.0	5.0	0.0
75.0	80.0	5.0	0.0
80.0	85.0	5.0	0.0
85.0	90.1	5.0	+0.1
90.0	95.0	5.0	0.0
95.0	100.0	5.0	0.0

FIGURE 3. Tangent Screw Test Data.

INSTRUMENT #3310

M2A2 @ 30°	M2A2 @ LEVEL
2512.2	2513.8
2512.2	2513.7
2512.2	2513.8
2512.3	2513.9
2512.2	2513.8
2512.1	2513.8
2512.2	2513.8
2512.2	2513.8
2512.2	2513.8
2512.2	2513.8
Mean = 2512.20 mils	Mean = 2513.80 mils

Error = 2512.50 - 2513,80 = -1.6 mils.

INSTRUMENT SERIAL NO.	ERROR
14403	Less than .5 mil
14433	Less than .5 mil
14426	Less than .5 mil

FIGURE 4. Orthogonality Collimation Test, Fort Belvoir, Virginia.

INSTRUMENT SERIAL NO.	RETICLE USED	ERROR MILS
10247	STANDARD	+1.0
12178	STANDARD	0.0
247	STANDARD	+1.5
10247	N70-80	+1.0
12178	N80-90	0.0
247	N60-70	+1.5
1198	STANDARD	+2.0
944	STANDARD	+2.0
1174	STANDARD	0.0
3885	STANDARD	+0.5
1879	STANDARD	-1.0
1781	STANDARD	0.0
780	STANDARD	-1.0
10260	STANDARD	-1.5
10213	STANDARD	-1.0
3632	STANDARD	0.0
10474	STANDARD	-1.5

FIGURE 5. Orthogonality Collimation Test, Fort Sill, Oklahoma.

Parallax was estimated by carefully leveling the aiming circle and sighting on a collimator at zero degree elevation with the eye centered in the eyepiece. The aiming circle telescope was adjusted so that the collimator reticle appeared at the 10-mil position on the reticle mil scale. The eye was then moved to the edge of the field of view away from the target position on the reticle. Moving the eye causes an apparent motion of the target image with respect to the reticle scale. THe magnitude of image motion was estimated by reading the reticle scale at both positions of the image. The difference in scale readings is a rough measure of error due to parallax at that point on the mil scale. This procedure was repeated with the target image positioned at 10-mil intervals along the reticle scale.

The circle diameters of two reticles were measured for compliance to specifications. The diameters were measured using a Model 1010A Microdensitometer as a comparator. The microdensitometer is considered accurate to $\pm$ 5 micrometers (μ m). (See figure 6 for test data).

DISCUSSION

The results of the laboratory tests are discussed first because of their influence on the evaluation of field test data.

LABORATORY TESTS. An analysis of the horizontal circle test data, figure 2, indicated that the horizontal circle error is well within the 0.6 mil specified in MIL-A-13338D(AR). The horizontal circle was not regarded as a significant contributor to the errors observed in field tests.

Tests on aiming circle S/N 3310 indicated that the maximum error observed in the tangent screw was $\pm$ 0.1 mil (figure 3). This was not regarded as a significant source of error if normal precautions are taken to minimize backlash by always turning the tangent screw in the same direction when alining on a target.

RETICLE N60-70

Large Circle	Middle Circle	Small Circle
10946 (µm)	9456 (µm)	2501 (µm)
10943 (µm)	9458 (µm)	2500 (µm)
10944.5 µm (Mean)	9457 µm (Mean)	2500.5 µm (Mean)
0.4309 inch (Mean)	0.3723 inch (Mean)	0.0984 inch (Mean)
+0.0003 inch (Error)	+0.0003 inch (Error)	+0.0002 inch (Error)

RETICLE N70-80

Large Circle	Middle Circle	Small Circle
10198 (µm)	9466 (µm)	2368 (µm)
10798 (µm)	9467 (µm)	2366 (µm)
10798 (µm)	9466.5 µm (Mean)	2367 µm (Mean)
0.4251 inch (Mean)	0.3727 inch (Mean)	0.0932 inch (Mean)
+0.0003 inch (Error)	+0.0003 inch (Error)	+0.0003 inch (Error)

FIGURE 6. Reticle Circle Diameter Measurement.

The orthogonality/collimation test data (figures 4 and 5) shows that only seven aiming circles met the 0.4 mil accuracy specified in MIL-A-13338A(AR). This error was believed to be a major contributor to the error observed in field test data and was investigated furhter by studies and additional laboratory tests. As a result of this investigation, two probable sources were found for the orthogonality/collimation error. The first source was probably the manner in which the plumbline test was performed at the depot. To perform the plumbline test, one suspends a plumbbob approximately 1 meter in front of the aiming circle telescope. The aiming circle has a fixed focus telescope, requiring that a small aperture be placed in front of the objective lens so that the plumbline can be seen at the very close range of 1 meter. Some of the small-aperture assemblies used by the depot were fabricated so that the aperture was not centered on the objective lens. Laboratory tests at ETL showed that an off-center aperture causes the plumbline image to be shifted with respect to the telescope optical axis. This was shown by centering the telescope on the plumbline using an aperture that was centered on the objective lens, then replacing the centered aperture with an aperture 9 millimeters off center. The plumb line image shifted as much as five mils off center. The use of an off-center aperture can mask the presence of orthogonality error in an aiming circle. This is explained in some detail in appendix A, which explains the effect of an off-center reticle in general. When performing the plumbline test, care must be taken to insure that the aiming circle tracks the plumbline to $\pm$ 0.25 mil (0.4 mil maximum) at all elevations, as specified in MIL-A-13338A. If the reticle cannot be adjusted to track the plumbline to the required accuracy, the aiming circle may have orthogonality error that must be removed at the depot.

The second probable source of orthogonality/collimation error was the method used by field units to remove and replace the reticle for aiming circle maintenance or repair. Field personnel normally loosen all the reticle centering screws when removing the reticle, making it impossible to replace the reticle in the same position. Also, field personnel do not check the reticle for proper centering. Apparently, this was not the fault of the field units because the technical manuals do not provide a procedure for checking the aiming circle for proper centering of the reticle (collimation error). It was found that the best procedure for replacing the reticle was to loosen the upper-centering screws and the left-centering screw (not touching the bottom- and right-centering screws). When the reticle is replaced, only the left- and top-centering screws should be tightened. This procedure will help to minimize changes

in reticle position when the reticle is removed and replaced. This procedure will not remove any collimation error the aiming circle had prior to removing the reticle. It is desirable to check for collimation error whenever the reticle is removed. This is because a small collimation error may cause an appreciable error when sighting on objects at relatively high elevation angles, such as occurs when sighting on the circumpolar stars at middle or high latitudes.

The results of parallax tests performed on aiming circles S/N 14433, 14403, and 14426 were averaged and are presented:

Target Position on Reticle (mils)	Estimated Parallax Error (mils)
0	0.0
10	0.3
20	0.5
30	1.0
40	1.2
50	1.3
60	2.0

It is believed that these estimates are higher than the parallax error actually obtained in field test data. This is discussed in the next section on field test results.

The measured diameters of the reticle circles, figure 6, were compared to the reticle specifications. All the measurements were within the specified accuracy of $\pm$0.0005 inch.

FIELD TESTS. The field test data are presented and discussed in chronological order to indicate the progressive identification of error sources. The first set of field observations using the circumpolar method was taken by ETL at Fort Belvoir. The test data from figure B22 is summarized as follows:

Instrument	Reticle	Date	Observer	Average Error
S/N 3310	N80-90	12-80	Dere	-1.4 mil

The maximum error that could be expected due to the reticle being out of date was -0.4 mil. The source of the residual error of -1.0 mil was not understood at the time. The aiming circle was checked by Letterkenny Arsenal and the reticle was adjusted. A second set of field observations was taken by ETL and the test data from figure B23 is summarized as follows:

Instrument	Reticle	Date	Observer	Average Error
S/N 3310	N80-90	1/81	Dere	-1.7 mil

Since there was no improvement in accuracy after Letterkenny Arsenal adjusted the reticle, the aiming circle was checked at ETL for orthogonality/collimation error. Aiming circle S/N 3310 was found to have an orthogonality/collimation error of -1.6 mil (see figure 4). This seemed to explain the observed errors, so circumpolar reticles were installed by the ETL test engineer in three aiming circles at Fort Sill for user tests. Several survey instructors from the Field Artillery School were taught the circumpolar method by ETL test personnel. These instructors taught several students prior to conducting field tests at Fort Sill in February 1981. The test data was received at ETL in March 1981. This data is presented in figures B1 through B21 and is summarized in figure 7. Assuming that the average error for each instrument represents the algebraic sum of all errors due to the instrument and the circumpolar method, the difference between the instrument error and the orthogonality/collimation error represents the error due to the circumpolar method[1] plus other instrument errors that, based on laboratory tests, are assumed to be small. The difference column in figure 7 indicates, as expected, that the accuracy of the circumpolar method depends on how much the reticle is out of date.

[1]The error due to the circumpolar method includes observer error which is mostly due to parallax. The amount of parallax depends on how well the observer keeps his eye centered in the eyepiece, whether glasses are worn, and other, less significant, factors. The error due to the reticle being out of date is also included in the error due to the circumpolar method.

As recommended by the Field Artillery School, the design of the circumpolar reticle was slightly modified and additional reticles were procured for testing. Three additional aiming circles were loaned to ETL by AARCOM and the modified reticles were installed. The orthogonality/collimation error for each of these three instruments (S/N 14433, 14403, and 14426) was measured and determined to be less than 0.5 mil (See figure 4). Field tests were conducted with these instruments, plus S/N 3310, by ETL personnel in July and August 1981 and by Field Artillery School personnel at Fort Sill in September 1981. The results of these tests are presented in figures B24 - B58, B62 - B80, and B86 - B105 and are summarized in figure 8. At first glance, the errors in figure 8 seem unduly large in view of the fact that the aiming circles (except S/N 3310) have almost no orthogonality/collimation error. This seemed to indicate that parallax may be the largest contributor to the remaining error since the error due to the reticle being out of date was calculated and had a maximum value of 0.4 mil. To prove this, the objective lens of aiming circles 14433, 14403, and 14426 were adjusted to provide zero parallax at the 45 mil graduations on the reticle scale (Note that the objective lens is normally adjusted to provide zero parallax at the optical axis of the telescope). Field tests were run at Fort Belvoir and Fort Sill with the adjusted instruments in August and September 1981. The test data from figures B59, B60, B61, B81 through B85 and B106 are summared in figure 9. The overall average of the difference values in figure 9 is -0.2 mil, which is less than the overall average of the difference in figure 7 (-0.6 mil) and figure 8 (-1.1 mil), indicating that parallax was indeed a larger contributor to the observed error than the error due to the reticle being out of date.

Instrument	Reticle	Observer	Average Error	Orthogonality/ Collimation Error	Difference
247	N60-70	Dague	+0.1	+1.5	-1.4
		Montalbo	-1.0	+1.5	-2.5
		Price	-0.5	+1.5	-2.0
		Kauzlarich	+1.2	+1.5	-0.3
Instrument Average			-0.4		-1.5
10247	N70-80	Moore	+1.1	+1.0	+0.1
		Dague	+0.6	+1.0	-0.4
		Connell	+0.3	+1.0	-0.7
		Montalbo	0.0	+1.0	-1.0
		Caum	+1.0	+1.0	0.0
Instrument Average			+0.6		-0.4
12178	N80-90	Barth	+0.6	0.0	+0.6
		McGinty	-0.4	0.0	-0.4
		Caum	+0.2	0.0	+0.2
		Connell	+0.3	0.0	+0.3
		Kauzlarich	-0.8	0.0	-0.8
Instrument Average			0.0		0.0

FIGURE 7. Fort Sill Field Test Data, February 1981.

Instrument	Reticle	Observer	Average Error	Orthogonality/ Collimation Error	Difference
3310	N80-90	Niles	-2.6	-1.6	-1.0
	(modified)	Jarrett	-2.7	-1.6	-1.1
		Dere	-2.7	-1.6	-1.1
		*Foster	-2.4	-1.6	-0.8
		*Furr	-2.3	-1.6	-0.7
	Instrument Average		-2.5		-0.9
14433	N80-90	Oliver	-0.7	0.0	-0.7
	(modified)	Jarrett	-0.7	0.0	-0.7
		Niles	-1.3	0.0	-1.3
		*Furr	-1.5	0.0	-1.5
		*Foster	-1.8	0.0	-1.8
	Instrument Average		-1.2		-1.2
14403	N80-90	Tyson	-1.2	0.0	-1.2
	(modified)	Niles	-1.1	0.0	-1.1
		Oliver	-1.3	0.0	-1.3
	Instrument Average		-1.2		-1.2
14426	N80-90	Jarrett	-1.1	0.0	-1.1
	(modified)	Oliver	-1.3	0.0	-1.3
		Dere	-0.8	0.0	-0.8
		*Hunter	-1.6	0.0	-1.6
		*Wilson	-0.9	0.0	-0.9
		*VanNest	-1.0	0.0	-1.0
	Instrument Average		-1.1		-1.1

*At Fort Sill

FIGURE 8. Field Test Data; July, August and September 1981.

Instrument	Reticle	Observer	Average Error	Orthogonality/ Collimation Error	Difference
14433	N80-90 (modified)	Niles	-0.9	0.0	-0.9
14403	N80-90 (modified)	Dere	-0.1	0.0	-0.1
		*Tetreault	+0.1	0.0	+0.1
		*Hunter	0.0	0.0	0.0
	Instrument Average		0.0		0.0
14426	N80-90 (modified)	Dere	-0.2	0.0	-0.2

*At Fort Sill

FIGURE 9. Field Test Data, August & September 1981, with Reduced Parallax Error

A final field test was performed by ETL at Fort Belvoir in April 1982. The reticle on aiming circle 3310 was adjusted using the plumbline method so that the orthogonality/collimation error was near zero (less than 0.5 mil). Special care was taken to keep the observer's eye at the center of the eyepiece to minimize parallax. The test data from figures B107, B108, and B109 are summarized as follows:

Instrument	Reticle	Observer	Average Error	Orthogonality/ Collimation Error	Difference
S/N 3310	N80-90 (modified)	Dere	-0.4	0.0	-0.4

Since the error due to the reticle being out of date is believed to be near zero,[2] it would seem that parallax error for this observer was approximately -0.4 mil, which is much less than the 2.0 mils estimated for parallax error in laboratory tests.

To summarize the analysis of field test data, it has been shown that orthogonality/collimation error was the largest source of instrument error and that it can be minimized by centering the reticle with the plumbline method if the stated precautions are taken. The accuracy of the circumpolar method is approximately 0.5 mil if there is minimal instrument error and if parallax is minimized. Since the method of minimizing parallax used during this test program tends to increase the parallax error at the optical axis of the telescope, it would be desirable to provide a corrector element that would produce a flat focal plane, thus minimizing parallax across the whole reticle. Perhaps this corrector element can be attached to the objective side of the reticle, making it very simple to implement this improvement. With parallax and instrument error minimized, the error due to the reticle being out of date would be the only significant source of error in the circumpolar method. As indicated before, this error is no more than 0.1 mil for each year the reticle is out of date.

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2 Ursae Minoris was near east elongation during the April 82 tests. The star near elongation will largely determine the magnitude of the reticle error, which is zero for Ursae Minoris when using the N80-90 reticle.

CONCLUSIONS

Field and laboratory tests of the new reticles have shown that

1. The procedure is practical and can be applied by Army personnel who are familiar with the operation of the M2A2 Aiming Circle with less than 1 hour of additional training.

2. Due to the presence of orthogonality/collimation error in 60 percent of the aiming circles tested, the accuracy of azimuth determination was approximately 2.0 mils.

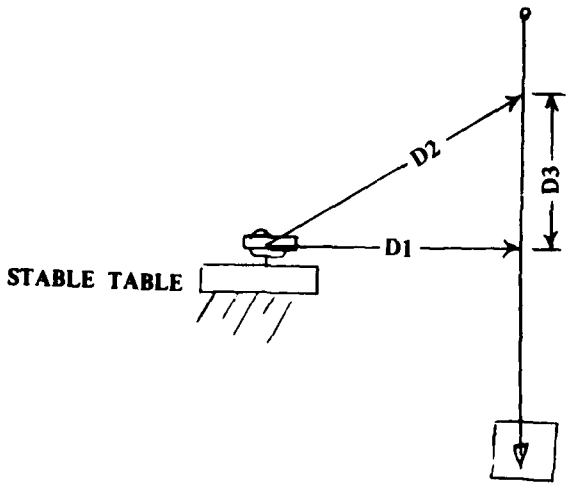
3. The accuracy could be improved to approximately 1 mil if the instruments met specifications for orthogonality/collimation.

4. The accuracy could be further improved to approximately 0.5 mil by minimizing errors due to parallax.

APPENDIX A. Evaluating the Current Test of the M2A2 Aiming Circle for Axis Orthogonality

The method currently used to test the plumb travel (axis orthogonality) of the M2A2 Aiming Circle (ref. MIL-A-13338D section 3.2.3.3.4) uses a plumbline whose bob is dampened in a container of liquid. This line is hung at a distance of about 1 meter from the M2A2 as shown in figure A1. The M2A2 is fitted with a small aperture for this test so that the plumbline will be in focus despite its nearness.

The M2A2 is carefully leveled, and with the sight line level, the plumbline is placed on the crosshair of the reticle. The sight line is then elevated to +850 mils. If the plumbline is still centered on the reticle crosshairs, the sight line is depressed to -430 mils. If the plumbline remains centered on the reticle crosshairs, the instrument is accepted as having met specifications. If, at the +850 mils sight line, the plumbline is no longer centered on the reticle crosshairs, one-half of the decentering is removed by tangent screw adjustment, and the remaining one half of the decentering is removed by adjusting the reticle. This procedure is repeated until the plumbline remains centered on the reticle crosshairs to an apparent accuracy of $\pm$0.25 mils. Then the instrument is accepted as having met specifications.

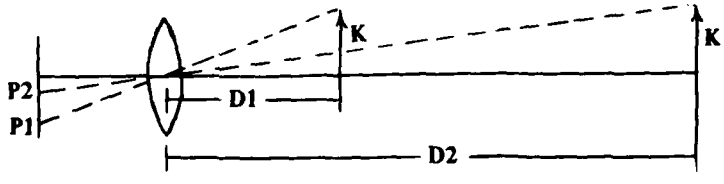


Note: A dampened plumbline is placed at distance D1 from the center of the M2A2 to be tested.

FIGURE A1. Current Test Set-up.

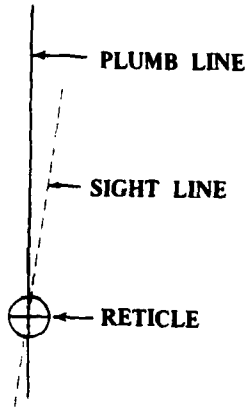
Let us first consider a "perfect" instrument; one that has no nonorthogonality of axis, is perfectly level, and whose reticle is exactly alined to the optical axis of the scope. If, using this perfect instrument, we aline the vertical line of the reticle with a plumbline, this alinement will not be affected as the sight line is raised or lowered, nor will the alinement be affected as the distance from the objective lens of the scope to the plumbline is varied. However, if we offset the plumbline from the optical axis of the scope, the offset between the vertical line of the reticle and the plumbline will appear to change as the distance from the plumbline to the objective lens of the scope is changed. This effect is shown in figure A2. By the same effect, if we decenter the reticle and then aline the vertical crosshair of the reticle with a plumbline at distance D1 from the objective lens of the scope to the plumbline, the verticle crosshair and the plumbline will not be in alinement when the plumbline is at distance D2.

Now let us consider what happens for an instrument that has nonorthogonal elevation and azimuth axes. If the crosshair of the reticle is centered on a plumbline at zero elevation, the plumbline image will move away from the crosshair center as the sight line is elevated because of the angle between the plumbline and the trace of the sight line as shown in figure A3. This effect can also be caused by improper leveling of the instrument, but the accuracy of the level can be checked separately and a perfectly leveled instrument will be assumed from here on.



Note: As distance of an object with constant offset K is varied from the imaging lens, the height of the image on the reticle plane will change so that the tip of the arrow is imaged at position P1 for an object distance D1 and is imaged at P2 for an object distance D2.

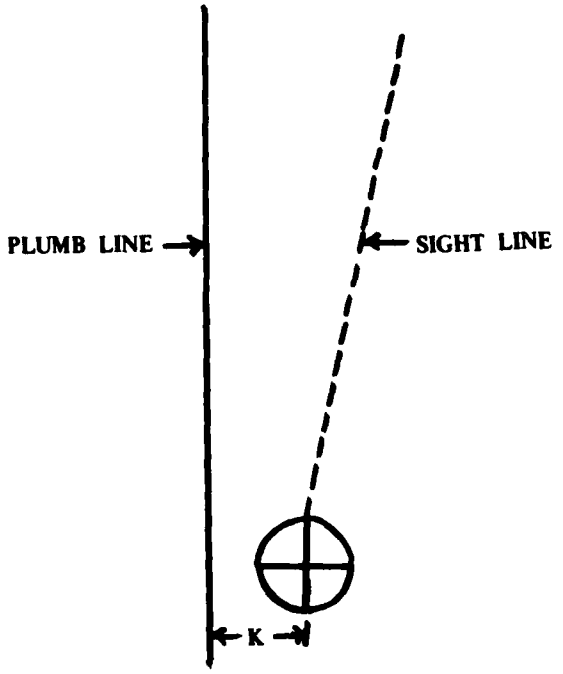
FIGURE A2. Apparent Change in Position of Plumbline Caused by Change in Distance.



Note: For an instrument that has nonorthogonal rotation axes (or is out of plumb), the trace of the optical axis as the telescope sight line is elevated will not lie along a plumbline as shown.

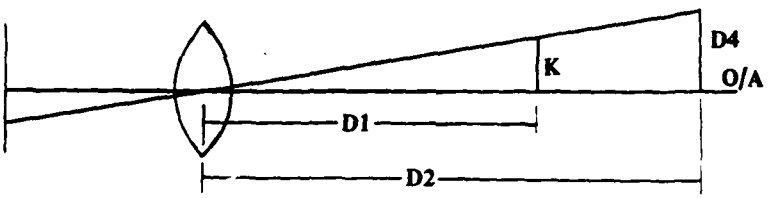
FIGURE A3. Plumbline and Sight Line With Nonorthogonal Axes.

The most interesting condition for this discussion is that shown in figure A4 where an instrument with nonorthogonal rotation axes, but having a crosshair centered on the telescope optical axis, is misalined with the plumbline. As shown in figure A5, if the misalinement is properly matched to the tilt angle between the sight-line trace and the plumbline, then the relative movements of the plumbline and the crosshair, owing to the effects shown in figures A2 and A3 and discussed above, will approximately cancel each other. As a result, the plumbline image will not move relative to the crosshair as the sight line is elevated. An orthogonal instrument can be distinguished from a nonorthogonal one by the fact that a plumbline image should remain stationary on a reticle only when the plumbline is centered on the crosshair and the crosshair is centered in the optical axis of the telescope. However, if the crosshair is decentered to a point where the effect of demagnification approximately cancels the error caused by being out of plumb or because of nonorthogonality, then the instrument will appear to be perfect while still remaining in error.



Note: An instrument with nonorthogonal rotation axes that has been misalined with the plumbline.

FIGURE A4. Plumbline and Sight Line With Nonorthogonal Axes and Misalinement.



Note: The optical effect resulting from a proper match of a nonvertical sight line trace with a decentered plumbline. It is evident that the plumbline image will not move across the reticle as the sight line is elevated, since the greater distance of the plumbline from the sight line is just compensated by the decreased magnification of the plumbline that is not at a greater distance.

FIGURE A5. Apparent Correction of Nonorthogonal Axes Owing to Decreased Magnification.

APPENDIX B. Field Test Data

STATION 302
RETICLE (N70-80)
DATE 17 FEB 81
OPERATOR MOORE
INSTRUMENT NO. 10247

TRUE AZIMUTH 2389.1 MILS
AZIMUTH MARK MJS
TIME 1930
RECORDER MOORE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2388.4	2388.4	-0.7	-1.8
	6398.0	2388.8	2390.8	1.7	0.6
	6397.7	2388.3	2390.6	1.5	0.4
	6397.5	2388.5	2391.0	1.9	0.8
	6398.5	2389.0	2390.5	1.4	0.3
	6399.1	2388.2	2389.1	0.0	-1.1
	6398.4	2388.8	2390.4	1.3	0.2
	6398.2	2388.6	2390.4	1.3	0.2
	6398.4	2389.0	2390.6	1.5	0.4
	6397.8	2388.2	2390.4	1.3	0.2
MEAN	-1.64	2388.58	2390.22	1.12	0.00
S.D.	0.74	0.31	0.81	RMS 1.36	

FIGURE B1
FIELD TEST DATA

STATION 300
RETICLE (N70-30)
DATE 23 FEB 81
OPERATOR DAGUE
INSTRUMENT NO. 10247

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 1930
RECORDER DAGUE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2391.5	2391.5	0.9	0.3
	6400.0	2391.5	2391.5	0.9	0.3
	6399.7	2391.3	2391.6	1.0	0.4
	0.3	2390.5	2390.2	-0.4	-1.0
	6399.3	2391.5	2391.7	1.1	0.5
	6399.8	2390.8	2391.0	0.4	-0.2
	6399.3	2391.5	2391.7	1.1	0.5
	0.1	2391.5	2391.4	0.8	0.2
	0.6	2391.5	2390.9	0.3	-0.3
	6400.0	2390.7	2390.7	0.1	-0.5
MEAN	0.01	2391.23	2391.22	0.62	0.00
S.D.	0.27	0.40	0.50	DMS 0.78	

FIGURE B2
FIELD TEST DATA

STATION 300
RETICLE (N70-80)
DATE 23 FEB 81
OPERATOR CONNELL
INSTRUMENT NO. 10247

TRUE AZIMUTH 4323.3 MILS
AZIMUTH MARK OSC
TIME 2130
RECORDER CAUM

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4323.4	4323.4	0.1	-0.2
	0.4	4323.6	4323.2	-0.1	-0.4
	6400.0	4323.9	4323.9	0.6	0.3
	0.2	4323.8	4323.6	0.3	-0.0
	0.8	4324.1	4323.3	0.0	-0.3
	0.2	4324.5	4324.3	1.0	0.7
	6400.0	4324.2	4324.2	0.9	0.6
	0.5	4323.7	4323.2	-0.1	-0.4
	6399.9	4323.9	4324.0	0.7	0.4
	0.7	4323.8	4323.1	-0.2	-0.5
MEAN	0.27	4323.89	4323.62	0.32	0.00
S.D.	0.32	0.31	0.45	RMS 0.53	

FIGURE B3
FIELD TEST DATA

STATION 302
RETICLE (N70-80)
DATE 25 FEB 81
OPERATOR MONTALBO
INSTRUMENT NO. 10247

TRUE AZIMUTH 4321.8 MILS
AZIMUTH MARK OSC
TIME 1930
RECORDER MONTALBO

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4322.1	4322.1	0.3	0.3
	1.8	4323.2	4321.4	-0.4	-0.5
	1.2	4322.8	4321.6	-0.2	-0.3
	6400.0	4322.2	4322.2	0.4	0.4
	1.2	4322.2	4321.0	-0.8	-0.9
	0.1	4322.0	4321.9	0.1	0.1
	0.1	4322.0	4321.9	0.1	0.1
	0.1	4322.0	4321.9	0.1	0.1
	6399.8	4322.0	4322.2	0.4	0.4
	6399.8	4322.1	4322.3	0.5	0.5
MEAN	0.41	4322.26	4321.85	0.05	0.00
S.D.	0.71	0.41	0.41	RMS 0.39	

FIGURE B4
FIELD TEST DATA

STATION 302
RETICLE (N70-80)
DATE 25 FEB 81
OPERATOR CAUM
INSTRUMENT NO. 10247

TRUE AZIMUTH 2389.1 MILS
AZIMUTH MARK MJS
TIME 2030
RECORDER CONNELL

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2391.0	2391.0	1.9	0.9
	0.8	2390.9	2390.1	1.0	-0.0
	0.6	2390.4	2389.8	0.7	-0.3
	0.1	2390.3	2390.2	1.1	0.1
	1.9	2391.4	2389.5	0.4	-0.6
	1.3	2389.5	2388.2	-0.9	-1.9
	6399.8	2389.6	2389.8	0.7	-0.3
	6398.7	2388.8	2390.1	1.0	-0.0
	6399.1	2391.8	2392.7	3.6	2.6
	0.3	2390.3	2390.0	0.9	-0.1
MEAN	0.26	2390.40	2390.14	1.04	0.00
S.D.	0.96	0.92	1.14	RMS 1.50	

FIGURE B5
FIELD TEST DATA

STATION 300
RETICLE (N60-70)
DATE 25 FEB 81
OPERATOR DAGUE
INSTRUMENT NO. 247

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 2030
RECORDER KAVZLARICH

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2391.9	2391.9	1.3	1.2
	1.2	2392.0	2390.8	0.2	0.1
	1.0	2391.9	2390.9	0.3	0.2
	1.5	2391.9	2390.4	-0.2	-0.3
	1.1	2392.0	2390.9	0.3	0.2
	1.0	2392.1	2391.1	0.5	0.4
	1.5	2392.0	2390.5	-0.1	-0.2
	2.0	2392.0	2390.0	-0.6	-0.7
	2.0	2392.0	2390.0	-0.6	-0.7
	1.5	2392.0	2390.5	-0.1	-0.2
MEAN	1.28	2391.98	2390.70	0.10	0.00
S.D.	0.58	0.06	0.56	RMS 0.54	

FIGURE B6
FIELD TEST DATA

STATION 300
RETICLE (N60-70)
DATE 25 FEB 81
OPERATOR MONTALBO
INSTRUMENT NO. 247

TRUE AZIMUTH 4323.3 MILS
AZIMUTH MARK OSC
TIME 2030
RECORDER MONTALBO

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4321.8	4321.8	-1.5	0.2
	0.8	4321.8	4321.0	-2.3	-0.6
	0.2	4321.6	4321.4	-1.9	-0.2
	0.3	4321.6	4321.3	-2.0	-0.3
	0.7	4321.8	4321.1	-2.2	-0.5
	6400.0	4322.8	4322.8	-0.5	1.2
	0.6	4322.2	4321.6	-1.7	0.0
	0.2	4322.5	4322.3	-1.0	0.7
	0.1	4321.4	4321.3	-2.0	-0.3
	0.4	4321.4	4321.0	-2.3	-0.6
MEAN	0.33	4321.89	4321.56	-1.74	0.00
S.D.	0.29	0.47	0.59	RMS 1.83	

FIGURE B7
FIELD TEST DATA

STATION 298
RETICLE (N60-70)
DATE 17 FEB 81
OPERATOR PRICE
INSTRUMENT NO. 247

TRUE AZIMUTH 2392.1 MILS
AZIMUTH MARK MJS
TIME 2130
RECORDER PRICE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2391.5	2391.5	-0.6	-0.3
	6399.5	2391.5	2392.0	-0.1	0.2
	6400.0	2391.5	2391.5	-0.6	-0.3
	6399.1	2391.5	2392.4	0.3	0.6
	6399.5	2391.5	2392.0	-0.1	0.2
	6399.4	2391.5	2392.1	0.0	0.3
	6399.7	2391.5	2391.8	-0.3	-0.0
	6399.6	2391.5	2391.9	-0.2	0.1
	6400.0	2391.5	2391.5	-0.6	-0.3
	6399.9	2391.5	2391.6	-0.5	-0.2
MEAN	-0.33	2391.50	2391.83	-0.27	0.00
S.D.	0.31	0.00	0.31	RMS 0.40	

FIGURE B8
FIELD TEST DATA

STATION 298
RETICLE (N60-70)
DATE 17 FEB 81
OPERATOR PRICE
INSTRUMENT NO. 247

TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 1951
RECORDER PRICE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4324.4	4324.4	-0.5	0.0
	6400.0	4324.4	4324.4	-0.5	0.0
	0.2	4324.4	4324.2	-0.7	-0.2
	6399.4	4324.4	4325.0	0.1	0.6
	0.3	4324.4	4324.1	-0.8	-0.3
	0.2	4324.4	4324.2	-0.7	-0.2
	0.2	4324.4	4324.2	-0.7	-0.2
	6399.8	4324.4	4324.6	-0.3	0.2
	6400.0	4324.4	4324.4	-0.5	0.0
	6399.9	4324.4	4324.5	-0.4	0.1
MEAN	0.00	4324.40	4324.40	-0.50	0.00
S.D.	0.26	0.00	0.26	RMS 0.56	

FIGURE B9
FIELD TEST DATA

STATION 298
RETICLE (N60-70)
DATE 17 FEB 81
OPERATOR PRICE
INSTRUMENT NO. 247

TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 2330
RECORDER PRICE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4324.5	4324.5	-0.4	0.0
	6400.0	4324.5	4324.5	-0.4	0.0
	0.1	4324.5	4324.4	-0.5	-0.1
	6400.0	4324.5	4324.5	-0.4	0.0
	0.1	4324.5	4324.4	-0.5	-0.1
	6400.0	4324.5	4324.5	-0.4	0.0
	6399.9	4324.5	4324.6	-0.3	0.1
	6400.0	4324.5	4324.5	-0.4	0.0
	6400.0	4324.5	4324.5	-0.4	0.0
	6400.0	4324.5	4324.5	-0.4	0.0
MEAN	0.01	4324.50	4324.49	-0.41	0.00
S.D.	0.06	0.00	0.06	RMS 0.41	

FIGURE B10
FIELD TEST DATA

STATION 298
RETICLE (N60-70)
DATE 18 FEB 81
OPERATOR PRICE
INSTRUMENT NO. 247

TRUE AZIMUTH 2392.1 MILS
AZIMUTH MARK MJS
TIME 0130
RECORDER PRICE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2392.3	2392.3	0.2	1.1
	1.0	2392.2	2391.2	-0.9	-0.0
	1.1	2392.2	2391.1	-1.0	-0.1
	1.0	2392.2	2391.2	-0.9	-0.0
	1.0	2392.2	2391.2	-0.9	-0.0
	1.3	2392.1	2390.8	-1.3	-0.4
	1.0	2392.1	2391.1	-1.0	-0.1
	1.0	2392.2	2391.2	-0.9	-0.0
	1.3	2392.3	2391.0	-1.1	-0.2
	1.3	2392.3	2391.0	-1.1	-0.2
MEAN	1.00	2392.21	2391.21	-0.89	0.00
S.D.	0.38	0.07	0.40	RMS 0.97	

FIGURE B11
FIELD TEST DATA

STATION 298
RETICLE (N60-70)
DATE 23 FEB 81
OPERATOR KAUZLARICH
INSTRUMENT NO. 247

TRUE AZIMUTH 2392.1 MILS
AZIMUTH MARK MJS
TIME 1930
RECORDER MCGINTY

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2393.5	2393.5	1.4	0.2
	6399.6	2393.5	2393.9	1.8	0.6
	6400.0	2393.5	2393.5	1.4	0.2
	0.5	2393.5	2393.0	0.9	-0.3
	6400.0	2393.5	2393.5	1.4	0.2
	0.5	2393.5	2393.0	0.9	-0.3
	6399.5	2393.5	2394.0	1.9	0.7
	0.5	2393.5	2393.0	0.9	-0.3
	0.5	2393.5	2393.0	0.9	-0.3
	0.5	2393.5	2393.0	0.9	-0.3
MEAN	0.16	2393.50	2393.34	1.24	0.00
S.D.	0.39	0.00	0.39	RMS 1.30	

FIGURE B12
FIELD TEST DATA

STATION 298
RETICLE (N60-70)
DATE 23 FEB 81
OPERATOR MONTALBO
INSTRUMENT NO. 247

TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 2130
RECORDER DAGE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4324.6	4324.6	-0.3	0.1
	6399.8	4324.5	4324.7	-0.2	0.2
	0.2	4324.5	4324.3	-0.6	-0.2
	6400.0	4324.6	4324.6	-0.3	0.1
	6400.0	4324.5	4324.5	-0.4	0.0
	6400.0	4324.8	4324.8	-0.1	0.3
	0.2	4324.5	4324.3	-0.6	-0.2
	0.2	4324.4	4324.2	-0.7	-0.3
	6400.0	4324.5	4324.5	-0.4	0.0
	0.2	4324.5	4324.3	-0.6	-0.2
MEAN	0.06	4324.54	4324.48	-0.42	0.00
S.D.	0.13	0.11	0.20	RMS 0.46	

FIGURE B13
FIELD TEST DATA

STATION 300
RETICLE (N80-90)
DATE 17 FEB 81
OPERATOR BARTH
INSTRUMENT NO. 12178

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 2130
RECORDER MCGINTY

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2391.0	2391.0	0.4	-0.1
	6400.0	2390.8	2390.8	0.2	-0.3
	6399.6	2390.6	2391.0	0.4	-0.1
	6399.3	2390.8	2391.5	0.9	0.4
	6399.6	2390.8	2391.2	0.6	0.1
	6399.8	2390.9	2391.1	0.5	0.0
	6399.4	2390.6	2391.2	0.6	0.1
	6399.4	2390.8	2391.4	0.8	0.3
	6399.9	2390.5	2390.6	0.0	-0.5
	6399.8	2390.7	2390.9	0.3	-0.2
MEAN	-0.32	2390.75	2391.07	0.47	0.00
S.D.	0.26	0.15	0.27	RMS 0.54	

FIGURE B14
FIELD TEST DATA

STATION 300
RETICLE (N80-90)
DATE 17 FEB 81
OPERATOR MCGINTY
INSTRUMENT NO. 12178

TRUE AZIMUTH 4323.3 MILS
AZIMUTH MARK OSC
TIME 2330
RECORDER MCGINTY

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4323.2	4323.2	-0.1	-0.1
	6400.0	4323.4	4323.4	0.1	0.1
	0.3	4323.2	4322.9	-0.4	-0.4
	0.1	4323.5	4323.4	0.1	0.1
	6400.0	4323.4	4323.4	0.1	0.1
	0.3	4323.1	4322.8	-0.5	-0.5
	0.1	4323.6	4323.5	0.2	0.2
	6399.8	4323.7	4323.9	0.6	0.6
	0.2	4323.4	4323.2	-0.1	-0.1
	0.3	4323.3	4323.0	-0.3	-0.3
MEAN	0.11	4323.38	4323.27	-0.03	0.00
S.D.	0.17	0.19	0.32	RMS 0.31	

FIGURE B15
FIELD TEST DATA

STATION 300
RETICLE (N80-90)
DATE 17 FEB 81
OPERATOR BARTH
INSTRUMENT NO. 12178

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 1930
RECORDER MCGINTY

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2391.2	2391.2	0.6	-0.1
	0.6	2391.2	2390.6	0.0	-0.7
	6399.3	2391.2	2391.9	1.3	0.6
	6400.0	2391.5	2391.5	0.9	0.2
	6399.6	2391.1	2391.5	0.9	0.2
	6399.5	2391.0	2391.5	0.9	0.2
	6400.0	2391.2	2391.2	0.6	-0.1
	6399.8	2391.3	2391.5	0.9	0.2
	6400.0	2391.4	2391.4	0.8	0.1
	6399.9	2391.0	2391.1	0.5	-0.2
MEAN	-0.13	2391.21	2391.34	0.74	0.00
S.D.	0.36	0.16	0.34	RMS 0.81	

FIGURE B16
FIELD TEST DATA

STATION 300
RETICLE (N80-90)
DATE 18 FEB 81
OPERATOR MCGINTY
INSTRUMENT NO. 12178

TRUE AZIMUTH 4323.3 MILS
AZIMUTH MARK OSC
TIME 0130
RECORDER MCGINTY

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4322.0	4322.0	-1.3	-0.1
	0.2	4322.4	4322.2	-1.1	0.1
	6399.9	4322.1	4322.2	-1.1	0.1
	0.1	4322.3	4322.2	-1.1	0.1
	0.3	4322.5	4322.2	-1.1	0.1
	0.1	4322.2	4322.1	-1.2	-0.0
	6399.8	4322.0	4322.2	-1.1	0.1
	6400.0	4322.2	4322.2	-1.1	0.1
	6400.0	4322.1	4322.1	-1.2	-0.0
	0.2	4322.2	4322.0	-1.3	-0.1
MEAN	0.06	4322.20	4322.14	-1.16	0.00
S.D.	0.15	0.16	0.08	RMS 1.16	

FIGURE B17
FIELD TEST DATA

STATION 302
RETICLE (N80-90)
DATE 23 FEB 81
OPERATOR CAUM
INSTRUMENT NO. 12178

TRUE AZIMUTH 4321.8 MILS
AZIMUTH MARK OSC
TIME 1930
RECORDER CONNELL

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4320.8	4320.8	-1.0	-1.3
	6398.8	4320.8	4322.0	0.2	-0.1
	6398.8	4321.5	4322.7	0.9	0.6
	6398.4	4321.5	4323.1	1.3	1.0
	0.1	4321.3	4321.2	-0.6	-0.9
	6398.9	4321.3	4322.4	0.6	0.3
	6399.3	4321.3	4322.0	0.2	-0.1
	6399.8	4321.7	4321.9	0.1	-0.2
	6398.4	4320.5	4322.1	0.3	0.0
	6397.9	4320.3	4322.4	0.6	0.3
MEAN	-0.96	4321.10	4322.06	0.26	0.00
S.D.	0.74	0.47	0.67	RMS 0.69	

FIGURE B18
FIELD TEST DATA

STATION 302
RETICLE (N80-90)
DATE 23 FEB 81
OPERATOR VICINITY
INSTRUMENT NO. 12178

TRUE AZIMUTH 2389.1 MILS
AZIMUTH MARK MJS
TIME 2130
RECORDER VICINITY

	SCANS POINTING	TARGET POINTING	AZIMUTH RECORDED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	2388.7	2388.7	-0.4	-0.3
	[illegible]	[illegible]	2390.0	0.9	1.0
	6399.1	2388.0	2388.9	-0.2	-0.1
	6399.0	2388.0	2389.0	-0.1	-0.0
	6399.0	2388.0	2389.0	-0.1	-0.0
	6399.1	2388.2	2389.1	0.0	0.1
	6399.1	2388.0	2388.9	-0.2	-0.1
	6399.1	2388.0	2388.9	-0.2	-0.1
	6399.2	2388.1	2388.9	-0.2	-0.1
	6399.3	2388.2	2388.9	-0.2	-0.1
MEAN	-0.81	2388.22	2389.03	-0.07	0.00
S.D.	0.30	0.35	0.36	RMS 0.34	

FIGURE B19
FIELD TEST DATA

STATION 298
RETICLE (N80-90)
DATE 25 FEB 81
OPERATOR CONNELL
INSTRUMENT NO. 12178

TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 1900
RECORDER CAUM

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	4325.4	4325.4	0.5	0.2
	6399.4	4325.6	4326.2	1.3	1.0
	6399.9	4325.3	4325.4	0.5	0.2
	0.5	4325.4	4324.9	0.0	-0.3
	0.3	4325.2	4324.9	0.0	-0.3
	0.5	4325.5	4325.0	0.1	-0.2
	0.3	4325.3	4325.0	0.1	-0.2
	0.4	4325.2	4324.8	-0.1	-0.4
	0.4	4325.6	4325.2	0.3	0.0
	0.5	4325.4	4324.9	0.0	-0.3
MEAN	0.22	4325.39	4325.17	0.27	0.00
S.D.	0.36	0.14	0.42	RMS 0.48	

FIGURE B20
FIELD TEST DATA

STATION 298
RETICLE (N80-90)
DATE 25 FEB 81
OPERATOR KAVZLARICH
INSTRUMENT NO. 12178

TRUE AZIMUTH 4324.9
AZIMUTH MARK OSC
TIME 2030
RECORDER DAGE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ.
	6400.0	4324.0	4324.0	-0.9	-0.1
	6400.0	4323.9	4323.9	-1.0	-0.2
	6399.9	4324.0	4324.1	-0.8	-0.0
	6400.0	4323.9	4323.9	-1.0	-0.2
	6400.0	4323.9	4323.9	-1.0	-0.2
	6399.9	4323.9	4324.0	-0.9	-0.1
	6399.5	4324.5	4325.0	0.1	0.9
	6399.0	4323.5	4324.5	-0.4	0.4
	6400.0	4323.6	4323.6	-1.3	-0.5
	6399.8	4324.0	4324.2	-0.7	0.1
MEAN	6399.81	4323.92	4324.11	-0.79	0.00
S.D.	0.32	0.27	0.39	RMS 0.87	

FIGURE B21
FIELD TEST DATA

STATION EPG OBS
RETICLE (N80-90)
DATE 17 DEC 80
OPERATOR DERE
INSTRUMENT NO. 3310

TRUE AZIMUTH 2996.6 MILS
AZIMUTH MARK DAVISON
TIME 1930
RECORDER MCDONNELL

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.0	2995.6	2995.6	-1.0	0.4
	0.1	2995.6	2995.5	-1.1	0.3
	6399.3	2995.2	2995.9	-0.7	0.7
	6398.8	2994.9	2996.1	-0.5	0.9
	6399.7	2994.8	2995.1	-1.5	-0.2
	1.1	2995.4	2994.3	-2.3	-1.0
	0.2	2994.7	2994.5	-2.1	-0.8
	0.3	2995.2	2994.9	-1.7	-0.4
	0.0	2995.0	2995.0	-1.6	-0.3
	6399.5	2995.1	2995.6	-1.0	0.4
MEAN	-0.10	2995.15	2995.25	-1.35	0.00
S.D.	0.63	0.31	0.59	RMS 1.46	

FIGURE B22
FIELD TEST DATA

STATION ETL 2591
RETICLE (N80-90)
DATE 8 JAN 81
OPERATOR DERE,VENA
INSTRUMENT NO. 3310

TRUE AZIMUTH 6399.8 MILS
AZIMUTH MARK NORTH ETL
TIME 0530
RECORDER DERE,VENA

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ.
	1.0	6398.8	6397.8	-2.0	-0.3
	1.1	6398.9	6397.8	-2.0	-0.3
	1.0	6399.0	6398.0	-1.8	-0.1
	1.2	6399.3	6398.1	-1.7	-0.0
	1.1	6399.1	6398.0	-1.8	-0.1
	6399.5	6398.0	6398.5	-1.3	0.4
	6399.7	6398.4	6398.7	-1.1	0.6
	2.0	6399.9	6397.9	-1.9	-0.2
	1.9	6399.9	6398.0	-1.8	-0.1
	3.0	1.6	6398.6	-1.2	0.5
MEAN	1.15	6399.29	6398.14	-1.66	0.00
S.D.	1.03	1.00	0.33	RMS 1.69	

FIGURE B23
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR NILES
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2145-2215
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.0	380.3	377.3	-3.0	-0.1
	3.8	380.7	376.9	-3.4	-0.5
	2.5	380.2	377.7	-2.6	0.3
	2.7	380.2	377.5	-2.8	0.1
	2.0	380.4	378.4	-1.9	1.0
	2.9	380.0	377.1	-3.2	-0.3
	2.1	380.0	377.9	-2.4	0.5
	3.3	380.2	376.9	-3.4	-0.5
	3.0	380.1	377.1	-3.2	-0.3
	3.0	380.5	377.5	-2.8	0.1
MEAN	2.83	380.26	377.43	-2.87	0.00
S.D.	0.54	0.22	0.48	RMS 2.91	

FIGURE B24
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR NILES
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2225-2305
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.8	380.5	377.7	-2.6	-0.1
	2.5	380.5	378.0	-2.3	0.2
	2.3	380.6	378.3	-2.0	0.5
	3.1	380.5	377.4	-2.9	-0.4
	3.3	380.5	377.2	-3.1	-0.6
	2.9	380.5	377.6	-2.7	-0.2
	2.8	380.7	377.9	-2.4	0.1
	2.9	380.8	377.9	-2.4	0.1
	2.5	380.7	378.2	-2.1	0.4
	2.8	380.6	377.8	-2.5	0.0
MEAN	2.79	380.59	377.80	-2.50	0.00
S.D.	0.30	0.11	0.34	RMS 2.52	

FIGURE B25
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR NILES
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2418-2448
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.2	380.3	377.1	-3.2	-0.5
	2.2	380.2	378.0	-2.3	0.4
	2.9	380.5	377.6	-2.7	-0.0
	3.5	380.5	377.0	-3.3	-0.6
	2.9	380.4	377.5	-2.8	-0.1
	2.9	380.8	377.9	-2.4	0.3
	3.1	380.8	377.7	-2.6	0.1
	2.7	380.9	378.2	-2.1	0.6
	3.0	380.7	377.7	-2.6	0.1
	3.0	380.7	377.7	-2.6	0.1
MEAN	2.94	380.58	377.64	-2.66	0.00
S.D.	0.34	0.23	0.37	RMS 2.68	

FIGURE B26
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR NILES
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 0105-0140
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.8	380.5	377.7	-2.6	0.1
	2.6	380.1	377.5	-2.8	-0.1
	2.7	380.4	377.7	-2.6	0.1
	2.8	380.3	377.5	-2.8	-0.1
	2.9	380.4	377.5	-2.8	-0.1
	2.5	380.0	377.5	-2.8	-0.1
	2.6	380.2	377.6	-2.7	0.0
	2.8	380.1	377.3	-3.0	-0.3
	2.4	380.2	377.8	-2.5	0.2
	2.5	380.2	377.7	-2.6	0.1
MEAN	2.66	380.24	377.58	-2.72	0.00
S.D.	0.16	0.16	0.15	PMS 2.72	

FIGURE B27
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR NILES
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 0205-0232
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	380.1	378.1	-2.2	0.1
	1.9	380.0	378.1	-2.2	0.1
	1.8	380.1	378.3	-2.0	0.3
	1.9	380.0	378.1	-2.2	0.1
	1.8	379.9	378.1	-2.2	0.1
	2.2	380.0	377.8	-2.5	-0.2
	2.0	380.1	378.1	-2.2	0.1
	2.5	380.1	377.6	-2.7	-0.4
	1.8	380.1	378.3	-2.0	0.3
	2.3	380.1	377.8	-2.5	-0.2
MEAN	2.02	380.05	378.03	-2.27	0.00
S.D.	0.24	0.07	0.23	RMS 2.28	

FIGURE B28
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR DERE
INSTRUMENT NO. 03310

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2100
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.8	387.3	385.5	-2.3	0.2
	1.1	387.3	386.2	-1.6	0.9
	1.5	387.1	385.6	-2.2	0.3
	1.5	387.3	385.8	-2.0	0.5
	2.1	387.2	385.1	-2.7	-0.2
	2.0	386.9	384.9	-2.9	-0.4
	2.7	387.1	384.4	-3.4	-0.9
	2.3	387.2	384.9	-2.9	-0.4
	2.0	387.1	385.1	-2.7	-0.2
	2.2	387.3	385.1	-2.7	-0.2
MEAN	1.92	387.18	385.26	-2.54	0.00
S.D.	0.46	0.13	0.52	RMS 2.59	

FIGURE B29
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR DERE
INSTRUMENT NO. 03310

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2150
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	387.3	385.3	-2.5	0.5
	3.0	387.2	384.2	-3.6	-0.6
	3.0	387.3	384.3	-3.5	-0.5
	2.7	387.3	384.6	-3.2	-0.2
	2.5	387.7	385.2	-2.6	0.4
	2.8	387.6	384.8	-3.0	0.0
	2.6	387.5	384.9	-2.9	0.1
	2.5	387.0	384.5	-3.3	-0.3
	2.0	387.5	385.5	-2.3	0.7
	2.5	387.1	384.6	-3.2	-0.2
MEAN	2.56	387.35	384.79	-3.01	0.00
S.D.	0.35	0.22	0.43	RMS 3.04	

FIGURE B30
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR DERE
INSTRUMENT NO. 03310

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2300
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	5.2	389.0	383.8	-4.0	-1.1
	3.1	388.1	385.0	-2.8	0.1
	2.9	388.2	385.3	-2.5	0.4
	3.8	388.1	384.3	-3.5	-0.6
	3.1	387.9	384.8	-3.0	-0.1
	3.5	388.0	384.5	-3.3	-0.4
	2.8	388.0	385.2	-2.6	0.3
	3.2	388.3	385.1	-2.7	0.2
	2.1	387.9	385.8	-2.0	0.9
	3.0	387.9	384.9	-2.9	0.0
MEAN	3.27	388.14	384.87	-2.93	0.00
S.D.	0.81	0.33	0.56	RMS 2.98	

FIGURE B31
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR DERE
INSTRUMENT NO. 03310

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2320
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.1	388.0	384.9	-2.9	-0.1
	2.7	387.3	384.6	-3.2	-0.4
	2.8	388.1	385.3	-2.5	0.3
	3.1	387.5	384.4	-3.4	-0.6
	2.0	387.7	385.7	-2.1	0.7
	2.5	387.6	385.1	-2.7	0.1
	3.0	387.7	384.7	-3.1	-0.3
	2.4	387.7	385.3	-2.5	0.3
	3.6	388.1	384.5	-3.3	-0.5
	2.6	387.8	385.2	-2.6	0.2
MEAN	2.78	387.75	384.97	-2.83	0.00
S.D.	0.45	0.26	0.42	RMS 2.86	

FIGURE B32
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR DERE
INSTRUMENT NO. 03310

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2425
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.0	387.9	384.9	-2.9	-0.3
	2.8	387.5	384.7	-3.1	-0.5
	2.1	387.5	385.4	-2.4	0.2
	2.3	387.6	385.3	-2.5	0.1
	2.6	387.4	384.8	-3.0	-0.4
	2.5	387.4	384.9	-2.9	-0.3
	2.1	387.6	385.5	-2.3	0.3
	2.1	387.7	385.6	-2.2	0.4
	2.4	387.5	385.1	-2.7	-0.1
	2.2	387.6	385.4	-2.4	0.2
MEAN	2.41	387.57	385.16	-2.64	0.00
S.D.	0.31	0.15	0.32	RMS 2.66	

FIGURE B33
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 3310

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2120-2136
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.1	384.2	381.1	-3.0	-0.4
	3.1	384.6	381.5	-2.6	-0.0
	3.1	384.6	381.5	-2.6	-0.0
	3.1	384.8	381.7	-2.4	0.2
	3.1	384.4	381.3	-2.8	-0.2
	2.8	384.8	382.0	-2.1	0.5
	3.2	384.9	381.7	-2.4	0.2
	3.3	384.8	381.5	-2.6	-0.0
	3.2	384.8	381.6	-2.5	0.1
	3.2	384.7	381.5	-2.6	-0.0
MEAN	3.12	384.66	381.54	-2.56	0.00
S.D.	0.13	0.22	0.24	RMS 2.57	

FIGURE B34
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 3310

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2150-2210
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.0	384.2	381.2	-2.9	-0.1
	3.0	384.2	381.2	-2.9	-0.1
	3.0	384.2	381.2	-2.9	-0.1
	3.0	384.2	381.2	-2.9	-0.1
	3.1	384.3	381.2	-2.9	-0.1
	2.7	384.5	381.8	-2.3	0.5
	3.0	384.6	381.6	-2.5	0.3
	3.0	384.4	381.4	-2.7	0.1
	3.0	384.2	381.2	-2.9	-0.1
	3.0	384.2	381.2	-2.9	-0.1
MEAN	2.98	384.30	381.32	-2.78	0.00
S.D.	0.10	0.15	0.21	RMS 2.79	

FIGURE B35
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 3310

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK CAT-4
TIME 2255-2315
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.0	384.1	381.1	-3.0	-0.0
	3.0	384.1	381.1	-3.0	-0.0
	3.0	384.2	381.2	-2.9	0.1
	3.0	384.1	381.1	-3.0	-0.0
	3.0	384.1	381.1	-3.0	-0.0
	3.0	384.2	381.2	-2.9	0.1
	3.0	384.2	381.2	-2.9	0.1
	3.0	384.0	381.0	-3.1	-0.1
	2.9	384.2	381.3	-2.8	0.2
	3.0	384.0	381.0	-3.1	-0.1
MEAN	2.99	384.12	381.13	-2.97	0.00
S.D.	0.03	0.08	0.09	RMS 2.97	

FIGURE B36
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 3310

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2330-2350
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.8	384.2	381.4	-2.7	0.1
	2.4	384.1	381.7	-2.4	0.4
	3.0	384.2	381.2	-2.9	-0.1
	3.0	384.2	381.2	-2.9	-0.1
	2.9	384.1	381.2	-2.9	-0.1
	2.9	384.2	381.3	-2.8	-0.0
	2.9	384.1	381.2	-2.9	-0.1
	2.5	384.0	381.5	-2.6	0.2
	2.9	384.1	381.2	-2.9	-0.1
	2.5	384.0	381.5	-2.6	0.2
MEAN	2.78	384.12	381.34	-2.76	0.00
S.D.	0.23	0.08	0.18	RMS 2.77	

FIGURE B37
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 3310

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2430-2445
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.5	384.0	38. .5	-2.6	-0.1
	2.8	384.1	381.3	-2.8	-0.3
	2.5	384.0	381.5	-2.6	-0.1
	2.8	384.1	381.3	-2.8	-0.3
	2.3	383.9	381.6	-2.5	0.0
	2.3	384.0	381.7	-2.4	0.1
	2.3	384.0	381.7	-2.4	0.1
	2.3	384.0	381.7	-2.4	0.1
	2.0	384.0	382.0	-2.1	0.4
	2.2	383.9	381.7	-2.4	0.1
MEAN	2.40	384.00	381.60	-2.50	0.00
S.D.	0.25	0.07	0.21	RMS 2.51	

FIGURE B38
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 25 AUG 81
OPERATOR DERE
INSTRUMENT NO. 3310

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2402-2425
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.0	385.0	382.0	-2.1	0.4
	2.9	384.9	382.0	-2.1	0.4
	3.1	384.5	381.4	-2.7	-0.2
	3.4	384.5	381.1	-3.0	-0.5
	3.1	384.7	381.6	-2.5	-0.0
	3.0	384.6	381.6	-2.5	-0.0
	2.9	384.7	381.8	-2.3	0.2
	3.0	384.6	381.6	-2.5	-0.0
	2.9	384.5	381.6	-2.5	-0.0
	3.0	384.5	381.5	-2.6	-0.1
MEAN	3.03	384.65	381.62	-2.48	0.00
S.D.	0.15	0.18	0.27	RMS 2.49	

FIGURE B39
FIELD TEST DATA

STATION SD 300
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR FOSTER
INSTRUMENT NO. 3310

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 2208-2242
RECORDER FURR

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	2390.1	2388.1	-2.5	0.3
	1.5	2388.9	2387.4	-3.2	-0.4
	2.0	2388.9	2386.9	-3.7	-0.9
	2.0	2389.1	2387.1	-3.5	-0.7
	2.2	2388.9	2386.7	-3.9	-1.1
	1.9	2390.0	2388.1	-2.5	0.3
	1.9	2390.1	2388.2	-2.4	0.4
	2.0	2390.9	2388.9	-1.7	1.1
	2.5	2390.6	2388.1	-2.5	0.3
	2.0	2390.5	2388.5	-2.1	0.7
MEAN	2.00	2389.80	2387.80	-2.80	0.00
S.D.	0.25	0.78	0.73	RMS 2.88	

FIGURE B40
FIELD TEST DATA

STATION SD 300
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR FOSTER
INSTRUMENT NO. 3310

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 2249-2305
RECORDER FURR

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	2391.0	2389.0	-1.6	0.4
	2.5	2391.0	2388.5	-2.1	-0.1
	2.5	2391.2	2388.7	-1.9	0.1
	2.3	2390.8	2388.5	-2.1	-0.1
	2.5	2390.8	2388.3	-2.3	-0.3
	2.2	2391.1	2388.9	-1.7	0.3
	2.4	2391.0	2388.6	-2.0	-0.0
	2.9	2391.1	2388.2	-2.4	-0.4
	2.2	2391.3	2389.1	-1.5	0.5
	2.5	2390.9	2388.4	-2.2	-0.2
MEAN	2.40	2391.02	2388.62	-1.98	0.00
S.D.	0.24	0.16	0.30	RMS 2.00	

FIGURE B41
FIELD TEST DATA

STATION SD 300
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR FURR
INSTRUMENT NO. 3310

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 2038-2103
RECORDER FURR

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	2390.0	2388.0	-2.6	0.1
	1.8	2390.4	2388.6	-2.0	0.7
	2.0	2390.0	2388.0	-2.6	0.1
	2.5	2390.2	2387.7	-2.9	-0.2
	2.9	2390.1	2387.2	-3.4	-0.7
	2.5	2390.5	2388.0	-2.6	0.1
	2.0	2390.0	2388.0	-2.6	0.1
	2.0	2390.0	2388.0	-2.6	0.1
	2.2	2390.2	2388.0	-2.6	0.1
	2.2	2390.0	2387.8	-2.8	-0.1
MEAN	2.21	2390.14	2387.93	-2.67	0.00
S.D.	0.33	0.18	0.35	RMS 2.69	

FIGURE B42
FIELD TEST DATA

STATION SD 300
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR FURR
INSTRUMENT NO. 3310

TRUE AZIMUTH 2390.6 MILS
AZIMUTH MARK MJS
TIME 2199-2145
RECORDER FURR

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	2391.0	2389.0	-1.6	0.3
	2.2	2391.1	2388.9	-1.7	0.2
	2.6	2391.0	2388.4	-2.2	-0.3
	1.8	2391.0	2389.2	-1.4	0.5
	2.5	2391.0	2388.5	-2.1	-0.2
	1.9	2391.0	2389.1	-1.5	0.4
	2.3	2391.0	2388.7	-1.9	-0.0
	2.8	2391.0	2388.2	-2.4	-0.5
	2.8	2391.1	2388.3	-2.3	-0.4
	2.0	2391.0	2389.0	-1.6	0.3
MEAN	2.29	2391.02	2388.73	-1.87	0.00
S.D.	0.37	0.04	0.36	RMS 1.90	

FIGURE B43
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14433

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK CAT-4
TIME 1930-2000
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6399.9	375.9	376.0	-0.4	0.4
	0.6	375.8	375.2	-1.2	-0.4
	0.3	375.8	375.5	-0.9	-0.1
	0.1	375.8	375.7	-0.7	0.1
	0.2	376.0	375.8	-0.6	0.2
	0.4	375.8	375.4	-1.0	-0.2
	0.1	375.7	375.6	-0.8	0.0
	0.1	375.9	375.8	-0.6	0.2
	0.2	375.7	375.5	-0.9	-0.1
	0.5	375.9	375.4	-1.0	-0.2
MEAN	0.24	375.83	375.59	-0.81	0.00
S.D.	0.21	0.09	0.24	RMS 0.84	

FIGURE B44
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14433

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2315-2400
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.1	375.8	375.7	-0.7	0.2
	0.6	375.9	375.3	-1.1	-0.2
	0.5	375.8	375.3	-1.1	-0.2
	0.5	375.8	375.3	-1.1	-0.2
	0.5	376.0	375.5	-0.9	-0.0
	0.3	375.9	375.6	-0.8	0.1
	0.3	375.8	375.5	-0.9	-0.0
	0.3	376.1	375.8	-0.6	0.3
	0.3	376.0	375.7	-0.7	0.2
	0.2	375.8	375.6	-0.8	0.1
MEAN	0.36	375.89	375.53	-0.87	0.00
S.D.	0.16	0.11	0.18	RMS 0.89	

FIGURE B46
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14433

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2415-0100
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.1	375.9	375.8	-0.6	0.0
	0.1	375.8	375.7	-0.7	-0.1
	6400.0	376.1	376.1	-0.3	0.3
	0.1	376.1	376.0	-0.4	0.2
	0.2	375.8	375.6	-0.8	-0.2
	6400.0	375.8	375.8	-0.6	0.0
	0.2	375.9	375.7	-0.7	-0.1
	0.3	375.7	375.4	-1.0	-0.4
	0.1	375.8	375.7	-0.7	-0.1
	0.3	376.1	375.8	-0.6	0.0
MEAN	0.14	375.90	375.76	-0.64	0.00
S.D.	0.11	0.15	0.20	RMS 0.67	

FIGURE B47
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14433

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 0200-0240
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6399.9	375.6	375.7	-0.7	-0.1
	6399.9	375.5	375.6	-0.8	-0.2
	0.1	375.6	375.5	-0.9	-0.3
	6400.0	375.9	375.9	-0.5	0.1
	6399.8	375.8	376.0	-0.4	0.2
	6399.9	375.9	376.0	-0.4	0.2
	0.1	376.1	376.0	-0.4	0.2
	0.2	375.7	375.5	-0.9	-0.3
	6400.0	375.7	375.7	-0.7	-0.1
	6400.0	376.1	376.1	-0.3	0.3
MEAN	-0.01	375.79	375.80	-0.60	0.00
S.D.	0.12	0.21	0.23	RMS 0.64	

FIGURE B48
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14433

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2110-2135
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
	6400.0	384.0	384.0	-0.1	0.0
MEAN	0.00	384.00	384.00	-0.10	0.00
S.D.	0.00	0.00	0.00	RMS 0.10	

FIGURE B49
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14433

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2150-2215
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	384.0	384.0	-0.1	0.4
	6400.0	384.0	384.0	-0.1	0.4
	0.6	384.0	383.4	-0.7	-0.2
	0.6	384.0	383.4	-0.7	-0.2
	0.5	384.0	383.5	-0.6	-0.1
	0.5	384.0	383.5	-0.6	-0.1
	0.8	384.1	383.3	-0.8	-0.3
	0.2	384.1	383.9	-0.2	0.3
	0.8	384.1	383.3	-0.8	-0.3
	0.6	384.0	383.4	-0.7	-0.2
MEAN	0.46	384.03	383.57	-0.53	0.00
S.D.	0.30	0.05	0.28	RMS 0.59	

FIGURE B50
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14433

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2300-2320
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	384.0	383.0	-1.1	-0.2
	0.9	384.1	383.2	-0.9	0.1
	0.9	384.0	383.1	-1.0	-0.1
	0.9	384.1	383.2	-0.9	0.1
	0.9	384.3	383.4	-0.7	0.3
	0.9	384.0	383.1	-1.0	-0.1
	0.9	384.2	383.3	-0.8	0.2
	1.0	384.1	383.1	-1.0	-0.1
	1.0	384.0	383.0	-1.1	-0.2
	1.0	384.1	383.1	-1.0	-0.1
MEAN	0.94	384.09	383.15	-0.95	0.00
S.D.	0.05	0.10	0.13	RMS 0.96	

FIGURE B51
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14433

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2230-2300
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.4	376.1	375.7	-0.7	0.0
	0.1	375.8	375.7	-0.7	0.0
	0.1	375.8	375.7	-0.7	0.0
	0.2	376.2	376.0	-0.4	0.3
	0.1	375.9	375.8	-0.6	0.1
	0.3	376.0	375.7	-0.7	0.0
	0.5	375.8	375.3	-1.1	-0.4
	0.3	376.1	375.8	-0.6	0.1
	0.4	376.1	375.7	-0.7	0.0
	0.3	375.9	375.6	-0.8	-0.1
MEAN	0.27	375.97	375.70	-0.70	0.00
S.D.	0.14	0.15	0.18	RMS 0.72	

FIGURE B45
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14433

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2330-2345
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.1	384.0	382.9	-1.2	-0.3
	0.9	384.1	383.2	-0.9	0.1
	1.1	384.1	383.0	-1.1	-0.2
	1.0	384.2	383.2	-0.9	0.1
	0.9	384.2	383.3	-0.8	0.2
	1.1	384.3	383.2	-0.9	0.1
	1.0	384.1	383.1	-1.0	-0.1
	1.0	384.2	383.2	-0.9	0.1
	0.8	384.2	383.4	-0.7	0.3
	1.1	384.1	383.0	-1.1	-0.2
MEAN	1.00	384.15	383.15	-0.95	0.00
S.D.	0.11	0.08	0.15	RMS 0.96	

FIGURE B52
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14433

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2425-2440
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.1	384.2	383.1	-1.0	-0.1
	1.1	384.2	383.1	-1.0	-0.1
	1.0	384.2	383.2	-0.9	0.0
	0.9	384.0	383.1	-1.0	-0.1
	1.0	384.2	383.2	-0.9	0.0
	1.1	384.1	383.0	-1.1	-0.2
	0.9	384.2	383.3	-0.8	0.1
	0.8	384.1	383.3	-0.8	0.1
	0.8	384.2	383.4	-0.7	0.2
	0.8	384.1	383.3	-0.8	0.1
MEAN	0.95	384.15	383.20	-0.90	0.00
S.D.	0.13	0.07	0.12	RMS 0.91	

FIGURE B53
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2120-2136
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.4	380.3	378.9	-1.4	-0.1
	1.4	380.3	378.9	-1.4	-0.1
	1.0	380.3	379.3	-1.0	0.3
	1.3	380.3	379.0	-1.3	0.0
	1.8	380.3	378.5	-1.8	-0.5
	1.1	380.2	379.1	-1.2	0.1
	1.5	380.3	378.8	-1.5	-0.2
	1.1	380.3	379.2	-1.1	0.2
	1.0	380.3	379.3	-1.0	0.3
	1.4	380.2	378.8	-1.5	-0.2
MEAN	1.30	380.28	378.98	-1.32	0.00
S.D.	0.25	0.04	0.25	RMS 1.34	

FIGURE B54
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2152-2209
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	380.3	379.3	-1.0	0.4
	1.0	380.0	379.0	-1.3	0.1
	1.0	380.1	379.1	-1.2	0.2
	1.5	380.1	378.6	-1.7	-0.3
	1.0	380.0	379.0	-1.3	0.1
	1.5	380.0	378.5	-1.8	-0.4
	1.0	380.0	379.0	-1.3	0.1
	1.3	380.0	378.7	-1.6	-0.2
	1.5	380.1	378.6	-1.7	-0.3
	1.3	380.1	378.8	-1.5	-0.1
MEAN	1.21	380.07	378.86	-1.44	0.00
S.D.	0.23	0.09	0.26	RMS 1.46	

FIGURE B55
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2235-2311
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.3	380.1	378.8	-1.5	-0.0
	1.0	380.1	379.1	-1.2	0.3
	1.0	380.0	379.0	-1.3	0.2
	1.3	380.0	378.7	-1.6	-0.1
	1.0	380.1	379.1	-1.2	0.3
	1.5	380.1	378.6	-1.7	-0.2
	1.3	380.0	378.7	-1.6	-0.1
	1.5	380.0	378.5	-1.8	-0.3
	1.1	380.0	378.9	-1.4	0.1
	1.1	380.1	379.0	-1.3	0.2
MEAN	1.21	380.05	378.84	-1.46	0.00
S.D.	0.20	0.05	0.21	RMS 1.47	

FIGURE B56
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2330-2345
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.3	380.5	379.2	-1.1	0.4
	1.5	380.3	378.8	-1.5	0.0
	1.5	380.3	378.8	-1.5	0.0
	1.4	380.5	379.1	-1.2	0.3
	1.7	380.3	378.6	-1.7	-0.2
	1.8	380.3	378.5	-1.8	-0.3
	1.5	380.3	378.8	-1.5	0.0
	1.8	380.2	378.4	-1.9	-0.4
	1.1	380.3	379.2	-1.1	0.4
	1.7	380.3	378.6	-1.7	-0.2
MEAN	1.53	380.33	378.80	-1.50	0.00
S.D.	0.23	0.09	0.29	RMS 1.52	

FIGURE B57
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2430-2440
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.8	380.3	378.5	-1.8	0.0
	1.8	380.5	378.7	-1.6	0.2
	1.9	380.4	378.5	-1.8	0.0
	1.9	380.3	378.4	-1.9	-0.1
	1.9	380.4	378.5	-1.8	0.0
	1.9	380.4	378.5	-1.8	0.0
	2.0	380.3	378.3	-2.0	-0.2
	1.7	380.3	378.6	-1.7	0.1
	1.9	380.4	378.5	-1.8	0.0
	1.9	380.4	378.5	-1.8	0.0
MEAN	1.87	380.37	378.50	-1.80	0.00
S.D.	0.08	0.07	0.11	RMS 1.80	

FIGURE B58
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 25 AUG 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2330-2355
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.8	382.6	379.8	-0.5	0.2
	2.9	382.7	379.8	-0.5	0.2
	2.9	382.5	379.6	-0.7	0.0
	2.9	382.7	379.8	-0.5	0.2
	2.9	382.6	379.7	-0.6	0.1
	3.0	382.5	379.5	-0.8	-0.1
	2.8	382.4	379.6	-0.7	0.0
	3.2	382.4	379.2	-1.1	-0.4
	3.1	382.5	379.4	-0.9	-0.2
	2.9	382.4	379.5	-0.8	-0.1
MEAN	2.94	382.53	379.59	-0.71	0.00
S.D.	0.13	0.12	0.20	RMS 0.73	

FIGURE B59
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 25 AUG 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2402-2425
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.9	380.3	379.4	-0.9	0.0
	0.8	380.4	379.6	-0.7	0.2
	1.0	380.3	379.3	-1.0	-0.1
	1.0	380.3	379.3	-1.0	-0.1
	1.2	380.4	379.2	-1.1	-0.2
	0.5	380.5	380.0	-0.3	0.6
	1.1	380.4	379.3	-1.0	-0.1
	1.2	380.4	379.2	-1.1	-0.2
	1.0	380.4	379.4	-0.9	0.0
	1.0	380.3	379.3	-1.0	-0.1
MEAN	0.97	380.37	379.40	-0.90	0.00
S.D.	0.21	0.07	0.24	RMS 0.93	

FIGURE B60
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 25 AUG 81
OPERATOR NILES
INSTRUMENT NO. 14433

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 0108-0124
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	380.1	379.1	-1.2	-0.0
	0.9	380.3	379.4	-0.9	0.3
	0.9	380.3	379.4	-0.9	0.3
	0.9	380.3	379.4	-0.9	0.3
	1.0	380.2	379.2	-1.1	0.1
	1.0	380.3	379.3	-1.0	0.2
	1.0	380.2	379.2	-1.1	0.1
	1.2	380.3	379.1	-1.2	-0.0
	2.0	380.5	378.5	-1.8	-0.6
	1.7	380.5	378.8	-1.5	-0.3
MEAN	1.16	380.30	379.14	-1.16	0.00
S.D.	0.38	0.12	0.29	PMS 1.19	

FIGURE B61
FIELD TEST DATA

STATION SD 298
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR FUBR
INSTRUMENT NO. 14433

TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 2040-2118
RECORDER FOSTER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4324.4	4322.4	-2.5	-0.8
	1.0	4324.9	4323.9	-1.0	0.7
	1.3	4325.0	4323.7	-1.2	0.5
	1.2	4324.8	4323.6	-1.3	0.4
	1.1	4324.0	4322.9	-2.0	-0.3
	2.0	4324.9	4322.9	-2.0	-0.3
	1.8	4325.0	4323.2	-1.7	0.0
	0.9	4324.3	4323.4	-1.5	0.2
	1.8	4324.3	4322.5	-2.4	-0.7
	1.2	4324.5	4323.3	-1.6	0.1
MEAN	1.43	4324.61	4323.18	-1.72	0.00
S.D.	0.42	0.35	0.50	RMS 1.78	

FIGURE B62
FIELD TEST DATA

STATION SD 296
RETICLE (N30-90)
DATE 3 SEPT 81
OPERATOR FURR
INSTRUMENT NO. 14433

TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 2211-2236
RECORDER FOSTER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	[illegible]	4322.9	-2.0	-0.5
	1.2	4324.4	4323.2	-1.7	-0.2
	1.5	4325.0	4323.5	-1.4	0.2
	1.5	4324.9	4323.4	-1.5	0.1
	1.5	4325.0	4323.5	-1.4	0.2
	1.5	4324.9	4323.4	-1.5	0.1
	1.1	4325.0	4323.9	-1.0	0.6
	1.5	4324.9	4323.4	-1.5	0.1
	1.8	4325.0	4323.2	-1.7	-0.2
	1.9	4325.0	4323.1	-1.8	-0.3
MEAN	1.55	4324.90	4323.35	-1.55	0.00
S.D.	0.28	0.18	0.27	RMS 1.57	

FIGURE B63
FIELD TEST DATA

STATION SD 298
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR FURR
INSTRUMENT NO. 14433

TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 2124-2146
RECORDER FOSTER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4325.9	4323.9	-1.0	0.1
	1.0	4325.7	4324.7	-0.2	0.9
	1.1	4325.1	4324.0	-0.9	0.2
	1.4	4325.1	4323.7	-1.2	-0.1
	1.9	4325.1	4323.2	-1.7	-0.6
	2.0	4325.0	4323.0	-1.9	-0.8
	2.1	4325.2	4323.1	-1.8	-0.7
	2.0	4325.9	4323.9	-1.0	0.1
	1.5	4325.6	4324.1	-0.8	0.3
	1.8	4325.9	4324.1	-0.8	0.3
MEAN	1.68	4325.45	4323.77	-1.13	0.00
S.D.	0.40	0.38	0.53	RMS 1.24	

FIGURE 864
FIELD TEST DATA

STATION SD 298
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR FOSTER
INSTRUMENT NO. 14433

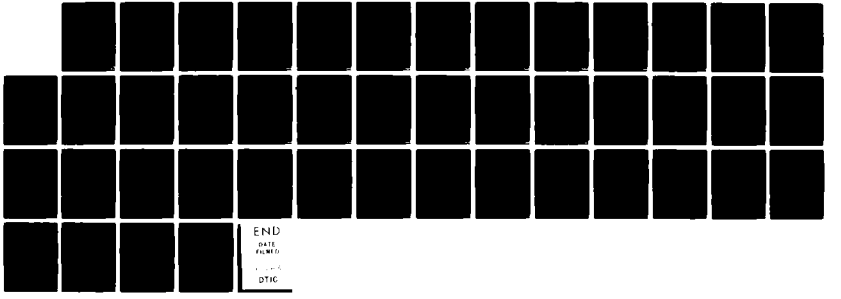
TRUE AZIMUTH 4324.9 MILS
AZIMUTH MARK OSC
TIME 2249-2305
RECORDER FURR

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4325.1	4323.1	-1.8	-0.0
	1.9	4325.3	4323.4	-1.5	0.3
	2.0	4325.1	4323.1	-1.8	-0.0
	2.5	4325.4	4322.9	-2.0	-0.2
	2.0	4325.3	4323.3	-1.6	0.2
	2.0	4325.0	4323.0	-1.9	-0.1
	2.0	4325.3	4323.3	-1.6	0.2
	2.3	4325.1	4322.8	-2.1	-0.3
	1.8	4325.3	4323.5	-1.4	0.4
	2.0	4325.0	4323.0	-1.9	-0.1
MEAN	2.05	4325.19	4323.14	-1.76	0.00
S.D.	0.20	0.14	0.23	RMS 1.77	

FIGURE B65
FIELD TEST DATA

A128 395 CIRCUMPOLAR METHOD FOR DETERMINING AZIMUTH(U) ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA D P DERE ET AL. FEB 83 ETL-0317 2/2

CLASSIFIED F/G 19/5 NL



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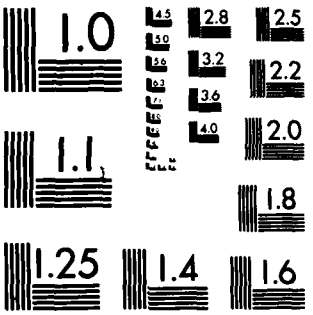


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

STATION ETL WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR TYSON
INSTRUMENT NO. 14403

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2130-2215
RECORDER TYSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	387.5	387.5	-0.3	0.4
	0.2	387.5	387.3	-0.5	0.2
	0.1	387.5	387.4	-0.4	0.3
	0.2	387.5	387.3	-0.5	0.2
	6400.0	387.5	387.5	-0.3	0.4
	1.5	388.0	386.5	-1.3	-0.6
	1.2	387.9	386.7	-1.1	-0.4
	1.0	387.9	386.9	-0.9	-0.2
	0.5	387.6	387.1	-0.7	0.0
	1.2	387.8	386.6	-1.2	-0.5
MEAN	0.59	387.67	387.08	-0.72	0.00
S.D.	0.58	0.21	0.38	RMS 0.80	

FIGURE B66
FIELD TEST DATA

STATION ETL WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR TYSON
INSTRUMENT NO. 14403

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK CAT-4
TIME 2215-2300
RECORDER TYSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.2	387.5	387.3	-0.5	0.5
	0.5	387.5	386.9	-0.9	0.1
	0.5	387.5	387.0	-0.8	0.2
	0.2	387.2	387.0	-0.8	0.2
	0.2	387.0	386.8	-1.0	-0.0
	0.3	387.0	386.7	-1.1	-0.1
	6400.0	387.0	387.0	-0.8	0.2
	0.5	387.0	386.5	-1.3	-0.3
	0.5	387.0	386.5	-1.3	-0.3
	0.4	387.0	386.6	-1.2	-0.2
MEAN	0.34	387.17	386.83	-0.97	0.00
S.D.	0.19	0.24	0.26	RMS 1.00	

FIGURE B67
FIELD TEST DATA

STATION ETL WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR TYSON
INSTRUMENT NO. 14403

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2420-0100
RECORDER TYSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.5	387.0	386.5	-1.3	-0.0
	0.5	387.0	386.5	-1.3	-0.0
	6400.0	386.5	386.5	-1.3	-0.0
	0.1	386.8	386.7	-1.1	0.2
	0.2	387.0	386.8	-1.0	0.3
	0.2	387.0	386.8	-1.0	0.3
	0.2	386.5	386.3	-1.5	-0.2
	0.2	386.5	386.3	-1.5	-0.2
	0.1	386.5	386.4	-1.4	-0.1
	6400.0	386.5	386.5	-1.3	-0.0
MEAN	0.20	386.73	386.53	-1.27	0.00
S.D.	0.18	0.25	0.18	RMS 1.28	

FIGURE B68
FIELD TEST DATA

STATION ETL WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR TYSON
INSTRUMENT NO. 14403

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 0100-0155
RECORDER TYSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	386.8	385.8	-2.0	-0.5
	0.8	386.8	386.0	-1.8	-0.3
	6399.8	386.0	386.2	-1.6	-0.1
	6399.9	386.1	386.2	-1.6	-0.1
	6399.5	386.2	386.7	-1.1	0.4
	6399.6	386.0	386.4	-1.4	0.1
	6399.6	386.0	386.4	-1.4	0.1
	6399.9	386.2	386.3	-1.5	0.0
	6399.9	386.2	386.3	-1.5	0.0
	6399.9	386.2	386.3	-1.5	0.0
MEAN	-0.01	386.25	386.26	-1.54	0.00
S.D.	0.50	0.30	0.24	RMS 1.56	

FIGURE B69
FIELD TEST DATA

STATION ETL WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR TYSON
INSTRUMENT NO. 14403

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 0200-0250
RECORDER TYSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6399.2	386.0	386.8	-1.0	0.3
	6399.2	386.0	386.8	-1.0	0.3
	6399.3	385.5	386.2	-1.6	-0.3
	6399.2	385.5	386.3	-1.5	-0.2
	6399.2	385.5	386.3	-1.5	-0.2
	6399.1	385.5	386.4	-1.4	-0.1
	6399.0	385.5	386.5	-1.3	0.0
	6399.0	385.6	386.6	-1.2	0.1
	6399.0	385.5	386.5	-1.3	0.0
	6399.0	385.5	386.5	-1.3	0.0
MEAN	-0.88	385.61	386.49	-1.31	0.00
S.D.	0.11	0.21	0.20	RMS 1.32	

FIGURE B70
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14403

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2425-2443
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	380.2	379.2	-1.1	-0.1
	1.3	380.3	379.0	-1.3	-0.3
	1.0	380.5	379.5	-0.8	0.3
	1.1	380.1	379.0	-1.3	-0.3
	0.9	380.3	379.4	-0.9	0.2
	1.0	380.3	379.3	-1.0	0.1
	1.0	380.1	379.1	-1.2	-0.2
	1.0	380.1	379.1	-1.2	-0.2
	0.8	380.4	379.6	-0.7	0.4
	1.0	380.3	379.3	-1.0	0.1
MEAN	1.01	380.26	379.25	-1.05	0.00
S.D.	0.13	0.13	0.21	RMS 1.07	

FIGURE B71
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14403

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2106-2132
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.1	381.0	379.9	-0.4	0.6
	1.5	381.0	379.5	-0.8	0.2
	1.3	380.8	379.5	-0.8	0.2
	1.2	380.9	379.7	-0.6	0.4
	1.1	380.8	379.7	-0.6	0.4
	2.0	380.9	378.9	-1.4	-0.4
	2.1	380.8	378.7	-1.6	-0.6
	2.3	380.9	378.6	-1.7	-0.7
	1.9	380.6	378.7	-1.6	-0.6
	1.3	380.9	379.6	-0.7	0.3
MEAN	1.58	380.86	379.28	-1.02	0.00
S.D.	0.45	0.12	0.50	RMS 1.12	

FIGURE B72
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14403

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2151-2215
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.3	380.2	378.9	-1.4	-0.1
	1.0	380.1	379.1	-1.2	0.1
	1.0	380.1	379.1	-1.2	0.1
	0.9	380.0	379.1	-1.2	0.1
	1.3	380.0	378.7	-1.6	-0.3
	1.1	380.0	378.9	-1.4	-0.1
	1.2	380.0	378.8	-1.5	-0.2
	0.9	380.0	379.1	-1.2	0.1
	1.0	380.2	379.2	-1.1	0.2
	1.3	380.1	378.8	-1.5	-0.2
MEAN	1.10	380.07	378.97	-1.33	0.00
S.D.	0.16	0.08	0.17	RMS 1.34	

FIGURE B73
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14403

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2258-2320
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.9	380.3	379.4	-0.9	-0.0
	0.8	380.3	379.5	-0.8	0.1
	0.5	380.1	379.6	-0.7	0.2
	0.9	380.3	379.4	-0.9	-0.0
	1.1	380.3	379.2	-1.1	-0.2
	1.0	380.4	379.4	-0.9	-0.0
	0.9	380.3	379.4	-0.9	-0.0
	1.0	380.3	379.3	-1.0	-0.1
	1.0	380.5	379.5	-0.8	0.1
	1.0	380.4	379.4	-0.9	-0.0
MEAN	0.91	380.32	379.41	-0.89	0.00
S.D.	0.17	0.10	0.11	RMS 0.90	

FIGURE B74
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR NILES
INSTRUMENT NO. 14403

TRUE AZIMUTH 380.3 MILS
AZIMUTH MARK GAT-4
TIME 2334-2345
RECORDER NILES

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	380.3	379.3	-1.0	0.1
	1.1	380.3	379.2	-1.1	-0.0
	1.0	380.5	379.5	-0.8	0.3
	1.2	380.3	379.1	-1.2	-0.1
	1.1	380.3	379.2	-1.1	-0.0
	1.0	380.3	379.3	-1.0	0.1
	1.0	380.2	379.2	-1.1	-0.0
	1.0	380.3	379.3	-1.0	0.1
	1.0	380.2	379.2	-1.1	-0.0
	1.3	380.3	379.0	-1.3	-0.2
MEAN	1.07	380.30	379.23	-1.07	0.00
S.D.	0.11	0.08	0.13	RMS 1.08	

FIGURE B75
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14403

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2120-2148
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.2	377.8	374.6	-1.8	-0.3
	3.0	377.6	374.6	-1.8	-0.3
	2.5	377.5	375.0	-1.4	0.1
	2.7	377.6	374.9	-1.5	0.0
	2.5	377.6	375.1	-1.3	0.2
	2.4	377.4	375.0	-1.4	0.1
	2.5	377.6	375.1	-1.3	0.2
	2.7	377.5	374.8	-1.6	-0.1
	2.8	377.6	374.8	-1.6	-0.1
	2.7	377.5	374.8	-1.6	-0.1
MEAN	2.70	377.57	374.87	-1.53	0.00
S.D.	0.25	0.11	0.18	RMS 1.54	

FIGURE B76
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14403

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2200-2230
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.1	377.1	375.0	-1.4	0.1
	2.2	377.3	375.1	-1.3	0.2
	2.7	377.3	374.6	-1.8	-0.3
	2.6	377.2	374.6	-1.8	-0.3
	2.6	377.3	374.7	-1.7	-0.2
	2.3	377.2	374.9	-1.5	0.0
	2.3	377.3	375.0	-1.4	0.1
	2.4	377.2	374.8	-1.6	-0.1
	2.6	377.3	374.7	-1.7	-0.2
	1.9	377.3	375.4	-1.0	0.5
MEAN	2.37	377.25	374.88	-1.52	0.00
S.D.	0.26	0.07	0.25	RMS 1.54	

FIGURE B77
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14403

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2255-2315
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.5	377.3	375.8	-0.6	0.5
	1.8	377.3	375.5	-0.9	0.2
	1.7	377.3	375.6	-0.8	0.3
	1.9	377.3	375.4	-1.0	0.1
	2.1	377.2	375.1	-1.3	-0.2
	1.9	377.3	375.4	-1.0	0.1
	2.3	377.2	374.9	-1.5	-0.4
	2.0	377.2	375.2	-1.2	-0.1
	2.3	377.2	374.9	-1.5	-0.4
	2.0	377.3	375.3	-1.1	-0.0
MEAN	1.95	377.26	375.31	-1.09	0.00
S.D.	0.25	0.05	0.29	RMS 1.12	

FIGURE 878
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14403

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2320-2340
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.8	377.2	375.4	-1.0	0.1
	1.9	377.3	375.4	-1.0	0.1
	2.4	377.2	374.8	-1.6	-0.5
	2.0	377.4	375.4	-1.0	0.1
	2.0	377.2	375.2	-1.2	-0.1
	1.9	377.1	375.2	-1.2	-0.1
	2.0	377.2	375.2	-1.2	-0.1
	1.8	377.2	375.4	-1.0	0.1
	1.8	377.2	375.4	-1.0	0.1
	1.9	377.3	375.4	-1.0	0.1
MEAN	1.95	377.23	375.28	-1.12	0.00
S.D.	0.18	0.08	0.19	RMS 1.13	

FIGURE B79
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14403

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2428-2448
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	377.1	375.1	-1.3	-0.2
	1.8	377.2	375.4	-1.0	0.1
	1.9	377.1	375.2	-1.2	-0.1
	1.9	377.2	375.3	-1.1	0.0
	1.8	377.2	375.4	-1.0	0.1
	1.8	377.3	375.5	-0.9	0.2
	2.0	377.1	375.1	-1.3	-0.2
	2.1	377.3	375.2	-1.2	-0.1
	1.9	377.2	375.3	-1.1	0.0
	2.0	377.2	375.2	-1.2	-0.1
MEAN	1.92	377.19	375.27	-1.13	0.00
S.D.	0.10	0.07	0.13	RMS 1.14	

FIGURE B80
FIELD TEST DATA

STATION SD 302
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR TETREAULT
INSTRUMENT NO. 14403

TRUE AZIMUTH 4321.8 MILS
AZIMUTH MARK OSC
TIME 2217-2244
RECORDER HUNTING

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.1	4323.9	4321.8	0.0	0.4
	2.1	4323.4	4321.3	-0.5	-0.1
	2.0	4323.4	4321.4	-0.4	-0.0
	1.8	4323.0	4321.2	-0.6	-0.2
	1.5	4323.0	4321.5	-0.3	0.1
	1.8	4323.3	4321.5	-0.3	0.1
	2.0	4323.4	4321.4	-0.4	-0.0
	1.7	4323.3	4321.6	-0.2	0.2
	1.7	4323.2	4321.5	-0.3	0.1
	1.8	4323.0	4321.2	-0.6	-0.2
MEAN	1.85	4323.29	4321.44	-0.36	0.00
S.D.	0.20	0.27	0.18	RMS 0.40	

FIGURE B81
FIELD TEST DATA

STATION SD 302
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR TETREAULT
INSTRUMENT NO. 14403

TRUE AZIMUTH 4321.8 MILS
AZIMUTH MARK OSC
TIME 2110-2134
RECORDER HUNTING

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4323.8	4321.8	0.0	-0.6
	1.4	4324.0	4322.6	0.8	0.3
	1.2	4323.8	4322.6	0.8	0.3
	1.0	4323.8	4322.8	1.0	0.5
	1.1	4323.5	4322.4	0.6	0.1
	1.1	4323.4	4322.3	0.5	-0.1
	1.2	4323.8	4322.6	0.8	0.3
	1.0	4323.0	4322.0	0.2	-0.4
	0.8	4323.0	4322.2	0.4	-0.2
	0.8	4323.0	4322.2	0.4	-0.2
MEAN	1.16	4323.51	4322.35	0.55	0.00
S.D.	0.35	0.39	0.31	RMS 0.62	

FIGURE B82
FIELD TEST DATA

STATION SO 302
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR HUNTING
INSTRUMENT NO. 14403

TRUE AZIMUTH 4321.8 MILS
AZIMUTH MARK OSC
TIME 2015-2100
RECORDER TETREAULT

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4324.0	4322.0	0.2	-0.4
	2.0	4324.4	4322.4	0.6	0.0
	2.0	4324.5	4322.5	0.7	0.1
	1.5	4324.5	4323.0	1.2	0.6
	2.0	4324.6	4322.6	0.8	0.2
	2.0	4324.5	4322.5	0.7	0.1
	2.0	4324.5	4322.5	0.7	0.1
	2.0	4324.0	4322.0	0.2	-0.4
	2.0	4324.5	4322.5	0.7	0.1
	2.0	4324.0	4322.0	0.2	-0.4
MEAN	1.95	4324.35	4322.40	0.60	0.00
S.D.	0.16	0.25	0.32	RMS 0.67	

FIGURE B83
FIELD TEST DATA

STATION SD 302
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR HUNTING
INSTRUMENT NC. 14403

TRUE AZIMUTH 4321.8 MILS
AZIMUTH MARK OSC
TIME 2200-2211
RECORDER TETREAULT

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.5	4322.3	4320.8	-1.0	-0.4
	1.5	4323.0	4321.5	-0.3	0.3
	2.0	4323.0	4321.0	-0.8	-0.2
	2.0	4323.2	4321.2	-0.6	0.0
	1.7	4323.1	4321.4	-0.4	0.2
	2.0	4323.2	4321.2	-0.6	0.0
	2.0	4323.3	4321.3	-0.5	0.1
	2.0	4323.0	4321.0	-0.8	-0.2
	1.9	4323.1	4321.2	-0.6	0.0
	1.9	4323.2	4321.3	-0.5	0.1
MEAN	1.85	4323.04	4321.19	-0.61	0.00
S.D.	0.21	0.28	0.21	RMS 0.64	

FIGURE B84
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 25 AUG 81
OPERATOR DERE
INSTRUMENT NO. 14403

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 0103-0124
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.5	385.0	383.5	-0.6	-0.5
	1.0	385.0	384.0	-0.1	0.0
	1.2	385.1	383.9	-0.2	-0.1
	1.0	385.0	384.0	-0.1	0.0
	0.9	385.0	384.1	0.0	0.1
	1.0	385.1	384.1	0.0	0.1
	1.0	385.2	384.2	0.1	0.2
	1.0	385.0	384.0	-0.1	0.0
	1.2	385.2	384.0	-0.1	0.0
	1.2	385.0	383.8	-0.3	-0.2
MEAN	1.10	385.06	383.96	-0.14	0.00
S.D.	0.18	0.08	0.20	RMS 0.23	

FIGURE B 85
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14426

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2300
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6400.0	384.1	384.1	0.0	0.2
	6400.0	384.1	384.1	0.0	0.2
	6400.0	384.1	384.1	0.0	0.2
	0.1	384.1	384.0	-0.1	0.1
	6400.0	384.1	384.1	0.0	0.2
	0.8	384.1	383.3	-0.8	-0.6
	0.7	384.1	383.4	-0.7	-0.5
	0.1	384.1	384.0	-0.1	0.1
	6400.0	384.1	384.1	0.0	0.2
	6400.0	384.1	384.1	0.0	0.2
MEAN	0.17	384.10	383.93	-0.17	0.00
S.D.	0.31	0.00	0.31	RMS 0.34	

FIGURE B86
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14426

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2135-2330
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ.
	6400.0	381.9	381.9	-2.2	-0.7
	6399.1	381.9	382.8	-1.3	0.2
	6398.9	381.9	383.0	-1.1	0.4
	6399.2	381.9	382.7	-1.4	0.1
	6399.1	381.9	382.8	-1.3	0.2
	6399.2	381.9	382.7	-1.4	0.1
	6399.8	381.9	382.1	-2.0	-0.5
	6400.0	382.0	382.0	-2.1	-0.6
	6399.2	381.9	382.7	-1.4	0.1
	6398.8	382.0	383.2	-0.9	0.6
MEAN	-0.67	381.92	382.59	-1.51	0.00
S.D.	0.44	0.04	0.44	RMS 1.57	

FIGURE B87
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14426

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2430
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ.
	6399.0	381.1	382.1	-2.0	-0.4
	6398.9	381.2	382.3	-1.8	-0.2
	6398.2	381.2	383.0	-1.1	0.6
	6399.0	381.1	382.1	-2.0	-0.4
	6398.2	381.1	382.9	-1.2	0.5
	6399.8	381.1	381.3	-2.8	-1.2
	6398.2	381.1	382.9	-1.2	0.5
	6398.8	381.1	382.3	-1.8	-0.2
	6398.1	381.1	383.0	-1.1	0.6
	6398.5	381.1	382.6	-1.5	0.2
MEAN	-1.33	381.12	382.45	-1.65	0.00
S.D.	0.54	0.04	0.54	RMS 1.73	

FIGURE B88
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14426

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 0105-0145
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	383.9	382.9	-1.2	-0.0
	1.1	384.0	382.9	-1.2	-0.0
	0.9	384.0	383.1	-1.0	0.2
	1.1	384.0	382.9	-1.2	-0.0
	1.0	383.9	382.9	-1.2	-0.0
	1.1	384.0	382.9	-1.2	-0.0
	1.0	383.9	382.9	-1.2	-0.0
	1.0	383.9	382.9	-1.2	-0.0
	0.9	383.9	383.0	-1.1	0.1
	1.1	384.0	382.9	-1.2	-0.0
MEAN	1.02	383.95	382.93	-1.17	0.00
S.D.	0.08	0.05	0.07	RMS 1.17	

FIGURE B89
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 15 JULY 81
OPERATOR JARRET
INSTRUMENT NO. 14426

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 0200-0240
RECORDER JARRET

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	0.9	384.0	383.1	-1.0	0.2
	1.1	384.0	382.9	-1.2	-0.1
	1.5	384.1	382.6	-1.5	-0.4
	0.9	384.1	383.2	-0.9	0.3
	1.1	384.1	383.0	-1.1	0.1
	0.9	384.0	383.1	-1.0	0.2
	0.9	384.1	383.2	-0.9	0.3
	0.9	384.1	383.2	-0.9	0.3
	1.1	383.1	382.0	-2.1	-1.0
	0.8	384.0	383.2	-0.9	0.3
MEAN	1.01	383.96	382.95	-1.15	0.00
S.D.	0.20	0.31	0.38	RMS 1.21	

FIGURE B90
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14426

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2105-2135
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.8	377.4	375.6	-0.8	0.7
	1.9	377.3	375.4	-1.0	0.5
	2.2	377.3	375.1	-1.3	0.2
	2.0	377.4	375.4	-1.0	0.5
	2.3	377.3	375.0	-1.4	0.1
	2.4	377.3	374.9	-1.5	-0.1
	3.0	377.2	374.2	-2.2	-0.8
	2.1	377.5	375.4	-1.0	0.5
	3.0	377.2	374.2	-2.2	-0.8
	2.9	377.2	374.3	-2.1	-0.7
MEAN	2.36	377.31	374.95	-1.45	0.00
S.D.	0.46	0.10	0.54	RMS 1.54	

FIGURE B91
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14426

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2150-2215
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	3.3	377.8	374.5	-1.9	-0.2
	3.2	378.0	374.8	-1.6	0.1
	3.0	377.7	374.7	-1.7	0.0
	3.0	377.7	374.7	-1.7	0.0
	2.9	377.9	375.0	-1.4	0.3
	3.0	377.7	374.7	-1.7	0.0
	3.0	377.6	374.6	-1.8	-0.1
	2.9	377.6	374.7	-1.7	0.0
	3.1	377.7	374.6	-1.8	-0.1
	3.2	377.8	374.6	-1.8	-0.1
MEAN	3.06	377.75	374.69	-1.71	0.00
S.D.	0.13	0.13	0.14	RMS 1.71	

FIGURE B92
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14426

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2300-2320
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.6	377.7	375.1	-1.3	-0.1
	2.5	377.8	375.3	-1.1	0.1
	2.6	377.7	375.1	-1.3	-0.1
	2.5	377.6	375.1	-1.3	-0.1
	2.6	377.7	375.1	-1.3	-0.1
	2.5	377.7	375.2	-1.2	0.0
	2.3	377.7	375.4	-1.0	0.2
	2.6	377.6	375.0	-1.4	-0.2
	2.5	377.7	375.2	-1.2	0.0
	2.4	377.7	375.3	-1.1	0.1
MEAN	2.51	377.69	375.18	-1.22	0.00
S.D.	0.10	0.06	0.12	RMS 1.23	

FIGURE B93
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14426

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2322-2343
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.7	377.7	375.0	-1.4	-0.1
	2.6	377.6	375.0	-1.4	-0.1
	2.4	377.7	375.3	-1.1	0.2
	2.5	377.7	375.2	-1.2	0.1
	2.6	377.6	375.0	-1.4	-0.1
	2.6	377.6	375.0	-1.4	-0.1
	2.6	377.6	375.0	-1.4	-0.1
	2.5	377.7	375.2	-1.2	0.1
	2.7	377.7	375.0	-1.4	-0.1
	2.7	377.6	374.9	-1.5	-0.2
MEAN	2.59	377.65	375.06	-1.34	0.00
S.D.	0.10	0.05	0.13	RMS 1.35	

FIGURE B94
FIELD TEST DATA

STATION EPG EAST
RETICLE (N80-90)
DATE 29 JULY 81
OPERATOR OLIVER
INSTRUMENT NO. 14426

TRUE AZIMUTH 376.4 MILS
AZIMUTH MARK GAT-4
TIME 2420-2445
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.5	377.7	375.2	-1.2	-0.1
	2.4	377.8	375.4	-1.0	0.1
	2.1	377.6	375.5	-0.9	0.2
	2.3	377.6	375.3	-1.1	0.0
	2.3	377.5	375.2	-1.2	-0.1
	2.3	377.6	375.3	-1.1	0.0
	2.6	377.5	374.9	-1.5	-0.4
	2.3	377.6	375.3	-1.1	0.0
	2.3	377.6	375.3	-1.1	0.0
	2.1	377.6	375.5	-0.9	0.2
MEAN	2.32	377.61	375.29	-1.11	0.00
S.D.	0.15	0.09	0.17	RMS 1.12	

FIGURE B95
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR DERE
INSTRUMENT NO. 14426

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2100
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	388.6	387.6	-0.2	0.0
	0.7	388.5	387.8	0.0	0.2
	1.1	388.7	387.6	-0.2	0.0
	0.9	388.7	387.8	0.0	0.2
	1.0	388.7	387.7	-0.1	0.1
	1.1	388.5	387.4	-0.4	-0.2
	0.8	388.5	387.7	-0.1	0.1
	1.0	388.5	387.5	-0.3	-0.1
	1.0	388.5	387.5	-0.3	-0.1
	1.1	388.2	387.1	-0.7	-0.5
MEAN	0.97	388.54	387.57	-0.23	0.00
S.D.	0.13	0.15	0.21	RMS 0.30	

FIGURE B96
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR DERE
INSTRUMENT NO. 14426

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2150
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	388.0	387.0	-0.8	-0.1
	1.0	388.0	387.0	-0.8	-0.1
	1.0	387.9	386.9	-0.9	-0.2
	1.5	388.1	386.6	-1.2	-0.5
	0.9	388.0	387.1	-0.7	0.0
	1.0	387.9	386.9	-0.9	-0.2
	1.0	388.0	387.0	-0.8	-0.1
	1.1	387.8	386.7	-1.1	-0.4
	0.9	388.8	387.9	0.1	0.8
	1.0	388.9	387.9	0.1	0.8
MEAN	1.04	388.14	387.10	-0.70	0.00
S.D.	0.17	0.38	0.45	RMS 0.82	

FIGURE B97
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR DERE
INSTRUMENT NO. 14426

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2255
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	387.1	386.1	-1.7	-0.2
	1.1	387.0	385.9	-1.9	-0.4
	0.5	387.0	386.5	-1.3	0.2
	1.0	387.1	386.1	-1.7	-0.2
	0.6	387.0	386.4	-1.4	0.1
	0.2	387.2	387.0	-0.8	0.7
	1.0	387.5	386.5	-1.3	0.2
	0.6	387.0	386.4	-1.4	0.1
	1.3	387.0	385.7	-2.1	-0.6
	1.0	387.0	386.0	-1.8	-0.3
MEAN	0.83	387.09	386.26	-1.54	0.00
S.D.	0.34	0.16	0.37	RMS 1.58	

FIGURE B98
FIELD TEST DATA

STATION EPG WEST
RETICLE (N80-90)
DATE 30 JULY 81
OPERATOR DERE
INSTRUMENT NO. 14426

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK GAT-4
TIME 2330
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	1.0	388.0	387.0	-0.8	0.1
	0.7	387.8	387.1	-0.7	0.2
	1.0	387.9	386.9	-0.9	-0.0
	1.0	387.6	386.6	-1.2	-0.3
	0.8	387.8	387.0	-0.8	0.1
	0.9	387.8	386.9	-0.9	-0.0
	0.9	388.0	387.1	-0.7	0.2
	0.7	387.9	387.2	-0.6	0.3
	0.9	387.6	386.7	-1.1	-0.2
	1.0	387.8	386.8	-1.0	-0.1
MEAN	0.89	387.82	386.93	-0.87	0.00
S.D.	0.12	0.14	0.19	RMS 0.89	

FIGURE B99
FIELD TEST DATA

STATION EPG WEST
RETICLE (M80-90)
DATE 30 JULY 81
OPERATOR DERE
INSTRUMENT NO. 14426

TRUE AZIMUTH 387.8 MILS
AZIMUTH MARK SAT-4
TIME 2430
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ.
	6400.0	386.9	386.9	-0.9	-0.1
	6399.9	387.0	387.1	-0.7	0.2
	0.1	387.0	386.9	-0.9	-0.1
	6399.8	386.9	387.1	-0.7	0.2
	0.1	387.0	386.9	-0.9	-0.1
	6400.0	387.0	387.0	-0.8	0.1
	6399.8	386.8	387.0	-0.8	0.1
	0.3	386.7	386.4	-1.4	-0.6
	6399.8	386.8	387.0	-0.8	0.1
	6399.5	386.7	387.2	-0.6	0.3
MEAN	-0.07	386.88	386.95	-0.85	0.00
S.D.	0.22	0.12	0.22	RMS 0.87	

FIGURE B100
FIELD TEST DATA

STATION SD 302
RETICLE (N80-90)
DATE 1 SEPT 81
OPERATOR HUNTING
INSTRUMENT NO. 14426

TRUE AZIMUTH 4321.8 MILS
AZIMUTH MARK OSC
TIME 2055-2202
RECORDER BILLUPS

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4322.0	4320.0	-1.8	-0.2
	1.5	4322.0	4320.5	-1.3	0.3
	2.0	4322.0	4320.0	-1.8	-0.2
	1.0	4321.5	4320.5	-1.3	0.3
	1.5	4321.5	4320.0	-1.8	-0.2
	1.5	4321.5	4320.0	-1.8	-0.2
	1.5	4322.0	4320.5	-1.3	0.3
	2.0	4322.0	4320.0	-1.8	-0.2
	2.0	4322.0	4320.0	-1.8	-0.2
	1.5	4322.0	4320.5	-1.3	0.3
MEAN	1.65	4321.85	4320.20	-1.60	0.00
S.D.	0.34	0.24	0.26	RMS 1.62	

FIGURE B101
FIELD TEST DATA

STATION SD 304
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR WILSON
INSTRUMENT NO. 14426

TRUE AZIMUTH 4320.4 MILS
AZIMUTH MARK OSC
TIME 2155-2221
RECORDER VANNEST

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4321.6	4319.6	-0.8	0.1
	2.0	4321.7	4319.7	-0.7	0.2
	2.1	4321.5	4319.4	-1.0	-0.1
	2.0	4321.5	4319.5	-0.9	-0.0
	2.0	4321.5	4319.5	-0.9	-0.0
	2.1	4321.4	4319.3	-1.1	-0.2
	2.0	4321.5	4319.5	-0.9	-0.0
	2.0	4321.5	4319.5	-0.9	-0.0
	2.0	4321.6	4319.6	-0.8	0.1
	2.0	4321.6	4319.6	-0.8	0.1
MEAN	2.02	4321.54	4319.52	-0.88	0.00
S.D.	0.04	0.08	0.11	RMS 0.89	

FIGURE B102
FIELD TEST DATA

STATION SD 304
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR VANNEST
INSTRUMENT NO. 14426

TRUE AZIMUTH 4320.4 MILS
AZIMUTH MARK OSC
TIME 2102-2133
RECORDER WILSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4321.5	4319.5	-0.9	-0.2
	2.0	4321.6	4319.6	-0.8	-0.1
	2.0	4321.5	4319.5	-0.9	-0.2
	2.0	4321.7	4319.7	-0.7	0.0
	2.0	4321.8	4319.8	-0.6	0.1
	2.0	4321.5	4319.5	-0.9	-0.2
	2.0	4321.8	4319.8	-0.6	0.1
	2.2	4321.8	4319.6	-0.8	-0.1
	2.0	4322.0	4320.0	-0.4	0.3
	2.2	4321.8	4319.6	-0.8	-0.1
MEAN	2.04	4321.70	4319.66	-0.74	0.00
S.D.	0.08	0.17	0.16	RMS 0.76	

FIGURE B103
FIELD TEST DATA

STATION SD 304
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR VANNEST
INSTRUMENT NO. 14426

TRUE AZIMUTH 4320.4 MILS
AZIMUTH MARK OSC
TIME 2035-2058
RECORDER WILSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4321.3	4319.3	-1.1	0.0
	2.0	4321.3	4319.3	-1.1	0.0
	2.0	4321.2	4319.2	-1.2	-0.1
	1.8	4321.3	4319.5	-0.9	0.2
	2.0	4321.3	4319.3	-1.1	0.0
	2.0	4321.2	4319.2	-1.2	-0.1
	2.0	4321.2	4319.2	-1.2	-0.1
	2.0	4321.3	4319.3	-1.1	0.0
	2.0	4321.3	4319.3	-1.1	0.0
	2.0	4321.3	4319.3	-1.1	0.0
MEAN	1.98	4321.27	4319.29	-1.11	0.00
S.D.	0.06	0.05	0.09	RMS 1.11	

FIGURE B104
FIELD TEST DATA

STATION SD 304
RETICLE (N80-90)
DATE 3 SEPT 81
OPERATOR VANNEST
INSTRUMENT NO. 14426

TRUE AZIMUTH 4320.4 MILS
AZIMUTH MARK OSC
TIME 2225-2243
RECORDER WILSON

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	2.0	4321.3	4319.3	-1.1	-0.0
	2.0	4321.4	4319.4	-1.0	0.1
	2.0	4321.3	4319.3	-1.1	-0.0
	2.0	4321.5	4319.5	-0.9	0.2
	2.0	4321.3	4319.3	-1.1	-0.0
	2.0	4321.3	4319.3	-1.1	-0.0
	2.0	4321.2	4319.2	-1.2	-0.1
	2.0	4321.3	4319.3	-1.1	-0.0
	2.0	4321.3	4319.3	-1.1	-0.0
	2.0	4321.3	4319.3	-1.1	-0.0
MEAN	2.00	4321.32	4319.32	-1.08	0.00
S.D.	0.00	0.08	0.08	RMS 1.08	

FIGURE B105
FIELD TEST DATA

STATION MID-WEST
RETICLE (N80-90)
DATE 25 AUG 81
OPERATOR DERE
INSTRUMENT NO. 14426

TRUE AZIMUTH 384.1 MILS
AZIMUTH MARK GAT-4
TIME 2330
RECORDER DERE

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ
	6399.4	383.5	384.1	0.0	0.2
	6399.5	383.5	384.0	-0.1	0.1
	6399.5	383.5	384.0	-0.1	0.1
	6399.8	383.6	383.8	-0.3	-0.1
	6399.4	383.6	384.2	0.1	0.3
	6399.5	383.1	383.6	-0.5	-0.3
	6399.4	383.2	383.8	-0.3	-0.1
	6399.7	383.2	383.5	-0.6	-0.4
	6399.1	383.1	384.0	-0.1	0.1
	6399.2	383.2	384.0	-0.1	0.1
MEAN	-0.55	383.35	383.90	-0.20	0.00
S.D.	0.21	0.21	0.22	RMS 0.29	

FIGURE B106
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 1 APRIL 82
OPERATOR DERE
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3
AZIMUTH MARK GAT-4
TIME 2225-2245
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ.
	8.1	388.0	379.9	-0.4	-0.2
	7.0	387.9	380.9	0.6	0.8
	7.8	388.1	380.3	0.0	0.2
	7.8	388.0	380.2	-0.1	0.1
	7.6	387.9	380.3	0.0	0.2
	7.1	387.3	380.2	-0.1	0.1
	6.9	387.0	380.1	-0.2	0.0
	7.8	387.0	379.2	-1.1	-0.9
	7.8	387.9	380.1	-0.2	0.0
	8.0	387.5	379.5	-0.8	-0.6
MEAN	7.59	387.66	380.07	-0.23	0.00
S.D.	0.43	0.42	0.46	RMS 0.50	

FIGURE B107
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 1 APRIL 82
OPERATOR DERE
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3
AZIMUTH MARK GAT-4
TIME 2250-2320
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF. FROM TRUE AZ.	DIF FROM MEAN AZ.
	8.0	387.9	379.9	-0.4	0.1
	8.0	387.5	379.5	-0.3	-0.3
	8.3	388.0	379.7	-0.6	-0.1
	7.9	387.9	380.0	-0.3	0.2
	8.0	388.0	380.0	-0.3	0.2
	8.0	387.9	379.9	-0.4	0.1
	7.7	387.5	379.8	-0.5	0.0
	8.3	388.0	379.7	-0.6	-0.1
	8.0	387.9	379.9	-0.4	0.1
	8.1	387.5	379.4	-0.9	-0.4
MEAN	8.03	387.81	379.78	-0.52	0.00
S.D.	0.18	0.22	0.20	RMS 0.55	

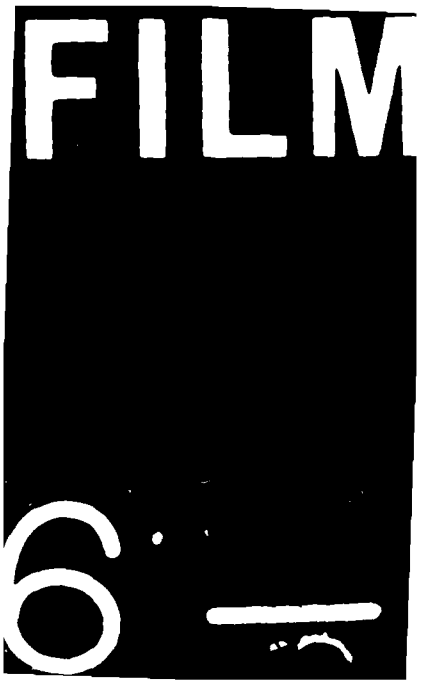
FIGURE B108
FIELD TEST DATA

STATION MID-EAST
RETICLE (N80-90)
DATE 1 APRIL 82
OPERATOR DERE
INSTRUMENT NO. 3310

TRUE AZIMUTH 380.3
AZIMUTH MARK GAT-4
TIME 2400-2430
RECORDER OLIVER

	STARS POINTING	TARGET POINTING	AZIMUTH MEASURED	DIF FROM TRUE AZ.	DIF FROM MEAN AZ.
	7.5	387.1	379.6	-0.7	-0.2
	8.1	387.9	379.8	-0.5	0.0
	7.9	387.5	379.6	-0.7	-0.2
	7.5	387.6	380.1	-0.2	0.3
	8.1	387.8	379.7	-0.6	-0.1
	8.0	387.2	379.2	-1.1	-0.6
	7.2	387.3	380.1	-0.2	0.3
	7.2	387.3	380.1	-0.2	0.3
	7.5	387.4	379.9	-0.4	0.1
	7.8	387.3	379.5	-0.8	-0.3
MEAN	7.68	387.44	379.76	-0.54	0.00
S.D.	0.35	0.26	0.30	RMS 0.61	

FIGURE B109
FIELD TEST DATA


FILM