The genealogy of Johann Theodor Peters's great mathematical tables

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29 August 2016
(last version: 4 May 2017)

Abstract

Johann Theodor (Jean) Peters (1869–1941) is the author of numerous mathematical tables, in particular the well-known 8-place tables of logarithms coauthored with Julius Bauschinger and published in 1910–1911. This article reviews Peters's main tables, and presents their genealogy, in order to supplement Peters's tables and their reconstructions.

In 2016, we published reconstructions of almost all of the large mathematical tables authored by Johann Theodor Peters (1869–1941), after having earlier already reconstructed a table of factors coauthored by Peters [60]. This represents a total of 22 volumes for which we have each time written an introduction and tried to analyze as best as we could the methods employed by Peters.

Working on all these tables, or even on only some of them, may give rise to some confusion and numbness, as one becomes easily drowned by the various tables, sometimes with almost identical titles. And yet, all these tables are actually different.

The purpose of this article is to sort all these tables out and to give a global picture. It does also serve as a general introduction to all the tables which have been reconstructed.

1 A brief biography

Peters was born Johann Theodor Peters in Köln in 1869 [33, 26, 32, 31, 30], but throughout his life he was mostly known as "Jean Peters." He studied mathematics and astronomy at the University of Bonn. He became interested

K. H. W. KRUSE, L. J. COMRIE, J. T. PETERS 1930

Figure 1: From left to right, the astronomer Karl Heinrich Willy Kruse (1889–1945), Leslie John Comrie (1893–1950) and Peters, 1930. (from [12])

in calculations at the beginning of the 1890s. In his dissertation, he used eight lunar occultations of the Pleiades by the Moon to compute the coordinates and radius of the Moon. After having obtained his PhD in 1894, he stayed for a few years at the Bonn observatory.

In 1899, Peters came to the *Astronomisches Rechen-Institut* (ARI) in Berlin. In 1901 he was named "observator," and in 1910 he obtained the position of professor.[1] He soon started to work on new general tables of logarithms and trigonometry, which would in particular be useful for astronomical applications.

Peters's main work at the Institute was to compute the *Berliner Astronomisches Jahrbuch* in which he was involved for almost 30 years. He also worked on the *Nautisches Jahrbuch* and the Prussian *Grundkalender*.

From 1922 to 1924, Peters was the director of the ARI. He retired in 1934 and devoted himself to the sole computation of tables. In 1938, he was honored by the silver Leibniz Medal from the Prussian Academy of Sciences. He died in 1941.

[1]For more particulars on Peters's activities at the ARI, see Holland's summary [30]. Holland has gone through the ARI annual research accounts in search of mentions of Peters. The ARI also holds a file on Peters with a few items, see Wielen's summary of its contents [107].

2 Peters's tables

Although Peters has been working on mathematical and more specialized astronomical tables, we will concern ourselves only with his largest tables, which are general in nature, but particularly aimed at astronomical and geodetical applications. The range of Peters's tables displays both his interests and desire to provide a number of useful tables for different audiences, but also is a testimony to the changes in technology and usage. Tables of trigonometrical values started to gain importance in the 1910s and at the same time tables of logarithms were less needed, merely because calculating machines could be used for multiplications. Decimalization was another drive and at the end of the 1910s, Peters published tables where the arguments were given at intervals of thousandths of sexagesimal degrees, and not at intervals of seconds or tens of seconds. A few years later, total decimalization was reached with the centesimal division of the quadrant.[2] These changes have not taken over the old sexagesimal division, perhaps because in turn digital computers made it again easier to stick with the old division. This is the background of Peters's work, going from traditional hand-computed tables to more rational tables, and taking advantage of mechanical calculators, but without anticipating the death of table-computing.

2.1 Logarithms

Together with Julius Bauschinger, Peters published in 1910 and 1911 a table of the logarithms of numbers from 20000 to 200000 and the logarithms of trigonometrical functions for every second of the quadrant, all to 8 places [15]. For this table, the computations were done to 12 places, and in some cases to 20 places. The basis for this table were Briggs's tables published in 1624 [16] and 1633 [17].

Bauschinger and Peters's table spawned a number of other tables, as summarized in the genealogical chart below (figure 2).

From the 12-place table used in preparing the 8-place table, a 7-place table was derived in 1911 [38] and a 5-place table of the logarithms of the trigonometrical functions followed in 1912 [39], the latter mostly derived from the 8-place table.

Peters then prepared a 12-place manuscript table giving the logarithms of the trigonometrical functions at $0°.001$ intervals. This table was used to construct the 10-place table of the logarithms of trigonometrical functions, together with a volume of auxiliary tables [44, 43].

[2]In 1937, decimalization was made mandatory in Germany for surveying, see [26, p. 349].

In 1919, Peters also published a fundamental table of 52-place logarithms [62][3] containing 52-place values of $\log a$, $\log(1 + a \cdot 10^{-n})$ and $\log(1 - a \cdot 10^{-n})$ for $1 \le a \le 9$ and $1 \le n \le 26$. Using a number of multiplications by numbers $1 \pm a \cdot 10^{-n}$, a given number can be expressed as a product of such factors, and consequently its logarithm can be found. This is the well-known "radix method" already used by Briggs [16].

In 1921, Peters derived 6- and 7-place tables of the logarithms of trigonometrical functions [45, 46] from the above mentioned 12-place manuscript.

Then in 1922, Peters published a 10-place table of the logarithms of the numbers [47], being the first volume of the tables published in 1919. This first volume also contained an extensive appendix with numerous auxiliary tables, written with Johannes Stein.

After a long hiatus devoted to other types of tables, Peters returned to logarithms in 1940, when he published a 2-volume 7-place table of logarithms of numbers, of antilogarithms, of addition and subtraction logarithms and of logarithms of trigonometrical functions for the new division [58].

2.2 Trigonometrical functions

In 1911, Peters computed a fundamental table of 21-place values of sines and cosines at $10'$ intervals in the semi-quadrant, as well as at $1''$ intervals between 0° and $10'$ [37].[4] These values can therefore be used to compute 20-place values for other angles in the quadrant. Peters also gave the first, second and third differences of the values for arguments below $10'$, and they could be used to perform interpolations.

But Peters's first large table of trigonometrical functions for every day purpose was his 7-place table published in 1918 [42]. It gave the values of the trigonometrical functions at intervals of $0^\circ.001$ and was derived from Briggs's table published in 1633 [17].

In 1929, Peters published a table of 6-place values of all six trigonometrical functions [48], this time based on Andoyer's great tables published in 1915–1918 [3].

A 6-place table published in 1930 and giving the trigonometrical values for the new centesimal division [51] was actually derived from an 8-place manuscript table, and so may have been the 6-place table published in 1938 [56].

In 1937, Peters published a sexagesimal 6-place table of trigonometri-

[3]This table has not yet been reconstructed, but might be reconstructed in the future.

[4]This table has also not yet been reconstructed, but might be reconstructed in the future.

cal and involute functions, with auxiliary tables useful for gear computations [55].

The 8-place table published in 1939 with Leslie Comrie and giving the sines, cosines, tangents and cotangents for every sexagesimal second [57] was ultimately based on Andoyer's tables [3]. The secants and cosecants had also been computed, but could not be published.

Peters's final publication was a 7-place table for the new centesimal division and published in 1941 [59].

2.3 Other tables

Apart from tables of logarithms and trigonometrical functions, Peters prepared, and sometimes published, several other general mathematical tables.

Peters's first large table was a multiplication table, published in 1909 [36]. It gave the products of all integers from 0 to 9999 by all integers from 1 to 99, and spanned 500 pages.

In 1922, Peters revised the Hütte tables [63].

Peters also published several more specialized tables for astronomical purposes, in particular in the 1930s [40, 49, 61, 52, 53, 54].

Around 1929 [30], Peters was working on a table of factors up to 100000. This table was collated with two other tables computed independently by Lodge, Ternouth and Gifford and published in 1935 [60].

Peters left unpublished manuscripts for a 8-place table of the trigonometrical functions, presumably to the 1000th of the degree of the old division (and used in the table published in 1930 [51], although the latter is for the new division), for a 8-place table of reciprocals (computed around 1924 [30]) and for 8-place tables of antilogarithms, and 8-place tables of addition and subtraction logarithms (computed between 1924 and 1926). Whether any of these manuscripts do still exist is unknown.

In his obituary [33], Kopf mentioned that a traverse table ("Strichtafel") was due to be printed, but such a table never seems to have been published.[5]

3 Chronology of Peters's great tables

We give here a chronological list of Peters's main mathematical tables, and table 1 shows a summary organized by the main features of the tables.

[5] An example of an early table of that kind can be found in the *Handbuch der Schiffahrtskunde* published in 1819 [27]. For another example, see Shortrede's table published in 1864 [100].

		places					
		3	5	6	7	8	10
	log N	100 to 999 (1913)			10000 to 100000 (1940)	20000 to 200000 (1910)	10000 to 99999 (1922)
trig	old ($^\circ$)	$6'$ (1913)		0.01° (1937) $10''$ (1929)	0.001° (1918)	$1''$ (1939)	
	new ($^{\mathrm{g}}$)			0.01^{g} (1930) 0.001^{g} (1938)	0.001^{g} (1941)		
log trig	old ($^\circ$)	$6'$ (1913)	$15''$ (1912)	0.001° (1921)	0.001° (1921) $1''$ (1911)	$1''$ (1911)	0.001° (1919)
	new ($^{\mathrm{g}}$)				0.001^{g} (1940)		

Table 1: Summary of the features of Peters's great tables. The lines correspond to the types of tables (for instance of logarithms of trigonometrical functions), the columns give the number of places, and at the intersections of the lines and columns we give the ranges or the intervals, and the years the tables were published.

- 1909: Multiplication table, with products of 1 to 99 by 0 to 9999 [36];
- 1910: Logarithms of the numbers 20000 to 200000 to eight places (with Julius Bauschinger) [15];
- 1911: Logarithms of trigonometrical functions to eight places and at intervals of $1''$ (with Julius Bauschinger) [15];
- 1911: Logarithms of trigonometrical functions to seven places at intervals of $1''$ [38];
- 1912: Logarithms of trigonometrical functions to five places and at intervals of 15 seconds of the arc [39]; ($\log\sin$ and $\log\tan$ every $1.5''$ below 2°)
- 1913: Trigonometrical functions and of logarithms of trigonometrical functions, all to three places, and at intervals of $6'$ [41];
- 1918: Trigonometrical functions to seven places, at intervals of 0.001° [42];
- 1919: Logarithms of trigonometrical functions to ten places, at intervals of 0.001° [44];
- 1922: Logarithms of numbers 10000 to 99999 to ten places [47];
- 1921: Logarithms of trigonometrical functions to six places, at intervals of 0.001° [45];

- 1921: Logarithms of trigonometrical functions to seven places, at intervals of 0.001° [46];
- 1929: Trigonometrical functions to six places, at intervals of $10''$ [48];
- 1930: Trigonometrical functions to six places, at intervals of 0.01^{g} (new division) [51];
- 1937: Trigonometrical functions and involute functions to six places, at intervals of 0.01° [55];
- 1938: Trigonometrical functions to six places, at intervals of 0.001^{g} (new division) [56];
- 1939: Trigonometrical functions to eight places, at $1''$ intervals [57];
- 1940: Logarithms of numbers (10000 to 100000), antilogarithms, addition and subtraction logarithms, all to seven places [58]
- 1940: Logarithms of trigonometrical functions to seven places, at intervals of 0.001^{g} (new division) [58];
- 1941: Trigonometrical functions to seven places, at intervals of 0.001^{g} (new division) [59].

4 Conclusion

It is very easy to be impressed by the considerable volume of tables produced by Peters, and it is therefore not surprising that Archibald called Peters "perhaps the greatest mathematical table maker of all time" [12, p. 68].

Having worked through most of Peters's tables as well as many other great tables, we think that Archibald's statement is somewhat exaggerated. Peters has indeed produced a large number of tables, and these tables were all remarkable for their quality. But Peters's main tables do not make use of very advanced concepts, and they lack the groundbreaking features found in Napier's [71], Briggs's [16, 17], Prony's [72], Sang's [22] and some other tables. Instead, the greatness of Peters lies in his ability to organize computations, to check them, to use simple interpolations with first and second differences, in particular with calculating machines, to anticipate which tables would be needed, and to have been able to produce remarkable tables using earlier large tables. None of the large tables constructed by Peters were actually

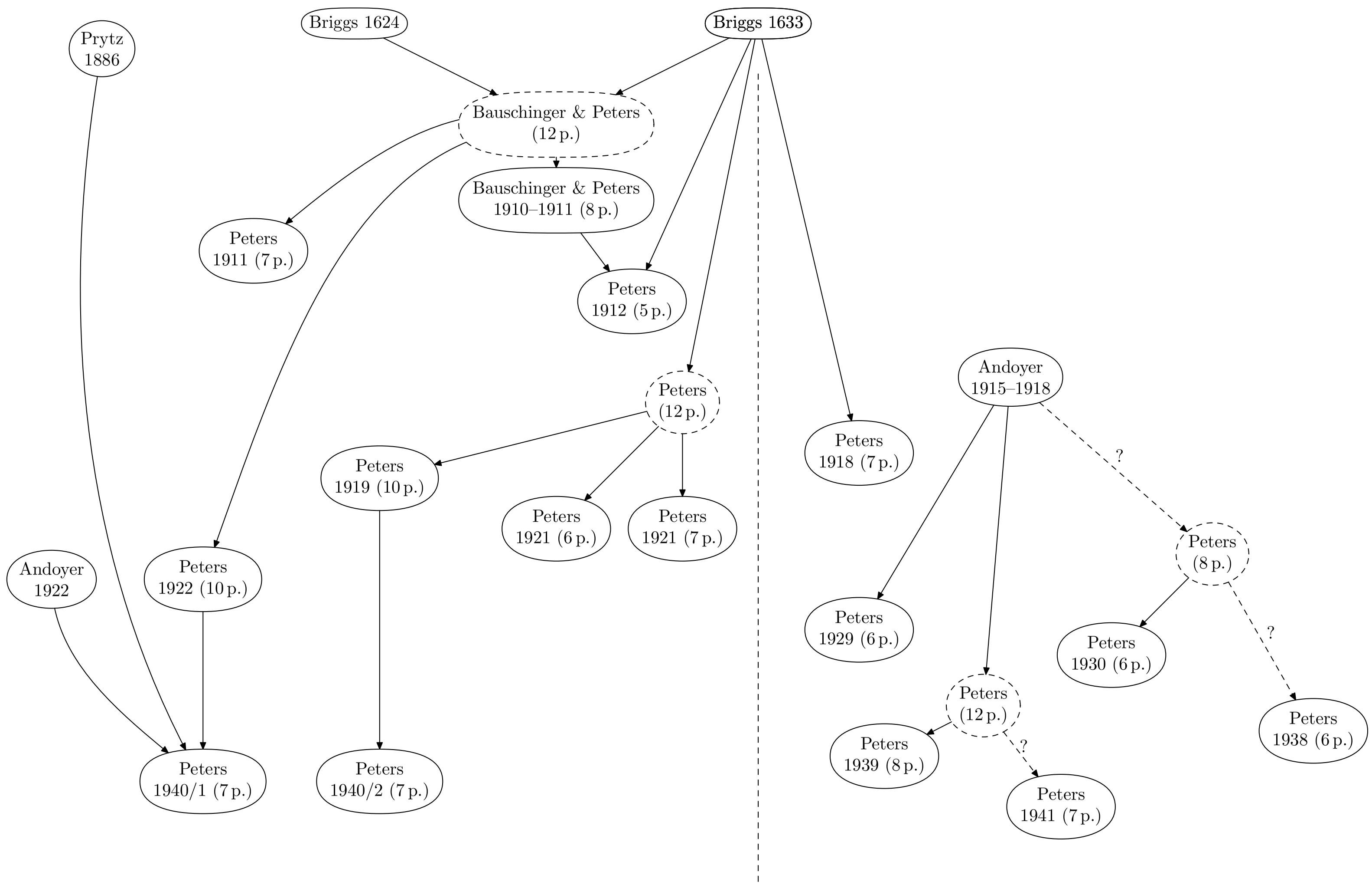

Figure 2: The genealogy of Peters's major numerical tables. Dashed circles indicate manuscript tables. The vertical line separates the tables of logarithms (left) from the (non logarithmic) tables of trigonometrical functions (right).

produced *de novo*, but they were based almost entirely on those of Briggs and Andoyer.

Peters's work first highlights the greatness of Briggs's work, as well as the importance and usefulness of such fundamental tables as constructed by Andoyer, and second stresses the importance of an efficient management in the construction of tables, and that great tables can be produced without computing everything from scratch.

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