onto the upper cylinder, the telescoping joint is exposed. You can then similarly slip the shims between the lower cylinder and the upper cylinder tabs, and pull the two cylinders apart.

Why Different Constructions?

Given the simplicity of the older construction, I am inclined to wonder what prompted a change in design. We may never know, but I speculate the following two reasons.

First, if there was much need to take an Otis King apart, for cleaning or scale replacement, the greater difficulty presented by the older construction is a negative. On the other hand, repetition eases the process, so maybe this reason can be discounted.

Second, the older model involves metal-to-metal friction. The mechanics are consequently scratchy where the later model's friction is all felt-to-metal and the action is smooth. That yields a more comfortable user experience, which may have justified the design change.

Wichman "Aristo" P.A. 44

Determining True North from the Azimuth of Polaris

Richard Smith Hughes

The P.A. 44 is not a true slide rule, not having the multiply, divide, or find trig functions. The P.A 44's function is to locate the azimuth of the pole star; the horizontal angle of Polaris to true north, at the observer's longitude, latitude, month and day, and time of day from 1944 to the end of 1948.

Figure 1 illustrates the daily rotation of Polaris around true north (with a radius of 1° 02.5′). Assume Polaris is sighted with a "transit"; a telescope mounted on a horizontal plate with very accurate horizontal and vertical angle scales.

When Polaris is at position A or B (lower and upper culmination), the "transit" telescope is horizontally aligned towards true north. (see example 3). If the "transit" is pointing at position D (west elongation), move the horizontal angle 1° 02.5′ to the right and the telescope will be pointed towards true north (see example 4). If Polaris is sighted at an arbitrary position C, to determine true north your longitude, latitude, date, and time of day must be accurately known. Celestial navigation tables (which are published yearly) in conjunction with five place log and log trig tables must be used to calculate the azimuth of Polaris to true north.

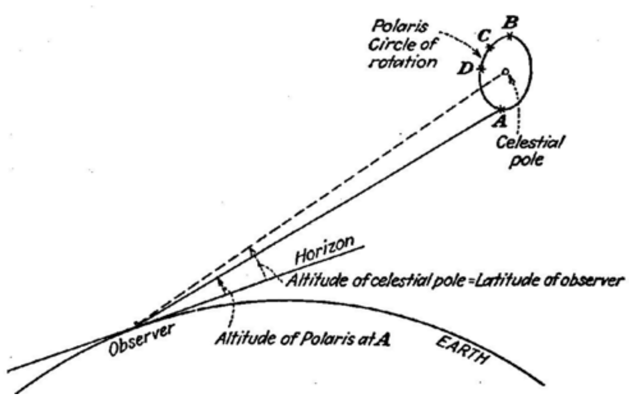


FIGURE 1. Polaris's path around true north

Although not a formidable task, the task must be repeated every time your location, date, or time changes. The P.A. 44 easily removes the need for celestial navigation and log tables, at least from 1944 to 1948. The P.A. 44 presents, in a graphical (front side) and tabular (back side) format true north for the observer's position, date, and time in World War II Germany, from 1944 to the end of 1948.

The P.A. 44 would have saved the user much calculating time and the need to carry celestial navigation and log tables. Certainly the data could have been given in printed tables but this would have required some sixty-seven million entries! The P.A. 44, Figure 2, is easy to use, and provides an advertised +/- 1 Mil accuracy. The following is a brief discussion of the history, operation, and examples. The bibliography lists several articles and books for those interested.

Firing long range artillery requires exact pointing directions from a known reference; typically true north. Artillery personnel use a 6400 Mil circle (1 Mil = 0.056250° {degrees} = 0.033750′ {minutes} = 0.06250^g {grads}). Gary LaPook (see the Bibliography) discusses two methods for determining true north used by the U.S. Army in artillery laying. One uses the celestial position of the Sun, the other the azimuths of the star Kochab (in Ursa Minor-the little dipper) and Polaris, also in Ursa Minor.

The P.A. 44, produced in Germany during World War II (probably in 1944), for the German army takes a different approach; determining the azimuth of Polaris to true north using the observer's known position, day/month, and time of day.

The position of celestial objects, planets, and stars, change (for a given position and time) from year to year, necessitating publishing celestial navigation tables every year. How-

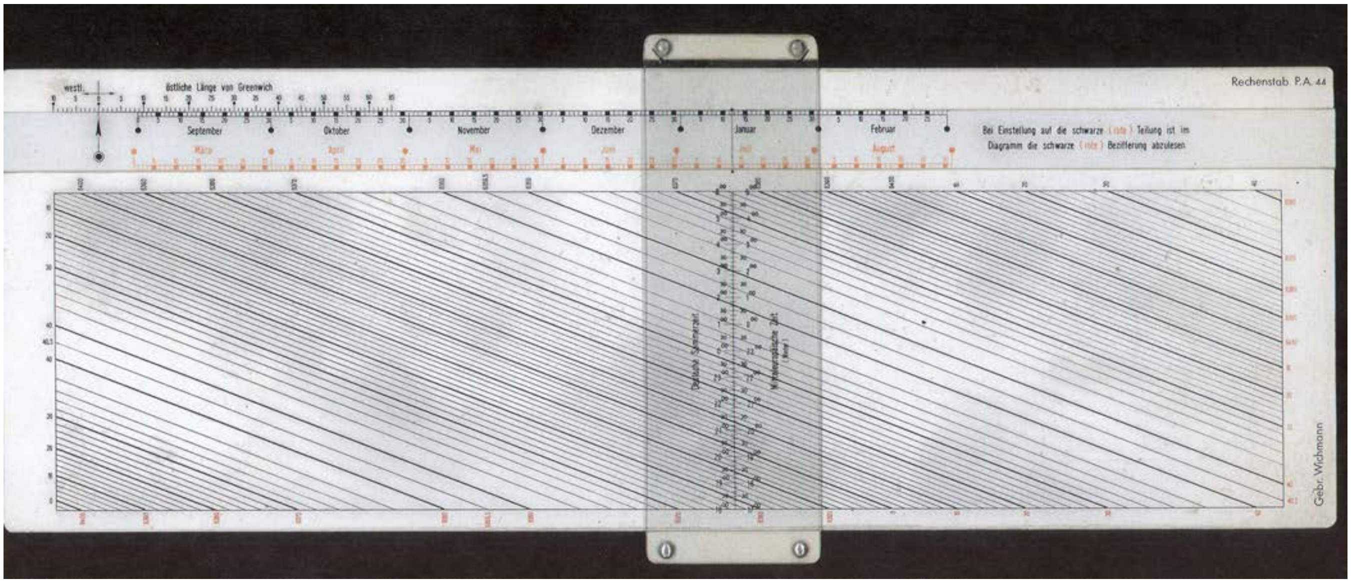


FIGURE 2. Front Latitude independent azimuth, D Mil

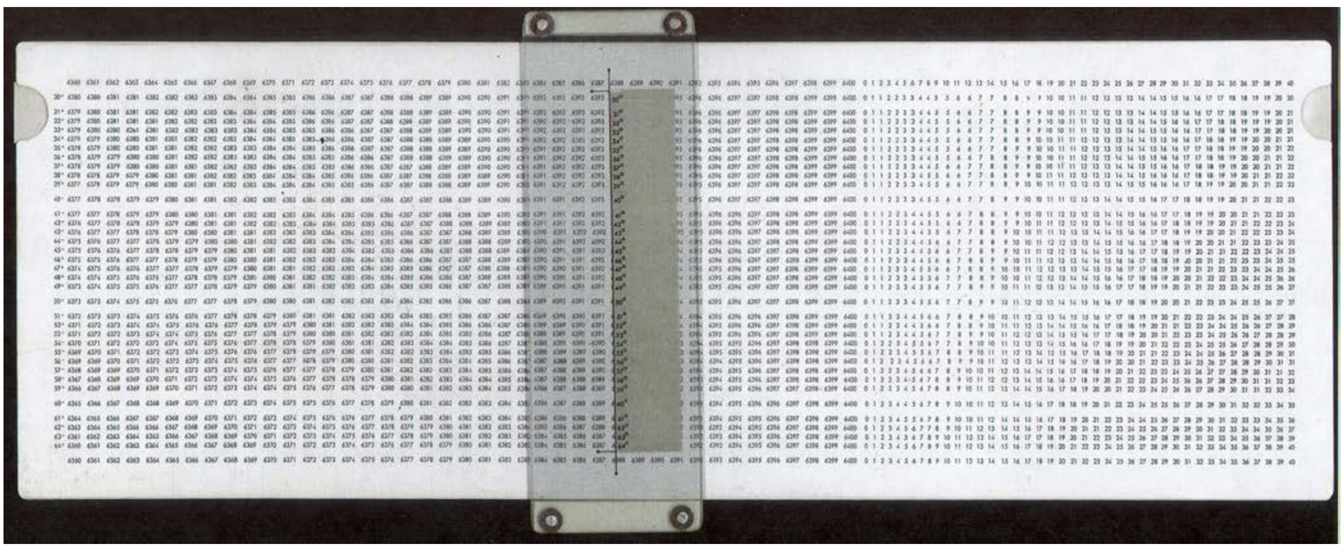


FIGURE 3. Back Latitude dependent azimuth, Δ Mil

ever, the P.A. 44 is accurate from 1944 to the end of 1948 (by incorporating the applicable astronomical values only for those years within the slide rule). Knowing your longitude, latitude, month, and day (the P.A. 44 has 29 days for February, noting 1944 was a leap year, the probable year first used), and time of day, the simple procedure shown in Table 1 determines your azimuth to true north.

Who manufactured the P.A. 44 and what P.A. 44 means is somewhat problematic. Both Peter Holland and Ronald van Riet suggest the P.A. stands for "Polarstern Azimut" [Polestar (Polaris) Azimuth]. Ronald suggests that the 44 may stand for the year of manufacturing. Wichman was a seller of slide rules, not a manufacturer; so one could suppose the manufacturer was Aristo.

The following examples are from the German manual (see the Appendix).

See Table 1 for the operational procedure. True north = 6400/0 Mil; see Table 1 "Back Side" number 3 for a brief discussion.

Example 1

Longitude = 10°30′ west of Greenwich, Latitude = 53°, 23 December at 20:00 hours. The instructions use the red (summer months) scale. This is an obvious error, however I will present the example as given in the instructions and use the red scales.

Front side; latitude independent azimuth, D Mil.

Move the slide index to longitude 10°30′ west.
Move the cursor to 23 Dec.

Table 1
P.A. 44
Polaris Azimuth to True North

Description	
Front Side Latitude independent azimuth of Polaris to true north, D Mil	
Top	Longitude; 10° west of Greenwich to 65° east of Greenwich, in 1° increments.
Slide	Months and days; note February has 29 days (leap year). September through February in black and March through August in red
Cursor	Time of day Left cursor, daylight savings time; Greenwich mean time + 2 hours, from 18:00 to 06:00 hours. Right cursor, German standard time; Greenwich mean time + 1 hour, from 17:00 to 05:00 hours. Both in 10 minute increments
Body	Graph of the latitude independent azimuth of Polaris to true north, D Mil; read red scales for red months and black scales for black months.
Back Side Latitude dependent azimuth of Polaris to true north, Δ Mil	
Cursor	Observer's north latitude, 30° to 64° in 1° increments
Body	Tables of the latitude dependent azimuth of Polaris to true north, Δ Mil; true north = 6400/0 Mil.
Operation	
Front Side Latitude independent azimuth of Polaris to true north, D Mil	
1	Move the slide index to your longitude.
2	Move the cursor over the month and day; September through February in black and March through August in red.
3	For your known time of day; daylight savings or German mean, read the latitude independent azimuth of Polaris to true north, D Mil, along the diagonal lines. Read D Mil, 63xx or yy, at the top/bottom or sides; read black months on black scales and red months on red scales.
Back Side Latitude dependent azimuth of Polaris to true north, Δ Mil	
2	Move the cursor reference, , , to D Mil, 63xx (left table) or the two digit reading, yy, (right table) at the top or bottom of the table.

Read the latitude independent azimuth, D Mil, at German summer time, on the left side of the cursor, 20:00 hours.

Follow the diagonal line down and to the right and read: D Mil = 10, red scale.

Back side; latitude dependent azimuth, Δ Mil tables.

Move the cursor reference, ⌟, at the top or bottom of the right table, to D Mil = 10.

Read the azimuth of Polaris to true north to the left of latitude = 53°; Δ Mil = 7 Mil; Δ Mil = 7 Mil, which is 7 Mil greater than true north.

Example 2

Longitude = 4° east of Greenwich, Latitude = 42°, 7 May at 02:40 hours German standard time.

Front side, latitude independent azimuth, D Mil
Move the slide index to longitude 4° east.
Move the cursor to 7 May, red scales.

Read the latitude independent azimuth, D Mil, for German standard time, on the right side of the cursor at 02:40 hours. Follow the diagonal line down and to the right and read D Mil = 29.5 on the red scale (use D Mil = 30).

Back side; latitude dependent azimuth, Δ Mil tables.

Move the cursor reference, ,, at the top or bottom of the right table to D Mil = 30.

Read the azimuth of Polaris to true north to the left of latitude = 42°; Δ Mil = 18 Mil and is 18 Mil greater than true north.

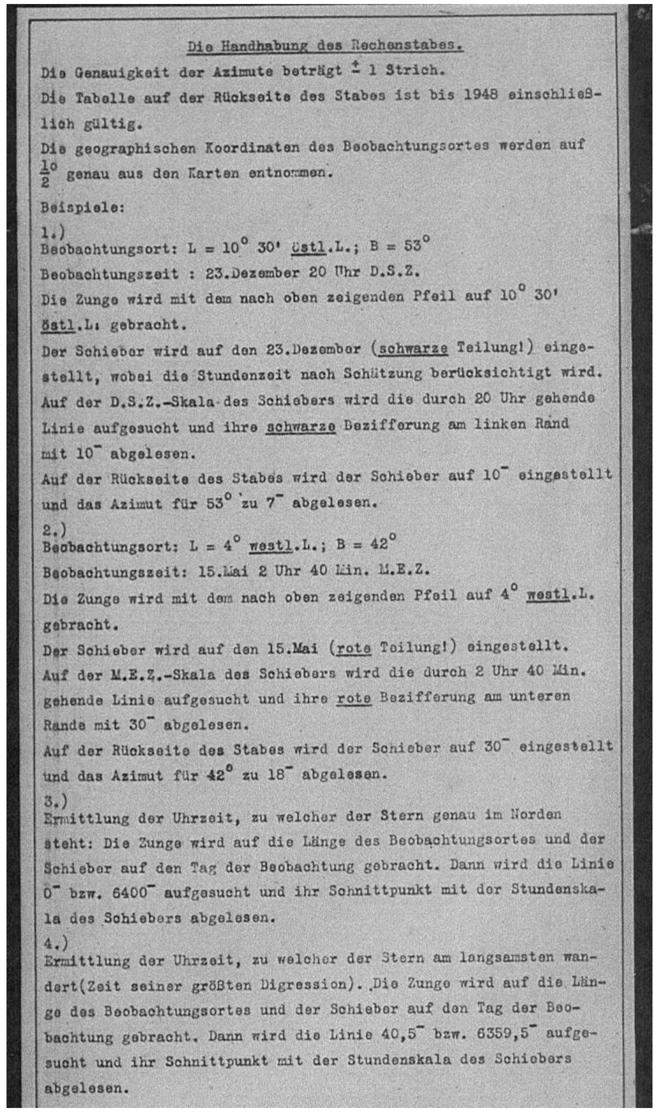
Examples 3 and 4, see the appendix, were translated by Ronald van Riet. The comments in brackets [ ] are mine.

Example 3; see Figure 1 Points A and B

Determination of the time at which the star is exactly north. Position the slide index at the longitude of the place of observation and the cursor on the day of observation [lower or upper culmination]. Look for the line marked 0" respectively 6400" and determine its intersection with the hour line on the cursor [true north = 6400/0 Mil].

Example 4; see Figure 1 Point D

Determination of the time at which the star moves the slowest (the time of its largest displacement) [elongation]. Set the slide index on the longitude of the place of observation and the cursor on the day of observation. Then look for the line



Die Handhabung des Rechenstabes.

Die Genauigkeit der Azimute beträgt ± 1 Strich.
Die Tabelle auf der Rückseite des Stabes ist bis 1948 einschließlich gültig.
Die geographischen Koordinaten des Beobachtungsortes werden auf $\frac{1}{2}^{o}$ genau aus den Karten entnommen.

Beispiele:

1.)
Beobachtungsort: L = 10° 30' östl.L.; B = 53°
Beobachtungszeit : 23.Dezember 20 Uhr D.S.Z.
Die Zunge wird mit dem nach oben zeigenden Pfeil auf 10° 30' östl.L. gebracht.
Der Schieber wird auf den 23.Dezember (schwarze Teilung!) eingestellt, wobei die Stundenzeit nach Schützung berücksichtigt wird.
Auf der D.S.Z.-Skala des Schiebers wird die durch 20 Uhr gehende Linie aufgesucht und ihre schwarze Bezifferung am linken Rand mit 10¯ abgelesen.
Auf der Rückseite des Stabes wird der Schieber auf 10¯ eingestellt und das Azimut für 53° zu 7¯ abgelesen.

2.)
Beobachtungsort: L = 4° westl.L.; B = 42°
Beobachtungszeit: 15.Mai 2 Uhr 40 Min. M.E.Z.
Die Zunge wird mit dem nach oben zeigenden Pfeil auf 4° westl.L. gebracht.
Der Schieber wird auf den 15.Mai (rote Teilung!) eingestellt.
Auf der M.E.Z.-Skala des Schiebers wird die durch 2 Uhr 40 Min. gehende Linie aufgesucht und ihre rote Bezifferung am unteren Rande mit 30¯ abgelesen.
Auf der Rückseite des Stabes wird der Schieber auf 30¯ eingestellt und das Azimut für 42° zu 18¯ abgelesen.

3.)
Ermittlung der Uhrzeit, zu welcher der Stern genau im Norden steht: Die Zunge wird auf die Länge des Beobachtungsortes und der Schieber auf den Tag der Beobachtung gebracht. Dann wird die Linie 0¯ bzw. 6400¯ aufgesucht und ihr Schnittpunkt mit der Stundenskala des Schiebers abgelesen.

4.)
Ermittlung der Uhrzeit, zu welcher der Stern am langsamsten wandert(Zeit seiner größten Digression). Die Zunge wird auf die Länge des Beobachtungsortes und der Schieber auf den Tag der Beobachtung gebracht. Dann wird die Linie 40,5¯ bzw. 6359,5¯ aufgesucht und ihr Schnittpunkt mit der Stundenskala des Schiebers abgelesen.

FIGURE 4. German Instructions

marked 40.5 "and respectively 6359.5", then determine their intersections with the hour line on the cursor.

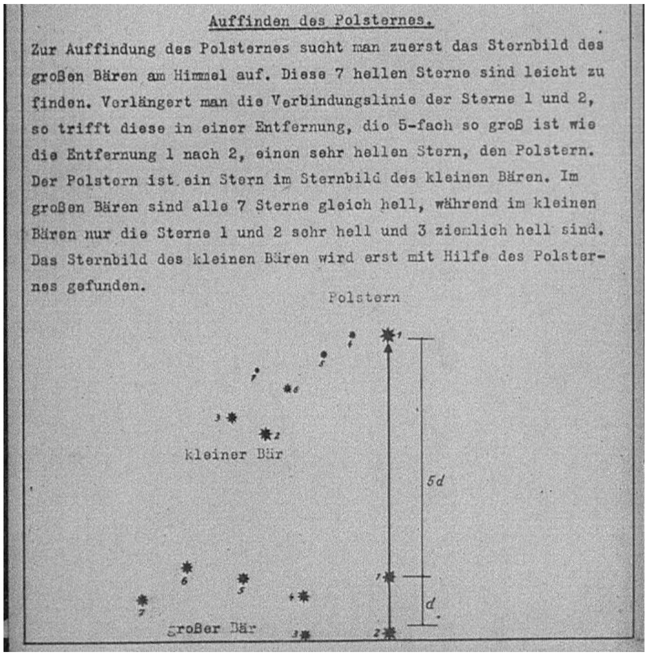
This was a functional and useful tool in World War II Germany. Those readers knowledgeable in celestial navigation will appreciate the simplicity and accuracy of the PA. 44. The Bibliography lists several articles and books on celestial navigation for those interested.

Acknowledgements

This paper would not have been developed without the help of Peter Holland and Ronald van Riet. My thanks to you both. Thanks also to Otto van Poelje and friend Don Ruff for their comments and suggestions.

Bibliography

1. van Riet, Ronald, *Position Line Slide Rules: Bygrave*


Auffinden des Polsternes.

Zur Auffindung des Polsternes sucht man zuerst das Sternbild des großen Bären am Himmel auf. Diese 7 hellen Sterne sind leicht zu finden. Verlängert man die Verbindungslinie der Sterne 1 und 2, so trifft diese in einer Entfernung, die 5-fach so groß ist wie die Entfernung 1 nach 2, einen sehr hellen Stern, den Polstern. Der Polstern ist ein Stern im Sternbild des kleinen Bären. Im großen Bären sind alle 7 Sterne gleich hell, während im kleinen Bären nur die Sterne 1 und 2 sehr hell und 3 ziemlich hell sind. Das Sternbild des kleinen Bären wird erst mit Hilfe des Polsternes gefunden.

FIGURE 5. Locating the Pole Star (Polaris)

and Hohenrechenschieber IM 2008. A copy may be found at
http://www.rechenschieber.org/PositionLineSlideRules.pdf

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The papers identified as references 5 and 6 are available at www.rechenschieber.org/pa44.html. These are two articles that should be translated and published; they would certainly aid in a better understanding of this unique slide rule.

Alternative Trigonometric Solutions for Rietz-type Slide Rules

JOS Plus

Marion Moon

Introduction

This paper investigates the possibility of using the Rietz-type trigonometric scales in a manner not usually described in manuals or books but first, some background material is needed to describe the basis for the alternatives.

Reciprocals—A reciprocal is a quotient with the dividend equal to 1 or a ratio with numerator as 1 and the denominator as the other factor. On a slide rule if the number is set on the C scale over the D index, the quotient is found on the D scale under the opposite C index. I call this operation "index exchange". This property was described in [4], [5], and [6] but the authors do not exploit it in solutions. Most manuals do not appear to describe this property nor use it. However, the Hemmi manual [8] pp 29 describes and uses this technique in simpler ways. This property can play a convenient role in some applications, as we will see later.

Recently, Jeremy Kelly in the International Slide Rule Group (ISRG) message 40942 asked how to do exponentiation calculations on a Darmstadt rule. Such rules are a solid body simplex with log-log scales on the back of the slide. These rules have an opening or gap in the gutter or valley at each end usually filled by a clear window with a hairline aligned with the index marks on the face of the rule similar to Rietz-type rules. Normally the Darmstadt rule manuals suggest removing the slide, flipping it over and reinstalling it. Computations are then done more or less directly using the D scale. Virtually all manuals and books recommend using a Darmstadt rule in this manner.

After seeing this solution, I wondered if Rietz-type slide rules could handle trigonometric functions is a similar manner. This would be different than what is commonly used in virtually all manuals and books which recommend flipping the slide over to do trigonometric computations. A very good description of using the trigonometric scales in this manner can be seen in [1]. As I have not spent any time learning the