shadow of the wire line E falls upon the slit F in the sight vane.

6. DECLINATION. When necessary to take this into consideration (for instance when using the instrument early A.M. or late P.M. in equatorial waters), set the cross wire G to the degrees marked on the wire line sight E, according to the SUN'S DECLINATION: follow previous directions until the shadow shown by the cross wires coincides with the cross cuts in the sight vane.

To use the Instrument with a STAR

1. Clamp the time circle horizontally.

2. Place the pointer A to "Ship's Head."

3. Sight the star, using the time circle divided to 180° to determine the position in usual manner.

To use the instrument WITHOUT THE SUN, BY A DISTANT OBJECT, the bearings of which are known.

1. Clamp the upper circle horizontally and place the sight vane pointer to XII or O.

2. Set and clamp the Compass dial Arrow pointer to the known bearing of the distant object.

3. Move the Compass dial by the projections, until you can sight the distant object through the sight vane.

The difference between the Compass dial of the instrument, and the compass on the Ship, is the deviation.

NOTE—The time circle H being divided also to 180°, it can be used with the aid of the sights to determine the correct or magnetic course, according to Burdwood's or other Tables, apart from the lower dial.

FRANK MORRISON & SONS
Compass Adjustors and Manufacturers
of Nautical Instruments
West Eleventh St., Cleveland, Ohio

Morrison was a dealer in Cleveland. The "Polaris" was made in London. Mine is signed "D. MacGregor, Glasgow", a "Nautical Optician", as dealers in navigation instruments and chronometers were called then, for whom it was made. I acquired it from a Great Lakes steamboat captain who was acquainted with Morrison.

HISTORY OF NAVIGATION

The Brown-Nassau Spherical computer

By John M. Luykx

GENERAL

The Brown-Nassau Spherical Computer is a plastic lightweight 12"x13" graphic device which weighs only 14 oz. It was designed in 1944 at the Case Institute of Technology, Cleveland, Ohio primarily for use in the rapid sight reduction of celestial observations for line of position (LOP). Its shape and handiness permits its use in lieu of sight reduction tables in small cramped areas such as the cockpit of a fighter aircraft. The computer solves the navigation triangle as well as other spherical trigonometric navigation problems in much the same way that a "coordinate converter" or "coordinate transformer" solves problems of spherical trigonometry through the relationship that exists between the Celestial Equator coordinate system and the Horizon coordinate system.

The celestial equator and horizon coordinate systems are described in great detail in the 1995 edition of Bowditch, pages 245-255. A description of how the navigation triangle is formed from elements of both the celestial equator and horizon coordinate systems is included on pages 254 and 255 of Bowditch and shown by diagram in figure 15309 on page 254.

CONSTRUCTION OF THE COMPUTER

The computer is constructed of laminated plastic sheets consisting of a rectangular opaque base plate and two transparent rotating quarter circles or "rotors", one against each side of the base plate. The main feature of each face of the base plate is a grid of curves enclosed in a quadrant of a circle 10" in diameter. The horizontal curves on each "rotor" represent parallels of latitude and the vertical curves represent hour angles. A circular declination scale is marked along the circumference of the quadrant on each face. (Figure 1) The two "rotors" are printed with curves matching the latitude curves of the base plate. The two rotors are pivoted at the lower left corner of each face of the base plate. (Figure 2)

OPERATION OF THE COMPUTER

The principal purpose of the computer is to determine computed altitude (Hc) and azimuth angle (Z) from values of latitude (L), meridian angle (t) and declination (d). The computer may also be used to compute initial Great Circle course (C) and Great Circle distance (D) between two points on the earth's surface and to identify stars from values of observed azimuth (ZN) and altitude (H).

Instructions printed on each side of the base plate direct the user to the exact sequence of operations in solving problems which may vary in accordance with the:

Declination (d) and Latitude(L) which may be "same name" or "contrary name"

Meridian Angle (t) - which may be greater or less than 90°

Declination (d) - which may be greater or less than Latitude (L)

For sight reduction the computed altitude (Hc) is obtained first from values of L, t and d. Once Hc is obtained, then, azimuth angle (Z) is computed from values of Hc, d and L.

Based on whether a) d and L are "same" or "contrary" name, b) t is greater or less than 90° and c) whether d is greater or less than L, one side or the other of the base

INDEX	B	A
ROTOR SETTING	$d = 53° \; 22'$	$H_c = 15° \; 30'$
ROTOR CURVE	$H_c = 15° \; 30'$	$d = 53° \; 22'$
GRID LAT. SCALE	$L = 28°$	$L = 28°$
GRID LHA SCALE	$LHA = 102°$	$Z = 37°$

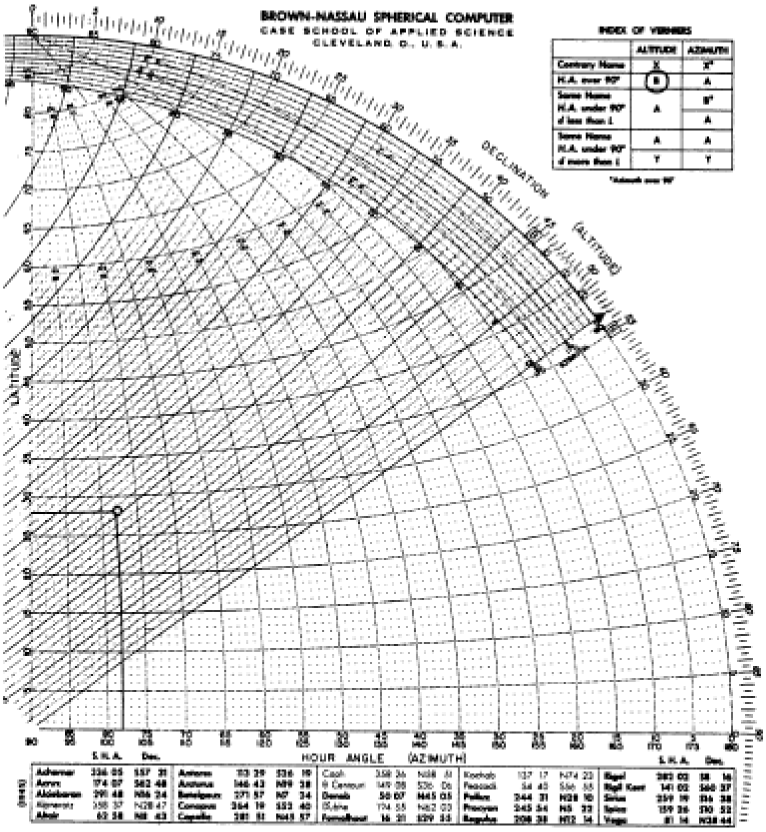

plate is selected for the sight reduction calculations.

Step One: A mark is placed on the intersection of the L and t curves on the base plate. This establishes the DR or the assumed position.

Step Two: The rotor is then set to the value of d.

Step Three: Hc is determined by the position of the selected mark (Step One) among the altitude curves on the rotor.

Step Four: The rotor is then set to the altitude (Hc) determined in Step Three.

Step Five: The point of intersection of the Declination (d) curve on the rotor and the Latitude (L) curve on the base plate is now determined. This point when extended to the Latitude scale on the left side of the rotor is the azimuth angle (Z).

Note: When solving for initial Great Circle Course and Great Circle Distance (D) follow the same procedure as above, substituting difference of Longitude (Dlo) between two places on the earth's surface for meridian angle t. Latitude (L) of the point of arrival is substituted for C and Great Circle Distance (D) is substituted for 90°-Hc. Initial Great Circle Course is equal to Z corrected to true azimuth (ZN).

ACCURACY OF THE COMPUTER

Although tests of the Brown-Nassau computer conducted by the Aeronautical Instruments Laboratory at the Naval Air Experimental Station at the Navy Yard, Philadelphia from January to June 1944 indicate that general accuracy ranges from 5 to 10 arc minutes, the writer has found that with careful handling and proper setting of the rotors, accuracy of within 2 to 3 arc minutes is possible in altitude and within 0°.3 in azimuth.

Results of accuracy tests conducted by the author

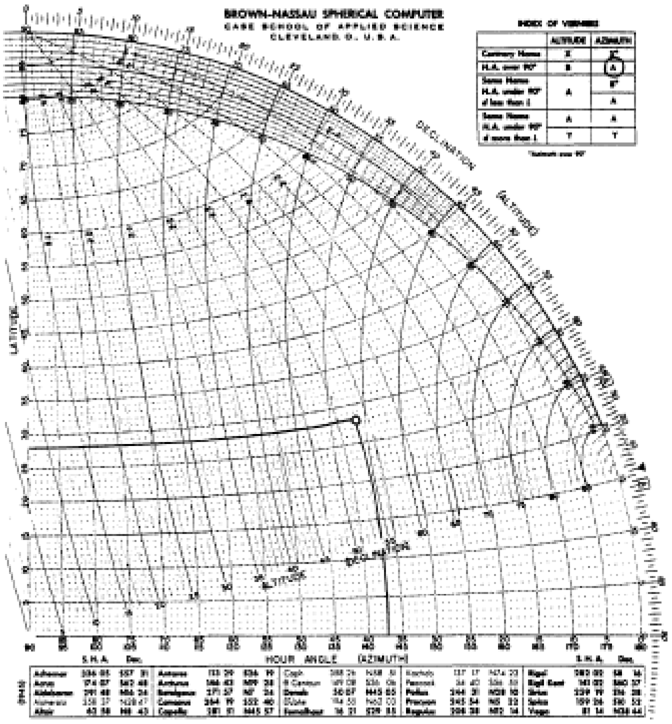

TABLE I
RESULTS OF THE ACCURACY TESTS

GIVEN VALUES			COMPUTED VALUES	
	1		2	3
L	d	t	Hc	ZN
N 35°04'	S 10°23'	E 55°36'	20°35' (20°34)' +1'	120.°0+ (119.°5+) +0.°5
N 22°49'	N 35°17'	W 75°20'	24°30' (24°29)' +1	299°.9+ (299.°9+) 0.°0
N 55°36'	N 40°29'	E 115°45'	20°20' (20°26)' +3'	047°.1+ (046°6.+) +0.°5
N 27°15'	S 17°47	W 45°18'	27°04' (27°06)' -2'	229.°7+ (229°3+) +0°.4
S 11°29'	N 10°19'	W 40°56'	43°54' (43°51)' +3'	296°.4+ (296°.4+) 0°.0
S 44°56'	S 50°41'	E 100°16'	27°51' (27°48)' +3'	135°.2+ (135°.1+) +0°.1
S 63°32'	S 40°29'	E 65°39'	46°12' (46°08)' +4'	089°.8+ (090°.4+) -0°.6
S 27°21'	N 25°11'	W 40°22'	24°35' (24°39)' -4'	319°.5+ 319°.9+ -0°.4
Arithmetic Mean Value of Error			Hc 2.'6	ZN 0°.3

give the following results:

Column 1 of the table provides the input data for each problem and columns 2 and 3 indicate the solution for the Hc and Z respectively by the Brown-Nassau Computer. Column values in parenthesis indicate the solution by electronic computer for comparison purposes.

SUMMARY

In 1944, at the height of air operations against Japan during World War II, one of the major problems in air navigation was the development of a computer or celestial navigation method suitable for use in small aircraft, such as fighters and attack bombers. The Navy requirements at that time were that:

The computer should be compact and light.

The computer should be simple to operate and unambiguous.

The computer should be sturdy and easy to use under cramped and adverse conditions.

Computer solutions should be rapid and accurate.

The Brown-Nassau computer fulfilled most of these requirements.

The last sentence in the NAES(AIL) report of 29 August 1944 mentioned in Paragraph IV above states:

"Considered as a whole the Brown-Nassau Computer is the first device tested warranting very extensive and complete service testing in small airplanes."

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