



NATIONAL SECURITY AGENCY
FORT GEORGE G. MEADE, MARYLAND 20755-6000

FOIA Case: 102239
29 September 2021

JOHN GREENEWALD JR
THE BLACK VAULT
27305 W LIVE OAK RD
SUITE 1203
CASTAIC CA 91384

Dear John Greenewald:

This responds to your Freedom of Information Act (FOIA) request dated 6 August 2017, for "a copy of records, electronic or otherwise, of the NSA TECHNICAL JOURNAL article, 'The Maya Astronomical Computer' published in Winter 1977."

As mentioned in our initial response, your request was received on 7 August 2017, and assigned Case Number 102239. There are no assessable fees for this request; therefore, we did not address your fee category.

Your request has been processed under the FOIA and the document you requested is enclosed. However, certain information in the enclosure has been protected.

Some of the information protected in the document was found to be currently and properly classified in accordance with Executive Order 13526. This information meets the criteria for classification as set forth in Subparagraph (d) of Section 1.4 and remains classified CONFIDENTIAL as provided in Section 1.2 of the Executive Order. The information is classified because its disclosure could reasonably be expected to cause damage to the national security. The information is exempt from automatic declassification in accordance with Section 3.3(b)(6) of E.O. 13526. Because the information is currently and properly classified, it is exempt from disclosure pursuant to the first exemption of the FOIA (5 U.S.C. Section 552(b)(1)).

In addition, this Agency is authorized by statute to protect certain information concerning its activities, as well as the names of its employees. Such information is exempt from disclosure pursuant to the third exemption of the FOIA, which provides for the withholding of information specifically protected from disclosure by statute. The specific statute applicable in this case is Section 6, Public Law 86-36 (50 U.S. Code 3605, formerly 50 U.S. Code 402 note). We have determined that such information exists in these records, and we have protected it accordingly.

You may appeal this decision. If you decide to appeal, you should do so in the manner outlined below. NSA will endeavor to respond within 20 working days of receiving any appeal, absent any unusual circumstances.

- The appeal must be sent via U.S. postal mail, fax, or electronic delivery (e-mail) and addressed to:

NSA FOIA/PA Appeal Authority (P132)
National Security Agency
9800 Savage Road STE 6932
Fort George G. Meade, MD 20755-6932

The facsimile number is 443-479-3612.

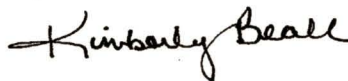
The appropriate email address to submit an appeal is
FOIA_PA_Appeals@nsa.gov

- It must be postmarked or delivered electronically no later than 90 calendar days from the date of this letter. Decisions appealed after 90 days will not be addressed.
- Please include the case number provided above.
- Please describe with sufficient detail why you believe the denial of requested information was unwarranted.

You may also contact our FOIA Public Liaison at foialo@nsa.gov for any further assistance and to discuss any aspect of your request. Additionally, you may contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services they offer. The contact information for OGIS is as follows:

Office of Government Information Services
National Archives and Records Administration
8601 Adelphi Rd - OGIS
College Park, MD 20740
ogis@nara.gov
877-684-6448
(Fax) 202-741-5769

Sincerely,



KIMBERLY BEALL
Acting Chief, FOIA/PA Division
NSA Initial Denial Authority

Encl:
a/s

This document is made available through the declassification efforts
and research of John Greenewald, Jr., creator of:

The Black Vault



The Black Vault is the largest online Freedom of Information Act (FOIA) document clearinghouse in the world. The research efforts here are responsible for the declassification of hundreds of thousands of pages released by the U.S. Government & Military.

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(U) The Maya Astronomical Computer

Charles H. Lacombe and [REDACTED]

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The following article was first published in the Winter 1977 issue of NSA Technical Journal, Vol. XXII, No. 1.

(U) This paper presents evidence of a visual astronomical computer which would have enabled Maya astronomer-priests to accomplish complex astronomical calculations simply and accurately. Their observations were recorded in hieroglyphic books, in which they developed tables for prediction. Three surviving books—the Dresden, Paris, and Madrid codices—contain such tables, with the explanations and specific applications.

(U) Introduction

(U) From circa 300 A.D. to 900 A.D., the Mayan civilization flourished in Guatemala, El Salvador, and the Yucatan Peninsula of Mexico, producing marvels of architecture and indubitably one of the world's most puzzling systems of writing. In spite of extensive efforts by scholars of many countries, no one has yet solved the riddle of the Maya Hieroglyphics. Their decipherment is a more difficult task than solving the Egyptian, Hittite, Babylonian, Cretan, and other ancient scripts, for a lot more is involved than merely equating signs with sounds. We can hope for a Rosetta Stone or a Behistun inscription in three languages, one of which can be read, such as Spanish. But until one appears, we must be satisfied with the scant materials available.

(U) This enigmatic writing system is so different from any other in human history that it will certainly require cryptanalytic techniques to make plain text out of the Maya mélange of double-duty ideographs, rebuses, and phonograms. Not only is a knowledge of the Maya religion a necessary prerequisite to ultimate solution of the writing, but also an appreciation of the Maya mentality and concept of the cyclical nature of all things in heaven and earth.

(U) The circle is basic to their religion and philosophy of life. It is basic to their calendars, almanacs, and tables of prediction of celestial events. They viewed the universe and all within it as an unending and expanding circle of time and space. This is a concept unique to the ancient Maya—at least it was unique to the Maya until Einstein came along. They even conceived of the directions as circular, counting from the east quadrant counterclockwise around the circle. We know this from their incantations and the positioning of the directional glyphs in the Maya codices.

(U) Even the glyphs are written within a circle, in a cartouche, with prefixes, postfixes, superfixes, subfixes, and infixes added to the circle as required by the text. In the three surviving codices, in murals, and on pottery, the circle is used to enclose the characters, and the affixes cluster around it. In the stone inscriptions, the block form is substituted for the circle, but the principle is still the same.

(U) The Maya astronomer-priests, in their obsession with time, showed an uncanny ability to play their calendars against one another to achieve extraordinary accuracy through a system of mutual correction and to arrive at common "resting places" when two or more celestial events would coincide. This report will present evidence of a visual astronomical computer which would have enabled the Maya to accomplish these complex calculations simply and accurately.

(U) For centuries the priests watched the heavenly bodies parade across the sky in perfect, predictable order, exactly on cue. All was recorded in their hieroglyphic books, in which they developed tables for prediction. Three of these books which have survived—the Dresden, Paris, and Madrid

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codices—contain such tables, with explanations and specific applications. Tables that can be read include the 104-year Venus cycle and an 11,960-day cycle of solar eclipses in the Dresden Codex. Much of the explanatory text is not understood; however, its connection with weather and the agricultural cycle is indicated by illustrations which depict rain, cutting, burning, planting, and associated malevolent and benevolent deities.

(U) One table, on pages 12-18 of the Madrid Codex, has been under study by the hieroglyphics section of the Institute of Maya Studies. In the course of this study, one of the members of the group, the architect [REDACTED] developed an analytic technique that has led to startling discoveries that not only reveal the subject matter and significance of the pages under study but also provide researchers with a new Maya key to deciphering almanacs in all three codices. The introductory page (page 12) of Madrid Codex 12-18 shows the long-nosed rain god Chac suspended over a snake whose body emerges from a band of glyphs for the planets Mercury, Mars, Venus, and Jupiter. The six pages which follow, plus a missing one, comprise the ritual calendar of 260 days, called a *Tsolkin* in Mayan. It is laid out in four lines of 65 days each, in sequential order. Explanatory panels continue across the top sections.

(U) In sum, the [REDACTED] technique is the application of graphics to interpretation of the table, and to reconstruction of the missing page and serpent. [REDACTED] found that columns of hieroglyphics for days, appearing in the top explanatory sections, formed repetitive geometric patterns when applied to the days in the table. On these patterns, the table presents the days on which principal events in the synodical revolution of Venus occur. These days are plotted along diagonal lines in recurring patterns with an interval of 584 between each. This is the number of days in a synodical revolution of Venus, according to the Maya. The Solar calendar, equinoxes and solstices, solar eclipses, and days on which two or more celestial events can coincide can also be read from the table. The serpents

depicted are believed to provide critical input into the computer, among other functions. Spacing of the serpents can be related to the synodical cycles of Mercury, Mars, and Jupiter, as described below.

(U) Such a phenomenal device can only be described as an astronomical computer, almost unbelievable in its perfection and simplicity, instantly performing the incredible combination of mathematical functions required to program and retrieve the astronomical data. While much remains to be done to relate the table to the Maya agricultural cycle, religious beliefs, weather, gods, and hieroglyphs as yet undeciphered, the discovery of the computing device and the graphic technique itself are deemed important enough to justify an interim report.*

(U) The Language of the Computer

(U) The language of the table is the *Tsolkin*, the 260-day ritual calendar. It consists of 20 days, each with a numerical coefficient of 1-13. The numbers are attached to the day names as follows on the next page.

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(U) The numbering system continues until 20 counts of 1-13 are completed ($13 \times 20 = 260$ days). Madrid 12-18 consists of four lines of days, 65 to a line, adding up to 260 ($65 \times 4 = 260$). Actually, the *Tsolkin* as shown is incomplete. There are only 52 days on each of the four lines. Thirteen more days on each line are required to maintain the sequence of days throughout. Obliteration accounts for five days each line on page 18, and it is a reasonable assumption that a continuing page with eight days more is missing, whatever the reason: scribal error, poor planning, or ritual killing.

(U) Note that the days in the chart appear without the required numerical coefficients. The reason for this has emerged. The table can be read both horizontally and vertically, and the omission of coefficients permits this flexibility.

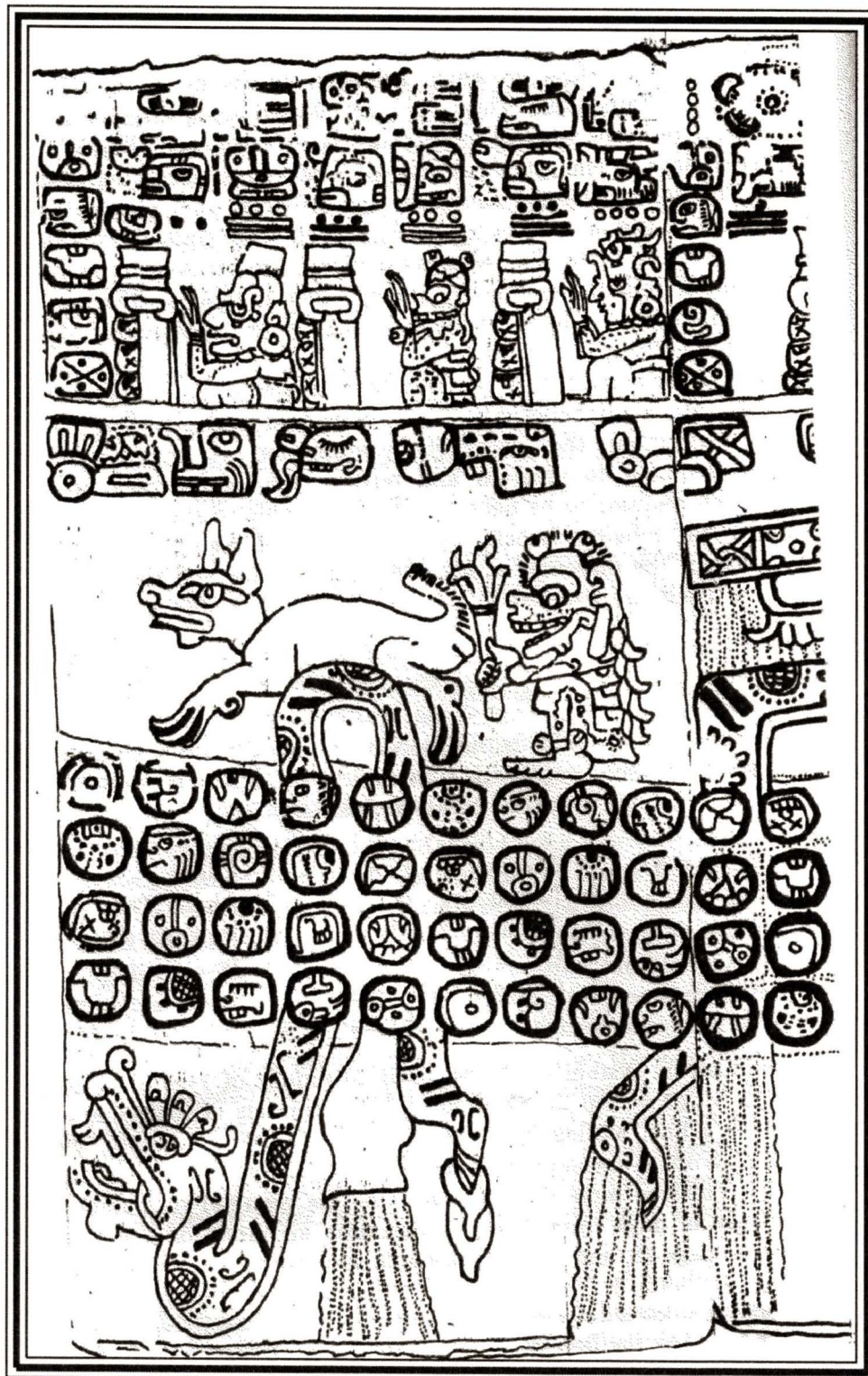
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(U) Fig. 1A Section of the "Maya Astronomical Computer"
(Madrid Codex, page 14)

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1	Imix (1st day)	7	Manik	13	Ben	6	Cauac
2	Ik	8	Lamat	1	Ix	7	Ahau (20th day)
3	Akbal	9	Muluc	2	Men	8	Imix (1st day)
4	Kan	10	Oc	3	Cib	9	Ik
5	Chicchan	11	Chuen	4	Caban	10	Akbal
6	Cimi	12	Eb	5	Etznab	11	Kan (etc.)

(U) Numbering vertically as well as horizontally produces readouts for different calendars.

(U) The horizontal system, used for the Venus calendar, consists of five groups of 1-13, numbered across the table, left to right. The vertical system, used for the Solar Calendar, consists of four groups of 1-13, numbered down the 65 columns of the completed table.

(U) The Mechanism of the Computer

(U) Numbering each of the 260 days in the total layout, in horizontal succession 1-13, results in five groupings of 13 columns. The number at the top of each column applies to all four days in each column.

(U) This is the computer's moving mechanism, which operates somewhat like a typewriter. As the carriage reaches the last position of each row, it returns to the first position on the row below until it has completed four horizontal "journeys." Four such vertical shifts return the roller to its original position (1 Imix to 1 Imix or 2 Ik to 2 Ik, etc.). The number 260 is registered, the Tzolkin repeats itself without end. In effect, a unit shift downward represents an interval of 65, and a unit shift horizontally and interval of one.. We can now proceed to pinpoint a particular time interval on the face of the computer. To arrive at points spaced 584 days apart on a diagonal, the computer shifts 65 spaces to the right nine times, and one space to the left ($65 \times 9 = 585 - 1 = 584$).

(U) Fig. 1B Prototype Group

1	2	3	4	5	6	7	8	9	10	11	12	13	1	2
Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men
Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men	Cib	Caban	Etznab	Cauac	Ahau
Chuen	Eb	Ben	Ix	Men	Cib	Caban	Etznab	Cauac	Ahau	Imix	Ik	Akbal	Kan	Chicchan
Cib	Caban	Etznab	Cauac	Ahau	Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc

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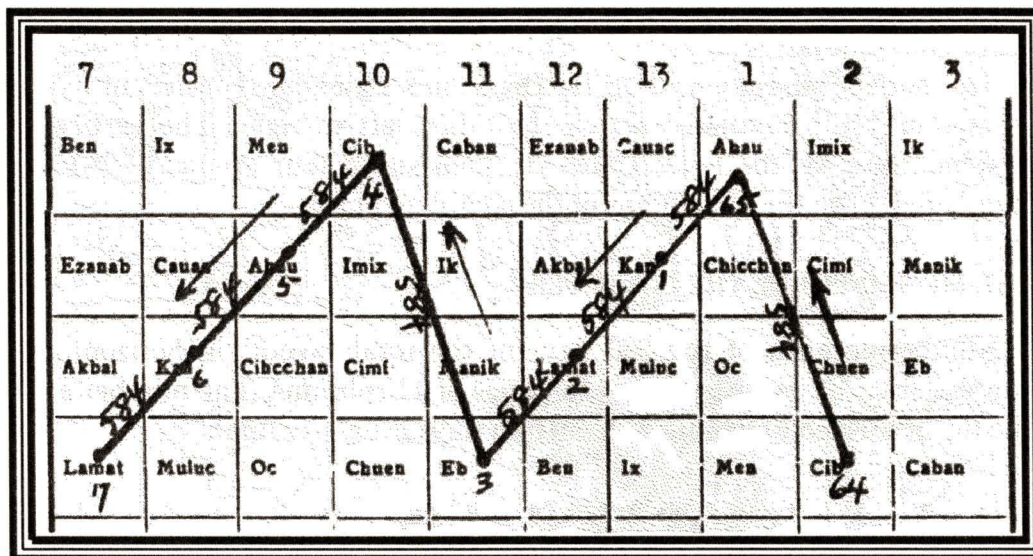
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(U) Fig. 2 Plotting intervals of 584 days

(U) To calculate 584 days from Ahau, the all-important day on which the Venus calendar ends and begins again, for example, the computer programs itself as follows:

1. From 1 Ahau, shift right 65 spaces, 8 times back to 1 Ahau.
2. From 1 Ahau, shift right 65 spaces, 1 time to 1 Chicchan (1 Chicchan is in the same column as is Ahau, but on the next line below.)
3. From 1 Chicchan shift left 1 space, to 13 Kan ($585 - 1 = 584$.)

(U) 13 Kan is the day on which Venus appears as a morning star in the first revolution, in the cycle of 65 revolutions. The progression of Venus revolutions continues down the diagonal, right to left, as the program repeats as shown in figure 2.

(U) In this manner, the computer mechanism operates to provide an instantaneous readout of particular revolutions of Venus in succession 1-65. And, in a demonstration of symmetry beautiful to behold, the computer has arranged the days involved so that the numerical coefficients are also in perfect succession, 1-13.

(U) Identification of each day on the diagonal is made by a check of the Venus calendar, reproduced in this report. For example:

1 Ahau = Morning star, 65th rev.

13 Kan = Morning star, 1st rev.

12 Lamat = Morning star, 2nd rev.

11 Eb = Morning star, 3rd rev.

(U) Pattern Programming

(U) There is a column of five days in each of the top explanatory sections of Madrid pages 14-18. On pages 14-17, the days are identical: Ahau, Eb, Kan, Cib, and Lamat. On page 18 the days are Oc, Ik, Ix, Cimi, and Eznab. Programming for the computer is accomplished by applying the patterns of these days to the table. That is, the days were connected by a continuous line in the sequence on the table. For example, Ahau, the first day in the column Ahau-Eb-Kan-Cib-Lamat, appears for the first time in the table, page 13, as the fifth day on the bottom or fourth line. Eb appears as the seventh day, second line. Kan follows as the ninth day, page 14,

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1	2	3	4	5	6	7	8	9	10	11	12	13	1	2
Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men
Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men	Cib	Cabán	Eznab	Canac	Ahau
Chuen	Eb	Ben	Ix	Men	Cib	Cabán	Eznab	Canac	Ahau	Imix	Ik	Akbal	Kan	Chicchan
Cib	Cabán	Eznab	Canac	Ahau	Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc

(U) Fig. 3 Ahau-Eb-Kan-Cib-Lamat pattern

fourth line. Cib is the 11th day, second line, and Lamat is the 13th day, fourth line.

(U) This is the basic Ahau-Eb-Kan-Cib-Lamat pattern (Fig. 3), and it continues as an unending succession of Ms across the entire layout. A similar pattern involving the third and first lines can be made by beginning with Ahau, second day, third line (page 14), and continuing to Eb, fourth day, first line, and so on across the table, and connecting at the beginning of the table. The entire interconnection of the two patterns results in the Venus calendar, with every day in proper sequence.

(U) In a further refinement, the two Ahau-Eb-Kan-Cib-Lamat patterns can be consolidated into connected diagonals, as shown below in Fig. 4.

The Oc-Ik-Ix-Cimi-Eznab pattern (Fig 5) can be applied to the layout in the same manner. Oc is the fifth day, second line (page 13). Ik is the seventh day, fourth line. Ix is the ninth day, second line (page 14). Cimi is the 11th day, fourth line, and Eznab is the 13th day, second line. The pattern is W-shaped, and a connecting pattern can be made, as shown for the Ahau-Eb-Kan-Cib-Lamat pattern.

1	2	3	4	5	6	7	8	9	10	11	12	13	1	2
Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men
Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men	Cib	Cabán	Eznab	Canac	Ahau
Chuen	Eb	Ben	Ix	Men	Cib	Cabán	Eznab	Canac	Ahau	Imix	Ik	Akbal	Kan	Chicchan
Cib	Cabán	Eznab	Canac	Ahau	Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc

(U) Fig. 4 Consolidated Ahau-Eb-Kan-Cib-Lamat pattern

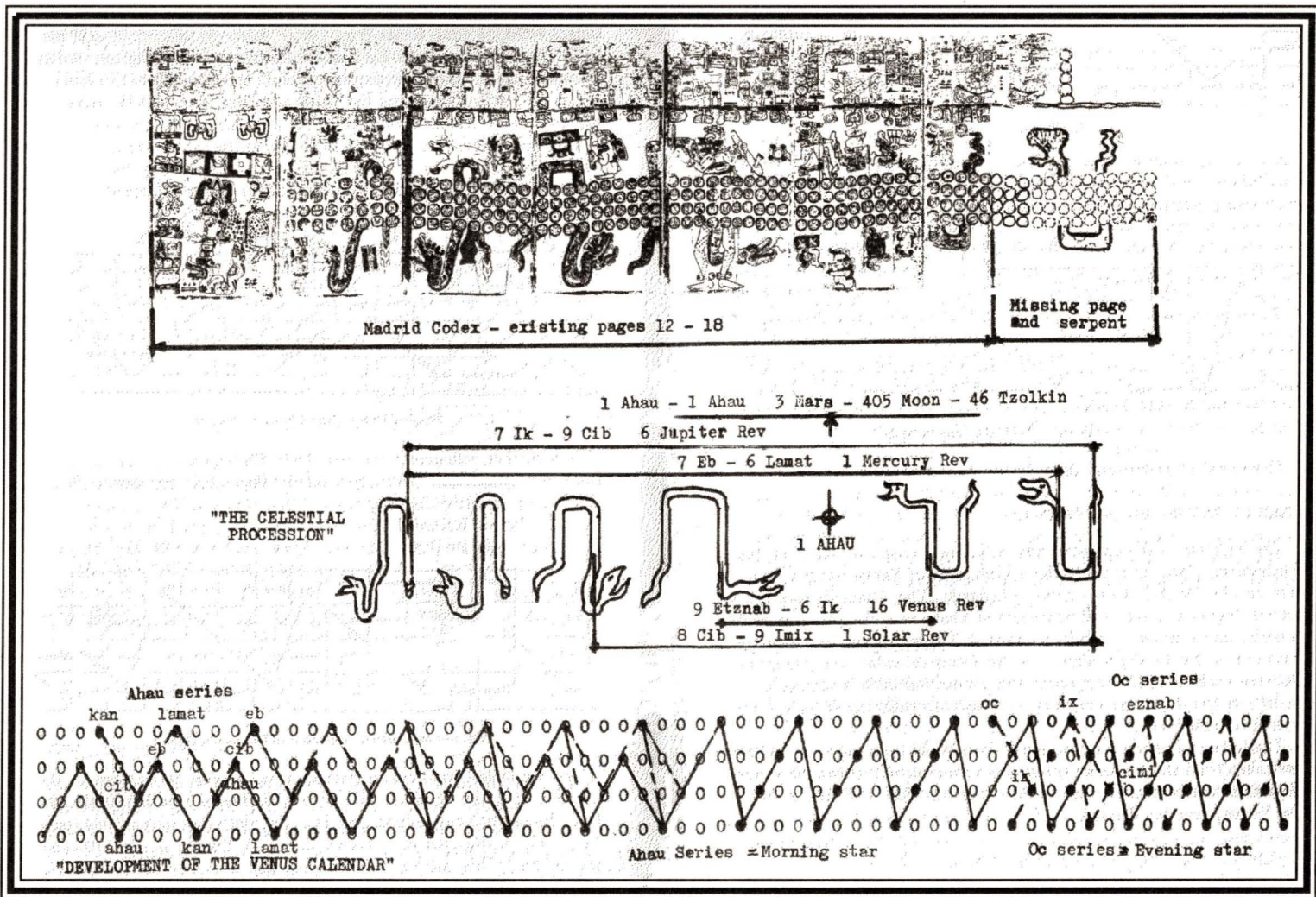
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1	2	3	4	5	6	7	8	9	10	11	12	13	1	2
Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men
Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men	Cib	Caban	Kanab	Cauac	Ahan
Chuen	Eb	Ben	Ix	Men	Cib	Caban	Kanab	Cauac	Ahan	Imix	Ik	Akbal	Kan	Chicchan
Cib	Caban	Kanab	Cauac	Ahan	Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc

(U) Fig. 5 Oc-Ik-Ix-Cimi-Etznab pattern

(U) As with the Ahau-Eb-Kan-Cib-Lamat pattern, the above can also be consolidated into connected diagonals. As shown below in figure 6, the two diagonal patterns alternate a space apart.

(U) These are Venus patterns, described in the following section.

(U) Readout of the Venus Calendar

(U) The astronomical computer has now been programmed, and the mechanism moves to retrieve the appearances of Venus as an evening star on Oc-Ik-Ix-Cimi-Etznab diagonals. The Ahau-Eb-Kan-Cib-Lamat diagonals produce appearances of

Venus as a morning star, and superior and inferior conjunctions as well. These ten days are the only days out of the 20 which appear in the Venus calendar, and the count between each along the diagonals and connection lines, counting right to left, is 584 days, the length of a synodical revolution of Venus (an average rounded out).

(U) The following values for days along the diagonals on pages 13 and 14 are taken from the Venus calendar as an example of retrieval of Venus data from the computer. (MS = Morning Star, ES = Evening Star.) See Venus calendar, Table 1.

1	2	3	4	5	6	7	8	9	10	11	12	13	1	2
Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men
Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men	Cib	Caban	Kanab	Cauac	Ahan
Chuen	Eb	Ben	Ix	Men	Cib	Caban	Kanab	Cauac	Ahan	Imix	Ik	Akbal	Kan	Chicchan
Cib	Caban	Kanab	Cauac	Ahan	Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc

(U) Fig. 6 Consolidated Oc and Ahau pattern

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	Date	Event	Rev.		Date	Event	Rev..
1	Cib	MS	39th	3	Etnab	ES	39th
2	Eb	MS	38th	4	Ix	ES	38th
3	Lamat	MS	37th	5	Oc	ES	37th
4	Kan	MS	36th	6	Cimi	ES	36th
5	Ahau	MS	35th	7	Ik	ES	35th
6	Cib	MS	34th	8	Etnab	ES	34th
7	Eb	MS	33rd	9	Ix	ES	33rd
8	Lamat	MS	32nd	10	Oc	ES	32nd
9	Kan	MS	31st	11	Cimi	ES	31st
10	Ahau	MS	30th	12	Ik	ES	30th

(U) The conjunctions of Venus also lie along the Ahau-Eb-Kan-Cib-Lamat diagonals in a curious but fascinating economy in programming. The day stays the same. All that changes is the number of the revolution. Checking with the Venus calendar, we can see that 1 Cib, which is a Morning Star in the 39th revolution, is also Inferior Conjunction in the 31st revolution, and Superior Conjunction in the 16th revolution. Identifying which of the three possibilities is meant in any particular case is the subject of further study.

(U) At this stage of research, the Oc-Ik-Ix-Cimi-Etnab diagonals produce only appearances of the Evening Star. Yet to be tested are elongations, stationary periods, and times of greatest brilliance.

(U) It is now possible, even at this early stage of research, to decode any sequences of the ten Venus days—Ahau, Eb, Kan, Cib, Lamat, and Oc, Ik, Ix, Cimi, Etnab—that are found elsewhere in the Madrid, Paris, Dresden codices, no matter what coefficients 1-13 are involved. There are many occurrences of these days in all three codices, and knowledge of the astronomy involved will aid decipherment of the textual portions of the pages concerned.

(U) The Resurrected Serpent

(U) J. Eric S. Thompson, among other authorities, has expressed the belief that the Tzolkin in question was meant to be completed, and that a page is missing. Yet, no in-depth examination of this condition seems to have been attempted. It cries out for completion by its uncharacteristic dissymmetry and terminal vagueness. The five serpents that are superimposed on the table with their directional facing and exact positioning, call up the vision, 1,500 years later, of an enigmatic priest setting the clues of a mystery for us to solve. Our clues are to be found in the introductory planetary band (Mercury-Mars-Venus-Jupiter) in the top section day sequences which introduce each page and in emphasized numbers.

(U) This section of the report will present evidence of the existence and placement of a sixth serpent on the missing last page of the layout and evidence of its probable function as a mechanism of the computer that can be described as "anchor-man" in a serpentine chain of indicators of the synodical revolutions of the four planets involved.

(U) Imposed on the Ahau-Eb-Kan-Cib-Lamat and the Oc-Ik-Ix-Cimi-Etnab grids of the com-

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Days		236 90 250 8				236 90 250 8				236 90 250 8				236 90 250 8				236 90 250 8			
Event		SC	ES	IC	MS	SC	ES	IC	MS	SC	ES	IC	MS	SC	ES	IC	MS	SC	ES	IC	MS
Day		Cib	Cimi	Cib	Kan	Ahau	Oc	Ahau	Lamat	Kan	Ix	Kan	Eb	Lamat	Etnab	Lamat	Cib	Eb	Ik	Eb	Ahau
Synodical Revolutions 1-65	1-5	3	2	5	13	2	1	4	12	1	13	3	11	13	12	2	10	12	11	1	9
	6-10	11	10	13	8	10	9	12	7	9	8	11	6	8	7	10	5	7	6	9	4
	11-15	6	5	8	3	5	4	7	2	4	3	6	1	3	2	5	13	2	1	4	12
	16-20	1	13	3	11	13	12	2	10	12	11	1	9	11	10	13	8	10	9	12	7
	21-25	9	8	11	6	8	7	10	5	7	6	9	4	6	5	8	3	5	4	7	2
	26-30	4	3	6	1	3	2	5	13	2	1	4	12	1	13	3	11	13	12	2	10
	31-35	12	11	1	9	11	10	13	8	10	9	12	7	9	8	11	6	8	7	10	5
	36-40	7	6	9	4	6	5	8	3	5	4	7	2	4	3	6	1	3	2	5	13
	41-45	2	1	4	12	1	13	3	11	13	12	2	10	12	11	1	9	11	10	13	8
	46-50	10	9	12	7	9	8	11	6	8	7	10	5	7	6	9	4	6	5	8	3
	51-55	5	4	7	2	4	3	6	1	3	2	5	13	2	1	4	12	1	13	3	11
	56-60	13	12	2	10	12	11	1	9	11	10	13	8	10	9	12	7	9	8	11	6
	61-65	8	7	10	5	7	6	9	4	6	5	8	3	5	4	7	2	4	3	6	1

SC = Superior Conjunction ES = Evening Star IC = Inferior Conjunction MS = Morning Star
 1 Synodical revolution = 584 days. 5 revolutions on each line = 2920 days or 8 solar years
 2920 days x 13 lines = 37,960 days (104 year cycle of Venus)

(U) Table 1 The Maya Venus calendar (from the Dresden Codex, pages 46-50)

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puter, each serpent is seen to intersect it at four points. The days involved are Ik, Eb, Cimi, Cib, Lamat, and Etznab. A frequency table of these intersections shows that Ik and Eb appear four times each, while the others appear only three times. Thus the addition of a sequence Cimi-Cib-Lamat-Etznab would reestablish the calendric symmetry of the "procession," with each day appearing four times, and placed exactly on the missing page in a prescribed position. Two cross checks of this reasoning are provided by the symmetry in the total number of days reached by counting between the points of intersection of each serpent, and in the symmetry of the directions in which the serpents face. After trial of multiple possibilities, a significant total of days between intersections was achieved by counting from tail to head. This information is summarized in the following chart (S = serpent).

(U) The five visible serpents are positioned in such an exact manner, mathematically and geometrically, that their relevance and probable function as a mechanism of the computer cannot be overlooked. Consider also the directional facing of the serpents. The first two face left, the second two face right, and the fifth faces left again, but in reversed fashion. The head is at the top and the

body loops at the bottom. The other four heads are at the bottom and the body loops at the top.

(U) The overall pattern can be maintained by placing the sixth serpent in the position indicated by the mathematical and geometric symmetry, facing left like the fifth serpent, on the grid 9 Cimi-9 Cib-6 Lamat-6 Etznab. Note that this positioning of the sixth serpent produces, like the fifth, a total of 452 days between grid intersections. Furthermore, it achieves a third identical pair in opposition to the "twin" pair initiating the procession. Very importantly, the day 1 Ahau, when the Venus cycle begins, is now seen to occupy a central position between the second and third pairs, as a functional element in the "procession." This is equal to ten Tzolkins. With the sixth serpent in this position, a relation of the serpents to the synodical revolutions of Mercury, Mars, Venus, and Jupiter can be presented.

(U) Readout of the Solar Calendar

(U) A solar calendar of 365 days can be read from each vertical column of the table. The four days in each column are numbered vertically in four cycles of 1-13, for a total of 18,980 days or 52 years. The count between each day is 365 ($13 \times 4 =$

(U) Days between points of intersection

S		Days Btwn		Days Btwn		Days Btwn		Total Days Btwn
1	7 Ik	130	7 Eb	194	6 Cimi	130	6 Cib	454
2	13 Lamat	130	13 Etznab	194	12 Eb	130	12 Ik	454
3	5 Lamat	130	5 Etznab	168	8 Cimi	130	8 Cib	328
4	1 Ik	130	1 Eb	200	6 Eb	130	6 Ik	460
5	12 Cib	130	12 Cimi	192	9 Etznab	130	9 Lamat	452
6	9 Cimi	130	9 Cib	192	6 Lamat	130	6 Etznab	452
Total:								2600

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2	3	4	5	6	7	8	9	10	11
Men	Cib	Cabán	Ekanab	Canac	Ahan	Imix	Ik	Akbal	Kan
Ahan	Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc
Chicchan	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix
Oc	Chuen	Eb	Ben	Ix	Men	Cib	Cabán	Ekanab	Canac

(U) Fig. 7 Example of intersection (Serpent number 3)

52; $52 \times 365 = 18,980$). Using the first column of the table as an example, we find that the sequence of numerical coefficients would be as shown in figure 8 below.

(U) Between 1 Imix and 2 Cimi are 365 days. Between 2 Cimi and 3 Chuen are 365 days, and so on until the sequence repeats itself again with 1 Imix, each vertical column of days is actually a perpetual calendar. This vertical numbering system can be applied to any column in the table or it can be applied across the entire table as seen in figure 9 on the following page.

(U) A solar calendar of 365 days naturally

requires correction. The Maya are credited with a system of corrections that brought their solar calendar to an accuracy of 365.2420. Gregorian accuracy is 365.250. Actual length off the tropical year is 365.2422. *The Maya Solar calendar is therefore more accurate than ours*, and just as the Gregorian Calendar adds one year in four, a leap year correction is inherent in the Maya astronomical computer. For example, the interval between 4 Cib and 1 Imix, in the first column, is 365, and the progression continues without correction. But, if we add 366 days to 4 Cib (a leap year correction), we arrive at 6 Ik in the second column. Thus, when desired, the priests could make a correction visually by simply increasing the numerical coefficient of the first date in each

(U) Fig. 7 Example of intersection (Serpent number 3)

Imix	1	5	9	13	4	8	12	3	7	11	2	6	10	1
Cimi	2	6	10	1	5	9	13	4	8	12	3	7	11	
Chuen	3	7	11	2	6	10	1	5	9	13	4	8	12	
Cib	4	8	12	3	7	11	2	6	10	1	5	9	13	

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Imix 1	Ik 5	Akbal 9	Kan 13	Chicchan 4	Cimi 8	Manik 12	Lamat 3	Muluc 7	Oc 11	Chuen 2	Eb 6	Ben 10	Ix 1	Men 5
Cimi 2	Manik 6	Lamat 10	Muluc 1	Oc 5	Chuen 9	Eb 13	Ben 4	Ix 8	Kan 12	Cib 3	Caban 7	Ezanab 11	Cauac 2	Ahau 6
Chuen 3	Eb 7	Ben 11	Ix 2	Men 6	Cib 10	Caban 1	Ezanab 5	Cauac 9	Ahau 13	Imix 4	Ik 8	Akbal 12	Kan 3	Chicchan 7
Cib 4	Caban 8	Ezanab 12	Cauac 3	Ahau 7	Imix 11	Ik 2	Akbal 6	Kan 10	Chicchan 1	Cimi 5	Manik 9	Lamat 13	Muluc 4	Oc 8

(U) Fig. 9 Progressive vertical numbering system

column by one. The original numbers heading each column (1-5-9-13, etc.) are retained, however, to preserve the cyclical nature of the table, just as we add one day every four years without disturbing the rest of the calendar. This method of keeping the Solar Calendar in good order also permits a shift to the next column in the chart. The calendar, corrected by leap years, can thus progress down the 65 columns of the table, through the 260 positions of the Tzolkin.

(U) The last position on the chart is 13 Ahau. Adding 366 days to Ahau brings us to 2 Cimi, the second day in the first column. The count then begins again for another 260-year cycle corrected by leap years ($365 \times 3 = 1095 + 366 = 1461 \times 65 = 94,965 / 365.2420 = 260.0057$ years).

(U) Readout of Other Planets

(U) Although some researchers believe that the tables on pages 44b-43b and 59 of the Dresden Codex are related to the synodical cycles of Mercury, Mars, Jupiter, or Saturn, the issue is controversial. Without taking sides, we note that such information would have been of use to the Maya-astronomer priests in their obsession to pinpoint

major celestial events in the circle of time. Conjunctions would be in this category. They are spectacular to observe, and could not have been passed unnoticed by priests.

(U) There are hieroglyphs that have been equated with the four planets, other than Venus, which are also visible to the naked eye. Conjunctions, or the order of procession, are possibilities for these groupings with Venus and each other that appear so many times in the three codices. But of all the planets visible to the naked eye, Venus is the only one that seems to have rated tables for accurate prediction of the major events in its synodical cycle, i.e., appearances as morning and evening star, and disappearances in superior and inferior conjunction with the sun. While acknowledging this, can we at least credit the Maya with the capability of counting out the synodical revolutions of the four other planets and predicting conjunctions with Venus and each other?

(U) It can be shown that the priests could accomplish this easily and visually, on their astronomical computer. To demonstrate this capability, we must first reconstruct the grand cycles of each of the four other planets. This can be done using the Maya technique, that is, by charting the synodical

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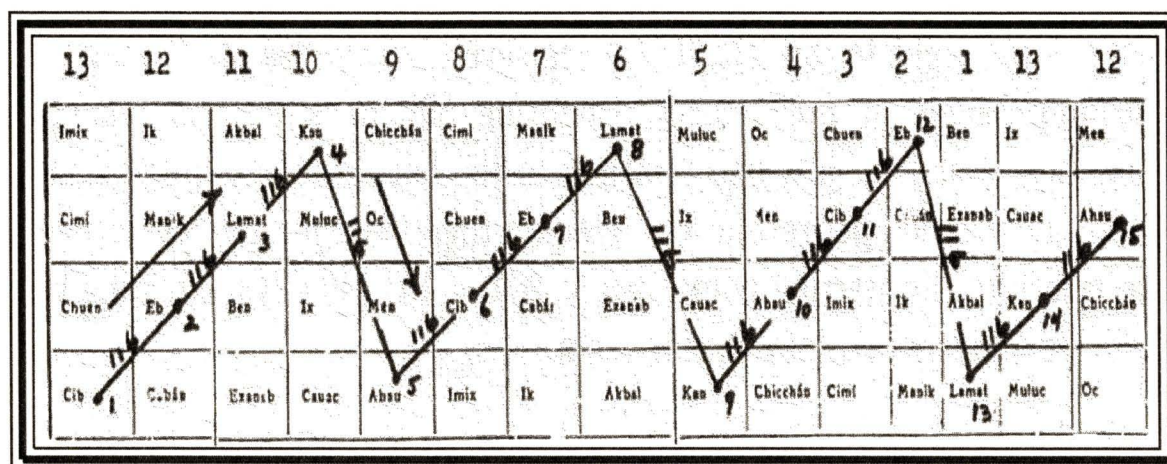
(U) Mercury

(U) The Maya used only whole numbers in their calendar, achieving phenomenal accuracy through correction systems. The Venus calendar in the Dresden codex, for example, is based on the nearest whole number of 584 days; the actual figure is 583.9209 days. The following reconstructions of synodical patterns for the four other planets are therefore, similarly based on the nearest integer. Obviously, any numerical interval can be plotted in a regular pattern on the 4-line layout of Tsolkin. Our concern here is to plot the patterns of the intervals related to the planetary revolutions.

(U) Since we are using Venus diagonals, the Mercury cycle would also take 65 revolutions to come back to the same day ($116 \times 65 = 7,540$ days). Dividing by 365 days, we get a cycle of 20.6575 years. The lub, or beginning day, of the Mercury calendar is not certain; 13 Cib was selected arbitrarily to illustrate development of the cycle.

Planet	Actual Synodical Revolution	Nearest Integer
Mercury	115.8774	116
Venus	583.9209	584
Mars	779.9363	780
Jupiter	398.8846	399
Saturn	378.0919	378

(U) Fig. 10 Typical segment of reconstructed Grand Cycle of Mercury



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6 10 1 5 9 13 4 8 12 3 7 11 2 6 10														
Chuen	Eb	Ben	Ix	Men	Cib	Cabán	Exanab	Cauac	Abau	Imix	Ik	Akbal	Kan	Chicchán
399													399	399
													197	196
Cib	Cabán	Exanab	Cauac	Abau	Imix	Ik	Akbal	Kan	Chicchán	Cimi	Manik	Lamat	Muluc	Oc
399													399	399
													132	131
Imix	Ik	Akbal	Kan	Chicchán	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men
399													399	399
													67	66
Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ben	Ix	Men	Cib	Cabán	Exanab	Cauac	Abau
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

(U) Fig. 11 Typical segment of reconstructed Grand Cycle of Jupiter

(U) Jupiter

(U) The synodical revolution of Jupiter (399 days) can be arrived at on the chart by numbering the 65 columns in the sequence, left to right, 1-5-9-13-4-8-12-3-7-11-2-6-10, and continuing 1-5-9, etc. The 399-day intervals are then counted off, right to left, moving just one position for each revolution.

(U) The numbering sequence for the columns is the same as that for counting out the solar calendar, with a modification. The number at the head of each column applies to each of the four days in the column, rather than just to the top line.

(U) The successive revolutions are read from right to left, bottom line first and then progressing to the top line, first glyph, 1 Imix. The table then repeats. Again, the lub is not certain; so the beginning day could be anywhere in the chart, but the method of reading the cycle remains the same.

(U) There is nothing unusual about reading a Maya table in this manner, from lower right to top left. There are several examples of this way of reading tables in the codices. Counting 399 days in this manner produces a shift of just one position, to the left. Since we are shifting only one position per revolution, it would therefore take 260 revolutions

to return to the starting point $399 \times 260 = 103,740$ days. Dividing by 365, we obtain a cycle of 284.2192 years.

(U) Saturn

(U) The synodical revolution of Saturn (378 days) can be patterned on the chart by reversing the numbering system of Jupiter to right to left, which produces the desired 378 days. The pattern, as shown, results in a more extended diagonal than the one for Venus, but the numerical succession of revolutions of is still in perfect order, 1-130, double the 65 revolutions of the Venus cycle.

(U) As mentioned, the lubs, or starting dates for the four "other" planets are in dispute. The proposed planetary cycles in the Dresden codex offer two. The lub of the table on pages 44b-43b is 3 Lamat, and the one on page 59 is 13 Muluc. Both tables are multiples of 78 and 780; 13 Muluc was picked arbitrarily as a starting day simply to illustrate reconstruction of a Maya cycle of synodical revolutions of Saturn.

(U) With 13 Muluc as the lub, a set of ten named days appears, in this succession: Muluc, Manik,

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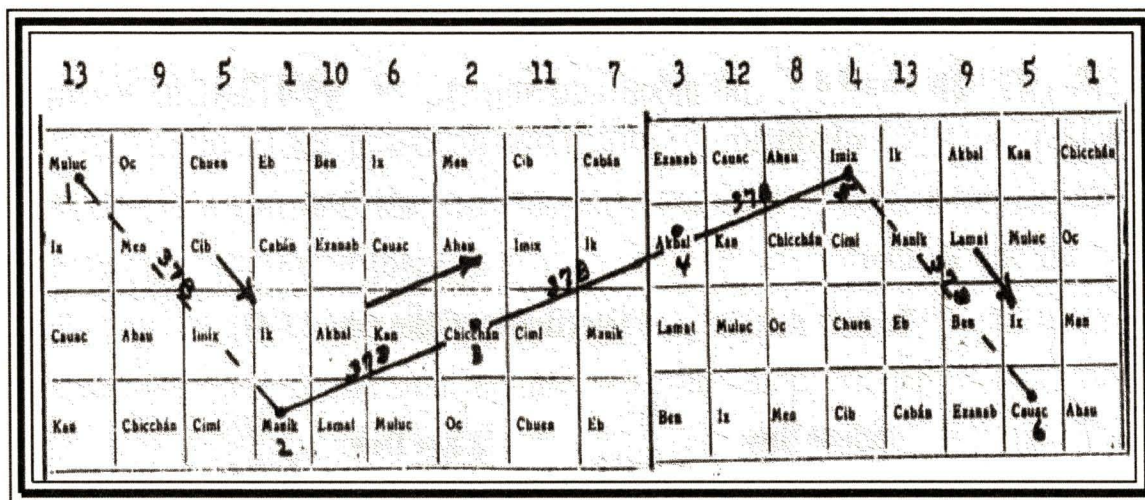
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(U) Fig. 12 Typical segment of reconstructed Grand Cycle of Saturn

Chicchan, Akbal, Imix, Cauac, Caban, Men, Ben, Chuen, and then again Muluc, Manik, etc. If 3 Lamat is the lub, a set of the other ten named days in the 20-day calendar would appear: Lamat, Cimi, Kan, Ik, Ahau, Etznab, Cib, Ix, Oc, and then again Lamat, Cimi, etc.

(U) The sequence of the ten days repeats 13 times until 130 revolutions are completed, and the starting point is reached for a repetitive cycle of 134.6301 years.

(U) Mars

(U) The 780-day synodical revolution of Mars is the easiest of all to compute visually on the chart, and the hardest of all to extrapolate into a cycle. Since we are counting in a 260-day calendar, and $260 \times 3 = 780$, we simply ring the computer register three times, and come back to the same day we started with. We do not know the lub of the Mars calendar for certain, but whatever day it turns out to be, it would apparently remain a constant. That would leave us with a one-day calendar, not a likely possibility. Patently, further study is required.

(U) In a final note on the cycles of "the other planets," it can be seen that none of the four pro-

duces a grand cycle that is a whole number. Only Venus produces a whole number when 37,960, the number of days in its grand cycle, is divided by 365. The whole number is exactly 104 years.

(U) Readout of Solar Eclipses

(U) Pages 51-58 of the Dresden Codex provide a repetitive lunar calendar of 11,960 days, consisting of 405 months divided into 69 groups of 177, 178, and 148 days. The calendar is considered to be a table of new moons for prediction of solar eclipses, and is accurate to the third decimal place ($11,960/405 = 29.530864$). the actual length of a lunation by modern astronomy is 29.530588. Also, $11,960/69 = 173.3333$. The paths of the moon and the sun cross every 173.31 days (the Node).

(U) The 69 groups of days given in Dresden are shown in table 2 on the following page. On these days, solar eclipses can occur as the new moons pass between the earth and sun. The number of days in each group is given, and the groups are numbered 1-69 for plotting and reference purposes. The lub of the calendar (beginning day) is 12 Lamat.

(U) Charting the three intervals of 177, 178, and

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(U) Table 2 Solar eclipse table (Dresden Codex, pages 51-58)

<u>Eclipse Date</u>			<u>Eclipse Date</u>		
		<u>Days</u> <u>Between</u>			<u>Days</u> <u>Between</u>
1.	12 Lamat	177	36.	11 Chuen	148
2.	7 Chicchan	177	37.	3 Cauac	178
3.	2 Ik	148	38.	12 Caban	177
4.	7 Oc	177	39.	7 Ix	177
5.	2 Manik	177	40.	2 Chuen	177
6.	10 Kan	177	41.	10 Lamat	177
7.	5 Imix	178	42.	5 Chicchan	148
8.	1 Cauac	177	43.	10 Ben	177
9.	9 Cib	177	44.	5 Oc	177
10.	4 Ben	177	45.	13 Manik	177
11.	12 Oc	177	46.	8 Kan	177
12.	7 Manik	177	47.	3 Imix	177
13.	2 Kan	148	48.	11 Etznab	177
14.	7 Eb	178	49.	6 Men	148
15.	3 Oc	177	50.	11 Akbal	177
16.	11 Manik	177	51.	6 Ahau	177
17.	6 Kan	177	52.	1 Caban	178
18.	1 Imix	177	53.	10 Men	177
19.	9 Etznab	148	54.	5 Eb	177
20.	1 Cimi	177	55.	13 Muluc	177
21.	9 Akbal	177	56.	8 Cimi	177
22.	4 Ahau	177	57.	3 Akbal	177
23.	12 Caban	178	58.	11 Ahau	148
24.	8 Men	177	59.	3 Lamat	177
25.	3 Eb	177	60.	11 Chicchan	178
26.	11 Muluc	148	61.	7 Akbal	177
27.	3 Caban	177	62.	2 Ahau	177
28.	11 Ix	177	63.	10 Caban	177
29.	6 Chuen	178	64.	5 Ix	177
30.	2 Muluc	177	65.	13 Chuen	148
31.	10 Cimi	177	66.	5 Cauac	177
32.	5 Akbal	177	67.	13 Cib	177
33.	13 Ahau	177	68.	8 Ben	177
34.	8 Caban	177	69.	3 Oc	178
35.	3 Ix	177		12 Lamat	

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Imix	Ix	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ban	Ix	Muc
	11	(177)		3 (178)	7									
Cimi	Manik	Lamat	Muluc	Oc	Chuen	Eb	Ban	Ix	Ikan	Cib	Caban	Ezanab	Cauac	Ikan
	16			15		14		(177)						
Chuen	Eb	Ban	Ix	Muc	Cib	Caban	Ezanab	Cauac	Ahan	Imix	Ik	Akbal	Kan	Chicchan
Cib	Caban	Ezanab	Cauac	Ahan	Imix	Ik	Akbal	Kan	Chicchan	Cimi	Manik	Lamat	Muluc	Oc
								15		(177)	7	(177)		11

(U) Fig. 13 Typical segment of solar eclipse pattern

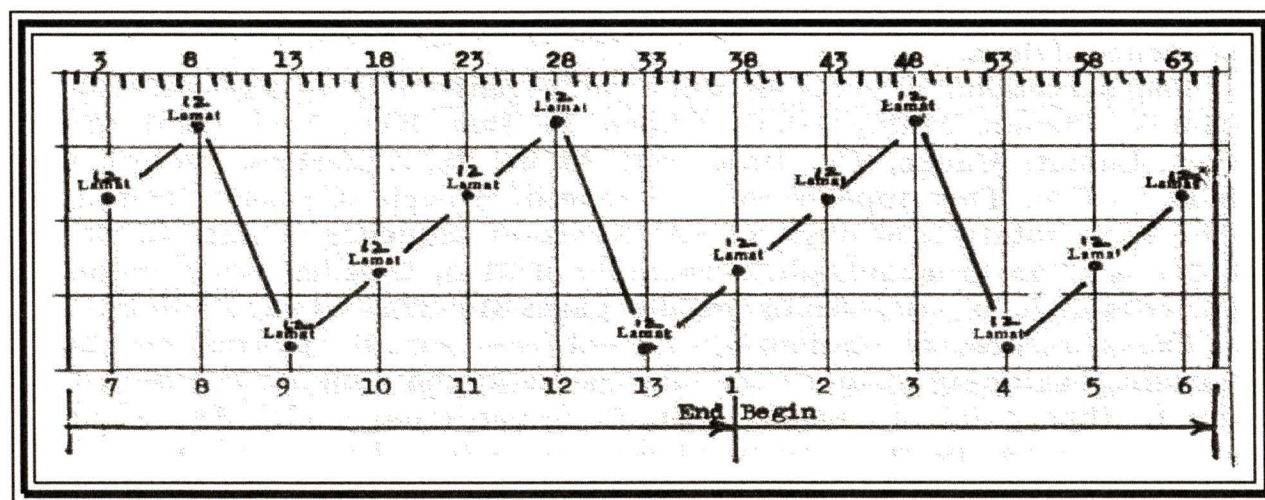
148 in a regular pattern on the four-line chart posed an interesting problem. In the case of the planets, the sun, and the seasons, only regularly spaced intervals are involved. After experimentation with many permutations of the data, the Jupiter pattern finally provided the clue to a "consistency of the inconsistencies" of the solar eclipse calendar. As previously shown, the 399-day interval of Jupiter's synodical cycle can be plotted horizontally, right to left. If the eclipses are plotted horizontally right to left, then the intervals of 148 serve as connecting diagonals, also in proper sequence. Along the lines, the intervals of 177 are two spaces apart, and the intervals of 178 are one space apart. The pattern

continues across the table with the lines changing each time the 148-day interval occurs (nine times each cycle).

(U) The cycle of 11,980 days, when charted in this way, is apparently repetitive only after 13 sequences of 12 Lamat to 12 Lamat are completed, a total of 155,480 days or grand cycle of almost 426 years. Each of the 13 cycles begins at a Lamat on the 4-line chart. Since there are 20 named days in the Tzolkin calendar, a Lamat appears in every fifth column. The progression is left to right.

(U) Beginning with the 12 Lamat in column 38,

(U) Fig. 14 Progression of 13 cycles of solar eclipse

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the progression continues through the 13 cycles until it reaches the beginning 12 Lamat point in column 38 once more. The grand cycle then repeats, *ad infinitum*.

(U) Readout of Equinoxes and Solstices

(U) The average count between the seasons is 91.31 days. Since the Maya mathematicians and astronomers dealt only in whole numbers so far as we know, a pattern of 91 days was sought and applied to the computer.

(U) It was found that a regular spacing of 91 between days was achieved by a serpentine pattern formed by moving from any space, up two rows, and over one, then down two rows and over one. The count is based on a constant numerical coefficient for each day. The constant could be any number 1-13.

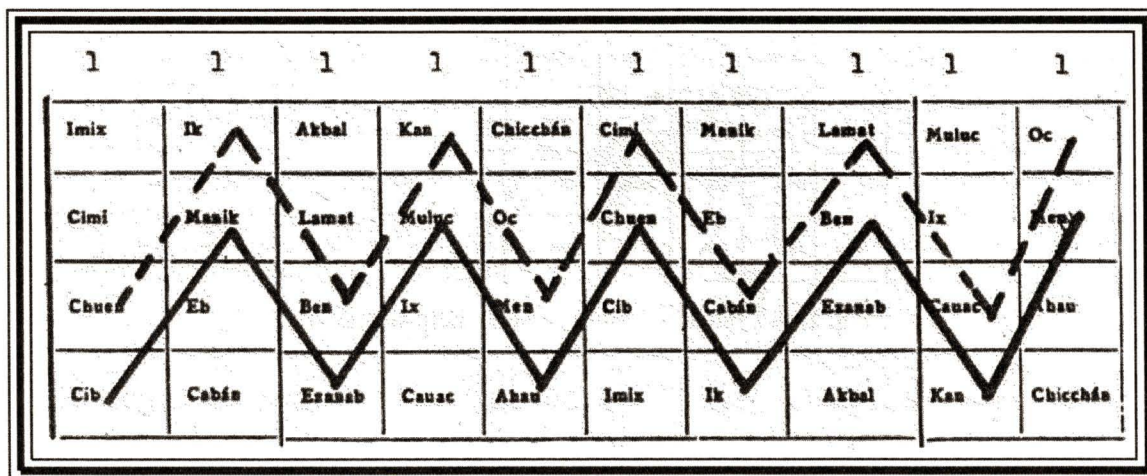
(U) The solid line M pattern continues to the end of the chart, and then moves up a row (shown in dotted lines), thus involving every day in the Tzolkin. This produces an unending count of 91 between each day. The converse (a W pattern) also produces a pattern of 91 in the same sequence of days.

The succession of days in the 91-day pattern is as follows: Cib, Manik, Etznab, Muluc, Ahau, Chuen, Ik, Ben, Kan, Men, Cimi, Caban, Lamat, Cauac, Oc, Imix, Eb, Akbal, Ix, Chicchan, and then back to Cib. This appears to be a repetitive cycle of season bearers. The cycle totals 1,820 days, or 4.98 years. A sequence of days in this order is given in a multiplication table of 91 in Dresden, pages 63-64. Other tables of 91 are given in Dresden, pages 31a-32a and page 45a.

(U) The sequence of equinoxes and solstices can be plotted on the pattern, beginning at any particular point in the Tzolkin and returning to that point, to begin again in a perpetual cycle. Any given sequence in the pattern can be placed into a time frame once a Maya date has been keyed to a known equinox or solstice. For example: there was a fall equinox on September 23, 1480. This day equates to the Maya calendar round date of 6 Ahau 3 Zip, according to Goodman-Thompson-Martinez- Hernandez correlation. The sequence of seasons beginning with this Tzolkin day of 6 Ahau can be plotted on the pattern, using the constant coefficient of six.

(U) Of course, a correction system must be intro-

(U) Fig. 15 Typical segment of 91-day pattern



duced to keep the pattern in step with reality (91 x 4 = 364 x 4 = 1,456 days). The actual count, using the Maya solar year is 4.9680 days for the four-year period. The simple addition of five days every four years would therefore provide acceptable accuracy over a short period in which the cumulative error would not exceed one day.

(U) It would not be characteristic of the Maya to settle for such a short term correction. The complete system must correct cumulative error over the centuries. This problem is still under study.

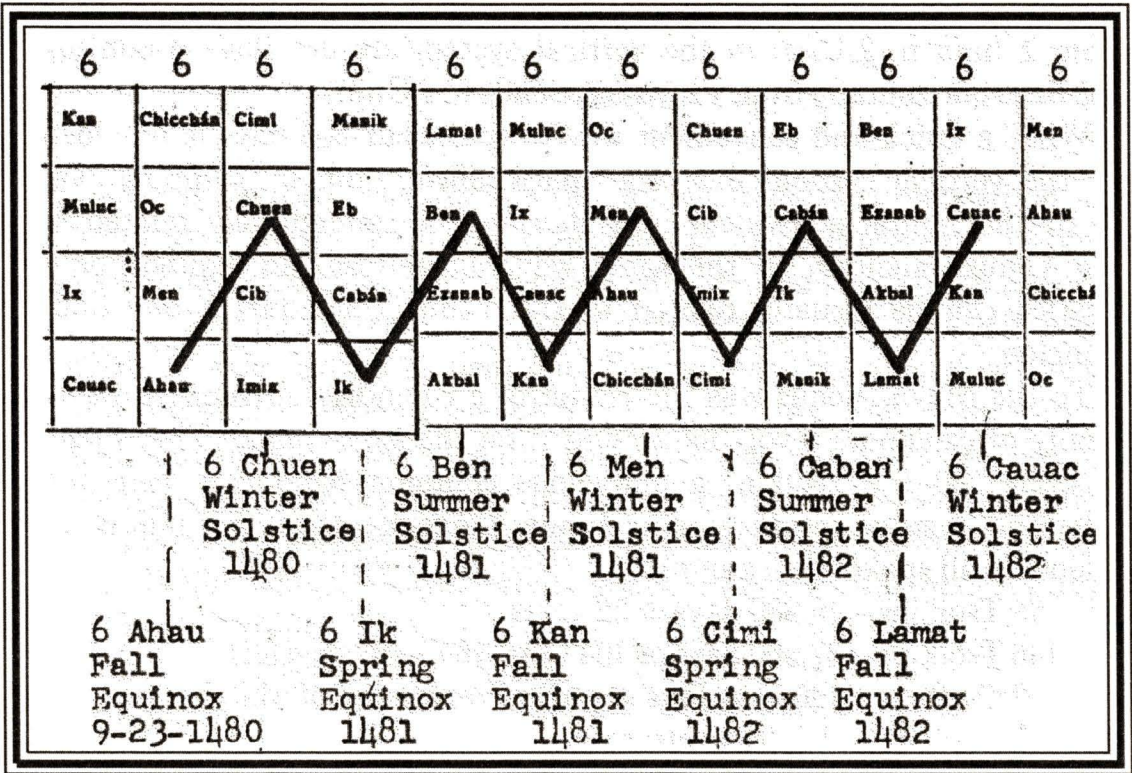
(U) Interrelating Horizontal and Vertical Numbering System

(U) It will be recalled that our computer comes with no numerical coefficients attached. This permits flexibility in numbering vertically as well as horizontally, as long as one is the reciprocal of the other. The alternate numbering systems suggested

for the computer qualify in this respect. The horizontal system results in identical numbers down each column and 1-13 across. The vertical system results in identical numbers across each of the four lines, and 1-13 down each column. Since the Venus calendar is programmed on the horizontal system of numbering, and the Solar, Eclipse and Equinox and Solstice Calendars are programmed on the vertical system, how is any interrelation possible? Quite simply. Any day numbered in the vertical system is identical to its horizontally numbered counterpart. For example: from 1 Imix to 2 Cimi in the vertical system are 365 days. Counting 365 days horizontally from 1 Imix also leads to 2 Cimi.

(U) What a quick and convenient way to count out 365 days is provided by the vertical system. Just one space down. And, by skipping over to the horizontal equivalent, any day can be immediately related to the Venus calendar. In the same way, an eclipse, an equinox, or a solstice can be visually

(U) Fig. 16 Match of a 91-day pattern with a time frame



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related to the Venus Calendar, if any days coincide.

(U) To the Maya, Venus was the center of a calendric universe, with its family of calendars revolving around it on the same plane. That plane was the 260-day Tzolkin, a marvelous common bond that held the calendric system together, a common language that the family of calendars all spoke. For example:

73 Tzolkin—18,980 days for 52 years

146 Tzolkin—37,960 days or 104 years (65 Venus cycles)

3 Tzolkin—780 days (one synodical revolution of Mars)

and so on, in multiples to eternity.

(U) It was in this 260-day calendar that the Maya recorded the eternal, cyclical clock they found in the sky. Perhaps it was with the aid of the visual astronomical computer described in this report that the Maya astronomer-priests achieved their mastery of the calendric art.

*The present article is a revised and expanded version of the original report in two parts: "The Maya Calendar Decoded," *Museum*, Vol. 7, No. 6 (November 1975), 6-13, and "Six Serpents: Did they Function as Computer Mechanism?," *Ibid.*, Vol. 7, No. 7 (December 1975), 24-33.

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