Historisk-filosofiske Meddelelser
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Det Kongelige Danske Videnskabernes Selskab
Bind **39**, nr. 1

Hist. Filos. Medd. Dan. Vid. Selsk. **39**, no. 1 (1960)

A NEW GREEK ASTRONOMICAL TABLE

(P. Heid. Inv. 4144 + P. Mich. 151)

BY

O. NEUGEBAUER

København 1960
i kommission hos Ejnar Munksgaard

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Through the courtesy of the Papyrussammlung der Universität Heidelberg I received photographs of the fragmentary astronomical table P. Heid. Inv. 4144 and was kindly given permission to publish my findings. The fragment contains zeros written like $\overline{\cdot}$, a form which led me to P. Mich. 151 where the same sign occurs[1]. A comparison of the numerical structure of the tables in both fragments made it obvious that both pieces belong to the same sheet of papyrus, separated by a gap of only about four lines[2].

The fragment P. Mich. 151 was dated by the editors as belonging to the third century A.D.[3] Since the verso is uninscribed it is more plausible that we are dealing with a piece from a roll, not from a codex[4].

The papyrus in its present form contains parts of four double

[1] For the forms of zeros in Greek papyri cf. Rida A. K. Irani, Centaurus 4 (1955/56) p. 11 and p. 4f. It may be remarked in passing that the forms attested in papyri make a derivation of these symbols from *οὐδέν* very unlikely; cf. also my "Exact Sciences in Antiquity" 2nd ed. p. 14 (Brown University Press, Providence 1957).

[2] Cf. the plate facing p. 8. I am very thankful to Dr. Peter Sattler, Heidelberg, and Prof. H. C. Youtie, Ann Arbor, for providing me with excellent photographs and for giving me all required information.

[3] Michigan Papyri, vol. III, Ann Arbor 1936, p. 118.

[4] For astronomical tables a codex is obviously more convenient than a roll. I know of the following codices:

(1) P. London 1279; fragments from "Handy Tables", written around A.D. 200. Publ.: Osiris 13 (1958) p. 93—113.

(2) P. Ryl. 522/523; fragments from "Handy Tables", 3rd cent.; proper order: 523 (end of tables of rising times) followed by 522 (famous cities). Publ.: C. H. Roberts, Catal. of... John Rylands Library, vol. III (1938) p. 142—150.

(3) P. Heid. Inv. 34; almanac for A.D. 348/9. Publ.: Danske Vidensk. Selsk., Hist.-filol. Meddel. 36,4 (1956). For its character as codex cf. Osiris 13 (1958) p. 112. For the method of computation cf. J. J. Burckhardt, Zwei griechische Ephemeriden, Osiris 13 (1958) p. 79—92.

(4) P. Mich. Inv. 1454; almanac for A.D. 467. Publ. by H. D. Curtis and F. E. Robbins: Publ. of the Observatory, Univ. of Michigan 6 (1937) No. 9 p. 77—100; cf. also Burckhardt l.c. sub (3).

(5) P. Oxy. 470; computation of waterclock and other material. Cf. L. Borchardt, Die altägyptische Zeitmessung, Berlin-Leipzig 1920, Pl. 7 and 8.

columns which I denote here by A, B, C, D, respectively[1]. Each column contains parts of two, or even three, individual tables of 33 lines in total length, namely one line for the heading of the table, two for the entries $^1/_3$ and $^2/_3$ respectively, and 30 lines for the 30 degrees of a zodiacal sign. Column A ends with the last line of a table, column B with the 13th line of a table[2]. Conse-

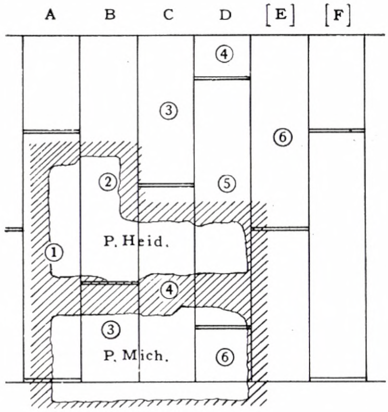


Fig. 1.

quently column B contained at least $33 + 13 = 46$ lines which require a column height of about 20 cm. Adding about 5 cm for the uninscribed upper and lower margins one obtains a sheet of about 25 cm height, a very common size for papyri[3]. Since an additional table would increase the height by about $13^1/_2$ cm one would have to assume sheets of much too great a height. Thus we are sure that the number of lines per column was 46 and not $46 + 33 = 79$ or more. Consequently we can say that column C contained the remaining 19 lines of the second table of B plus 27 lines of a new table. Then follows D with $6 + 33 + 7$ lines and finally we have to assume at least one more column ([E], cf. fig. 1) with 26 lines.

So far we have established the existence of at least 5 columns and of six individual tables. We know from column D that table

[1] Cf. the transcription on p. 7 which reproduces only the general appearance of the letters without any attempt at palaeographical accuracy.

[2] Actually it is the 14th line of the table, because the line for 7° has been skipped.

[3] The tables in the Almagest are arranged to give columns of 45 lines; cf. Ptolemaeus, Opera I, 1 p. 47,3 and p. 209,18 (Heiberg).

6 concerned the zodiacal signs Taurus and Gemini. If every single table had been associated with two signs the tables 1 to 6 would suffice for the whole zodiac from Cancer to Gemini. Such a reconstruction would leave 13 lines free at the beginning of column A and 20 lines at the end of [E]. If we, however, assume that some tables are only related to a single zodiacal sign we can continue [E] into [F]. But [F] would have the same arrangement

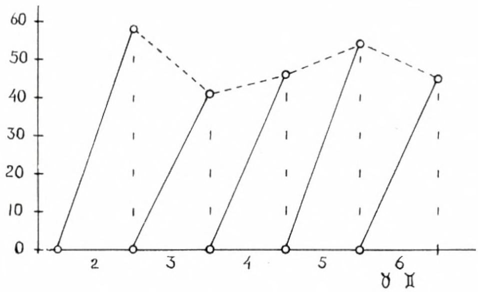


Fig. 2.

of individual tables as A, namely 13 + 33 lines. Thus the arrangement from A to [E] repeats itself periodically and we see that no individual table can ever have had its beginning at the top of a column (cf. fig. 1). Thus the few extant tables must have been preceeded by some other tables or by explanatory text.

We now turn to the individual tables, all of which follow the same pattern[1]: they give the multiples $k \cdot a$ from $k = 1$ to $k = 30$ of a given number a, preceeded by $0;20 \cdot a$ and $0;40 \cdot a$ i.e. $^1/_3$ and $^2/_3$ of a respectively. Each table consists of two columns, the first of which contains the numbers $k \cdot a$ the second the numbers k. In other words the second column gives the numbers for the entry — an arrangement which I do not recall from any other Greek table.

table (2)	$a =$	1,54	$30 \cdot a =$	57,0
(3)		1,21;30		40,45
(4)		1,32;18		46,9
(5)		1,48;27		54,13;30
(6)		1,29;48		44,54 .

[1] The numerous scribal errors (cf. the critical apparatus to the transcription) are all trivial and have no influence on the basic structure of the tables.

We denote the preserved tables with numbers from (1) to (6) as indicated in fig. 1 and fig. 2. Since the left part of column A is lost we know the numbers a only for the tables (2) to (6): The tables in the text give two places only, except for the first four entries (i.e. for $k = 0;20,\ 0;40,\ 1,$ and 2). The reduction to two places is obtained by truncation of the third place, not by rounding[1].

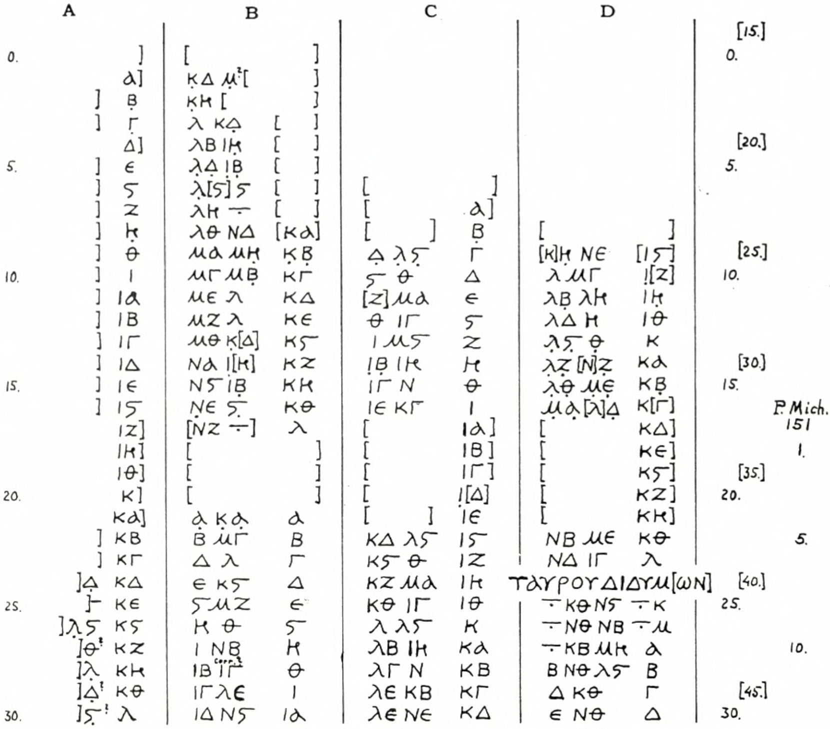
I have no suggestion to make as to the meaning of these tables. An interpretation which I gave 18 years ago[2] on the basis of P. Mich. 151 is now definitively disproved. I had assumed a connection with the rising times of the zodiacal signs but no such sequence as now established with two relative maxima can be related to the rising times of consecutive zodiacal signs. It would seem that we have here an unknown type of astronomical tables which will have to wait for their explanation until the discovery of additional fragments or parallel texts.

Summary

It is shown that P. Mich. 151 and the hitherto unpublished P. Heid. Inv. 4144 are two fragments of one document. The content is certainly astronomical, involving arithmetical progressions related to zodiacal signs. Tables of this type are not known in other sources of Greek astronomy.

[1] In my transcription on p. 8 I have given the unabbreviated numbers. In the text all digits are ignored which are to the right of the dotted line.

[2] "On some astronomical papyri and related problems of ancient geography". Trans. Amer. Philos. Soc., N.S. 32,2 (1942) p. 260 f.



Notes to the Transcription

A,24—30: The last digits should form an arithmetic progression, or, because of the truncation of a third digit, a sequence which occasionally deviates by one unit from an arithmetic progression. I did not succeed, however, in explaining on that basis the traces in the last seven lines.

B,1: The traces do not support the expected reading 26,36. The second numeral is in all probability δ, preceeded by a trace of $\varkappa$. Thus 24 is the most plausible reading. Perhaps the line with 26,36 was omitted and we have to read 24,42. The δ is followed by a vertical stroke which could be the beginning of a μ (similar forms occur in line 12 and 25) but ι and ν would be better; also γ or $\varkappa$ are not to be excluded.

B,11: 45,30: sic, instead of 45,36.

B,15: 56,12: sic, instead of 53,12.

B,18—20: It follows from the position of the first preserved line that the title plus the two following lines occupied a space of about four lines.

B,23: 4,30: sic, instead of 4,4,30.

B,24: 5,26: The ε is written so badly that it looks more like a θ.

B,27: One line is omitted here: 9,30,30 7.

B,28: 12,13,30: perhaps originally written 12,3 and then corrected to 12;13.

C,9: 4,36: the traces could also be interpreted as δ α γ but δ λ ς is required.

C,26: 30,36: sic, instead of 30,46.

C,30: 35,55: sic, instead of 36,55.

D,11: 32,38: sic, instead of 32,32.

D,12: 34,8: sic, instead of 34,20.

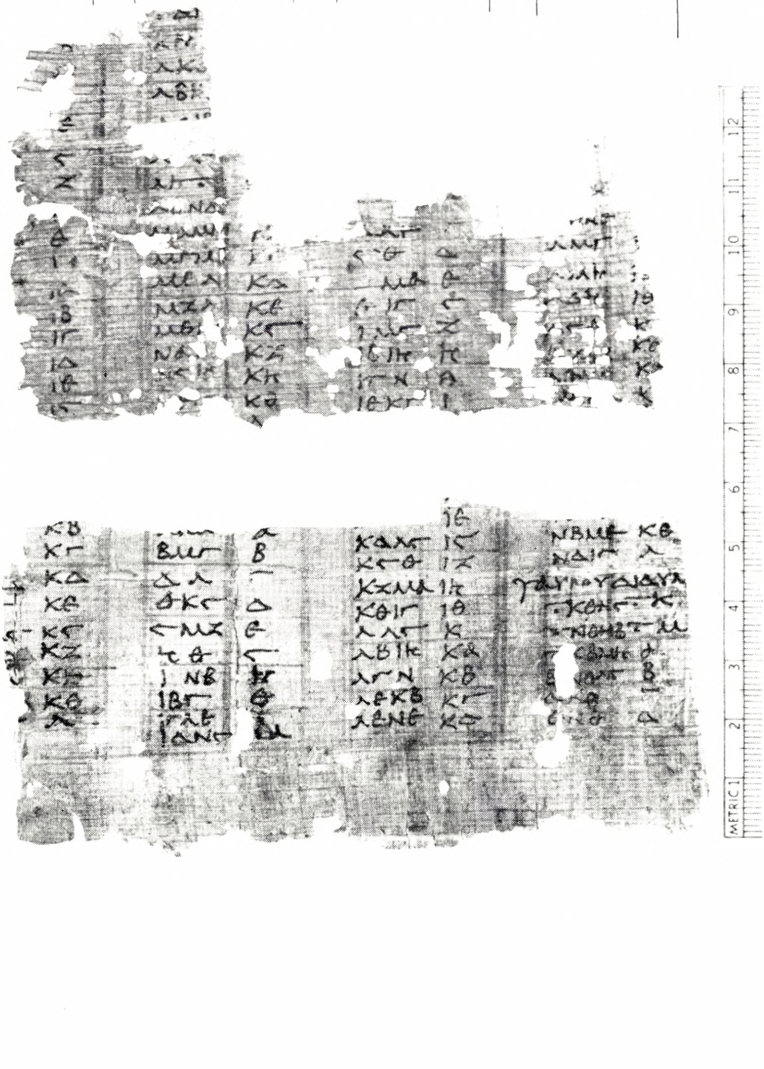
D,22: 52,45: sic, instead of 52,25.

D,27: 0,22,48: sic, instead of 1,29,48.

A		B		C		D	
		② [ ]					
		[0, 38	0, 20]				
		[1, 16	0, 40]			⋮	
		[1, 54	1]			⋮	
		⋮	⋮			[46, 9	30]
						⑤ [ ]	
		[19, 0	10]			[0, 36, 9	0, 20]
① [ ]		[20, 54	11]			[1, 12, 18	0, 40]
	0, 20]	[22, 48	12]			[1, 48, 27	1]
	0, 40]	24, 4[2	13]			[3, 36, 54	2]
	1]	[26, 36	14]			⋮	
]	2	28, [30	15]			⋮	
]	3	30, 24	[16]	[40, 45	30]	⋮	
	4]	32, 18	[17]	④ [ ]		⋮	
]	5	34, 12	[18]	[0, 30, 46	0, 20]	⋮	
]	6	3[6], 6	[19]	[1, 1, 32	0, 40]	⋮	
]	7	38, 0	[20]	[1, 32, 18	1]	⋮	
]	8	39, 54	[21]	[3, 4, 36]	2	[27, 6, 45	15]
]	9	41, 48	22	4, 36, 54	3	[2]8, 55, 12	[16]
]	10	43, 42	23	6, 9, 12	4	30, 43, 39	1[7]
]	11	45, 30	24	[7]41, 30	5	32, 38, 6	18
]	12	47, 30	25	9, 13, 48	6	34, 8, 33	19
]	13	49, 2[4]	26	10, 46, 6	7	36, 9	20
]	14	51, 1[8]	27	12, 18, 24	8	37, [5]7, 27	21
]	15	56, 12	28	13, 50, 42	9	39, 45, 54	22
]	16	55, 6	29	15, 23	10	41, [3]4, 21	2[3]
	17]	[57, 0]	30	[16, 55, 18	11]	[43, 22, 48	24]
	18]	③ [ ]		[18, 27, 36	12]	[45, 11, 15	25]
	19]	[0, 27, 10	0, 20]	[19, 59, 54	13]	[46, 59, 42	26]
	20]	[0, 54, 20	0, 40]	[21, 32, 12]	1[4]	[48, 48, 9	27]
	21]	1, 21, [30]	1	[23, 4, 30]	15	[50, 36, 36	28]
]	22	2, 43	2	24, 36, 48	16	52, 45, 3	29
]	23	4, 30	3	26, 9, 6	17	54, 13, 30	30
]4	24	5, 26	4	27, 41, 24	18	⑥ ♉	♊
] 0?	25	6, 47, 30	5	29, 13, 42	19	0, 29, 56	0, 20
]36	26	8, 9	6	30, 36	20	0, 59, 52	0, 40
]9?	27	10, 52	8	32, 18, 18	21	0, 22, 48	1
]30	28	12, 13, 30	9	33, 50, 36	22	2, 59, 36	2
]4?	29	13, 35	10	35, 22, 54	23	4, 29, 24	3
]6?	30	14, 56, 30	11	35, 55, 12	24	5, 59, 12	4

Indlevet til Selskabet den 17. juni 1960.
Færdig fra trykkeriet den 11. oktober 1960.

A B C D



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