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Vol. VI.—No. 1

COMMENTARY

UPON THE MAYA-TZENTAL

PEREZ CODEX

WITH A CONCLUDING NOTE UPON THE LINGUISTIC PROBLEM OF THE MAYA GLYPHS

BY

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NOTE

In presenting this Commentary on the Codex Perez to students of American Archaeology, the Peabody Museum adds another paper to its series relating to the study of the hieroglyphic writing of the ancient peoples of Mexico and Central America.

The Museum is fortunate in adding to its collaborators Mr. William E. Gates, of Point Loma, California, who for more than ten years has been an earnest student of American hieroglyphs. From his lifelong studies in linguistics in connection with his research in "the motifs of civilizations and cultures," he comes well-equipped to take up the difficult and all-absorbing study of American hieroglyphic writing. Mr. Gates has materially advanced this study by his reproduction of the glyphs in type. These type-forms he has used first in his reproduction of the Codex Perez, and now in this Commentary they are used for the first time in printing. The method used in the construction of this font of type is explained by Mr. Gates in the following pages. This important aid to the study will be highly appreciated by all students of American hieroglyphs, as it will greatly facilitate the presentation of the results of future research.

It will be seen that this Commentary is more in the line of suggestion to be expanded after further studies, than in the way of conclusions.

At the close of the paper the author presents the general deductions he has drawn from his comparative study of languages and cultures. His concluding paragraph forcibly presents the hope that the understanding of the Maya glyphs will furnish new and important data in the life history of man.

F. W. Putnam

Peabody Museum
October, 1910

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THE PEREZ CODEX

THE PEREZ CODEX was discovered just fifty years ago by Prof. Léon de Rosny, while searching through the Bibliothèque Impériale, Paris, in the hope of bringing to light some documents of interest for the then newly awakened study of Pre-Columbian America. It was found by him in a basket among a lot of old papers, black with dust and practically abandoned in a chimney corner. From a few words with the name Perez, written on a torn scrap of paper then around it but since lost, it received its name.

Being restored to its proper place in the Library, it was in 1864 photographed by order of M. Victor Duruy, Minister of Instruction, and a few copies issued without further explanatory notes than the printed wrappers. The number of copies is stated by Prof. de Rosny to have been very small; in Leclerc's *Bibl. Amér.* (1878, No. 2290) it is given as only 10, and in Brasseur's *Bibl. Mex.-Guat.* (page 95), as 50. A copy is in the library of the Bureau of Ethnology at Washington, and referred to in their publications as a most fortunate acquisition. I had the good fortune to secure a copy some ten years ago, and one other has recently appeared in a Leipzig catalog at a high price. Beyond these I have not traced any other copy.

In 1872 Prof. de Rosny published a reproduction, drawn by hand, which, as stated by him later, may be disregarded for practical purposes.*

* In *Archives paléographiques de l'Orient et de l'Amérique,* atlas, t. I, pl. 117-142.

In 1887 he issued a facsimile edition in colors, 85 copies, which up to the present time has remained the only attempt to show the Codex in its proper colors, and has become exceedingly difficult to procure; so much so that it was only after seven years search that I was able to secure my own copy.*

In 1888 he reissued the Codex, uncolored, with the same letter-press, and in an edition of 100 copies. This has also become scarce.

Each of these three editions has its advantages and disadvantages. The colored edition of 1887, having been worked over by hand, in lithography, is defective in various places, both as regards the black of the figures and glyphs, and in the colors. Coloring exists on the original codex which was not reproduced at all in the edition, and the colors given are in many cases not exact. Thus on pages 19 and 20 two different reds are used for the backgrounds, whereas but one is found in the original; on pages 15, 16 the figures are a turquoise green, and on pages 17, 18 an olive green, the correct color for all four being turquoise green.

I have been able to find no inaccuracy in the 1888 edition, which is indeed stated in the introduction to be entirely by mechanical process, without hand intervention; but being reproduced by printer's ink in black only, not only do the colors not appear, but the chromatic values are actually far inferior to the photographs of 1864. It was stated further by Prof. de Rosny that some features of the MS. had been lost by deterioration in the 25 years previous to his editions of 1887 and 1888, but this I have not been able to verify in any important point.

The photographs and the edition of 1888 are to all general purposes identical; but, notwithstanding that the photographs are steadily yellowing by age, the chromatic values are so far superior that I have continually come to find them the court of final decision in doubtful matters. In a very considerable number of instances a close examination of the photographs

* In his *Commentar zur Pariser Mayahandschrift,* Danzig, 1903, Dr. Förstemann does not know of the existence of this edition.

has suggested the presence of faint lines of color on glyphs or figures, which was entirely indistinguishable in both of the printed editions, and which was yet in every case confirmed, although sometimes with difficulty, by the examination of the original MS.

The proved value, as well as the scarcity, of these photographs was so great, that in 1905 I had my set photographed twice, by dry and wet plate processes, and a few copies printed after a careful comparison and selection of the two sets of plates. It is from these that the present edition has grown.*

The present edition, save for the photographs thus reproduced, having been entirely redrawn, and partly restored, it is fitting to detail just what has been done in this respect.

At the very beginning of my introduction to Maya studies the enormous burdens placed on research therein at every turn, bore upon me as upon every other student. The subject and its possibilities stimulate enthusiasm to the highest degree; the rewards of success are greater than those of any like problem today; and yet, fifty years since the present Codex was discovered, and thirty years since Dr. Förstemann's unsurpassable edition of the Dresden Codex, the actual workers on the problem are the barest handful. A few scattered and obscure references amongst the volumes on volumes of Spanish writers, nearly all untranslated, most of them scarce or almost unprocurable, and many not even printed, make up the literature to be searched out. And a few points of decipherment won and safely fixed by the researchers, from Brasseur, de Rosny, Pousse, Brinton and others a generation ago, to Messrs. Bowditch, Seler, Goodman and a few others of today, are all we have — standing out in a wilderness of guesses by many writers, needless of naming.

* *Codex Perez:* Maya-Tzental. Redrawn and Slightly Restored, and with the Coloring as it originally stood, so far as possible, given on the basis of a new and minute examination of the Codex itself. Mounted in the form of the Original. Accompanied by a Reproduction of the 1864 Photographs; also by the entire Text of the Glyphs, unemended but with some restorations, Printed from Type, and arranged in Parallel Columns for convenience of study and comparison. Drawn and edited by William E. Gates. (*Privately printed.*) Point Loma, 1909.

Of course the prime and absolute necessity of such a study is true facsimiles; but the task of using even these, taken as they must be from much defaced inscriptions and manuscripts, is too obvious for comment. So from the very first of my studies I began to cherish thoughts of the day when Maya could be printed with type, and classified indexes to the glyphs at hand. From one point of view such facilities can only be expected to come *after* decipherment; from another, in absence of bilingual keys, they are a necessity *before* that can be attained. So far as his work covers, a great deal has been done in this line by Mr. A. P. Maudslay in the field of the inscriptions.

At the very outset therefore I must enter acknowledgment of the assistance that I owe to the courtesy at that time of Prof. F. W. Putnam, of Peabody Museum, and Mr. Chas. P. Bowditch, in placing, with a freedom by no means universal among curators and researchers, their material at my disposal, with privilege of copying. I am safe to say that while I have reclassified the glyphs for my own use as my studies went on, yet without the copy which by Mr. Bowditch's courtesy I was allowed to make of his card index to the glyphs of the three codices, as a start, this edition of the Perez Codex would not yet have reached daylight through the many other occupations among which Maya studies have had to take their chances.

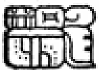
At first it seemed possible to prepare a font of separate types for the various elements of the compound glyphs we find in the texts; but after having such a font made a number of years ago, and printing a couple of pages of the Dresden Codex, the result was unsatisfactory; it became evident that the proper Maya font of type must be both separate and composite, as is used in Chinese, and not separate only as we have for Egyptian. The type for the text cards of this edition have therefore been made this way.

As to the colored plates of the Codex herewith, it is evident that nothing whatever is gained by preserving the irregularities of the defaced parts of the Codex, while everything is to be gained by making all as clear and distinct as possible. The

first step therefore was to have a set of photographed enlargements of two diameters, made direct from the 1864 issue. From these I made careful tracings, myself, of the black figure and glyph lines of the original, making at the same time the separate enlarged drawings from which the type were afterwards made. At this first drawing only the evident, the indisputable parts were drawn. The type forms were then classified, arranged in parallel columns, and compared. All was then gone over, and new points settled on the basis of the familiarity thus gained. It is a fair estimate to say that this process of checking and verifying was gone through, first to last, down to the final proof-reading of the printed sheets, some fifty times.

One most important fact was established by this process, and must be noted. In the Perez Codex at least, *nothing is to be taken for granted,* nothing charged to a careless scribe, and no variants regarded as being identical in value — with a very few exceptions, to which I shall advert later. Wherever there remains enough of any glyph to show its characteristic strokes, it can be regarded as safely indicated; whenever the strokes are not just those characteristic of any glyph, it cannot be inferred. Down to the very end of the various revisions I found myself able to add glyphs which at first seemed hopeless, and yet when once seen became clear and plain. Relying on the presence of the photographs to check the work, I have thus added a very considerable number to the glyphs at first apparent. In some cases, as in 6-b-11 and 17, and especially in 8-b-7, 8, 10, where glyphs were only partially erased, but no other instances of perfect glyphs existed to compare them with, I have let them alone, without attempting restoration. In short, I may have made some errors of eye, but I have guessed nothing.

In a very few places I have restored glyphs totally erased, relying on the parallelism of the passages. Such are some of the Ahau-numbers in the upper sections of pages 2 to 11, and in the central sections on those pages, the initial pairs of glyphs on pages 15 to 18-a, b, c, the first columns of pages 19 and 20,

and a few day-signs on pages 21, 23 and 24. These glyphs are all necessitated by their different series, and hence can cause no confusions; while it seemed advantageous to have them before the eye. A fair instance of the procedure is shown on page 3-b-1, 3. The temptation was strong to put the usual  glyph here as on all the other pages, but the slight variation in the lines left of glyph 3-b-3 forbade it.

The restoration will further be found a little bolder on the type-cards than in the colored plates, where I have in general only endeavored to reproduce what could be seen actually present. The glyphs restored on the upper part of page 7 would seem hopeless at first sight; but they are well-known and common forms, and the characteristic traces shown on the photographs belong to these and to no others known.

The cards of type-printed text, in parallel columns for convenience of study, are self-explanatory. Such an arrangement has from the first seemed to me indispensable for proper study and comparison. The paging of the de Rosny editions I have retained, except to change the practically blank page 1 to be page 25, since to number this as 1 is confusing. For the divisions and the numbering of the glyphs I have made my own arrangement. It is possible that section *b* on pages 2 to 11 should only go to the bottom line of the central figure, leaving section *d* to read clear across the page, and another section to be made to the left of the nearly erased figures at the bottom; but the chances as shown by the lining and arrangement of the columns seemed to favor it as I have given it. Only final decipherment can decide definitely.

THE COLORS

The colors of the Codex afforded a number of questions for solution, some of which I have cleared up and embodied in the plates; a few are I believe insoluble. I have also been able to add a few wholly new points, not indicated by any of the preceding editions.

Being unable to make a personal examination of the original, I prepared from my enlarged black drawings, above mentioned, another full set including the figures and all glyphs or other parts showing any suggestions of color. Upon these I prepared a list of nearly 200 questions covering every detail, together with certain general specifications, and had the whole made the subject of a careful and exhaustive comparison with the original at the Bibliothèque Nationale. This report, when duly returned with the various details set out, with the various colors shown in their exact tints by water-colors, and with a special analysis of the question of the fading of the colors, was again checked and verified by the evidence of the three editions.

In doubtful questions arising from faded colors, I have sought to show the condition of the original as it exists today. In the solid red backgrounds and other places I have aimed to show as far as possible what the Codex looked like when fresh.

This question as to what all the colors in detail were when fresh, I do not feel that I have quite solved. The following palette scheme seems to me about as near as the data permit us to formulate.

A permanent black, being the parts reproduced in black in the present edition.

A brick-red, tinged with crimson, used for backgrounds, red numerals, and probably elsewhere. This we may call unfading red.

A genuine brown, as on the animals, pages 5-a, 8-a; perhaps also elsewhere as lining ornament.

A pale pink as flesh color on the human figures.

A blue, as on the possible katun number series on pages 23 and 24.

A turquoise-green, with varying amounts of blue tinge, on the spotted figures and in the numeral columns of pages 15 to 18; also, with somewhat less of the blue, for the "water" bands on pages 21 to 24.

The above colors are all definite and positive.

Then next appears a brownish color used for lining or ornamenting various glyphs, and the clothing, headdress, etc., etc., of the figures. We find many shades from a pale neutral up to a darker clear brown, and also a definitely reddish, as on the tail of the bird on the right side of page 23. This brown may be a fading of the red of the backgrounds and numerals, but the permanence of the color in these latter places is so positive that I believe it is not so. I think it should be regarded as separate.

We next come to a color question related directly to decipherment, that of the very difficult numeral columns on pages 15 to 18. There is no practical reason discernable for the use of alternating colors save the avoidance of confusion between bar combinations. Three bars together of different colors stand of course for three 5's; of one color they would make a single number 15. We therefore find here our above black, red and blue-green alternating and clearly marked in places; but we also find many numerals of varying shades of brownish, bistre and grayish. I called for especial care in the examination of these points on the original Codex, and the water-color sheets and explanatory notes show in detail the facts of the present state of the Codex. Prior to the examination I supposed that these faded numerals were a faded red, but this is stated in the report to be certainly not the case; the suggestion is made that they are probably faded blacks.

From the latter conclusion I am inclined in part to dissent, at least as to certain passages, for two reasons. These are, first the actual permanence of the above noted main colors, everywhere else; and second, passages in the second columns of pages 16 and 17. In each of these we find faded brown or

gray bars, so placed between or next to plain black bars as would give, were they faded blacks, more than three black bars together.

Another point on page 17 is to be noted. In the top section, first column, are five blue 3's. Some of these blue dots, as shown in the 1887 edition and in my water-colors, have faded to the same light brown seen elsewhere. The brown and the blue 5 in the second column of this page, middle division, as just mentioned, have also an identical chromatic value in the photographs.

My whole conclusion therefore, so far as I can formulate one, is that in these columns we have:

Red, black, and blue-green numerals, as shown. Some of the blue numerals seem to have been *outlined* with black, of which traces still appear on the original, are seen in the photographs, and indicated in the present color plates.

Several instances where the Codex has been rubbed so as to leave only the outlines of original black numerals. These are now gray in the original, and I have left them as black outlines, touched in with gray.

Finally, a number of pale brown numerals which are either faded blue-greens, or else indicate a fourth color in the original. Which of these alternatives is the true one, I cannot say.

The original Codex is still in practically as good condition as when the three editions were taken from it. The material of which it is made is a maguey paper of grayish tinge, and *not* a yellowish brown as would be inferred from the 1887 edition. This is noteworthy, as the wearing away of the coating with which the paper was surfaced for the writing, does not leave a brownish place which, as in the 1887 edition, might be mistaken for traces of applied color. This coating is indeed better preserved in places than is shown by the 1887 edition; thus the headdress at the extreme left of page 20, just to the right of the restored 8 Ezanab on the present color plates, is shown with the coating all erased and the black writing as if left on the ground-paper — which is incorrect.

THE PAGES IN DETAIL

Coming then to the question of the subject-matter of the Codex, I feel that little is in order beyond a simple analytical description of the different pages, rather than any attempt at an interpretation. The road of general deductions from superficial resemblances between unknown elements and the details of other known things from other times and places, is strewn by the wrecks of too many theories to be attractive traveling. I am firmly convinced of the greatness and importance of the study we have before us, and the exalted civilization which produced it; but I do not know how to interpret these monuments. Indeed the very persistence with which the interpretation (which will certainly be self-evident and everywhere applicable when it does finally come) still eludes us, is a sufficient proof that we have not yet found the right road. When we do, great doorways to the past of mankind will open of themselves, and we will know more of human life and evolution than we now guess. Until then we can only describe, classify, and try to get rid of some of the mechanical impedimenta of the search.

What we have of the Perez Codex is manifestly but a fragment; the extent of it originally we have no means of even guessing. It is fortunate however that what we have gives several practically complete chapters or portions of the work. Taking first the side of the MS. paged 2 to 12, we find the entire side covered by a series of pictures with text, all identical in arrangement. The few remaining traces on page 12 show its likeness to the others, for we see in their proper places parts of the Tun-glyph on which the figures on the upper section are seated; of the Cimi, Tun and Cauac glyphs just as in pages 11-c-2, 6 and 8; also of the columns of glyphs to the left, and traces of the headdress. As will appear further, at least two more pages are required to complete this series, and it is as good a supposition as any other that they were those which would be numbered 1 and 13 — that is, one before page 2 and

one after page 12. For convenience of reference the divisions of these pages may be lettered from *a* to *e;* *a* being given to the upper portion, *b* to the left columns of glyphs, *e* to the large middle picture, and *c* and *d* to the text divisions above and below this.

Taking up first the central figures, section *e,* we find in each a standing figure, with ceremonial headdress of varying character, offering a dragon's head (a universal symbol of wisdom) to another figure, seated on a cushioned dais, the side of which bears various "constellation" signs. The latter in turn extends his hands, either holding some object, or else in a simple gesture. The standing figures are all almost completely preserved; the seated ones unfortunately largely or wholly obliterated. In front of the standing ministrant is a vase of offerings, usually a triple Kan figure, and in two cases with knives. In the upper part of the picture, facing in every case but one towards the ministrant, is a bird figure, different on each page, and having in two cases a human head. On each page is an Ahau sign with red numeral, all of them together forming a series which (starting on the supposed page 1 with 4 Ahau) gives the succession 4, 2, 13, 11, 9, 7, 5, 3, 1, 12, 10, 8, 6; in other words the numbers of thirteen consecutive katuns. The Ahau numerals 13, 11, 9, on pages 3, 4 and 5, are entirely distinct, and enough traces appear on other pages to establish this as a katun series beyond question. If this chapter includes just a round of numbers it would of course be complete in 13 pages. The chapter may be historical in contents, but the presence of this numeral Ahau-series clearly relates these pages to successive katuns in some way, whatever other bearings they may have. The ten pages thus in some way definitely have to do with the lapse of 72,000 days, or not quite 200 solar years, and the extension of the series to a full cycle of 20 katuns is quite likely. The background of this section *e* is red on each alternate page.

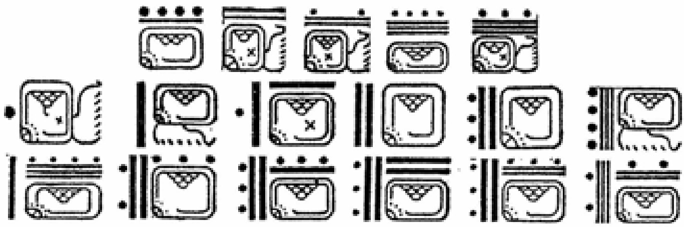
Returning now to section *a,* we find on each page three figures, nearly all of persons or animals, seated on a large base

 practically identical with the tun-glyph. Fourteen of the backgrounds to these figures are red. Above each figure there seems to have been at least six glyphs, of which but very few are left. Above these is a space entirely erased. In the center of the section on each page is a column containing at least two Ahaus with red numerals. The numerals of the upper row exceed those of the lower by 6; each row decreases from page to page by 4. The erased margins of the MS. do not afford space for another picture besides the three, on either side, but they do just give room for another Ahau-column on the left of each page. If this second Ahau-column existed, we have again the katun-series repeated in each row across. If it did not exist, the series (reading from the supposed page 1) of 13, 9, 5, etc., and 7, 3, 12, etc., decreasing by 4's, give the numbers of successive tuns. Once again the question of whether a simple number-round of thirteen terms, or a full round of twenty terms, whether tuns or katuns, was originally displayed on the Codex, must be left undetermined. It is further to be noted that faint but exact traces of a third Ahau, on a higher line, appear on page 5, as well as some doubtful traces on page 8. No definite relationship between the pictures of this section *a* and those of section *e* is apparent.

Section *b* is made up of 45 or more glyphs in three columns. The first column is almost totally erased on every page, and I have disregarded it both in assigning reference numbers and in the type cards. The other two columns I have numbered in double column sequence downwards; but this can be regarded as solely for convenience' sake. The glyph  which is three times repeated at the beginning of page 2, and recurs in parallel position repeated two to five times on each page, is the most common glyph in the whole Codex. It is identifiable probably 38 times, including twice at the top of the erased *first* column on page 4. It heads the second column several times on every page, except 7, which is too erased for any determination, and page 3, where a slight variation in what is left of the postfix at b-3 forbade its insertion under the rules I have given limiting restorations. I suspect that

this glyph should be repeated at 3-b-9 and 11-b-9, for the following reason. In positions b-6, b-8 or b-10 of each page occurs a certain face-glyph  that is found nowhere else in either the Perez, Dresden or Tro.-Cort. codices. If the initial glyph is repeated at 3-b-9 and 11-b-9 as suggested, then (with a slight variation on page 4) this series of repetitions of the initial glyph will in each case be closed by the face-glyph in question.

A marked feature of section *b* is the occurrence, near the bottom of each page, of a Cauac-sign, with or without the  wing-postfix, and with prefixed and superfixed  numerals, exactly as is so common in connexion with the Chuen-sign on the Inscriptions. This Cauac-sign is usually accompanied by an Ahau and a Tun, each with numerals that are for the most part erased. This combination suggests distance-numbers and dates, somewhat as on the Inscriptions; in this case the double-numbered Cauacs would stand for so many uinals plus so many days. The following combinations, besides the one above, are also found:

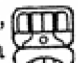


Section *c* consists of 16 glyphs in two rows, above the central picture. Glyphs 15 and 16 on each page are erased. The chief general characteristic is the frequent repetition of the Cimi-compound, ; the repetition on each page of a Cauac-sign with single or double numerals as in section *b*; and of Tun-compounds, with  subfix and with varying prefixes (frequently faces), as especially see page 5.

Section *d* is a triple row of glyphs, originally 21 in some instances, but with many now erased. I am able to establish few general characteristics for this section, save again the frequency of the Cimi-compound as in section *c*, of various Tun-

compounds, and of the two glyphs  and  With the exception of 10-b-4, the face with the tau-eye occurs only in this section *d* and on pages 15 to 18. This glyph is exceedingly common both in Dres. and Tro.-Cort., the form in which it appears at 3-d-4, 6,  occurring (including its secondary compounds) no less than 126 times in Dres. and 33 times in Tro.-Cort.

Beneath section *d* are the remains of red numerals and of heads and headdresses of figures which are now too much erased to give any basis for comment.

A most marked feature of the Codex is the very large number of Tun-compounds, a feature confined exclusively, with one exception, to the present pages 2 to 11, and pages 23, 24. A classified list shows 28 compounds of this glyph,  20 of these showing the subfix, and combined with a face or other prefix. The connexion of this fact with the Tun-bases of section *a*, and with the katun-rounds shown by the Ahau-series above referred to, is manifest.

To sum up the general characteristics of this side of the MS., and without attempting to interpret any separate glyphs, we find the following data:

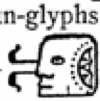
The Cimi-compound  and its sub-compound  occurs 25 times.

The numeral-compounded Cauac occurs 20 times.

The glyph  occurs 13 times on this side and once on page 23.

The Chuen-compound  occurs 19 times and probably oftener — once only on the other side of the MS.

The various Tun-glyphs occur 45 times, on the two sides.

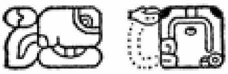
The face-glyph  occurs 10 times.

The Kan-Ymix glyph  occurs 10 times.

The glyph  occurs 37 times on this side and, with a prefix and a changed postfix, once on page 24.

With the exceptions noted, none of the above glyphs occur at all on the reverse side of the MS.

There are finally 19 different Yax () compounds, occurring in all 25 times, 16 of them on this side of the MS.

With three exceptions the above glyphs are the only ones that are repeated in the Codex with any marked frequency. The three exceptions are the face with tau-eye, already  mentioned, and the two glyphs occurring as an initial  pair twelve times on pages 15 to 18, sections *a*, *b*, *c*.

Of month signs used as such I am only   satisfied of 12 Cumhu, at 18-b-4 and of 16 Zac, at 4-c-7. The glyph  at 7-c-2 may also be 1 Yaxkin.

The only cardinal point sign is that of the West,  occurring at 4-b-14 and again at 16-a-6.

There are besides these numeral Cauacs, 15 other Cauac  compounds, occurring in all 17 times on this side, and twice on pages 23, 24.

Upon turning over the Codex, we find that whereas on the side we have been considering the scribe limited himself to the conventional red numerals and backgrounds, with here and there a touch of brown, upon this other side we have a wealth of color united with a harmony of composition and structure that marks a very high degree of artistic skill. It is not alone the accuracy of the drawing and the writing, such as we have noted in connexion with the study of the glyphs, but the whole manuscript as it lies open before us shows that sense of proportion, that ability to unify without seeming effort a multitude of details into a perfectly balanced whole, which is the positive mark of developed and genuine culture. When we remember the exceeding difficulty of combining primary colors into a brilliancy that is not garish, and the equal difficulty of achieving artistic mastery in a conventional treatment of forms, we are simply forced to recognize that we have here the evidence of an advanced school of art with full rights of independent citizenship. If the figures look strange and sometimes distorted, we must remember that our whole training has been

in the realistic school, by which we are prone to judge all others, but by which they must not be judged. We have no more right to weigh these compositions in the scales of our art motifs than we have to weigh Greek rhythm of quantity or Saxon of alliteration against our weights by which we measure rhythm of rhyme and stress. In fact it is impossible for us even to judge concerning the true harmonic effect of these other measures, and it may well be doubted whether the very soul itself of our meter is not empty and tinny as compared with these others — quality for quality.

There is one great broad line that divides the nations and civilizations of the earth, past and present, in all their arts of expression. We may call it that of the ideographic as against the literal. It controls the inner form of language and of languages; it manifests in the passage of thought from man to man; it determines whether the writing of the people shall be hieroglyphic or alphabetic; it gives both life and form to the ideals of their art. It is a distinction that was clearly recognized by Wilhelm von Humboldt, when he laid down that the incorporative characteristic essential to all the American languages is the result of the exaltation of the imaginative over the ratiocinative elements of mind.

The time has passed when we think that the absence of our perspective drawing in Japanese pictures is due to the fact that these "children of nature" never happened to recognize that a thing looks smaller in proportion to its distance, so that they ought to come to us to learn. We have come, in some measure if not yet fully, to recognize that whereas we show a thing to the eye, these other peoples suggest a thought to the mind, by their pictures. And we should remember, and remember always, that while our modern art having won its technical and artistic skill within the past few hundred years, is now beginning to emancipate itself from the materialism of the eye by efforts towards the "impressionist" methods, these ancient peoples had long since arrived at the ability to convey "impressions" through the medium of harmonious compositions of the most rigid conventional elements — an artistic

achievement which those who know its difficulties can alone begin to appreciate.

It may be quite easily forgiven to one trained with Western, modern eyes, who at first sight of these monuments, in total ignorance of their meanings, sees them as strange or grotesque. But when, as their strangeness wears away, one comes to see the unfailing accuracy with which the glyphs are drawn, one's opinion of their makers has to change. And when, with this familiarity gained, one advances to an appreciation of the work in its bearings as a whole, one has to acknowledge himself facing the production of craftsmen who had the inheritance of not only generations, but ages of training. Such a combination of complete mastery in composition, perfect control of definite and fixed forms, and hand technique, can grow up from barbarism in no few hundred years. I would hesitate to think it could even come in a few thousands, unless they were years of greater settledness and peaceful civilization than our two thousand years of disturbed and warring European Christendom have yet had an example of to show us. It is easy enough in the absence of definite historical records, and in our general ignorance of human evolution, to theorize and speculate about it all; but the commonly accepted picture in our minds of a few savage wandering tribes settling and growing up in this country some several hundred or a thousand years after the Christian era, simply will not fit in with the fact of their ability to produce such works a few hundred years later. Had we nothing but the Perez Codex and Stela P at Copan, the merits of their execution alone, weighed simply in comparison with observed history elsewhere, would prove that we have to do not with the traces of an ephemeral, but with the remains of a wide-spread, settled race and civilization, worthy to be ranked with or beyond even such as the Roman, in its endurance, development and influence in the world, and the beginnings of whose culture are still totally unknown. As to the Codex before us, we can only imagine what the beauty, especially of the pages we now come to discuss, must have been when the whole was fresh and perfect.

The second side of the Codex has to be treated in four divisions or chapters, the first of which includes pages 15 to 18. For numerical reasons which will appear, this chapter must probably have begun, however, at least one page further to the left.

These four pages are laid out with three main divisions, upper, middle and lower. Too much of the upper section is erased for any comment other than that its arrangement seems to have been parallel in all respects with the middle section. This latter shows three subsections, the backgrounds in some cases being red,* containing each a picture (probably of a god or a human figure in every instance), surmounted by a black and a red numeral and by six glyphs, in double column. This gives 12 subsections for the four pages, which we may refer to respectively as 15-*a, b, c,* etc. Of the initial pairs of glyphs in each subsection many are complete, and no section is left without the correct traces of the corresponding glyph for one or other of the positions; so that although 5 of the 24 glyphs are totally erased, we may safely restore them all. Other features of the comparative use and frequency of the glyphs on these pages have already been given.

At the top of each picture is found a black and a red numeral. These form the consecutive black " counters " or interval numbers, and the corresponding red day numbers of subdivided tonalamatls, so common in Dres. and Tro.-Cort. It is customary to find these tonalamatls divided into fifths or fourths, 52 or 65 days respectively — four or five trecenas. At the 53rd or 66th day the initial red number is again reached, and the calculation is (by hypothesis) repeated, starting again at the left with a new day-sign below the first. Such a column is seen in the lower part of page 17, where we find 6 Oc, Ik, Ix; these are to be completed by restoring below an erased Cimi

* Dr. Förstemann (*Comm. z. Par. Mayahds.*) speaks of the background to the central figure on page 16 as black, instead of red; he also describes the number columns as made up of red and black numerals only. There are many similar errors in his Commentary, due to his ignorance of the colors, and to the obscurity of the photographic reproductions.

and Ezanab, completing the 260 days and bringing us around again to 6 Oc. The total of all the black "counters" in any series must always be some multiple of 13, usually 52 or 65, as stated. And since each "counter" is the interval between its adjoining red numbers, wherever a red and a black number are given, the other red number, whether before or after, can always be filled in.

No traces of this initial column appear for the series in the middle division, and several of the numerals are also erased. Two obscurities must be cleared up before trying to fill out the series. On page 16 right is a partly erased black numeral, which from the traces may be either 10 or 11. Taking it as 10, we have 13 plus 10 equals an erased red 10; plus 5 (on page 17) equals the red 2 below the 5. This verifies so far. But we next find — plus 5 equals 8, which is of course incorrect. An inspection of the MS. and the photographs reveals a reddish spot (or perhaps even *three* such spots) in the extreme upper right corner of the picture space, 17-a, and also a dark spot *under* the black 5 in 17-b. It is possible that the separated red dots (one doubtful) are to be read together as 3; or that the red dots under the 5 are to be disregarded in the count (just as is the red 8 on the next page, 18-a), and the red number for 17-a found in the upper right, above the seated figure. If the red number in 17-a is 3, the two numbers in 16-c must be 11. Or it may be assumed that the spot under the 5 in 17-b belongs to it, making 6 instead of 5, which figures out. The final result is the same, as we have either 10 and 6, or 11 and 5, in these two places, and either reaches properly the clear red 8 in 17-b.

In 18-a we find black 26, with a small red 8 below, and a large red 13 in the usual place at the side. The red 8 will have to be disregarded, as not part of the series, which requires 13, and nothing else.

We may now possibly set down the series as follows, using small figures above the the line for the black counters, and putting in parentheses all numbers restored:

$$(6)^{39}9^{(6)}(2)^{5}7^{6}13^{11}(11)^{5}3^{5}8^{5}(13)^{26}13^{10}10, \text{ or else}$$

$$(6)^{39}9^{(6)}(2)^{5}7^{6}13^{10}(10)^{5}2^{6}8^{5}(13)^{26}13^{10}10$$

This leaves us the black number at the beginning, in 15-a, and both numbers at the end, 18-c, still not filled in. Adding together all the counters we get 82, plus at least the two missing black numbers, one at each end. If the total were 104, we might expect it to have been comprised within the four subsections 15-a to 18-a. But 104 is not a tonalamatl fraction. 130 days, although a tonalamatl half, is an unknown division, and would hardly get into the space. If we begin the series in the upper division of the page (as occurs in Dres.) and come around to the middle division, the probabilities would require that it displayed a full series of 260 days, and again also that it began *to the left* of page 15. The probabilities of this series as it is, therefore, indicate at least a page 14 to the left, arranged like the other four, and forming one chapter with them.

We have now to deal with the puzzling numeral columns, in alternating colors, found to the left of each subsection of the upper and middle divisions — 24 columns in all. These have been referred to at some length in the preliminary discussion of the colors, and there is little more that can be said. As there said, the entire reason for alternating the colors can not be certainly assumed. Alternation of color occurs not only where it is needed to distinguish bars, but also where we have only lines of dots, which are of course self-separating. And to say that it is only for artistic purposes is a mere begging of the question. Only four or five of these columns are complete, and a footing of the numbers in each gives us varying amounts from 113 to 153, and tells us nothing. On the parts that are left we six times have a Chuen  with a black number apparently belonging to it (perhaps a multiplier), and also once a double Chuen, as in Tro.-Cort. The use of the red *kal*-sign, or 20, is frequent.

The lower division of these pages was also subdivided, into four sections on each, which we may refer to as *d, e, f, g*. Each contains a picture, with black and red numerals as above, surmounted by four glyphs only. The pictures are all quite incomplete; neither is there anything to add to what has been already said of the glyphs.

In the middle of page 17 one tonalamatl ends, with a red 6, and another begins, also with 6. The second starts with the day 6 Oc, is divided into fifths, and the initial column must have been in full: 6 Oc, Ik, Ix, Cimi, Ezanab. The restoration of the series gives: $6^{22}2^{(15\text{ in two stages})}(4)^{10}1^{4}6$. This however only gives a total of 51 for the black counters. There is space to the right for another section, but whatever may have been written there has entirely disappeared. The last three numbers $1^{4}6$ seem unmistakable, the ●●●● especially so. If we regard the last 6 as an error for 5, and then restore $^{1}6$ in section 18-g, it would give the necessary 52. This is the one passage in the Codex where I can see no way but to assume a mistake in the writing; for 1 plus 4 does not equal 6, and unless for some entirely unknown reason the error is clear.

The preceding tonalamatl may have been divided either into 52- or 65-day periods. If the period was 52, it must have begun with an initial column on page 15, right side. In this event it would be restored as follows:

$$(\text{initial } 6)^{(19\text{ in two stages})}(12)^{6}5^{7}12^{(12\text{ in two stages})}(11)^{8}6,$$

giving 52. In this case a third tonalamatl must have begun somewhere to the left, and ended on the erased right side of page 15.

A different restoration would carry the initial column back to the extreme edge of page 15, when we would have this:

$$(\text{initial } 6)^{(2)}(8)^{8}3^{11}(1)^{(11\text{ two stages})}(12)^{6}5^{7}12^{(12\text{ two stages})}(11)^{8}6$$

giving 65.

To choose between these two would be mere guessing.

The well-known pages 19 and 20 come next. Together they make four compartments, up and down the full length of the pages, two with red and two with black backgrounds. Each is, or rather was, preceded by a column of 13 "year-bearers." The left column on each page I have restored, although no traces of it are left. But apart from its manifest necessity, as part of the series, if the width of the red ground on page 20 (see the photographs) is measured, it will be found to be just the correct proportion, and part of the straight left

edge of the red can still be seen, just left of the rod in the hand of the mummy-figure, and leaving just room for the Ezanab column. In the colored plates I have only shown 12 instead of 13 day-signs in each column, but a measurement of the space above and below shows that the missing four are to be placed at the top and not at the bottom. These two pages therefore have application in some way to 52 solar years, beginning with 1 Lamat and ending with 13 Akbal (Votan).

These "year-bearers" are those of the Tzental instead of the Yucatecan system, as described by Landa, and on these two pages rests, so far as regards known subject-matter, the assignment of the Codex Perez to the Palenque rather than to the northern Maya district. It is thus to be considered with the Inscriptions of that region, and with the Dresden Codex.* And in accord with what is known of the state of the different parts of the country at the time of the Conquest, and of the history of the break-up and extinction of the Maya empire, it must be assigned the greater antiquity on that account.

It is probable that pages 19 and 20 had no text passages.

Pages 21 and 22 again, judging from the coloring and the arrangement, seem to form a pair. Each had on the upper part probably five rows of glyphs, some 70 in all, of which only 10 or 12 are at all recognizable. Contrary to all the pages hitherto discussed, it may be that these glyphs are to be *read from right to left.* The faces in these all look to the right, and the customary prefixes are all on the right. In classifying these glyphs, therefore, they must be all reversed.

The greater part of page 21 is framed in and divided up by green bands, evidently for water, two branches of which, after crossing a constellation band near the bottom, end one in falling torrents, the other in a circle surrounding a *kin*-sign, , the sun, and itself surrounded by four dragon's heads, all figured in the midst of the torrents. Below this symbol

* Where to place the Tro.-Cort., in view of the *apparent* Kan, Muluc Ix, Cauac years indicated on pages 34-37, and the 13 Cumhu immediately next to 13 Ahau on page 73 (13 Ahau 13 Cumhu falling only possibly in a year 12 Lamat) I am not ready to say.

is the open mouth of a dragon, towards which is looking and pointing a black-faced figure, of the god D, the Ancient of Days, described by Schellhas as the moon and night god. To the left of the torrents is a figure, nearly erased, but with the wristlets characteristic of the god of death, and holding in the hand a torch. The glyph  occurs written in the torrents, at the left side.

The green bands divide the middle of the page into six compartments containing, so far as not totally erased, 65 day-signs, in columns of five. All my efforts to relate these signs either to each other or to any other series in the codices, have so far been fruitless. The upper seven columns have each a black numeral beneath, running from right to left, 1 2 3 3 5 6 and the dot of another 6.

Each of the columns of five day-signs forms a closed circuit returning into itself. In the upper row the 1st and 6th columns show successive days 8 apart in order; columns 2, 3, 4, 5 and 7 are 16 apart in order. The 1st in the lower row is at intervals of 8, the 2nd and 5th at intervals of 16. The 3rd column is, with the 4th, an exception, the intervals being successively 8, 4, 4, 8, 16. That this is probably not a scribal error is shown by the fact that the same series, though beginning with different days, occurs in both columns. The 6th and possible 7th columns of the lower part are indeterminable.

We thus have three rounds of 5 times 8, or 40 days; seven rounds of 5 times 16, or 80 days; two irregular rounds of 40 days. These are not such columns as could form the beginning of a series of tonalamatl fifths, in which the successive days come 12 apart. So that this section must be left unexplained.*

* Mr. Bowditch suggests to me that the numbers 1 2 3 3 5 6 6 are to be read with each of the day signs in their respective columns, and, being placed in the middle, may apply both to the upper and lower sets. The strongest objection I can see to this is that the numbers are black, instead of the usual red. In this case, instead of intervals of 8 and 16, giving rounds of $5 \times 8 = 40$ and $5 \times 16 = 80$ days, we would have intervals of 156 and 208 (from 1 Ymix to 1 Muluc, etc.), giving rounds of 780 and 1040 days respectively. Or, if read *upwards,* we would have 52 and 104 day intervals (1 Ben to 1 Chicchan, etc.), and rounds of 260 and 520 days. But whichever be the case, the page is *sui generis,* and its why is still beyond us.

At the right of page 21 begins a solid red background which probably extended right across page 22. Two standing spotted green figures appear on page 21; seven seated figures, one green spotted, on page 22.

Page 22 is crossed by a winding dragon whose body is covered by the "constellation band." A narrow green band also winds across the page, inclosing two of the upper figures. Below the dragon and this green band are seen, seated above the open mouths of two erect dragons, two figures in conversation, each bearing various insignia of the death god. A very curious cartouche outline, partly erased, at the lower right, incloses what seems to be 13 Ahau, 3, 6, the right hand dot of the 3 being erased.

On pages 23 and 24 the brilliant backgrounds of the preceding pages disappear, and we have two pages, to be read together, of glyphs, day-signs and small figures, finely and sparingly illuminated with the usual four colors. The body of the dragon is apparently continuous from page 21, and crosses these pages entirely with the constellation band, displayed along its full length.

The upper part of these two pages contained originally 91 glyphs, perhaps to be read *from right to left,* the same as 21 and 22. The faces look to the right, the usual *pre*fixes and the few numerals are also on the right of their respective compounds. Many of the glyphs are the same as those on pages 2 to 11, reversed right for left. Glyph 23-a-11 should be specially noted. At first sight the numeral prefix, 6, appears to belong, postfixed, to glyph 23-a-17. But on investigation we find the same compound, a *yax-chuen* with  prefix, also at 21-a-8 and 24-a-26, in each case with the 6 attached. The  affix just below this number 6 is also plainly a *pre*fix to glyph 23-a-12; so that glyph 23-a-11 must be read  and include the 6 as prefix. At 24-a-26,  the same glyph is written left to right.

There are also a few other glyphs on these pages which cannot be regarded as right to left. Such for instance, as

 at 23-a-19 and 24-a-17. In this glyph the affix  at the side is properly a prefix (perhaps the possessive), and I do not recall any instance of its use as a postfix. In the affixes, the superfix and prefix positions may as a general rule be regarded as wholly identical; also the subfix and postfix positions. But also as a general rule the two pairs are I believe not to be interchanged, any more than we interchange prefixes and endings in English; this rule is not universal for all affixes, as some seem able to go anywhere, but it is one I have always regarded in my glyph classifying. As to  it is to be noted that this is a symmetrical glyph and as there can be no doubt that these glyphs were equally legible to the Maya reader written in either direction, it may well be regarded as unimportant, and not to be rated even as an error.  is a still stronger similar case. Here the wing  affix to the right is certainly a postfix, the superfix is in the usual left to right order,  and the main element written left to right, as in all its other instances. And  is again in point.

The face-*tun* compounds on these pages, and also on the opposite side of the manuscript, should be particularly noted.

Below the constellation band, inscribed on a wavy green band (the waters of space ?) are seven repetitions of  or the sun glyph  within the shields.* Between each appeared probably two black 8's. The sun-shields are about to be seized by different animals, dragon, tortoise, bird, etc., a seeming evident suggestion of either an eclipse, or the passage of the sun into some zodiacal sign. Another series of seven sun-shields, on the green band, separated by numeral 8's, and attacked by animals and a skeleton, crosses the lower part of the pages.

Between these two bands we find a series of columns of five day-signs each preceded by red numerals. Allowing for the space erased I have restored the last column to the right,

* I have retained the usual term "shields" for the flaring forms which embrace the sun glyph, though without accepting its appropriateness. They might with equal likelihood be conventionalized wings.

and part of the preceding. This gives 12 columns only, whereas at least 13 are required. There may have been a 12th column to the left of page 23, where there is just the proper space for this,* leaving the dragon's body to curve above the column so as to pass to page 22. The series may have continued on across page 25; 13 columns on pages 23, 24, and 7 more filling page 25, would make a full cycle of 20 columns. And in this connexion it should be noted that the dragon's body with constellation band goes almost to the edge of page 24 with no sign of ending or turning, such as might be expected if the chapter ends here. And if the constellation dragon continues over page 25, the column series may well have done the same.

Before discussing this series it will be of advantage to review what the Codex gives us on the question of reading left to right or right to left.

First, in both the Dresden and Tro.-Cort. the glyph faces look to the left; and, as shown by the calculations, reading is from left to right, with a very few possible exceptions, such as the tables on Dres. 24, 64, 69, etc.

In the Perez, as shown by the tonalamatls on 15 to 18, the 52 year-bearers on 19 and 20, and the katun-series on 2 to 12, the general direction of the reading is also left to right.

Above or below each of the red number columns of these pages 23, 24, is to be found a blue number. These numbers make a katun-series, starting with 4, decreasing by 2, if we read it left to right. It is not, to be sure, accompanied by the customary Ahau-sign, , but, taken in connexion with the marked parallelism of the glyphs, face-tun glyphs and also others, on these two pages with those on pages 2 to 11, already discussed, the possibility that a katun-series is a part of this subject-matter must be considered.

On the other hand, the glyphs in the upper part of all four

* Dr. Förstemann ignores the space on the right of page 24, and restores two columns to the left of page 23 in order to make up the thirteen columns; but, as shown by the edges of the pages in the photographs, one column restored in each place will just fill the obliterated space.

pages 21 to 24 face to the right, and, as already set out in detail, are practically all written in *reverse position* as regards their prefixes, etc. And so also does the Eb-glyph in the day-columns we are now considering face to the right. These columns, unlike those on page 21, which include all of the 20 day-signs, only include 5 of the day-signs: Kan, Lamat, Eb, Cib and Ahau; Eb being the only non-symmetrical one of these.

We have thus quite strong evidence, especially as provided by the position of the prefixes, for a right to left reading, opposed by the direction of this katun-number series — if it be one. In Egyptian writing, of course, the direction of the reading changes with the facing of the figures.

To return now to the columns themselves, all the day-signs in any one column have each the same red numeral, so that we have: 8 Cib, 8 Ahau, 8 Kan, 8 Lamat, 8 Eb; and so on. The red numerals to each column also decrease by 2 towards the right, pari passu with the blue numerals. If we read each column downwards, it will form a closed circuit or round, returning into itself, with intervals of 104 days, from 8 Cib to 8 Ahau, etc., and again from 8 Eb back to 8 Cib. But if we next try to go to the next column, the series breaks, for from 8 Eb to 6 Lamat is only 76 days. We get a like break whether we read upward or downward, or right to left. Taking the columns separately then, the entire series (whether made up of 13, 20 or any other number of columns) cannot be made to read in one regular series, with a constant interval between the successive days of the whole.

But, if we restore two columns, making 13 columns, and then read horizontally *across*, either right to left, or left to right, one line after another, the first day of the second line follows the last of the first, and after going through the whole 65 terms, we return again from the last of the last line to the first of the first— always with a constant interval. In other words, this section could be written around a wheel. If we read left to right, the distance from (10 Kan) to 8 Cib, etc., is 232 days; $232 \times 65 = 15{,}080$. Or if from right to left,* the

* Dr. Seler's reading; *Gesammelte Abhandlungen*, I, 515.

interval from (12 Lamat) to 1 Cib, etc., is 28 days; $28 \times 13 = 364, \times 5 = 1820$. That both of these products are multiples of 260 is a truism, and cannot in any way require us to see a tonalamatl reckoning as the basis of this passage. Nor is each separate day-column a tonalamatl in fifths, as so often found.

Finally, if we should assume that the series went on across page 25, to a full katun-round of 20 terms, the circuit would be broken; line 2 would not regularly follow line 1, and so on. The probabilities then, as derived from the succession of the days, seem almost conclusive that this is a section of 65 terms, to be read horizontally, in whichever direction. And then, since the subdivision of 15,080 days (or 1820, if read right to left) into 65 terms, *necessarily* gives us successive day-*numbers* decreasing (or increasing) by 2, the likeness to the katun-series may be only apparent — a simple truism. Or, on the other hand, in view of the glyph similarities (a point which I think should always be given close attention), there *may* be some relation to the katun-series — all in spite of the right-left or left-right difficulties.

What part the blue * number series plays, I cannot say. Dr. Seler,† suggests that they are "corrections," to set each term ahead 20 days. This states a fact, but does not give any explanation. Each blue number is 6 less than its red column, and 7 Kan *is* of course 20 days later than 13 Kan.

* The blue is a true blue, quite distinct from the turquoise blue elsewhere, and is found in the case of these numbers only.

† *Gesammelte Abhandlungen*, I, 515; "Zur mexik. Chronologie."

THE MAYA GLYPHS

Up to date our knowledge of the meanings of the glyphs is still to all intents and purposes limited to the direct tradition we have through Landa, and the deductions immediately involved in these. We know the day and month signs, the numbers, including 0 and 20, four units of the archaic calendar count (the day, tun, katun and cycle), the cardinal point signs, the negative particle. We have not fully solved the uinal or month sign, which seems to be *chuen* on the monuments and a *cauac,* or *chuen,* in the manuscripts. We are able to identify what must be regarded as metaphysical or esoteric applications of certain glyphs in certain places, such as the face numerals.* But every one of these points is either deducible directly by necessary mathematical calculation, or else from the names of certain signs given by Landa in his day and month list, and then found in other combinations, such as *yax, kin,* etc. That we have as many of the points as we have, and still cannot form from them the key — that we cannot *read* the glyphs — is a constant wonder; but a fact nevertheless.

The innumerable efforts to identify the glyphs by their superficial appearance, calling the banded headdress a "pottery decoration," and explaining the face-glyph of the North thereby, because in Maya *xaman* is north and *xamach* a tortilla dish (to say nothing of others still more fanciful, by a host of writers), have broken down, as was to be expected. I mention this instance because it illustrates fully the results of superficial analysis, united with a seeming ineradicable tendency even among those most able students who have added the most to our stock of Maya knowledge (among whom Dr. Brinton was certainly one of the foremost), to treat these glyphs as carelessly done, to disregard the differences between manifest variants, or else to talk freely, whenever a passage

* The Tibetan use of symbolical words in place of numerals is worth noting here, even though we do not know the Maya face numerals well enough as yet for any comparison. See Csoma de Kőrös, *Tibetan Grammar,* Calcutta, 1824, pp. 155 *et seq.;* also Ph. Éd. Foucaux, *Grammaire Tibétaine,* Paris, 1858, pp. 157 *et seq.*

does not fit the explanation which is being worked out, of scribal errors.

In the first place, *if* these glyphs are to be interpreted primarily by the Yucatecan Maya dialect (one in which we have most ample printed and MS. lexicographic material), and if in that dialect no other words at all resembling *xaman* and *xamach* are found, as we are told, then (*if* the Mayas named the north star, or the North, by a pun on a tortilla dish) wherever this banded headdress is found, we must assume the text to be treating either of the North, or of tortillas. That might safely be left to break down of its own weight; but we shall also see that the explanation is given in total disregard of manifest, important variants. This banded headdress appears ornamenting at least five separate and distinct  faces; one a wholly human face, the others with various other definite characteristics, the most frequent and prominent of which are the monkey-like face and mouth we see in the  glyph for the north, and a sort of bird's plumage covering the back of the head. These two are separate, are never combined, and must be classified rigidly apart. We have therefore three elements, the monkey face, the plumage covering (if we may call it so), and the banded headdress. It is obvious that while the monkey face may be specific of the North, the bands are not specific at all, but general.

It is with the greatest diffidence that I suggest any interpretations on my own part as yet, but it is of course certain that the distinction of masculine and feminine existed in the spoken language, and it must exist somewhere in the glyphs. And it will have to be a prefix, not a postfix; for what I may call the syntax of glyph formation must follow that of the speech. At the bottom of Dres. 61 and 62 are seven identical Oc-glyphs with subfix, and with prefixes. Five of these prefixes are faces with the woman's curl, recognized on the figured illustrations. One is a face with the banded headdress. Remembering that this headdress occurs not infrequently on a plain human face with no other characteristic, it is not a far guess that it may

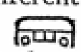
have denoted a freeman, a lord, entitled to such a headdress. In this event it may on the one hand serve as a simple masculine definitive, the prefix *ah-*, and on the other, to attach the idea of lordship to other glyphs with which it is incorporated, as: the North Star, or region, the Lord of the Firmament.

This illustration serves to show what seems to me an essential preliminary of the work we have in hand, and the part to which I have so far devoted most effort. The glyphs must be determined, compared and classified, and what I have called the "syntax" of their composition, studied. The particles and their positions, the various *incorporated* elements, are of the utmost importance, though they are very frequently ignored. *They are the written picture of the spirit of the spoken language.* The task I have most looked forward to in this connexion has of course been with the Dresden, but having started upon the Perez for the reasons I have given, it was a smaller task in itself, and could be brought to completion within less time, while serving as part of the larger work. As the determination and classification of the glyphs had to proceed all as one work, it has enabled me not only to complete my Index for this codex, but also to print the text in type, and to verify and bring out such facts regarding the color questions as was possible to do — both of them stages needed in the general work. In doing it I have studied with my hands as well as with eyes, and I have been well repaid. The actual labor has not been small, but it has been worth it all if only to see before the eyes something of what this Codex must have been when fresh and new. For as I have said, while in my colored restoration I may have made some mistakes of eye, for which the photographs will be a check, I have *guessed* nothing.

The classification of the glyphs meets of course with some difficulties in detail, but it can readily be cast into a quite simple general outline. Something over 2000 different compound forms are found in the three codices. The simple elements composing these are perhaps 350 in number, and may be divided broadly into main elements and affixes or particles. First of course come day and month signs, which, with *kin*,

tun, kal, and a few marked variants, use up 50 numbers. Next will come the faces, about 75 simple elements. Next the animal and bird heads and figures, about 50 numbers. Next the hands, crosses, etc., and the list of conventional or geometric forms, another 75. Then some 75 particles.

The cards required for the first 50 numbers, including only compounds formed from day-signs and excluding day-signs used simply as such, amount to practically one half of the number required for the whole index. Certain elements, notably the *kin,* the *tun,* the monkey-face with banded headdress, already referred to, the face with tau-eye, the *yax,* the cross, produce a great number of compounds — a fact of note, as it is evident that the number of compounds, having due regard to our limited material, is an index to the relative position of the idea in the Mayan vocabularies. Some of the day-signs produce practically no compounds, others a great many. The compounds fall readily into a system of primary and secondary derivatives, by which their relations may be easily studied, and their proportions recognized.

Coming to the distinguishing of variants, one first meets the fact that the three codices differ. The writing of the Dresden and Perez is regular and accurate, the Perez exceedingly so. Every different variant must here be accounted for. In Tro.-Cort. the writing is crude and careless, so that we have many evident abbreviations which are not genuine variants. In the next place, certain regular differences occur in this or that glyph or particle, between the forms of the different manuscripts. Thus the Perez uses  and the others  and so on. A comparison of the compounds shows that these must be the same. The regular variations between the three manuscripts and variations of abbreviation, when well evidenced, may be eliminated.

The day-signs have many variants, mostly quite simple, and all checked positively by the use of the form in some day-series. Ix has many forms. There are at least three entirely different Cimi forms:    There are found two different forms of the closed eye, one

of which certainly is Cimi, the other occurs regularly in such different compounds (and I think never as a simple day-sign), as to make it necessary to separate it;  it has probably a different meaning entirely — perhaps that of sleep.

A noteworthy technical line is to be found in the drawing of the glyphs. Whereas in the case of the day-signs, faces, and conventional forms in general, certain variations of handwriting, etc., are evidently permitted, but only within certain definite lines, in some few animal glyphs no two instances are just alike. In other words, the glyphs in general are conventions with established meanings — actual writing;* but we also have *pictures* of birds or animal forms, where the writer is not following convention, but nature. The freedom of style used in the latter case only serves to emphasize the conventionality of the former, and to separate the entire system from either picture or rebus writing. See the following fish-glyph forms:

These pictures are almost exclusively in uncompounded forms, whereas the conventional glyphs, whether human, animal or otherwise, are subject to the general rules of incorporation.

Writing is a system of conventional forms with established meanings, corresponding to and reflecting the structure of the spoken language; some picture elements whose value as such has remained either wholly or partly present in the minds of those who use them, are not inconsistent with genuine writing; when present they add vividness to the writing, and emphasize its ideographic character. A combination of picture forms only, may be used as means of communication to a certain degree, but can never constitute *writing;* that, like speech, must provide for the expression of the relationships and categories that make up the structure of language.

* "These [the Maya glyphs] do not represent a real script, as is so often maintained, but are only pictures which have been reduced to the appearance of letters, contracted to a narrow space, made cursive." ! —Dr. Eduard Seler, *Codex Vaticanus No. 3773,* page 65. — Well?

Egyptian writing, which is of course *true writing,* contains elements of every class. It has symbols and also pictures, not only of things or creatures, but of actions as well, "contracted to a narrow space, made cursive"; these pictures, although still ranking as such, stand for *words*—they can be *pronounced,* and have syntax, which is the crucial test. Egyptian next has unrecognizable forms, whose meaning has become a simple convention, but which still stand for *words,* or particles. It has elements which are not pronounced for themselves, but only serve as determinatives. (Such a use of determinatives is not limited to hieroglyphic writing, but is possessed also by alphabetic; the second *o* in the word *too* is strictly a determinative, to distinguish the adverb *too* from the preposition *to,* both pronounced alike. Tibetan has an elaborate system of silent letters used as grammatical determinatives.) And then Egyptian writing finally has pure alphabetic elements.

As to Maya, I think it far more than likely that, when at last deciphered, it will be found to contain most if not all of these classes—*mutatis mutandis.* There seems every evidence that it is made up of pictures with probably both concrete and abstract meanings; word-conventions; and grammatical particles. It is at least probable that there are also silent determinatives and not unlikely that there is also a pure phonetic or alphabetic element. That the latter element is not the basic one may I think be now regarded as established.

CONCLUSION

Introite, nam et hic dii sunt.

It is not my desire to add, as a conclusion to a comment bearing on the restoration and interpretation of Mayan hieroglyphic texts, any general discussion of the data which tradition and the early Spanish writers have left us of the mythology, rites and customs of the American races; and still less to run out a line of attractive analogies between isolated instances of their words, symbols or works, with those of any of the various nations of the other hemisphere; nor to build up any theory of descent or intercourse with any of these latter as today known to history. The subject before us is on its very face too vast; the written and traditional data are entirely too scanty and too little understood; and while we are still obliged to designate the various gods and personages of the Codices as god A, B, etc., and are unable to fix definitely* a single inscribed date in

* See *Memoranda on the Chilam Balam Calendars*, C. P. Bowditch, 1901. The obscurities of the Chronicles render the questions connected with Ahpula's death exceedingly difficult. For instance, the immediate context in the books of Mani and Tizimin make the date 1536, as given in numerals, an impossible one. But, if the date as given in *Maya terms* is to be accepted at all (and it certainly is too specific to be rejected), then by the long count such a date *must* have been either 1502, 5350, or 12,786 years after the date of Stela 9, Copan. Mr. Bowditch favors the lower figure, chiefly because it is the lower, and thus puts Stela 9 at A. D. 34. To get this date the longest possible distance from Ahpula's death to the end of the katun must be used — that is, "6 tuns short" must be taken to mean "almost 7 tuns short." I can only say here that if, in correcting the figures 1536, as demanded by the immediate context, we make the simplest possible correction, and put them one katun earlier, 1516, and then take as the unexpired time to the end of the katun the shortest of the three terms given as possible, or 5 tuns 139 days, bringing the end of Katun 13-Ahau on Jan. 28, 1522, we not only bring the end of Katun 11-Ahau within the year 1541, as is most positively stated by the practically contemporary Pech Chronicle, but we also bring in line nearly all the important events of the Chronicles, from the fall of Mayapan, ca. 1450, the coming of the Spaniards, and the smallpox, in 11-Ahau (1521 to 1541), the conversion to Christianity in 9-Ahau, down to Landa's death (1579) in 7-Ahau; as well as many outside references. Any other combination requires harsher emendations somewhere else. But the above choice of the term of 5 tuns 139 days, thus seemingly called for, means that Stela 9 at Copan is dated, by the long count, 5350 years before Ahpula's death, or B. C. 3824. Whether this is right, is a question for the future.

terms of our chronology, or tell the event attached to it, fancied comparisons amount to little. And the favorite "linguistic" method is more fragile yet, especially when the uncertainties of spelling and transliteration are considered, and above all the frequent total ignorance of the past history and changes the different words compared must have gone through since the time when by any possibility a physical transmission from one locality to the other could have taken place. These ought to be commonplaces of research, but it is to be feared that they have not quite yet become so.* There is no need to give instances of such false analogies which have served as the bases for a multitude of filiation theories, all equally well "supported" by details, and all mutually exclusive. Nor on the other hand can we deny the existence actually of a very great number of resemblances and identities which cannot be ignored, but must imply connexions of some kind. The English nation is not a Hebrew people because it had a prime minister Disraeli, nor Greeks because they have a Queen Alexandra, nor Romans because of certain local names. Such facts even when real, and established as such, may only be evidence of a single continental culture or transcontinental intercourse.

It has been the dictum of a certain school of archaeology,

* "In ethnology however one troubles oneself little with the detail of linguistic structure. It is held quite sufficient to gather from different peoples and collate a couple of hundred vocables, into whose actual nature all insight is lacking, and then upon dubious, often purely superficial and apparent similarities, to deduce linguistic affinities. Or else, as is now most in fashion, the claims of linguistic research towards the solution of ethnological questions are reduced to a 'most modest share' in comparison with other fields 'somewhat more in line with natural sciences'—meanwhile pointing for justification to the absurdities set forth as the results of too far-fetched linguistic deductions. . . . The errors and sophistries charged against ethnological linguistics are rather an accidental result of the individuality of single investigators, than essential to the subject. They are at least scarcely greater than those to the credit of recent Anthropometry. A brief glance at the strange changes of opinion in the latter field during the last three decades, in spite of all its boasted figures, shows how little ground it has to throw stones. Serious students, such as Wallace and Dall, whose critical ability in Zoomorphology no one can deny, and who do not rest content with a few skulls of doubtful *provenance*, gathered à la Hagenbeck, have come to a wholly negative view of the value of Craniometry."—Dr. Otto Stoll, *Maya-Sprachen der Pokom-Gruppe*, I, vii, ix.

still very much in general favor, that all these identities are to be explained as the natural result of the innate tendencies of untutored men, on their evolutionary rise, at certain cultural stages, to imagine the same myths and invent the same rites. From this as a principle I wholly dissent; it simply does not meet the facts. There are of course many facts to which it does apply, such as those that both Chinese and Americans made paper, tanned leather, made feather ornaments, used star and flower names for their children, and so on: facts which had been used to prove Chinese and American identity, and to which Dr. Brinton justly added in retort that they also slept at night, wore clothes when it was cold, and so on. But there is a very great number of facts, a number constantly growing with research, which cannot be so dismissed. Such are the employment of abstract symbolism, the erection of great structures all having a definite and identical astronomical bearing and evident use, the common possession of so-called myths all telling the one story, and only slightly modified locally, such as the birth-stories of Huitzilopochtli and of Herakles, and the stories of the travail of Latona pursued by the Python and of the Woman clothed with the Sun in *Revelation;* or the universal tradition of seven ancestral caves or cities in America, compared with the Tibetan and Purânic stories of the seven lotus-leaves of Śveta-dvîpa, the first continental home of the race; the *Hacha de cobre* of the Miztecs and the ever-turning spear of jade of the Japanese story of the place where the gods first descended on earth; or the whole question of the origin of the Zodiac. These things, and a host of others, need a different explanation — all the more since the more we are learning of them the more we find that they enclose facts of which the hypothetical "savage children" could not, *ex hypothesi,* have been aware — some facts indeed which our very latest modern science is only now learning.*

* Our present day speculators never seem to think for a moment that these things may conceal, *and thereby preserve,* some real meaning, or be more than nonsense. The theory of mythological interpretation pushed to such extremes as in the "animistic" *explanations* of Weber, Keightley, and others, and not absent from the writings of some

But while dissenting now wholly from this theory (of "coincidentalism"), one cannot but hold in all respect those who in their time held it. It is the duty of the savant to make the best logical use he can of what he has, and he cannot be criticised for not using finer scales than the time affords. And this theory was needed as an answer to the absurdities, brought out in utter disregard of physical possibilities, postulating offhand migrations and filiations and evolutionary advances totally impossible within the periods allowed for their completion, and utterly without parallel in any known part of the world or page of history. And yet, when this theory had its birth, the most of Christendom was still enthralled by the Ussherian chronology of the creation and history of the whole divine universe, which simply did not have room in it for all these things to happen naturally and connectedly.

And if it is urged that present science had already say a generation ago, a second's time we might say in the life of humanity, begun to emancipate our ideas of time and evolution, still it is the fact that that increase in breadth of vision has so far applied to every known thing but man himself. The old belief that gave the world 6000 years of life, at least put thinking man at its beginning; the modern nightmare gives us a world for hundreds of millions of years without *thought,* and makes human civilization an ephemeral episode of a few seconds of universal duration. Disregarding, one is forced to say wilfully, the fact that every single one of their own arguments in favor of anthropoid descent for man would equally

Americanists (namely, that it was all nothing but ridiculous or concocted fancy, taken soberly) is bad enough, and argues little breadth or insight, when applied to the myths of a single people, considered alone. Applied to comparative mythology, in the state of things today, it is simply impossible. The plain fact is, that such identities as these must indicate one of two things: a common tradition, locally modified by circumstances; or a *fact in nature* or *history,* symbolically expressed in different ways according to the times and modes. And it most probably indicates both of these. It is indeed hard to account for the extent, and the weight given to some of these "myths," now that we are coming to a better appreciation of the scope and greatness of ancient civilizations — everywhere — except they do correspond to actual *facts* in nature and history. And it might be worth our while to get at some of these.

support a theory that the anthropoids are debased offshoots of human stocks,* biology still demands such a lapse of time for its physical evolution that its adherents oppose and belittle to the utmost every bit of evidence of any antiquity even for the physical frame of man. We have, to say nothing of the rest of the world, Egyptian civilization now pushed back 10,000 years, and (together with others as we slowly uncover them) as far removed as ever from barbarism, if not indeed growing greater as we go back; but we are not allowed anything but apelike, half arboreal savages 50,000 years ago. And yet every observed *fact* shows us savage or worn-out races everywhere throughout the world deteriorating and dying out, and nowhere any savages progressing or, unaided by outside influence, developing what we know as civilization. We see everywhere the rise and fall of nations, races and civilizations, and their utter blotting out; and we refuse to accept that process as a universal law through which the destiny of the human race is working itself out. In fact, we do not seem to believe that the human race has any destiny; it may have beginning and an end, but no destiny.

And so although this modern scientific school began as a reaction against the narrowness of theological limitations, both of time and greatness, so hampered and hypnotized has our thought been by both, that man is of nearly as little universal

* We might just as well acknowledge, once for all, that in spite of its present-day currency in England and America, and its pre-emption of the field of "science for the people," the theory of man's physical *and mental* descent from the anthropoids, is not only *not proved*, but is vehemently denied by an equally able and scientific, and withal more logical, body of researchers than those who form its supporters. To *fabricate* a missing link in a chain (or even, as with Haeckel, several links), whose only authority is acknowledged to be its necessity in order to complete the evidence for the theory, and then to declare the theory proved because the fabricated link fits perfectly the gap it was created for, is equally vicious scientifically whether the fabrication be the work of a physicist of renown or a linguistic theorizer. Let it simply be agreed, as it now is by all science, that the *evolution of form* is a universal and well evidenced principle, working out through the various well established and comprehensible incidents, such as natural selection, adaptation to environment, and so on — yet this statement of the fact is not an explanation of its cause. And every scientific and logical requirement will be equally, and better, met by regarding all

account with one as with the other, and we find a seemingly ineradicable repugnance to admit that any people had "developed" writing before the least possible time ago we can fix it, usually this side of the year 1 of the Christian era. And thus we have M. Terrien de Lacouperie's "450 *embryo* scripts and writings" — which another fifty years may show to be nearly as many fragments of one or a few great stocks of ancient hieroglyphs. Of course it is impossible to derive the American races or civilizations from the Chinese, Phoenicians, Hittites, or any of the cultures of the other hemisphere, if we limit the latter to what we know of their history within the past two or three thousand odd years, and American civilization to the past fifteen hundred years. The matter is somewhat greater than that — just as man is somewhat greater than a fool of natural caprice.

There is one point from which this question of American

forms, whether physical, linguistic, or of any kind, as coming, or rather brought, into being by the force of a consciousness which needs them as the vehicles of its expanding activity. That this is absolutely true in language, anybody can see. That it is true in every department of daily life about us, everybody *does* see. That it should be equally true in biology and physics, would not affect the standing or verity of a single *observed* fact.

There was, along about the beginning of the Christian era, and for some time before and after, a very curious movement, which seemed to spread itself over nearly the entire world, east and west. It is told of the early Aztecs that "they destroyed the records of their predecessors, in order to increase their own prestige." It is related that writing once existed in Peru, but was entirely wiped out, and the Inca records committed to quipus alone. The "burning of the books" under Tsin Chi Hwangti in B. C. 213 sought to do the same for China. The times of Akbar witnessed much of the same in India. And in Europe almost nothing was left to tell the tale of the great pre-Christian eastern empires and systems of thought; so that from the establishment of State Christianity under Constantine, and the final settlement of the Canon at the Council of Nicaea, an impenetrable veil was drawn over the achievements and greatness of the Past, and all connexion therewith broken off. It was some time after this that we find the heliocentric theory, as well as that of other habitable worlds, denied (in Europe), because "it would deprive the Earth of its unique and central eminence." Just as we also today are served up with prehistoric savage and animal ancestors, to the greater glory of our own present-day magnificence. But it really is in sober truth only a question of mental perspective which does not affect the facts of history, biology, archaeology or language in the least. It is only a question of which end of the telescope we look through.

origins, at least of American place in human society and civilization, can be studied in its broader lines, even with what materials we have. It is that of language in general. All these other matters we have touched upon are necessary factors in the question of human evolution, and the position of America cannot be considered apart from them, and all of them. But Language touches both the glyphs directly and also all these other things, and is itself of surpassing interest and importance as a human study.

From one point of view Language is man himself, and it certainly is civilization. Without it man is not man, a Self-expressing and social being. It is, as von Humboldt laid down, not an act but an activity, or energy, not a thing done, but a doing. It is the constant effort of the conscious self to formulate thought. It is the use of the energy of creation, of objectivation, a veritable many-colored rainbow bridge between the inner or higher man and the outer or lower worlds. And it is not only the expression of Man as man, but in its varied forms it is the inevitable and living expression of each man or body of men at any and every point of time. Itself boundless as an ocean, it is in its infinite forms and streams and colors and sounds, the faithful and exact exponent both of the sources and channels by which it has come, and of the banks in which it is held, racial, national or individual. It is living or dead, forceful or weak, pure or foul, refreshing or flat, healing or poisonous. It limits us, but yields to our force. Every word or form comes to us with the thought impress of every man or nation that has used or molded it before us. We must take it as it comes, but we give it something of ourselves as we pass it on. If our intellectual and spiritual thought is aflame, whether as nation or individual, we may purify it, energize it, give it power to form and arrange the atoms around it — and we have a new literature, a new and beneficent, creative social vehicle of intercourse, mutual understanding, and human unification. Or if our mental or spiritual life is stale, and petty, or egoistic, or seeking for enjoyment

only rather than action; if we have nothing in us to give the words and forms we use, but only some national force left to use and play with them, we for a while refine, and paint, and pettify, and elaborate into meaningless subtleties of form, every one of which in turn reacts upon our mental and spiritual life, distracting and enchaining us, until at last the nation and its language — die out; for neither can live without the other.

Now it is evident that the criterion of the perfectness of any language is not to be found in a comparison of its forms or methods with those of any other, but in its fitness as a vehicle for the expression of deeper life, of the best and the greatest that is in those who use it, and above all in its ability to react and stimulate newer and yet greater mental and spiritual activity and expression. The force behind man, demanding expression through him, and him only, into the human life of all, is infinite — of necessity infinite. There is no limit, nor ever has been any limit, to what man may bring down into the dignifying, broadening and enriching of human life and evolution, save in his own ability to comprehend, express, and *live* it. And the brightness and cleanness of the tools whereby he formulates his thought, as well as the worthiness and fitness of the substance and the forms into which he shapes it for others to see, are the essentials of his craft. For such is the economy of nature, which wastes nothing in reality, that a fit vehicle will be taken possession of by its own tenant; and the unfit left to and be taken by those who can use no better.

Before, then, taking up the great formal classes into which language at large is usually divided, it will be necessary to say a few words as to the foundations of form itself in language, that we may then proceed to consider these classes from the standpoint of their inner meaning rather than solely of the outer form; and by seeking to understand the mental and spiritual equipment and life of those that used them, may perhaps in turn be better fitted finally to enter into the genius of their written and spoken languages, and to interpret through them in the detail more of the ideas which those forms were

both fitted and used to express. Such a method is essential for the understanding of any language or culture, but it is absolutely necessary in the case of these non-Aryan tongues, so great is the distance both of time and thought which separates us from them. If we set out to compare the forms by which they expressed their thought with those within which we develop ours, or approach these cultures and peoples in the attitude of alien criticism, study their "interesting ways" through a mental lorgnette and impale their dead forms on the needles of our collection, we shall not only show ourselves less broad in culture than many of them, but we shall simply close and lock the doors of discrimination and understanding before us. The question is not, How do their forms and ways appeal to us? but, How did those forms, and ways, achieve their underlying objects, and what was the *thought* behind them?

Life is action, and without activity whatever powers lie within any conscious being are only potential. Activity is the bridge between the inner man and the outer world, by which he impresses his thought, in forms, on chaos or the atoms about him, receiving in return increased knowledge and experience of all he touches, and knowledge of himself through the results of his own actions; and it is the bridge between man and man. For this reason the verb, the word of action, is the most important and most developed part of speech. The three hypostases of life, as of language, are the self, activity, and the world; and it is for the expression of all the possible varied relations between these three, that all the forms of any language come into being. And from the way in which these forms are developed, and the relative importance which is given to this or that form of thought or activity, the character of the people, their grasp of nature, and their own conception of themselves and their relation to the world, can be seen.*

* It is exceedingly interesting to trace the course of criticism since the appearance of Wilhelm von Humboldt's great work, *Ueber die Verschiedenheit des menschlichen Sprachbaues und ihren Einfluss auf die geistige Entwickelung des Menschengeschlechts* (Berlin, 1836). Dr. Brinton gave it most unqualified approval; (see especially his mono-

Some languages have the strong impress of impersonality, without any loss of virility; others are strongly egotistic and self-assertive, with perhaps the braggart's lack of genuine strength. Each spoken language that we know has its own color and tone, to which our thought must respond, if we would know and use it well. To speak good Swedish, for instance, requires clear thinking to an exceptional degree. To show this, the form "come here," which is the ordinary English expression, is simply *bad grammar* in Swedish; the use of "come *hither*" (*kom hit,* instead of *kom här*) is imperative. We have the "hither" in English, but it has become stilted, and the linguistic distinction lost. Compare also the use of *få,* as a common auxiliary; nor are these exceptions, but, on the contrary, characteristic examples. Also to enunciate the language rightly one must hold the back and neck erect and the muscles firm.

graph read before the American Philosophical Society in 1885, and printed the same year). Prof. H. Steinthal (*Grammatik, Logik und Psychologie,* 1855) calls the subject of "inner form" the most important one in linguistic science, and von Humboldt's treatment of it his greatest contribution to that science. And so on. But the work has nevertheless received little attention from a large number of writers, most of them declaring it "unclear." These two views, when one studies the various writers, seem to follow closely upon the standpoints from which each approaches the study. Those who study language (perhaps one should here say, languages) as a phenomenon, a set of external forms, an act, a thing done, get little use out of von Humboldt's work. Those who see it as a human "activity," an energy, get much. This is quite apparent in one of the clearest and ablest linguistic works which has recently appeared, Dr. Adolf Noreen's *Vårt Språk* (in 9 vols., still in course of publication, Lund, 1903 and later), a work of far wider linguistic value than appears from its title. Dr. Noreen, however, dismisses von Humboldt's work, and the subject of "inner form," with a few pages, and the results are apparent in several interesting points. In the first place, in the course of an acute and critical analysis, wherein he shows that the purpose of speech is not simply *expression* of thoughts or ideas, but the *communication* to some other person of the *knowledge* of the ideas so held by the speaker, he goes on to say: "the same knowledge of A's wishes could be as well communicated by his saying 'I want you to come' as by his saying just 'Come.'" This is quite true; but the *energic* effect is quite different. Language is the bridge from man to man, and it is also a *creative activity* of man. Of course Dr. Noreen, in a later volume, where he most lucidly analyses the terms 'words,' 'forms,' and 'concepts,' etc. (*ord, morfem, semem,* etc.), and corrects many errors of definition made by his predecessors, acknowledges the

In some languages the speaker thinks of himself and his completed action as inseparable, as a single idea, as the Latin *edi* for I have eaten; in others he thinks of himself subconsciously as possessing the results of his action, as our *I have eaten;* and in others, as among the Irish peasantry, he separates himself and his action entirely, as *I am after eating.* In some grammars, as in Maya, the verbal concept starts with the past; in others, as our own, we live in the present; in the Welsh, the future is the chief tense. The mere choice of *shall* or *will* as the first person future auxiliary denotes a specific mental quality.

Now the expression of all these infinite shades of relationtionship between the self, the activity and the world, is achieved in two ways: position or placement — syntax; and form. The customary division of languages is into Monosyllabic, Agglutinative, Incorporating, and Inflectional, and this division will suit our purpose, though it must be used with care. It is held in the ordinary theory that these classes must represent successive stages of linguistic perfection, each in turn being higher in the scale than the other, they having grown one from the other as the race advanced. By the theory the monosylla-

difference between the two forms; still his whole admirable work, analytical and critical as it is, is devoted to this phase of language as a mere phenomenon, a set of forms which serve as a medium of communication. From this standpoint, we know all there is to know about language when we have classified its forms. But from the other, the study is ever leading us into the regions and depths of man's consciousness, his creative activity as it goes out to the world; and the true definition of language, from this position, "can hence only be a genetic one." (von Humboldt, *Gesammelte Werke,* VI, 42)

It is further not unworthy of note that, except where directly required in treating of verbal categories, nearly all of the enormous number of illustrations which Dr. Noreen chooses for his points, are *nouns,* names of *things,* and vary rarely verbal forms, words of action and *doing.* But it is simply a fact that all the *potency* of language is in the verb, and almost all there is of language, in a philosophic sense, lies there. The verb is the bridge of communication and action *upon* external things, just as is language itself, going out of man. And it is also noteworthy that the recognition of this position of the verb, together with these other matters of which we are speaking, seems nearer at hand and clearer to those students who are led beyond Aryan languages to the study of American and Asiatic, especially Central and Northern Asiatic. For instance, G. v. d. Gabelentz, *Die Sprachwissenschaft,* and other works.

bic is lower than the agglutinative, and inherently less useful. But the theory does not work out in practical application to the facts we have to deal with, for while we cannot find still left in the world any agglutinative languages representative of sufficient culture to bring into our present consideration, we do find a monosyllabic in the highest rank, and meeting the highest cultural requirements. In short, the latter may be theoretically the inferior tool, but the genius of thought behind is greater than the form. One man can draw a masterpiece with a burnt stick, another only paint a daub with all the brushes made. Once again we must not judge by our preconceived preferences of form.

Omitting therefore the modern remnants of agglutinating languages, outside of America, as affording us no literary material of value for our study, we shall find at once drawn across all the other great classes a single broad line of division, between the ideographic and the literal — the same as already mentioned. And the moment we draw this line as an exponent of the mental and spiritual thought-life of the different peoples, we shall find it not only molding their language forms, both written and spoken, but manifest as well in their art, philosophy, and even their social polity. And of course we must be fair in our comparisons, and not set a Chinese coolie in the concrete against an English statesman, nor any concrete example of another kind of culture in its decay with the highest bloom to which we believe our own type to be able to carry us.

It would be absurd to say that the ratiocinative, literal mind is higher than the ideal. One man sees directly the meaning of the things, the events and situations before him; another reasons it all out. And contrary to many of our current beliefs, the former is often the man of action; he sees at a flash to the heart of the matter, and gets things done. His thought, his activity, is vivid; and his words are likely to be so as well. The idealist, if he be broadminded, and not merely sentimental, is indeed likely to be the practical man. And the type of mind that is made manifest to us by these great non-Aryan lan-

guages and their forms, is the former. Of course idealism in its decadence becomes negative, inactive, self-consuming and no longer creative. But in its bloom the direct vision may be even more active, more practical, than are the reasoned processes.

Much ink and paper has been spent over the question whether the Chinese hieroglyphs are ideograms or phonograms, whether the character 天, for instance, conveys to those using it primarily the idea of Heaven, or the spoken word *T'ien*. It is necessarily both, in a sense; it would not be written language otherwise. And it is equally true that the letter-combination *Heaven* is in a way as much to us a picture of the idea as of the sound; but the difference of procedure is radical. The glyph is related to the idea directly, the spelled word only through the formal combination of symbols for single vocal speech-elements, meaningless when separate. The relation of spoken sound to glyph is wholly adventitious; the relation of the idea to the spelled word is equally adventitious. The ascent, if we so call it, of written speech from the ideographic to the alphabetic, is the descent of the thought further into material forms.* And while it may be (and in the course of universal evolution rightly so) necessary for our thought to descend into the bondage of matter and form, for its know-

* It was not until after this paper was already in type that my attention was directed to the complete agreement of this and the succeeding sentences with the following passage in *The Secret Doctrine*, by H. P. Blavatsky, London, 1888, vol. II, page 199. After saying that some of the Atlantean races spoke the agglutinative languages, the passage continues: "While the 'cream' of the Fourth Race *gravitated* more and more toward the apex of physical and intellectual evolution, *thus* leaving as an heirloom to the nascent Fifth (the Aryan) Race the inflectional, highly developed languages, the agglutinative decayed and remained as a fragmentary fossil idiom, scattered now, and nearly limited to the aboriginal tribes of America." Note the words I have italicized, marking the evolution of the "inflectional" languages as an attendant phenomenon on physico-intellectual evolution, compare the passage with von Humboldt's thesis, already quoted, that the incorporative quality denotes an exaltation of the imaginative over the ratiocinative processes of mind in its users, and further with the surviving genius of Chinese, the type of monosyllabic languages, and the agreement is evident. Von Humboldt, however, did not carry out so fully the archaeological results, for which indeed the materials were in his day still lacking. See also other passages in *The Secret Doctrine*.

ledge and experience, and for the development of matter and form into fitter vehicles of thought, nevertheless the process is a binding and for a time an enchaining one, and the thought is, for a time at least, likely to be lost in the confusion of forms.

Thus we may lay down as our fundamental proposition that a hieroglyphic form of writing is better fitted to, and must properly, in the period of its natural development, accompany the imaginative processes of mind. Or, since imagination to our literal thought implies in some degree the fanciful (though wrongly so in essence), we might perhaps better say that that form of writing is the fit attendant and exponent of those functions of mind which cognize the inner meanings of the facts of life directly, rather than those which study them through the correlation of their phenomena. And also, that the development by any people of an alphabetic out of a hieroglyphic system, does not imply a greater advance in linguistic perfection on their part, but indicates a corresponding mental and inner change of attitude towards ideas and things, and a different conception of the self as related to them all.

It is not at all necessary to assume that the knowledge gained by one method is deeper or more exact than the other. True science may exist as fully under one set of circumstances as the other. If we will take the type of the so-called most primitive form, the monosyllabic — the Chinese, we shall find all this evidenced in the clearest manner. To note but one illustration, a study of the scientific and philosophical ideas involved in and conveyed by the word *k'ung*, for Space, ether, the fundamental substratum of sound or vibration, as well as the "interetheric" central point of balance and power, will disclose an understanding that has nothing to fear from modern comparisons.

And the very fact that Chinese has had to depend on placement of its monosyllables to express all the relations for which speech is called upon, instead of relying on changes of form, seems to have, and indeed has so stimulated the development of pure linguistic power that the language is actually as per-

fect and clear a medium of cultured and learned intercourse, as is the Sanskrit, the supreme type of the so-called most developed form, the inflectional. And by reason of its possession of the ideographic element it has a vividness which the Sanskrit has not. No language can be a highly developed one which does not provide in some way for the expression of all possible needed relations between the three fundamental postulates of life and activity — the self, the action and the world; and Chinese does this in spite of its monosyllabic structure by the development of its syntax of position. And it should be remembered further that Chinese syntax, in strict correspondence to the genius of the language, is not the same formal thing that syntax is with our inflectional tongues, but includes, or rather is primarily based on the *harmonic adjustment of the inherent basic ideas of or within the words.* The Chinese monosyllables are then not the naked separate things they are in the dictionary, but the whole phrase or sentence is on the contrary as much a unit as one of ours; and often more so.

This integral unity of the whole sentence or expression, dominated by a perspective of ideas rather than of forms, which is achieved in Chinese by the elaboration of placement, is also characteristic of the structure of the languages of the American continent; but, these languages being polysyllabic, the vividness and unity are attained by a method described as Incorporation, whereby the accessories of relation are so included in or attached to the leading word that the whole expression assumes the form and sound of a single word. And a similar process takes place with the various elements of a compound sentence. So that although this one of the divisions of language approaches very closely to the Inflectional in its external forms, it yet has held to the vividness and essential characteristics of the ideographic method. And it is a point of the utmost importance for the decipherment of the Maya glyphs, to note as has been stated before, that their syntax of combination must follow that of the spoken language, which we know.

There is one broad line of division marking all the languages and civilizations of the world — the line between the ideographic and the literal; it marks the use of hieroglyphic or of alphabetic writing, and it denotes a culture so widely different from ours, modes of thought so distinct, views of life and man's relation to it one might almost say so opposite to ours, as to point unmistakably to a most distant past, and a former world-culture probably as wide-spread in its day as is now ours — or more so. And it is one of the strangest and most remarkable of the phenomena we are considering, that the two divisions have overlapped each other in time to such a degree that whereas we have in Sanskrit, the most perfect type of Aryan, or inflectional languages, the oldest of them all; on the other hand we have in Chinese an equally perfect linguistic medium of the other type, kept alive into our own times.

When we consider the development and status of the American civilizations which have been revealed to us, and especially when we have once opened our minds to the possibility that world-civilizations different in their time from ours in ours, may for all we know have existed and been blotted out ages ago, leaving linguistic traces, and perhaps perpetuating cultural remnants in a few parts of the earth, it is impossible not to recognize the breadth of the problem we are considering. All over the American continent at the time of the Discovery we see cultures and systems whose time had come. Back of most of the North and South American tribes we find the remains of mighty and utterly extinct civilizations — only their dim memory left. In the centers of higher culture from Mexico to Peru we see the ancient civilization brought further down to our own times; but there also, in process, all the incidents of break-up and an expiring greatness. Internecine strife, invasion from outside, changes of center, are all going on, and all marked by a *steady decrease* in everything that means civilization. Of the ancient mathematical and astronomical knowledge a corner of which is revealed to us by the Maya glyph remains, only a distorted fragment appears in the Mexican,

where also hieroglyphs have yielded to a cruder rebus-writing. The stately and incomparable compositions and architecture of Palenque, Copan and Quiriguá have yielded to the ball courts and local strifes of Chichen Itza — all this following the very course of changing historical succession preserved in the Chronicles. The later the date, the lower in every case the culture; this is impossible not to recognize, nor have we traces of any different course of events. Of course we see the rise of the Aztec nation, a small cycle, but like the Gothic upon the Roman, it comes at the end of the general American break-up — an incursion of barbarians settling on and preserving for us fragments of the culture that preceded them, just as has happened over and over again all over the world. And the same with the Incas in Peru. And yet even the Mexican culture demands our high respect, comparing favorably with European of the same period. Indeed it was actually far ahead of the latter in matters of education and many points of polity.

But in spite of its seeming greatness, its heart and energy were gone, just as with Peru, and both yielded to what on the face seems a miracle, but was only the expression of that force which was preparing the American continent for a new race and civilization, still now only in its beginnings. The Mayan empire had already broken up. And even as we write, the archaeological history of the other hemisphere is being repeated here; on the heels of Manabi comes the Chimu Valley, and soon it will be with America as with Egypt — one will not be able to print an up-to-date work on its early history, for new discoveries will carry it back further, and to greater scope, before the previous ones can be edited and gotten to press. Compare the few pages of earliest Egypt in Sharpe's history, with Flinders Petrie's work of a decade or so ago, and that with the situation today.

It is a simple fact that decipherment and publication all over the world can no longer keep pace with discovery; and the time has come for archaeology to begin to survey these remnants, engineering works that would tax any modern na-

tion with all our appliances, vast ruined cities, one above the other, innumerable languages and writings, the traces of peoples whose very names are lost to history — as a whole, and to ask itself how long it must have taken for all these works to be accomplished, let alone for the birth and decay of the civilizations that supported them, and gave environment for the development of such technical skill as could finish the enormous bulk of the Great Pyramid with an accuracy beyond the fineness of our best instruments to measure. For not only mere bulk is to be considered — though there is enough of that scattered over the earth to keep all the possible available craftsmen of the world a wholly incommensurate time achieving them, but the ability to conceive and carry out such works. What *sort* of people leveled Monte Alban for its crown of pyramids, dreamed and executed the stucco modelings of Palenque, built the temple of Boro Budur in Java, cut the Bamian statues of the Hindû Kush, and so on, and so on, for page after page? If they had such appliances as we have, they must be ranked at least in our class for having them; if they did them without our great engines, what sort of men were they? And if they could do these things without our appliances, is it not a fair inference that they could easily have made the tools, or others better perhaps?

One fact is becoming more prominent with every advance of archaeology over the world, a fact of the greatest linguistic interest, namely that ancient civilizations and empires, as a whole, *lasted longer* than ours of today. Consider how many different and successive empires Europe has had in the last 2000 odd years, *our* history; and how long each of our cultures has lasted. All of them put together would go into one of these older periods, and have plenty to spare. Passing over what may be the real meaning and bearing of this fact on the problem of universal history and human evolution, and the position of our race today, the linguistic considerations which follow are most interesting.

If the fundamental thesis of language as a human activity is its direct correspondence to and expression of all the inner

motives and forces of the users, we have here a key to the survival to our day, an unknown period past its own time, of the Chinese type.

Of the development, modification and decay of languages we have ample material in our own times for study, the periods over which the modifying forces operate being an equal measure of the periods of national activity and change. And, what is perhaps not always sufficiently recognized, we have an elaboration of the formal elements going on under very different impulses, at different periods of the life of the language. The time has come in the history of a people for it to play a greater part on the world's stage: some danger has threatened the national life and aroused its energies, or other causes have worked to quicken the mental and spiritual life; an Elizabethan era is ushered in, frequently by a forerunner, a Chaucer, and the language responds, its forms develop and are perfected. Or else some fitting or amalgamating force comes in from outside, the life of the people is widened, new blood enters in every sense, and the forms of the language respond. Or perhaps, when they may seem to have come to the tether end of things, and men's minds turn back to older, even prehistoric times, seeds long buried and forgotten in the nature spring up, and a true national Renaissance follows. In these cases the change and elaboration of forms is a symptom of new life; the vehicle is being molded and expanded to fit the growing thought.

But it is not always so. There comes a time when the outgoing force, the activity of life, wanes and, after a greater or less period of settled conditions, a period of proper use and government of the regions occupied, a change sets in. And then we may have again the wholly deceptive phenomenon of linguistic amplification; but it is the false activity of decay. The energy has turned in and begun to feed upon itself. The national impulse has changed from achievement to gratification, more and more sources are drawn upon to minister to its enjoyment, and that enjoyment becomes an art; forms of every kind are subtly refined in its service, and linguistic forms

with them. And this is then the very period when all these material, formal elements are pointed to with pride as the evidence of culture and progress. The thought-life of the nation has lost itself in the conflict and confusion, in the distractions of the forms into which it has molded the matter its creative force had entered.

We have thus in nations and languages, as in individuals, the phenomena of birth, growth, use, and a quick or a slow death, all marked by various degrees and signs of health or disease, and *every one at root a moral question*. These are the facts of general average, quite corresponding to those that form the bases for life insurance tables. But, as with these latter, not only are there variations for inheritance, class, locality, and so on, but there are here and there cases of out and out exception — which from all we can see must be assigned to some external force in operation on the individual. We call them "freak" occurrences, only because we cannot see the wider law or causes at work. When we meet them in sufficient numbers, we make new tables to cover them as far as we can, again in general only. Other causes still elude us, though they must have a fountain somewhere.

We have, as great exceptions to our general averages, two opposite phenomena. One is the sudden inexplicable and dazzling rise on the world's stage of a totally insignificant people, the other the seeming arrest for long periods of time of the normal processes of even incipient decay. And touching the latter point, it is strange indeed that in two such widely different cultures as those of Iceland and China we should find the same law apparently at work; the periods are vastly unlike in actual, but not so in relative duration. We have no way of properly placing the maintenance of Icelandic and Chinese as they have been other than by simply laying down the existence of what we may call a Law of Retardation, whose ultimate causes we cannot fathom or classify, but which will stand as an opposite phase of the Law of Stimulation, which is more frequent in operation, but is equally unexplained.

If we will now regard the languages and cultures of the world, we will find all the phases of linguistic and cultural activity, operative with about the same degree of rapidity, all over both hemispheres, save in places protected by our Law of Retardation. We will find the rate of changes and successions generally far less rapid the farther back in time we go; and finally we will find a special and marked acceleration on both sides of the Atlantic during the last thousand years, all incident to the placing of a new race in America.

So for the facts as we find them. They point to the descent of past American civilizations from a past period of continental, or far more probably, of world-wide extent. For who can imagine that people great enough to build as these did, should not also have navigated? Why should we assume in the face of other experiences, that Maya dates and calculations mean nothing, except on the general principle that they did not know as much as we do, and were doubtless liars? Bailly proved over a hundred years ago that Hindû exact astronomical observations must date back at least 5000 years, and that they were in possession of minutely accurate tables * long before Europe was. And the rotundity of the earth was certainly known both to them and the other great nations of antiquity.

Archaeology is today pushing back the dates of fixed and acknowledged history almost to the date given by the Egyptians to Solon for the submersion of the great Atlantean island; and if we can but read the Maya glyphs, and open *that* door, another twenty years from now may show us beyond all possible dispute evidences in every part of the earth belt of a contemporaneous culture, different from and precedent to the Aryan.

I have so far in this monograph, based upon and having to do as it has with the Maya glyphs, their interpretation and their place in the linguistic field, limited myself to an analysis and consideration of the facts presented to us by those linguis-

* *Traité de l'Astronomie Indienne et Orientale,* Disc. Prél. et seq.

tic and cultural data we have actually before us. But there is one further problem which is suggested by it all. It is this: Where, in point of time and place, is the change in the world's linguistic and cultural life from ideographic to literal to be sought for, and what is its rationale? Separated from us by such an enormous period of time as it is, I still cannot believe that some view of it cannot be had. There are various facts of Old World history and language, partly of prehistoric Europe, partly of Asia, an analysis of which would extend this paper too far into other fields; but apart entirely from the question of myths or traditions, there are various actual observed phenomena both of language and writing, especially in Central Asia, which do not fit into any of the ordinary theories, and which do suggest this, as a simple linguistic conclusion. In point of locality, at least, the conclusion agrees with the usual "Aryan home" theory; but as far as concerns this latter it must be remembered that however fully it demonstrates the unity of the Aryan race, beyond that fact all questions of dates and even of the state of civilization at the time, are not matters of history as yet for us, but only of theory — as to which our present "perspective" may be once more as faulty as it has often been heretofore.*

* The suggestion above is linguistic, and in that phase is given as a corollary to the foregoing discussion; but, as stated, it is at the same time in accord with the "Aryan" theory in its essentials (though not in its hypothetical and ultra-historical speculations), and it also finds confirmation by various passages in *The Secret Doctrine,* by H. P. Blavatsky, as already quoted. "The traces of an immense civilization, even in Central Asia, are still to be found. This civilization is undeniably *prehistoric.* . . . The Eastern and Central portions of those regions — the Nan-Shan and the Altyn-Tagh — were once upon a time covered with cities that could well vie with Babylon. A whole geological period has swept over the land, since those cities breathed their last, as the mounds of shifting sand, and the sterile and now dead soil of the immense central plains of the basin of Tarim testify. . . . In the oasis of Cherchen some 300 human beings represent the relics of about a hundred extinct nations and races — the very names of which are now unknown to our ethnologists." (Vol. I, page xxxii *et seq.*) See also Col. Prjevalsky's *Travels.* Why should it not be so? The above was written in 1888, but the evidences are growing every day, and it will be against all archaeological precedent if far-reaching results do not follow from Dr. Stein's *small* find, and from Capt. d'Ollone's recent researches among the Lolos, and the securing by

I believe that this center of transition lay somewhere in Central Asia, to the north of the great Himâlayan range. That this region was a sort of alembic, a melting-pot (as America is today) for various peoples of an ancient world-wide culture, as broad at least in its scope as the term Aryan is today. That this culture displayed the ideographic traits we have discussed, and that it has left more or less definite traces at different places in the world. That it covered the two Americas, in whatever continental form they may then have existed, leaving us there "les débris échappés à un naufrage commun." That coincident with a new and universal world-epoch, as wide in its cultural scope as the difference between the ideographic and literal, there was finally formed a totally new vehicle for the use of human thought, the inflectional, literal, alphabetic. That this vehicle was perfected into some great speech, the direct ancestor of Sanskrit, into the *forms* of which were concentrated all the old power of the ancient hieroglyphs and their underlying concepts. For Sanskrit, while the oldest is also the mightiest of Aryan grammars; and no one who has studied its forms, or heard its speech from educated native mouths, can call it anything but concentrated spiritual power. That the force which went on the one hand into the Sanskrit forms, was on the other perpetuated on into the special genius of Chinese, in which, as we know it, we have a retarded survival, not of course of outer form so much as of method and essence. And in Tibetan, in spite of all that is said to the contrary, I suspect that we have a derivative, not from either Chinese or Sanskrit as we know them, but by a medial line from a common point.* Of

him, as we are informed, of the long-sought knowledge of their hieroglyphic system.

* The study of Tibetan has so far been approached almost exclusively from the south, that is by those already familiar with Sanskrit and Pâli. To this fact, as well as to the overwhelming influence exercised on literary Tibetan by the Buddhist propaganda, is due the difficulty one meets in any study of its origins. The traces, however, do nevertheless exist. Some interesting facts concerning both Chinese and Tibetan, which seem to be entirely omitted in such later standard works as those of Summers, Wade, and Giles, are to be found in the almost forgotten *Chinese Grammar* of Dr. Marshman, Serampore, 1814.

course the time for such changes must have been enormous; but whatever it was, it was no greater in its realm as time, than were the mental differences in theirs. And they both are equally human data.

Certain other facts point to the American or Atlantic source and center of this ancient epoch. They are briefly that all around the Mediterranean basin we find traces of a vanished culture, unknown to our history, and living only in tradition and some archaeological remains. And of this culture various investigators, each approaching it from his particular favorite locality, have constructed for us as many different "Empires," by theories each supported by various details of analogies. One calls them Tartars, another Hittites, another Pelasgians, and so on. And all of them, in each of the theories, have as a fact a great many unexplained characteristics, different from those of our historical nations. Some of these characteristics, most markedly the Basque, but also not a few at greater distance, have definite American similarities. It might not be a far guess that these fragments represent an eastward movement, which later in the history of the Aryan development met and was pushed back westward again by the fully formed and dominant Aryan race from its Central Asian center. This is the future province of Archaeology.

And I am convinced that the widest door there is to be opened to this past of the human race, is that of the Maya glyphs. The narrow limitations of our mental horizon as to the greatness and dignity of man, of his past, and of human evolution, were set back widely by Egypt and what she has had to show, and again by the Sanskrit; but the walls are still there, and advances, however rapid, are but gradual. With the reading of America I believe the walls themselves will fall, and a new conception of past history will come.

PAPERS

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A POSSIBLE SOLUTION OF THE NUMBER SERIES ON PAGES 51 TO 58 OF THE DRESDEN CODEX

BY

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NOTE

THE solution set forth in this paper formed a part of a thesis for the degree of Doctor of Philosophy, taken in Anthropology at Harvard University.

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CARL E. GUTHE

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A POSSIBLE SOLUTION OF THE NUMBER SERIES ON PAGES 51 TO 58 OF THE DRESDEN CODEX

DESCRIPTION

In the Dresden Codex, one of the three Maya manuscripts in existence, there is found a series of numbers covering eight pages, 51 to 58 (plate I). As early as 1886, Dr. Förstemann recognized this series as an important one, and one which probably referred to the moon in some way. Each page is divided into an upper and a lower half designated, respectively, " a " and " b." Pages 51a and 52a form a unit in themselves, but are clearly associated with the remaining pages. The probable meaning of this group is still so doubtful that it has been deemed best to omit entirely a discussion of it at the present time. The remaining sections of these pages form one long series of numbers which should be read from left to right, beginning at 53a, reading to 58a, continuing on 51b, and ending the series at 58b.

Each half-page is divided, horizontally, into four sections. The upper section consists of two rows of hieroglyphs. The section just below it contains a series of black numbers which increase in value from left to right. The third section consists of three rows of day glyphs with red numbers attached to them. The interval between the glyphs in successive rows can, of course, be mathematically obtained. The last, and bottom, division of the page is filled with a series of black numbers which are of three values only, namely, 177, 148, and 178, of which the first is the most frequent. At more or less regular intervals a vertical strip is run from the top of the half-page to the bottom. This strip contains, in the upper part, eight or ten glyphs. Below them in all but the first strip is a constellation band, and below that a figure of some kind. These strips divide the number series into groups, and are called " pictures," occurring on ten of the fourteen half-pages. Consid-

ered vertically the pages are composed of columns. Each column contains, beginning at the top, two hieroglyphs, a long number, three day glyphs, and their numbers, and finally, at the bottom, a short number. The pictures occur between these columns.

The series covers a period of 11,960 days, although the last number recorded in the upper series is only 11,958. By means of the columns this period of 11,960 days is divided into 69 unequal parts. Let columns 2, 3, and 4 on page 54b be taken as examples. Then each column in the series should be read in the following manner:[1] The lower number of column 3 is 8.17 or 177. Add this number to the upper number of column 2, which is 1. 2. 11. 9 or 8149. The result is 8326 which is expressed correctly as 1. 3. 2. 6 in the upper number of column 3. The lower number should also be added to the upper day glyph of column 2, which is 10 Caban, giving 5 Ix, which is the day glyph and number appearing as the first in column 3. The second day glyph and number is that of the day following 5 Ix, namely 6 Men. Similarly, 7 Cib is the day after 6 Men. Going through the same process for column 4, 148, that is, the lower number 7. 8 of that column, should be added to 8326 to obtain 8474, which is expressed in the upper number of column 4 as 1. 3. 9.14. Likewise, 148 days after 5 Ix comes 10 Ik, which is the upper day glyph of column 4, and below which are found the two days immediately following, namely, 11 Akbal and 12 Kan.

[1] For those unacquainted with Maya arithmetic the following points will explain matters: the Mayas used the vigesimal system of enumeration; they counted by twenties instead of tens. A bar represented five, and a dot stood for one. They represented numbers larger than twenty by position, just as we do. However, instead of having the smallest denomination at the right and the largest at the left of a horizontal series of figures, they had the smallest at the bottom and the largest at the top of a column of numbers. Instead of each unit in a given position representing ten times the value of that of the preceding position, it represented twenty times the value, except in the third position where it was only eighteen times as great. Thus each unit of the bottom number represented one (Kin), that of the number above it twenty (Uinal), that of the third number 20×18 or 360 (Tun), that of the fourth position 20×360 or 7200 (Katun), etc. For ease in handling, these numbers are written in our script with arabic numerals, the bottom number on the right, and separated by periods. Thus in column three, page 53a, the upper number is 1. 7. 2, which means that the kin of this group is 2, the Uinal 7, (7×20) and the Tun 1 (1×360), making in all $2 + 140 + 360$ or 502.

The Maya calendar, like ours, consisted of a series of numbers and a series of names for each day, each series repeating itself constantly, irrespective of the other. There were twenty different day names, which remained in an unchangeable order, and thirteen numbers. In the pages under discussion these day names appear as glyphs preceded by the necessary number.

For further details consult S. G. Morley, *An Introduction to Maya Hieroglyphs*, Bulletin 57, Bureau of American Ethnology, Washington, D. C., 1915, and C. P. Bowditch, 1910.

In short, then, the ideal arrangement of the series is as follows: Each upper number is the sum of all the lower numbers of the preceding columns and its own column. Each lower number expresses the difference between the upper number of its own column and that of the column immediately preceding it. The day names and numbers are three horizontal series, each starting a day later than the one above it, and recording three sets of day names and numbers which would fit the series formed by the upper numbers. It should be noticed that the mathematical interpretation of the series does not appear to depend in any way upon the hieroglyphs appearing at the top of the columns, or upon the pictures.

This series deals quite clearly with synodical revolutions of the moon. The entire series records 11,960 days, although the last number in the upper series is only 11,958, a condition that will be explained later. Four hundred and five synodical revolutions of the moon consume, according to modern astronomy, 11,959.889 days, or about .11 of a day less than the length of the series. Moreover, the difference groups 148, 177, and 178 which separate the upper numbers, also record synodical months, for five months consume 147.65 days, and six months 177.18 days. In fact the correspondence between the numbers in the series and the synodical months is so exact, that nowhere does an error of more than one day exist.[1]

Unfortunately the ideal arrangement given above is not followed exactly. The actual series as it occurs in the manuscript appears to be full of errors, a list of which will be found in Table I, p. 4. Most of these errors have been pointed out and discussed repeatedly.[2] There still exists some doubt as to which numbers should be considered errors of the original writer and which should be taken at their face value. For this reason the errors are here discussed in some detail, for in some cases the errors, or supposed errors, affect theories in regard to the series.

In Table II, pp. 6, 7, both the corrected and the uncorrected series are given. In the centre of the table are three columns containing the actual table. The third column contains the uncorrected upper number; the fourth the lower number; and the fifth the

[1] Bowditch, 1910, pp. 222, 223.

[2] By Dr. Förstemann, Dr. Thomas, and Mr. Bowditch.

first day sign and its number. Since the other two day series agree, except in a very few cases which will be mentioned later, with the first series, they have been omitted from the table. The sixth column contains the day signs as they probably should occur,

Table I

APPARENT IRREGULARITIES

Lower number series:

Absence of all 178's that occur in upper series.
Column 23. Presence of 178.
Column 26. 177 instead of 148.
Column 50. 157 " " 177.

Upper number series:

Column 1. 157 instead of 177.
Column 2. 353 " " 354.
Column 4. 674 " " 679.
Column 10. 1748 " " 1742.
Column 12. 2016 " " 2096.
Column 14. 3142 " " 2422.
Column 15. 2598 " " 2599.
Column 24. 4164 " " 4163.

Day series:

Column 5. 4 Chicchan instead of 11 Chicchan.
Column 11. Omission of ½ *tonalamatl.*
Column 17. 1 Ik instead of 2 Ik.
Column 36. 4 Ben instead of 4 Ahau.
Column 47. 10 Eznab instead of 11 Eznab.
Column 49. 11 Kan instead of 12 Kan.

Columns:

Columns 6 and 7 are reversed.
Columns 58 and 59 are reversed.

Totals:

Upper number series totals 11,958 instead of 11,960.
Day series totals 11,959 instead of 11,960.

and the second contains the corrected upper number. The first column gives the pages of the manuscript and the number of the columns on each in order to facilitate reference to the manuscript. Each column of Table II, with the exception of the first and fourth, is composed of two series of numbers, since each interval between the numbers of the manuscript has been placed in parentheses after the last of the pair of numbers it deals with, in order

to facilitate comparison with the lower numbers. The names and numbers in the fifth column which have parentheses have been obliterated in the manuscript, but are easily inferred from the other two rows of day signs and numbers.

The most prominent irregularity is the absence of the number 178 in the lower numbers when the differences in both the day series and the upper numbers show that 178 should be the difference. This occurs in columns 7, 14, 29, 37, 52 and 60 of the manuscript. The only place in which 178 does occur in the lower number is in column 23, when it agrees with the difference in the day series, but not with that of the upper number. In other words, the six occurrences of the 178-day group in the upper numbers are neglected in the lower numbers, and the only occurrence of 178 in the lower numbers does not agree with the upper numbers. This implies that it is of deeper significance than a mere error. There is another disagreement between the upper and lower numbers which could very well be the result of carelessness. In column 26, the lower number is 177, while both the upper number and the day series give a difference of 148. This is the only case in which the differences of 148 are not found at the same place in all series, and, consequently, is probably an error of the scribe. Again in the lower number of column 50, the careless omission of one dot in the Uinal place has resulted in the record of 157 instead of the correct number, 177.

With one exception all of the errors in the upper numbers occur in the first third of the series. That exception, i.e., the writing of 4164 for 4163 in the column 24, may be explained by the fact that the writer of the series had just added in column 23 the extra day to the day series, which threw it out of agreement with the upper numbers. For the moment this fact slipped his mind, but he corrected the mistake by subtracting one day from the difference between the upper numbers of columns 24 and 25.

The apparent error due to the addition of two dots in the Tun place in the upper number of column 14 is more the result of an error than an error in itself. This number shows a very clear case of erasure. The writer of this section of the manuscript in copying from the older source, at first overlooked column 14, and placed 7.3.18, the upper number in column 15 in this place. Realizing his mistake he erased the three dots in the Uinal place, but utilized

Table II

(1) Page and Column		(2) Corrected upper number	(3) Uncorrected upper number	(4) Lower number	(5) Uncorrected day signs		(6) Corrected day signs	
		0					11 Manik	
53a	1	177 (177)	157	177	6 Kan		6 Kan	(177)
	2	354 (177)	353 (196)	177	1 Imix	(177)	1 Imix	(177)
	3	502 (148)	502 (149)	148	6 Muluc	(148)	6 Muluc	(148)
				Picture				
	4	679 (177)	674 (172)	177	1 Cimi	(177)	1 Cimi	(177)
	5	856 (177)	856 (182)	177	9 Akbal	(177)	9 Akbal	(177)
	6	1034 (178)	1033 (177)	177	4 (Ahau)	(177)	5 Imix	(178)
54a	7	1211 (177)	1211 (178)	177	(13) Eznab	(178)	13 Eznab	(177)
	8	1388 (177)	1388 (177)	177	8 Men	(177)	8 Men	(177)
	9	1565 (177)	1565 (177)	177	3 Eb	(177)	3 Eb	(177)
	10	1742 (177)	1748 (183)	177	11 Muluc	(177)	11 Muluc	(177)
	11	1919 (177)	1919 (171)	177	6 Cib	(47)	6 Cimi	(177)
	12	2096 (177)	2016 (97)	177	1 Akbal	(307)	1 Akbal	(177)
	13	2244 (148)	2244 (228)	148	6 Chuen	(148)	6 Chuen	(148)
55a				Picture				
	14	2422 (178)	3142 (898)	177	2 Muluc	(178)	2 Muluc	(178)
	15	2599 (177)	2598(-544)	177	10 Cimi	(177)	10 Cimi	(177)
	16	2776 (177)	2776 (178)	177	5 Akbal	(177)	5 Akbal	(177)
	17	2953 (177)	2953 (177)	177	13 Ahau	(177)	13 Ahau	(177)
	18	3130 (177)	3130 (177)	177	8 ?	?	8 Caban	(177)
56a	19	3278 (148)	3278 (148)	148	? Chicchan	?	13 Chicchan	(148)
				Picture				
	20	3455 (177)	3455 (177)	177	8 Ik	(177)	8 Ik	(177)
	21	3632 (177)	3632 (177)	177	3 Cauac	(177)	3 Cauac	(177)
	22	3809 (177)	3809 (177)	177	11 Cib	(177)	11 Cib	(177)
57a	23	3986 (177)	3986 (177)	178	7 Ix	(178)	7 Ix	(178)
	24	4163 (177)	4164 (178)	177	2 Chuen	(177)	2 Chuen	(177)
	25	4340 (177)	4340 (176)	177	10 Lamat	(177)	10 Lamat	(177)
	26	4488 (148)	4488 (148)	177	2 Cib	(148)	2 Cib	(148)
				Picture				
58a	27	4665 (177)	? ?	177	10 Ben	(177)	10 Ben	(177)
	28	4842 (177)	4842 ?	177	5 Oc	(177)	5 Oc	(177)
	29	5020 (178)	5020 (178)	177	1 Lamat	(178)	1 Lamat	(178)
	30	5197 (177)	5197 (177)	177	9 Chicchan	(177)	9 Chicchan	(177)
51b	31	5374 (177)	5374 (177)	177	4 Ik	(177)	4 Ik	(177)
	32	5551 (177)	5551 (177)	177	12 Cauac	(177)	12 Cauac	(177)
	33	5728 (177)	5728 (177)	177	7 Cib	(177)	7 Cib	(177)
	34	5905 (177)	5905 (177)	177	2 Ben	(177)	2 Ben	(177)
	35	6082 (177)	6082 (177)	177	10 Oc	(177)	10 Oc	(177)
	36	6230 (148)	6230 (148)	148	2 Eznab	(148)	2 Eznab	(148)

TABLE II (*continued*)

Page and Column		Corrected upper number	Uncorrected upper number	Lower number	Uncorrected day signs		Corrected day signs	
52b				PICTURE				
	37	6408 (178)	6408 (178)	177	11 Cib	(178)	11 Cib	(178)
	38	6585 (177)	6585 (177)	177	6 Ben	(177)	6 Ben	(177)
	39	6762 (177)	6762 (177)	177	1 Oc	(177)	1 Oc	(177)
	40	6939 (177)	6939 (177)	177	9 Manik	(177)	9 Manik	(177)
53b	41	7116 (177)	7116 (177)	177	4 Kan	(177)	4 Kan	(177)
	42	7264 (148)	7264 (148)	148	9 Eb	(148)	9 Eb	(148)
				PICTURE				
	43	7441 (177)	7441 (177)	177	4 Muluc	(177)	4 Muluc	(177)
	44	7618 (177)	7618 (177)	177	12 Cimi	(177)	12 Cimi	(177)
	45	7795 (177)	7795 (177)	177	7 Akbal	(177)	7 Akbal	(177)
54b	46	7972 (177)	7972 (177)	177	2 Ahau	(177)	2 Ahau	(177)
	47	8149 (177)	8149 (177)	177	10 Caban	(177)	10 Caban	(177)
	48	8326 (177)	8326 (177)	177	5 Ix	(177)	5 Ix	(177)
	49	8474 (148)	8474 (148)	148	10 Ik	(148)	10 Ik	(148)
				PICTURE				
	50	8651 (177)	8651 (177)	157	5 Cauac	(177)	5 Cauac	(177)
55b	51	8828 (177)	8828 (177)	177	13 Cib	(177)	13 Cib	(177)
	52	9006 (178)	9006 (178)	177	9 Ix	(178)	9 Ix	(178)
	53	9183 (177)	9183 (177)	177	4 Chuen	(177)	4 Chuen	(177)
	54	9360 (177)	9360 (177)	177	12 Lamat	(177)	12 Lamat	(177)
	55	9537 (177)	9537 (177)	177	7 Chicchan	(177)	7 Chicchan	(177)
	56	9714 (177)	9714 (177)	177	2 Ik	(177)	2 Ik	(177)
	57	9891 (177)	9891 (177)	177	10 Cauac	(177)	10 Cauac	(177)
	58	10039 (148)	10039 (148)	148	2 Manik	(148)	2 Manik	(148)
56b				PICTURE				
	59	10216 (177)	10216 (177)	177	10 Kan	(177)	10 Kan	(177)
	60	10394 (178)	10394 (178)	177	6 Ik	(178)	6 Ik	(178)
	61	10571 (177)	10571 (177)	177	1 Cauac	(177)	1 Cauac	(177)
	62	10748 (177)	10748 (177)	177	9 Cib	(177)	9 Cib	(177)
57b	63	10925 (177)	10925 (177)	177	4 Ben	(177)	4 Ben	(177)
	64	11102 (177)	11102 (177)	177	12 Oc	(177)	12 Oc	(177)
	65	11250 (148)	11250 (148)	148	4 Eznab	(148)	4 Eznab	(148)
				PICTURE				
	66	11427 (177)	11427 (177)	177	12 Men	(177)	12 Men	(177)
	67	11604 (177)	11604 (177)	177	7 Eb	(177)	7 Eb	(177)
58b	68	11781 (177)	11781 (177)	177	2 Muluc	(177)	2 Muluc	(177)
	69	11958 (177)	11958 (177)	177	10 Cimi	(177)	10 Cimi	(177)
				PICTURE				

two of the bars and the three dots in the Kin place as the 13 needed in the Uinal in column 14, and erased the lower bar of the original 18. This procedure of the writer's threw the upper number of column 14 out of alignment, for the two dots of the Kin appear below the 13, somewhat below the line of Kins of the other columns. The seven in the Tun place should have been a six, so the scribe inserted an extra dot between the two of the original 7, neglecting, however, to erase the other two dots. As a result the upper number of column 14 records the number 3142, which is 720 greater than it should be, namely, 2422.

In column 10, 1748 was recorded instead of 1742, for a bar and three dots were written in the Kin place instead of only two dots. This is a very peculiar and unexpected form of carelessness, which is, however, corrected in the next column. The remaining irregularities in the upper numbers are all due to the omission of a part of the number. In columns 2 and 15, one dot was omitted in the Kin place, thus recording 353 instead of 354 in the former, and 2598 instead of 2599 in the latter. In column 4 one bar was omitted in the Kin place, making the number 674, five less than it should be, namely, 679. In column 1, one dot was omitted in the uinal place, and in column 12, four dots of the same denomination, recording, respectively, 157 and 2016 instead of 177 and 2096.

There is only one decided error in the day series. In column 11, 6 Cib, 7 Caban, 8 Eznab were written instead of 6 Cimi, 7 Manik, 8 Lamat. It should be noticed that the number of the day was right. In fact just one-half a tonalamatl, or 130 days, was dropped before the day series of column 11, and added on again immediately afterwards. This is an extremely curious error to make in calculating and may shed some light on the way in which the Mayas reckoned.

The five remaining irregularities in the day series are of two kinds. In column 5, the number preceding the third day, Chicchan, is 4 instead of 11. Apparently the writer of the manuscript forgot for the moment that the day was added to the one above it and not the one to the left, and wrote 4 because the number associated with the third day sign of column 4 was 3. The same mistake was made in the third day of column 36, except that in this case it was the day sign and not the number which was confused. Here, instead of writing Ahau, which followed the Cauac

in the second series, Ben was recorded because the sign to the left was Eb. The other three irregularities are all due to carelessness in placing sufficient dots in the number associated with the day sign, for in columns 17, 47 and 49, 1 Ik, 10 Eznab and 11 Kan were recorded, respectively, instead of the necessary 2 Ik, 11 Eznab and 12 Kan.

There are two places in which columns seem to be misplaced, although the mathematics of the series at these points is correct as it stands. For the sake of uniformity in the arrangement of the difference groups, the 178-day group of column 7 should occur in column 6, and for the same reason, the 148-day group of column 58 should occur in column 59. Professor Förstemann calls both of these variations errors, and arranges his version of the table so that each part is just like the other two. He gives no reason for his opinion other than the phrase " for the author [of the manuscript] had confused the differences 178 and 148. . . ."[1] Mr. Bowditch, on the other hand, allows both of the variations to stand as they appear in the manuscript, and quite rightly holds the opinion that, " It may possibly be that these numbers thus placed are errors of the scribe, but the mere plea for uniformity is not sufficient to lead us to make these changes."[2]

In Table II the apparent mistake in columns 58 and 59 remains as it occurs in the manuscript, for the reason which Mr. Bowditch gives. In the case of columns 6 and 7 there seems to be some evidence that there actually was an error made. The last column on page 53a, which is the one under discussion, contains no day glyph in the first day series. The glyph should have been that of Ahau. There is distinct evidence, altho very faint, that a glyph was once there. Moreover, the smooth coating which covered the material of the manuscript page is not broken. There are other obliterated glyphs in these pages of the manuscript, but few in which the surface, although unbroken, still contains a faint, almost continuous outline of a glyph. The glyph, then, was probably erased. The writer of the manuscript had probably completely finished column 6 and started column 7 before he detected the error. He began to erase the part that was wrong, then realized what an amount of alteration would be necessary, and finally compromised by making the difference come between columns 6 and 7 instead

[1] Förstemann, 1901, p. 123. [2] Bowditch, 1910, p. 217.

of columns 5 and 6. This hypothesis in regard to the manner in which the erasure was done may be wrong, but the erasure still stands as a strong evidence to show that the 178 should have occurred in column 6 rather than after it.

Finally there appears to be an error in the totals of the series, for the upper number series records as a total 11,958 days and the day series 11,959 days, although there is strong reason for believing that the series should record 11,960 days. This discrepancy in the totals will be referred to again.

In general, then, the apparent irregularities in the manuscript fall into two great classes, those which are corrected in the next column or are easily detected because of their disagreement with the record in the other two series, and those which are not obviously due to carelessness. The latter will be considered under the solutions. The former may be dismissed as clerical errors not affecting the solution. In this group are two of the irregularities in the lower numbers (columns 26 and 50), and all eight in the upper numbers, seven of which occur in the first third of the manuscript. The six errors in the day series, and the transposition of columns 6 and 7, also belong in this class.

By referring to Table II it will be noticed that the pictures occur after the 148-day groups in each case. The upper numbers immediately preceding the pictures are given in Table III (p. 11), together with the differences between them. By grouping these differences, it becomes apparent that the pictures may be divided into three large groups of 3986 days; two out of the three containing the same difference numbers, 1742, 1034, and 1210. If, in the last group, the number 10,039 were changed to 10,216 by adding 177, the differences for this group would also read as the others, when the end of the series and the beginning of the series are added together (708 + 502 = 1210), for the 10th picture is, in a sense, out of the grouping since it occurs after the last number in the series. The 148-day groups are arranged in the same order for they occur in the same columns as the numbers used above.

By applying the same process to the 178-day groups, it is found that they also can be divided into groups which contain 3986 days. In this case the second and third groups contain the same numbers, 2598 and 1388 (Table IV). If the number 1211 in the first group is changed to 1034 by subtracting 177, the last number

of this group would be 1388; and the first number 2598 could be formed by adding the remainder at both ends of the series (1564 + 1034 = 2598).

It should be remembered at this point that the only column in which the lower numbers contained 178 is column 23, of which the upper number is 3986. This gives further grounds for dividing the series as it stands into three parts of 3986 days, each containing 23 columns.

The three parts are not exactly alike, however, as has already been pointed out in considering the probable errors. If the upper

TABLE III

UPPER NUMBERS OF 148-DAY GROUPS

Number	Difference	Group
(0)		
	502	
502		
	1742	
2244		
	1034	3986
3278		
	1210	
4488		
	1742	
6230		
	1034	3986
7264		
	1210	
8474		
	1565	
10039		
	1211	
11250		3986
	708	
(11958)		
	(502)	

TABLE IV

UPPER NUMBERS OF 178-DAY GROUPS

Number	Difference	Group
	(1564)	
(0)		
	1211	3986
1211		
	1211	
2422		
	2598	
5020		3986
	1388	
6408		
	2598	
9006		3986
	1388	
10394		
	1564	
(11958)		

numbers and day numbers in column 6 should be altered, so that the difference 178 might occur in that column instead of column 7, and if, by the same process, the difference of 148 could occur in column 59 instead of 58, then the three parts of the series would be entirely alike. The three facts mentioned are, however, very strong evidence for supposing that the people who used this table considered it as consisting of three equal parts.

This series in the Dresden is very similar to other pages of the Dresden and other manuscripts, two examples of which are given as illustrations. One of the most interesting parallels is the series on pages 46–50 of this same manuscript. This series covers a period of 2920 days which is divided into 20 unequal subdivisions. On page 24, which just precedes page 46, this number is used as a

unit in multiplication, that is, the numbers occurring on page 24 are separated from each other by 2920 or multiples of this number. On pages 44b and 45b the number 78 is divided into four unequal parts, and on pages 43b and 44b it is used as a unit in a series which finally reaches the number 1940 × 78.

SOLUTIONS

The first references to these pages in the manuscript were concerned chiefly with the reading of the numbers without any theories in regard to the probable meaning of the series.

Dr. Förstemann, in 1886, was probably the first to mention these pages specifically. At this time he corrected many of the errors in the series, and related the rows of days to the number series.[1] He had already recognized a close relation between the difference between the 1st and 9th pictures, i. e., 10,748, and the Saturn sidereal period of 10,753 days. Of course, in order to do this he had also identified the various signs in the "constellation bands," assigning them to various planets.[2] These identifications are based on little more than the wish he had that they might be those planets, and for that reason they are seriously open to doubt.

Cyrus Thomas, two years later, also discussed this series at some length, but confined his considerations entirely to the mathematical side of the work. He also pointed out most of the errors, agreeing in the main with Förstemann. He considered that the series contained 11,960 days. In his conclusion he said "the sum of the series as shown by the numbers over the second column of Plate 58b is 33 years, 3 months, and 18 days. As this includes only the top day of this column (10 Cimi), we must add two days to complete the series, which ends with 12 Lamat." [3]

During the following years, Dr. Förstemann repeatedly referred to these pages in his publications and, in 1898, published an article devoted to these pages alone.[4] The most detailed as well as the final discussion of these pages is that given in his book on the Dresden Codex.[5] In pages 53–58, and 51b and 52b he recognizes the similarity to pages 46–50, and remarks that the Mayas not

[1] Förstemann, 1886, p. 34.
[2] Ibid., pp. 68–71.
[3] Thomas, 1888, p. 325.
[4] Förstemann, 1898.
[5] Ibid., 1901, pp. 118–133.

only combined the *tonalamatl* and the Mercury year, but also attempted to bring the lunar revolution into accord with these two. In other words, Förstemann seems to imply that the primary purpose of the series was the counting of the Mercury years, and that the lunar part of the problem was secondary.

He explains the number 11,958 as the result of attempts to make the lunar count agree with 11,960. " They [the Mayas] found that 405 lunar revolutions amounted approximately to 11,958 days, which is, in fact, the largest number on the second half page of page 58." [1] This will not stand at all as the reason for the 11,958 since 405 lunar revolutions come to 11,959.889 days, and if the Mayas knew the revolutions accurately enough to know when to intercalate a day, they most certainly would not have intentionally formed the number 11,958, when they were perfectly well aware of the fact that the time was more than 11,959 days. He recognizes in the numbers 177, 148 and 178 multiples of lunar months of 29 and 30 days.

Dr. Förstemann at this time divides the series into the three equal divisions in which it has since been considered. These are of 3986 days, thus causing the intercalated days to come at the same time in all three.[2] He also divided each of these three divisions into three unequal groups of 1742, 1034, and 1210 days each. He advances theories, based on the positions of the pictures in the series, to show that the series also referred to the siderial periods of Saturn and Jupiter, and discusses the meaning of the glyphs found on these pages.

This detailed discussion by Dr. Förstemann of pages 51–58 of the Dresden has been used as a foundation by many in further studies of these pages. It is highly probable, however, that a careful study of his interpretations will have to be made, in which the proved assumptions must be clearly differentiated from those in which the " wish is father to the thought."

Mr. Bowditch, in 1910,[3] discussed these pages and their relation to the astronomical knowledge of the Mayas. He divided the series into the same groups as Dr. Förstemann, basing his division upon the pictures which occur in every case immediately after the number 148.[4] Mr. Bowditch brought out very clearly that this

[1] Förstemann, 1901, p. 121.
[2] Ibid., p. 123.
[3] Bowditch, 1910, pp. 211–231.
[4] Ibid., p. 218.

series is a lunar series, by means of a table which compares the numbers recorded in the manuscript and the multiples of true lunations.[1] There can be no question on this point, for the difference between the recorded days and the true lunations is never more than .9 of a day. He also pointed out a way in which this series could be used over and over again in the form of a cycle,[2] and then discussed the relation of this series to the Saturn and Mercury periods, disagreeing with Förstemann on several points.

Mr. Bowditch also pointed out a peculiar coincidence between the synodical revolutions of Jupiter and the numbers in the series, but based his argument on quite different material from the similar theory of Dr. Förstemann's. The important fact brought out is that the three parts of the series under discussion are almost exactly equal to 10 revolutions of Jupiter, for one revolution of Jupiter consumes 398.867 days.[3] "This would give a reason for the selection of 11,958 to 11,960 days or 405 revolutions, and for the division of this number into three sections of 3986 days each."[4]

Dr. Förstemann and Mr. Bowditch differ in regard to some of the corrections which should be made in the manuscript, but on the whole the two discussions of these pages supplement one another. The general conclusion to be drawn from them is that these pages of the Dresden are closely associated with the synodical lunar month, and possibly, with the synodical revolution of Jupiter.

Three years after Mr. Bowditch's discussion, Mr. Meinshausen published an article in which the relation of this series to eclipses was first brought out.[5] He compared, by means of two tables, recorded eclipses of the 18th and 19th centuries with the numbers in the Dresden Codex. Out of the 69 dates in the manuscript all but 15 dates agreed with the first case, and, in the second, all but 13, due to the fact that all the eclipses are not visible at one place on the earth's surface. "Another indication that the numbers in the codex have arisen from the observation of eclipses lies in the fact that the exact grouping of the numbers which is induced by the insertion of pictures in the number periods is also possible in lunar eclipses which are visible at one particular point."[6] In the

[1] Bowditch, 1910, pp. 222, 223.
[2] Ibid., p. 224.
[3] Ibid., pp. 229, 230.
[4] Ibid., p. 231.
[5] Meinshausen, 1913, pp. 221–227.
[6] Ibid., p. 225.

table given to uphold this statement, the numbers, to be sure, can be grouped in the manner which he suggests; but they can also be grouped in other series. In his opinion the reason for the grouping " lies in the close proximity of a solar eclipse to a lunar eclipse," [1] that is, that at the date at which the pictures are inserted a solar eclipse occurred 15 days either before or after a lunar eclipse. There are two facts which tend to uphold this theory. One is the occurrence of the sun and the moon in shields over nearly all pictures, which he interprets as " signs of solar and lunar eclipses "; the other is the series of dates on pages 51a and 52a, which are 15 days apart. In a table of recorded eclipses proof is given that such double eclipses can occur at the intervals which separate the pictures in the manuscript. Since these intervals vary a great deal, Meinshausen believes that they will form the means of identifying the specific eclipses recorded in the manuscript.

His general conclusion is that " the material advanced will prove sufficiently that these numbers are associated in some way with solar and lunar eclipses, and this explanation must remain standing at least until other numbers, corresponding equally remarkably, are found." [2]

Professor R. W. Willson of the Astronomical Department of Harvard University, working on a similar theory at about the same time, had found, however, that no series of solar eclipses corresponding to the intervals of the pictures in the text was visible in Yucatan between the Christian era and the time of the Spanish conquest.[3] This apparently invalidates Meinshausen's theory.

Professor Willson believes that the table in the manuscript indicates the days of ecliptic conjunction (that is, New Moon occurring so near the moon's node that eclipses *may* occur) and, as Mr. Bowditch has shown, with a high degree of accuracy. Sufficient proof of this, in Professor Willson's opinion, is the close correspondence of the intervals of the codex with the intervals of Schram's lunar table.[4]

The similarity between the numbers in the Dresden and Schram's table is so remarkable that it seems advisable to point out some

[1] Meinshausen, 1913, p. 225. [2] Ibid., pp. 226, 227.

[3] Professor Willson's work on the Dresden manuscript has not yet been published. It is referred to here only through his kind permission.

[4] Schram, 1908, pp. 358, 359.

of the most outstanding features. In addition to giving the days of multiples of the lunar synodic months, this table also gives the time of possible occurrences of both solar and lunar eclipses. Eclipses occur in cycles, the best known of which is the Saros, although there are also smaller cycles which are not so accurate. Table V (p. 17) gives the occurrences of central solar eclipses according to Schram. It should be noticed that they occur in groups of threes and fours, each set being separated from the preceding one by 29 synodical months. The numbers in each group are only six months apart. Table VI (p. 17) is a corresponding series of lunar eclipses, which also occur in a grouping similar to that of the solar eclipses. It should be noticed in passing that the first numbers of these groups, in both the solar and lunar eclipses are separated by 47 and 41 lunations, the latter occurring after every third group in Table V.

Table VII (p. 17) contains the numbers which are in the same columns as the 178-day groups in the Dresden. By comparing Table V and Table VII, it will be found that the numbers in the Dresden are the same as the first numbers in groups 1, 2, 4, 5, 7 and 8 of the solar eclipses. In the last two numbers there is a difference of one day, which is explained by recalling the addition of an extra day in the day series but not in the upper numbers of the Dresden. If 679 days are added to each number in Table VII, which amounts to the same thing as advancing the Dresden table 679 days with respect to Schram's table, it will be found that these numbers will also agree with the first numbers in groups 2, 3, 5, 6 and 8 and with the second number in group 9 of the lunar eclipses, in Table VI. A similar agreement may be observed for the 148-day groups (see Table III).

This remarkable agreement between the 178-day groups in the Dresden and the occurrences of eclipses may have several meanings. (1) One possibility, and one which should always be kept in mind, is that this agreement is simply another coincidence, of which there are always many in chronological work. (2) It may be that the numbers refer to dates of prophesied eclipses which the Mayas had learned occurred at more or less regular intervals. (3) Since this table has a place in the calendar of the Mayas (for a date probably occurs on page 52a), it may be that these numbers refer to definite historical eclipses. If they do, they will afford a

means by which an absolute correlation between the Maya and the Julian calendars may be obtained. Professor Willson is at present working on this problem.

TABLE V

SOLAR ECLIPSES

Group	Eclipse	Month
1	1034	35
	1211	41
	1388	47
	1565	53
2	2422	82
	2599	88
	2776	94
	2953	100
3	3632	123
	3809	129
	3987	135
	4164	141
4	5020	170
	5197	176
	5375	182
	5552	188
5	6408	217
	6585	223
	6762	229
6	7619	258
	7796	264
	7973	270
	8150	276
7	9007	305
	9184	311
	9361	317
	9538	323
8	10395	352
	10572	358
	10750	364
9	11606	393
	11783	399
	11960	405

TABLE VI

LUNAR ECLIPSES

Group	Eclipse	Month
1	502	17
	679	23
	856	29
2	1713	58
	1890	64
	2067	70
	2244	76
3	3101	105
	3278	111
	3455	117
4	4311	146
	4489	152
	4666	158
	4843	164
5	5699	193
	5877	199
	6054	205
	6231	211
6	7087	240
	7264	246
	7442	252
7	8298	281
	8475	287
	8652	293
	8830	299
8	9686	328
	9863	334
	10040	340
9	10896	369
	11074	375
	11251	381
	11428	387

TABLE VII

178–DAY GROUPS

Number	Month
1034	35
2422	82
5020	170
6408	217
9006	305
10394	352

In order to determine the exact extent to which the eclipse seasons affect these pages in the Dresden Codex it is necessary to work out in as great detail as possible the calendar represented.

Modern astronomy shows that the synodical revolution of the moon consumes 29.53059 days, about .03 days more than 29½ days. Since a calendar must be based on whole days the natural method of combining the months would be to alternate one of 29 days with one of 30 days. At the end of two months or 59 days the true synodical month would be in advance of the calendrical month by .06118 days. Every two months this error is doubled so that at the end of 34 months the calendar would have completed 1003 days and the synodical month 1004.04 days. (See Table VIII, p. 19.) One method of correcting this would be to make the last month a 30-day month instead of one of 29 days as it would be by simple alternation. This 34-month period could then be repeated as a cycle with an accumulating error of .04 days at every repetition.

Such a series utterly disregards, however, all other phenomena such as eclipses, seasons, etc. As soon as eclipses are considered the arrangement of the months must be altered in order to use the periodicity of eclipses in the calendar. Eclipses occur at regular seasons, approximately six months apart. The average interval between eclipse seasons is 173.310 days, 3.874 days less than six synodical lunar months. In Table IX (p. 20) the eclipse season is compared with the nearest synodical lunar month. It will be noticed that the difference increases between the two series until it is necessary to use five synodical months for one interval instead of six to keep the difference less than half a month. It is necessary to do this three times in 135 synodical months, or 3986.630 days, which exceed 23 eclipse seasons, or 3986.131 days, by practically one half-day. It would be most logical to drop these extra months out of the set of six, during that group in which the difference tends to become most nearly half a month. That would be just before the 23d, 70th, and 117th month, that is, 47 months apart, requiring 41 months to complete the 135-month period.

This series of 135 lunar months, or 23 eclipse seasons, can be repeated almost indefinitely, alternating 3986 and 3987 days to the series and still keep the synodical month in accord with the eclipse season. But another factor must also be considered. Months of 29 and 30 days cannot be simply alternated and either conform with the true synodical month or complete the ecliptic series mentioned, for 3986 contains three more days than sixty-eight 30-day

months, and sixty-seven 29-day months. Therefore in the 3986 series three of the 29-day months must be changed to 30-day months, and in the 3987 series four must be changed. The position of these changes is arbitrary. They can, for example, be the 34th, 68th, and 102d months, and when necessary, the 134th.

TABLE VIII

Number of month	Number of days in month	Elapsed days calendar month	Elapsed days synodical month	Error
1	30	30	29.53	−.47
2	29	59	59.06	.06
3	30	89	88.59	−.41
4	29	118	118.12	.12
5	30	148	147.65	−.35
6	29	177	177.18	.18
7	30	207	206.71	−.29
8	29	236	236.24	.24
9	30	266	265.78	−.22
10	29	295	295.31	.31
11	30	325	324.84	−.16
12	29	354	354.37	.37
13	30	384	383.90	−.10
14	29	413	413.43	.43
15	30	443	442.96	−.04
16	29	472	472.49	.49
17	30	502	502.02	.02
18	29	531	531.55	.55
19	30	561	561.08	.08
20	29	590	590.61	.61
21	30	620	620.14	.14
22	29	649	649.67	.67
23	30	679	679.20	.20
24	29	708	708.73	.73
25	30	738	738.26	.26
26	29	767	767.80	.80
27	30	797	797.33	.33
28	29	826	826.86	.86
29	30	856	856.39	.39
30	29	885	885.92	.92
31	30	915	915.45	.45
32	29	944	944.98	.98
33	30	974	974.51	.51
34	29	1003	1004.04	1.04

The next logical step is a comparison between the theoretical calendars just described and the manuscript. A study of the man-

Table IX

COMPARISON OF SYNODIC MONTHS AND ECLIPSES

Eclipse season		Synodic month		
Number	Days	Number	Days	Difference
1	173.310	6	177.184	3.874
2	346.620	12	354.367	7.747
3	519.930	18	531.551	11.621
4	693.240	23	679.204	−14.036
5	866.550	29	856.387	−10.163
6	1039.860	35	1033.571	− 6.289
7	1213.170	41	1210.754	− 2.416
8	1386.480	47	1387.938	1.458
9	1559.790	53	1565.121	5.331
10	1733.100	59	1742.305	9.205
11	1906.411	65	1919.489	13.078
12	2079.721	70	2067.141	−12.580
13	2253.031	76	2244.325	− 8.706
14	2426.341	82	2421.508	− 4.833
15	2599.651	88	2598.692	− .959
16	2772.961	94	2775.875	2.914
17	2946.271	100	2953.059	6.788
18	3119.581	106	3130.243	10.662
19	3292.891	112	3307.426	14.535
20	3466.201	117	3455.079	−11.122
21	3639.511	123	3632.263	− 7.248
22	3812.821	129	3809.446	− 3.375
23	3986.131	135	3986.630	.499

Table X

148-DAY GROUPS

Upper number	Month number	Interval	Groups
502	17		
2244	76	59 }	94 (47 + 47)
3278	111	35 }	
4488	152	41	41
6230	211	59 }	94 (47 + 47)
7264	246	35 }	
8474	287	41	41
10039	340	53 }	94 (47 + 47)
11250	381	41 }	

uscript reveals that: (1) the series recorded represents 405 lunar months or three times 135 months, and that the series naturally falls into three great subdivisions of 3986 days each; (2) each

third consists of 23 columns or unequal subdivisions; (3) the intervals between the 178-day groups are 47 and 88 months; (4) the 148-day groups fall approximately at 47 and 41 month intervals (see Table X); (5) the first 178-day group in each third occurs between the 30th and 35th month inclusive, and the other 178-day group of the third comes 47 months later. Since the number 178 is composed of four 30- and two 29-day months, an extra day must have been added, that is, a 30-day month was substituted for one of the 29-day months, if the manuscript represents a regular alternating series.

The obvious conclusions to be drawn from these facts are: (1) that the series was divided into three groups of 3986 days each in order to associate the lunar calendar closely with the ecliptic cycle of the same length; (2) that the 23 columns in each third may represent the twenty-three eclipse seasons in each eclipse period of 3986 days; (3) that groups of 47 and 41 months were used in some way in the series, for the 178-day groups are separated by 47 and 88 months and 88 is composed of 47 and 41, the two periods so closely associated with the recurrence of eclipses; (4) that the six months period was changed to one of five months of 148 days approximately every 47 and 41 months, which is the method already advanced in the theoretical ecliptic lunar series for keeping the synodical months and ecliptic seasons together; (5) that one extra day was added to the alternating 29- and 30-day months, between the 30th and 35th month inclusive of each third, in accordance with the theoretical necessity for so doing already brought out, and that another of the three extra days was added 47 months later.

When the difference groups [1] are divided into months it is found that it is an easy matter to arrange the months in an alternating series. The group of 177 days is composed of three 30- and three 29-day months, either of which when alternated can begin the group, which then ends with the other, i.e., 29, 30, 29, 30, 29, 30, or 30, 29, 30, 29, 30, 29. The group of 148 days consists of three 30- and two 29-day months, necessitating that it begin and end with a 30-day month when alternated, thus, 30, 29, 30, 29, 30. In the 178-day group one of the 29-day months is replaced by a 30-day month, otherwise the group is exactly like that of 177 days,

[1] That is, the 177-day, 148-day, and 178-day groups.

which it exceeds by one day. It is evident that there will always be three 30-day months in succession in the 178-day group, and that care must be taken in choosing the right sequence of the 177-day groups which fall near those of 148 days in order to avoid having two 30-day months in succession.

There remains simply the substitution of the six or five months, as the case may be, in place of the difference groups in the manuscript. However, if the Mayas considered each third of the table as a unit, it is reasonable to assume that the sequence of the months in each third is identical. Therefore it is necessary to arrange a sequence for only one-third, that is, 135 months, and then, if the assumption is correct, this sequence will fit the other two-thirds of the series.

Each third of the table consists of 135 months covering three more days than would be covered by a simple alternation of 30- and 29-day months. These three intercalary days were inserted at definite intervals. A clue to the position of two of them is given by the 178-day groups. One was inserted between the 30th and 35th months, another 47 months later, between the 77th and 82d months. Theoretically the extra day should be inserted in the 34th month after the beginning of a series of alternating 29- and 30-day months, for then the error between the synodical revolution of the moon and the calendrical months becomes more than one day. In the 29-day month preceding the 34th, namely the 32d month, the error at the end is also practically one day, i.e., .98 days. The 29-day month most nearly the centre of the first 178-day group is the 32d month of the series, the third in the group. The Mayas may have chosen this month because of its position in the 178-day group, making the sequence of the months 29, 30, 30, 30, 29, 30, if the 30th month was a 29-day month as it would be by simple alternation.

The second time this intercalary day occurs in each third is 47 months later. Obviously, this may be the recurrence of this intercalation in a repetition of a smaller group of months than the 135-month group. If 47 months are subtracted from the 79th month which is the third in the second 178-day group the result is 32, which implies that the smaller division is 47 months. Two 47-month periods complete all but 41 of the 135 months in each third. Then, of necessity, if each third of the manuscript is a unit, a 41-

month group follows two 47-month groups, an arrangement which also agrees with the eclipse groups in Tables V.

The two 178-day groups account for only two of the three intercalated days, and since no 178-day group occurs in the 41-month division, the addition of this day must have been accomplished in some more obscure manner. Since both 47 and 41 are odd numbers, each group must contain at least one more month of one kind than the other. Since two synodical revolutions of the moon are slightly longer than two calendrical months it is wisest to start and end each group with a 30-day month. If this is done, the 47-month group will contain twenty-five 30-day and twenty-two 29-day months, and the 41-month group twenty-one 30-day and twenty 29-day months, making for the composition of the 135 months, seventy-one 30-day and sixty-four 29-day months, that is, seven more of the 30-day months than of those of 29 days, showing that actually three of the sixty-seven 29-day months expected in a normal repetition have become 30-day months. This is caused by the occurrence of two 30-day months in succession at the end of one series and the beginning of the next. If the 135 months in each third are numbered in succession it will be seen that in the first 47-month group and in the 41-month group, the 30-day months are the odd numbers. In the second 47-month group they are the even numbers, of which there is one more in this division than odd numbers, thus accounting for the additional one of the three days.

If the period of 3986 days were considered by itself, the arrangement given would be sufficient. As soon, however, as this period is repeated a number of times an error develops, since 135 synodical revolutions of the moon are completed in 3986.63 days. Twice this number gives 7973.26, or 1.26 days more than twice 3986. In order to keep the sequence of months in the arrangement given above in accordance with the moon, it becomes necessary to intercalate one more day every two repetitions of the 3986 period. This may be done by changing the last 29-day month in the 41-month group to a 30-day month, making the last 177-day group in the third one of 178 days. The Mayas certainly did this in the first third of the series given and arranged for it in the last third in a manner which will be demonstrated later.

Tabulating the solution here advanced will form Table XI (p. 25), in which the 30- and 29-day months in one-third of the

manuscript have been arranged in three columns, the first two of which represent the 47-month groups and the last one the 41-month group. Before the first column of months are numbers to facilitate locating any given month in the group. The two kinds of months occur in direct alternation in each group, with three exceptions. The 32d month in both of the 47-month groups is one of 30 days instead of 29, because of the addition of the intercalary day. The 40th month in the 41-month group is given as one of 29 days with a 30 in parentheses before it, representing the fact that every other third an extra intercalary day should be inserted in this month. To the right of the month columns are three columns giving the difference groups as found in the manuscript (see Table II), each column giving those numbers found in each third of the manuscript, the first third being the left one of the three. It should be noticed that the misplaced (?) 148-day group in the last third does not interfere with the sequence of the months.

Finally it only remains to review the irregularities of the manuscript in the light of the solution just advanced. Those irregularities which are corrected immediately afterwards, or are at variance with the rest of the column in which they occur, are, in all probability, errors on the part of the writer of the series, such as might have been caused by careless transcription from another copy of the table, and correction in the following column to avoid the task of erasure. Eliminating these irregularities, there remain three to be investigated, namely, (1) the absence of the 178 numbers in the lower number series, with one conspicuous exception; (2) the occurrence of 178 in column 7 instead of 6, and of 148 in column 58 instead of 59; and (3) the discrepancies in the totals of the series.

The great bulk of the difference groups as expressed by the lower number series are 177, the only departure from these being the designation of the 148-day groups and the extra 178-day group at the end of the first third. The complete disregard of all of the six normal 178-day groups by the lower numbers seems to imply that no attempt was made to have the latter agree with the actual differences in the upper numbers, a conclusion which is strengthened by the fact that none of the lower numbers shows evidence of the clerical errors in the differences of the upper numbers. It seems most probable that the lower number series was intended merely

TABLE XI. — THE ARRANGEMENT OF LUNAR MONTHS IN THE DRESDEN TABLE

No. of month	Days in month	Dresden groups 1	2	3	Days in month	Dresden groups 1	2	3	Days in month	Dresden groups 1	2	3
1	30				30				30			
2	29				29				29			
3	30	177	177	177	30	177	177	177	30	177	177	177
4	29				29				29			
5	30				30				30			
6	29				29				29			
7	30				30				30			
8	29				29				29			
9	30	177	177	177	30	177	177	177	30	177	177	177
10	29				29				29			
11	30				30				30			
12	29				29				29			
13	30				30				30			
14	29				29				29			
15	30	148	148	148	30	177	177	177	30	148	148	148
16	29				29				29			
17	30				30				30			
18	29				29				29			
19	30				30				30			
20	29	177	177	177	29			148	29	177	177	177
21	30				30	177	177		30			
22	29				29				29			
23	30				30				30			
24	29				29				29			
25	30				30				30			
26	29	177	177	177	29			177	29	177	177	177
27	30				30	148	148		30			
28	29				29				29			
29	30				30				30			
30	29				29				29			
31	30				30				30			
*32	30	178	178	178	30	178	178	178	29	177	177	177
33	30				30				30			
34	29				29				29			
35	30				30				30			
36	29				29				29			
37	30				30				30			
38	29	177	177	177	29	177	177	177	29	178	177	177
39	30				30				30			(178)
40	29				29				(30) 29			
41	30				30				−30			
42	29				29							
43	30				30							
44	29	177	177	177	29	177	177	177				
45	30				30							
46	29				29							
47	30				30							

as a guide to indicate the position of the five month periods and to place emphasis on the extra intercalary day added in the 23d column, without attempting to have this series accurate.

The presence of the 178-day group in column 7 instead of 6 has been discussed at some length under the description of the errors. The scribe, realizing that in neglecting to put in this 178-day group, the first one of the series, a serious error had been committed, may have attempted to erase the incorrect record in column 6; then, realizing that four numbers and three glyphs would have to be altered, decided to correct this mistake—although it was of more importance than the other two errors — as he had the former ones, i.e., by making the correction in the next column.

The very similar irregularity in the last third of the manuscript, the placing of the 148-day group one column ahead of its expected position, cannot be explained in the same manner. It is very evident that this column has been deliberately placed where it is. That it does not have to do with the month sequence is evident, since it does not affect it. It must then affect the ecliptic part of the series, for it causes a short season to occur six months earlier than expected. Upon comparison of Tables VI and X, it will be seen that all of the dates of the 148-day group occur during one of the eclipse groups given in Schram's table. However, had the 148-day group under discussion been placed in the 59th column, as uniformity demands, this number, 10,216, would not have fallen in one of the eclipse groups given in Table VI. This tends to show that there was some reason other than regulating the difference groups to agree with the eclipse seasons, for the position of the 148-day groups. This reason, as yet undetermined, is possibly associated with the pictures, which immediately follow the 148-day groups.

Finally there remain only the totals of the series to be considered. The total of the upper number series records 11,958 days. Sixty-nine eclipse seasons complete 11,958.39 days, less than half a day more than the recorded number. This close agreement and the failure to add the extra intercalary day to the upper number series at the end of the first third, give rise to the belief that the upper number series is a calendar in itself, and records a means by which dates of probable eclipses may be reckoned. The units of the count were eclipse seasons expressed as lunar months, 69 of which are represented in the calendar recorded on these pages.

The Mayas undoubtedly knew the relation of the eclipses to the moon, at least in a vague way, and felt that it was necessary to associate this eclipse calendar in some way with the lunar calendar, composed of 29- and 30-day months. Therefore the day series is found immediately below the upper number series. This series of days constitutes a lunar calendar which coincides as closely as possible with the eclipse calendar. It may be the formal lunar calendar of the Mayas, but it may also be an adaptation of the formal calendar to the eclipse periods. The day series varies from the eclipse series in two places only. At the end of the first third of the series, it was necessary to add one day to the lunar calendar, an addition strongly pointed out in the record, but not to the eclipse calendar, because of the increasing error between the revolutions of the moon and the calendrical lunar months. Therefore, throughout the remaining two-thirds of the series, the lunar calendar was one day in advance of the eclipse calendar. At the end of the series, since 405 of the moon's revolutions complete 11,959.89 days, and the day series only 11,959, one more day should be added, in order to keep the error as small as possible. This was accomplished by changing from the middle to the lower line of days.

On page 52a, immediately preceding the calendar, are four day signs with numbers. One of these, 12 Lamat, is the zero day of the day series, but is associated with the middle line of day glyphs and not the upper line, as might be expected. The series of days which come, calendrically speaking, just before and after the actual series, may have been placed in the record to show that slight variations from the average were to be expected. The entire record is based on the middle line of days until the end of the series. Here the day just below the last day of the middle line is 12 Lamat, the end of 46 *tonalamatls* (260-day cycle), and the zero day of the recorded series. The *tonalamatl* was probably as easily used by the Mayas as "60 days" and "90 days" are used now. The entire calendrical system of the Mayas is based on the cycle principle. The series recorded in these pages was probably also a cycle, and in order to repeat it, 12 Lamat must again be used as the zero date. If to these arguments is added the fact that an additional day is necessary to keep the calendar in accord with the synodic revolution of the moon, there remains little doubt but that the users of this calendar added the extra day by going from the middle

to the lower line of day glyphs, thereby keeping the error between the moon and the calendar as low as possible, completing the 46th *tonalamatl*, and at the same time making it possible to repeat the recorded series as a cycle. If the series is repeated once, at the end of 810 months, or about 66½ years, the eclipse calendar will be behind the average eclipse season .78 days, and the lunar calendar will be in advance of the synodical revolutions of the moon only .22 days.

In general, then, the irregularities in the calendar recorded on these pages fall into two groups, those which are clerical errors of the scribe and do not therefore affect the solution advanced, and those which do not appear to be of the clerical type. In the light of the solution advanced, it has been shown that there are perfectly logical reasons for the latter group of apparent irregularities.

CONCLUSION

On pages 51 to 58 of the Dresden Codex occurs a series of numbers, running continuously through all the pages except the upper halves of the first two. This series records a period of 11,960 days, divided by means of columns into sixty-nine unequal subdivisions, of 177, 148, and 178 days, of which the first is the most frequent.

There are three distinct series. One series of numbers is in the upper part of the record, and consists of totals increased step by step until the final total reached records 11,958 days. Just below this series are three series of day signs and numbers, the middle one of which is the actual series. These dates are separated by the same number of days as the upper number series, except in the 23d group, at which place one extra day is added to the day series and not to the upper number series, causing the former to be in advance of the latter one day throughout the remainder of the record. At the end of the day series another extra day is added by counting in the last day in the lower row of days, thus completing the 11,960-day period.

Below this day series is another number series no term of which exceeds 178. In a general way it records the differences between the dates appearing above each of its numbers. The agreement is however so inaccurate that this lower number series could, at best, have been used only as a general guide to the user of the manuscript, in that it calls attention to the intervals of unusual length.

The series recorded is composed of three equal parts, each composed of 23 subdivisions and covering 3986 days.

The number series on these pages record an eclipse calendar, that is, a series of dates by means of which the occurrence of eclipses was foretold. This calendar is composed of three identical parts, with the exception of one 148-day group which occurs six months earlier in the last third than in the other two. Each third is composed of 23 unequal subdivisions which represent the twenty-three eclipse seasons, expressed in lunar months, in 3986 days. The upper number series records this calendar, and its total of 11,958 days is only .39 days less than 69 eclipse seasons.

In order to make it more intelligible this eclipse calendar is accompanied by a probably more generally known lunar calendar, which may have been altered slightly to conform to the requirements of the eclipse calendar it accompanies. This lunar calendar is contained in the day series just below the eclipse calendar. It also is recorded in three divisions agreeing closely with the eclipse calendar. One hundred and thirty-five lunar months of 30 and 29 days complete 3986 days, .63 days less than 135 synodical revolutions of the moon. This error which amounts to more than one day when repeated once, necessitates the addition of an extra day in the lunar calendar every other third, which was done in the manuscript in the first and last third, making the total recorded by the lunar calendar 11,960, two days more than the eclipse calendar, and .11 days more than 405 synodical revolutions of the moon. This period of 11,960 days may have been used as a cycle, the zero day of which is 12 Lamat.

Each third of the lunar calendar consists of 30- and 29-day months arranged in alternating sequence, with intercalary days added by the substitution of a 30-day for a 29-day month when the error arising from the nonconformity of the moon's revolution reaches more than one day. In order that the lunar calendar might agree with the eclipse calendar more closely, these months were recorded in groups of five and six.

The months in each third of the series were divided into three groups, which are the same in each third. The first two groups contained 47 months each, and completed the first sixteen dates of the third. The last group was one of 41 months, which was represented by the last seven dates of the third. An intercalary

day was added in the 32d month of each of the 47-month groups to correct the accumulating error, thereby causing the 6th and 14th subdivisions of the third to be of 178 days. In the first and last third the 40th month of the 41-month group also contained an intercalary day for the same reason, making the 23d subdivision 178 days, but in the last column of the record this extra day is added by going from the middle to the lower line of day signs. Each of the 47- and 41-month divisions began and ended with a month of thirty days.

The numerical series of these pages of the Dresden record, then, an eclipse calendar which is referred to a lunar calendar. This solution explains all the irregularities of the series except those which seem clearly to be clerical errors of the scribe.

Only the numerical and calendrical series on these pages have been considered. No attempt has been made to explain the hieroglyphs, the pictures, or the first two pages, which, although showing a close association to the long series, are nevertheless a unit in themselves.

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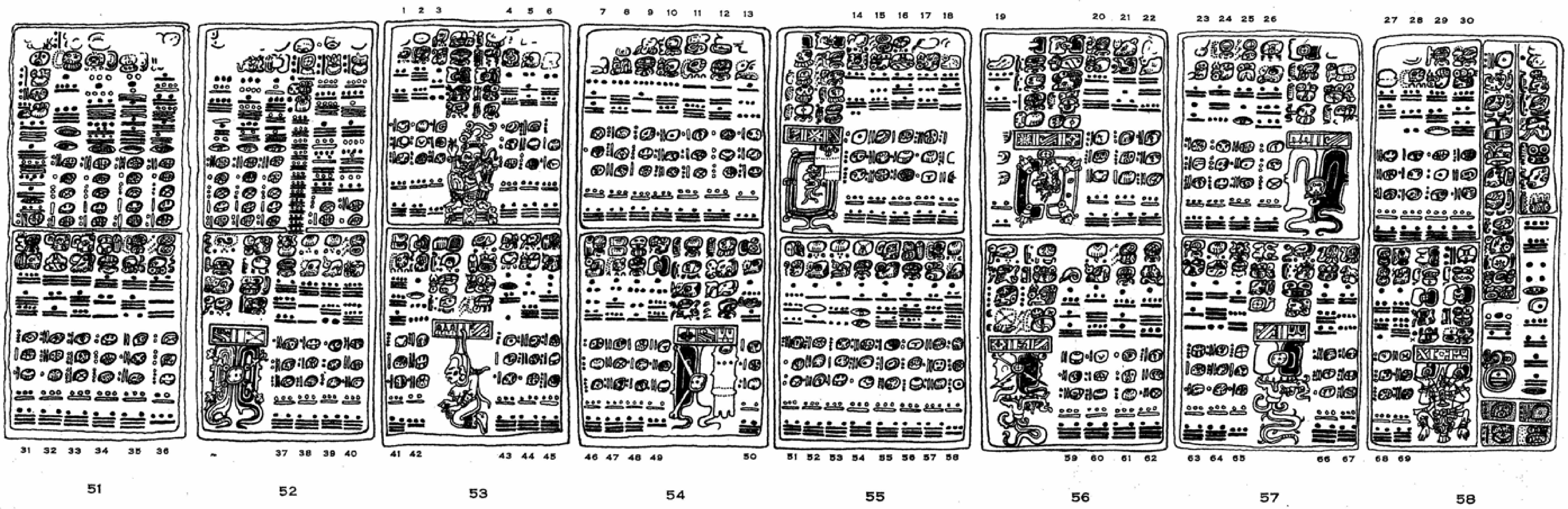

DRESDEN CODEX, PAGES 51 TO 58.

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PAPERS

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ASTRONOMICAL NOTES ON THE MAYA CODICES

BY

ROBERT W. WILLSON

NINE PLATES AND SIX ILLUSTRATIONS IN THE TEXT

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NOTE

The publication of the following paper, the work of the late Professor Willson, is made possible through the timely aid of Mrs. Willson, to whom the Museum is also indebted for many courtesies in connection with its preparation for the press.

Thanks are also due to Professor H. T. Stetson for the care he has taken in reading the manuscript and for the suggestions he has offered.

Charles C. Willoughby,
Director.

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INTRODUCTION

THIS study of the ancient astronomical knowledge of the Mayas was left unfinished by its author. It contains judgments of great interest to Americanists from a high scientific source, and its very incompleteness is a call for further research along the lines which are here laid down.

The correlation which Professor Willson suggests is one of several reached by following different lines of evidence and different structural possibilities in the record. The interest of Professor Willson was aroused by the publication of Mr. Charles P. Bowditch's "The Numeration, Calendar Systems and Astronomical Knowledge of the Mayas" in 1910, and by conversation and correspondence with this patron of Mayan archaeology and profound student of the ancient inscriptions. It was carried on at intervals from 1910 to 1923, periods of intensive work being followed by other periods when health and professional interests interfered. The study as now published would have received fuller treatment had Professor Willson lived because he had recently taken it up with new enthusiasm.

Another thing which should be borne in mind is that our kindly scientist in all these years was free to help other workers in the Central American field with advice and exact information on astronomical matters.

Professor Willson assumes a considerable knowledge of the Mayan calendar on the part of the reader. This knowledge can be most readily obtained from Mr. Bowditch's work already referred to, from "An Introduction to the Study of Mayan Hieroglyphs," by S. G. Morley, Bulletin 57 of the Bureau of American Ethnology, and from the general correlation explained by H. J. Spinden, which will be published in the present series in conjunction with this posthumous work.

H. J. S.

ASTRONOMICAL NOTES ON THE MAYA CODICES

PRIMITIVE ASTRONOMY

THE subject of which these pages treat is the Astronomical Tables of the ancient Mayas and the correlation of our own calendar with that which appears on their monuments and in the scanty remains of their manuscripts that have come down to us.

Many archaeologists who are interested in these subjects are not familiar with the methods of primitive astronomy. This introduction has been written in the hope that it will make easier reading of the argument for such archaeologists and even for some astronomers who are versed in modern methods but have never had an interest in the observing conditions of the early astronomers. Only the unaided eye was used by them, but they doubtless had some method of recording periods of time and some method of dividing a circle into halves and quarters and thirds.

We need not concern ourselves with periods of time less than a day, although a comparatively small acquaintance with the Maya literature will probably result in the belief that, at the time of which we have their records, they must have made use of some method of dividing the day.

I shall not apologize for beginning with a very elementary account of certain celestial phenomena, for a considerable experience in teaching astronomy to beginners has convinced me that few persons who have no knowledge of the subject except what has come from their own observations can accurately describe the daily motion of the sun and stars or the motion of the moon among the stars for a single month. It is easy to omit this introduction but whoever has never heard of the stations of the planets or does not know what retrograde motion is or is unacquainted with the terms *morning star* or *heliacal rising and setting* must consult some such source as pages 458–471 of Volume I of Lalande's "Astronomy" 3d ed., Paris, 1702, or keep on with our own explanation. Most modern textbooks on astronomy do not give that flavor of

the naked-eye astronomy which characterizes the medieval authors and which persisted down into the eighteenth century, a flavor that many of the twentieth century have never come to enjoy.

The sun rises in the east and sets in the west, almost exactly in the east and west on March 21 and September 23, but somewhat north of these directions in summer and somewhat south of them in winter (for we will consider only an observer in the northern hemisphere). It comes to its highest point at noon and is then due south (curiously enough the word noon, etymologically considered, means in the middle of the afternoon, approximately what we now write 3 Post Meridian and translate as 3 o'clock in the afternoon).

If the observer is in the tropics the sun rises nearly straight up from the horizon, and in the middle of the tropical zone on the equator it goes exactly overhead on March 21 and September 23, and remains above the horizon just half a day so that the day and night are exactly equal in length. But anywhere on the earth the days and nights are equal on these dates, which are therefore named the *Vernal Equinox* and *Autumnal Equinox* respectively.

In what follows we shall describe the phenomena of the motion of the sun, the stars, and the planets, as seen by an observer in the Maya country in about latitude 15° North of the Equator, say at the site of the ancient city of Copan.

The Sun

On the day of the equinox the sun rises at about 6 A.M., due East, and ascends on a slant tending southwards and passes at noon 15° south of the Zenith, descending during the afternoon on a path tending toward the North so that it sets at about 6 P.M., due West.

The table on page 3 gives the positions of the sunrise and sunset points for each ten days of the year as seen by an observer in latitude 15° N.

About an hour before sunrise a short faint arc of diffused light appears nearly at the point where the sun will rise above the horizon. This arc increases rapidly in a horizontal direction and somewhat more slowly in the vertical direction and the intensity of its light increases until, about a half-hour before sunrise, it becomes strong enough to produce an illumination of the whole visible sky so that all but the very brightest of the stars become invisible against the brightening background.

Table I. — Points of Sunrise and Sunset

	Rises	Sets		Rises	Sets
Jan. 1	23.9 S. of E.	23.9 S. of W.	July 10	23.1	23.1
Jan. 11	22.7	22.7	July 20	21.6	21.6
Jan. 21	20.7	20.7	July 30	19.3	19.3
Jan. 31	18.2	18.2	Aug. 9	16.6	16.6
Feb. 10	15.0	15.0	Aug. 19	13.5	13.5
Feb. 20	11.5	11.5	Aug. 29	9.9	9.9
Mar. 2	7.7	7.7	Sept. 8	6.1	6.1
Mar. 12	3.6	3.6	Sept. 18	2.2	2.2
Mar. 22	0.4 N. of E.	0.4 N. of W.	Sept. 28	1.8 S. of E.	1.8 S. of W.
April 1	4.5	4.5	Oct. 8	1.8	5.9
April 11	8.4	8.4	Oct. 18	9.7	9.7
April 21	12.1	12.1	Oct. 28	13.5	13.5
May 1	15.5	15.5	Nov. 7	16.7	16.7
May 11	18.4	18.4	Nov. 17	19.6	19.6
May 21	20.8	20.8	Nov. 27	21.8	21.8
May 31	22.6	22.6	Dec. 7	23.4	23.4
June 10	23.9	23.9	Dec 17	24.2	24.2
June 20	24.3	24.3	Dec. 27	24.3	24.3
June 30	24.1	24.1			

The twilight arc accompanies the point of sunrise. This point of sunrise makes a southward course from about 25° N. of E. in June to 25° S. of E. in December, as shown in Table I, and again northward from December to June. The southernmost point of sunrise is reached at the *Summer Solstice* and the northernmost point of sunrise is reached at the *Winter Solstice*. As in the case of the equinoctial points, the solstices occur at the same time for all parts of the world.

Sometimes the watcher of the dawn sees, just at the upper edge of the twilight arc, a star which was not seen the day before and which soon disappears in the growing light of the twilight arc. On this day the star is said to "rise heliacally." A week later it rises, nearly at the same point of the horizon, but before the appearance of the twilight glow and remains visible for about half an hour before being obliterated by the increasing light of the coming sunrise. At the end of a month it rises two hours before the twilight begins and attains a height of about 30° before it fades out in the increasing daylight; and at the end of three months it rises at midnight and is due south (on the meridian) at dawn: during all this time it is called appropriately a *morning star*.

At the end of the fifth month the star has increased its distance from the twilight arc to 150° and a month later it rises in the east at about 6 P.M., reaches the meridian at midnight, and sets at the western horizon just as the dawn appears in the east. It is then said to set acronychally. A month later it has moved another 30° westward and therefore *follows* the sun by about 150° and is seen 10° or 15° above the horizon in the east as soon as the evening twilight has diminished sufficiently to darken the background of the eastern sky. Two months later it is seen near the meridian just after sunset and about two months later still, that is, eleven months after heliacal rising, it has moved up from the east toward the sun, so that it is seen for a little while at the upper edge of the arc of the evening twilight, and, continuing its approach to the sun, is lost in his rays for about a month; after which it reappears at a second heliacal rising and repeats the configurations just described. The last day that it is seen in the evening twilight is called the day of heliacal setting. The old term *acronychal setting*, which has been used above is, in the strict sense, setting at the moment when the sun is exactly at the eastern horizon. It is now usual to say that on that day the star is in *opposition* and to define that term as the position of the star with respect to the sun when it is on the meridian at midnight and to speak of the star on the date half-way between heliacal setting and rising as being in *conjunction* with the sun.

The above description applies to a star which rises not far from the east point of the horizon as seen by an observer in a latitude of about 15° from the equator. For other stars the description would require some slight modifications which will readily suggest themselves to the intelligent reader. For instance, many stars do not rise and set at all, being seen at all times between the end of evening twilight and the beginning of morning twilight but in different parts of the circular paths that they seem to describe about a fixed point in the sky called the pole.

A comparatively short study of the stars suggests that their apparent motions are such as would result if they were attached to the inner surface of a spherical shell in the center of which is the point occupied by the observer and if this shell were revolving as a whole about an axis drawn from the observer's eye to the fixed point called the pole. Essentially this was the theory of the Greek astronomers.

The phenomena that we have described, the motions of the stars westward from night to night, away from the sunrise point and toward the sunset point, were easily explained by supposing that the sun was moving on the surface of the starry sphere toward the east. This motion of the sun with respect to the stars is called *direct* and the circuit is accomplished in the interval of time between two heliacal risings or settings of the same star. This interval determines the "sidereal year," or year of the stars, which is about twenty minutes longer than the "tropical year," or year of the seasons, which will now be explained.

The shifting of the points of sunrise from north to south and back again during the period was found to be explained completely by assuming that the path of the sun was a great circle on the surface of the sphere, crossing the plane of the equator at an angle of about 24°. In this path the sun was supposed to move from west to east at a nearly uniform rate of slightly less than one degree per day completing the 360° in 365¼ days. It is not known what theories the Mayas had concerning the nature of the universe but they measured celestial movements and recorded the movements of the heavenly bodies.

The tropical year marks the changes of the seasons which are due to the differing meridian altitudes of the sun. The cycle of the year of seasons was, of course, an important discovery to dwellers in the temperate zones, as also in less degree to inhabitants of the tropics.

There is a suggestion that the Mayas sometimes calculated in a year of 364 days, agreeing with a lunar year of thirteen sidereal months of twenty-eight days each. This appears in the series of 1820 days = seven tonalamatls = five years of 364 days = sixty-five months of twenty-eight days each, found on pp. 23, 24, 25 of the Codex Peresianus.

It is likely that the Mayas knew that the length of the year as determined by heliacal rising of stars was about 365¼ days or an excess of two days over eight of their calendar years of 365 days each. They may have assumed that the tropical year was the same length, namely, 365¼ days. This is exactly the length of the years of the Julian calendar which intercalated one day every four years and which was in universal use in the western world until 1582. It gave the true length of the tropical year, on which the

seasons depend, with an error of about three days in 400 years. The date of one position of the sun being known, the subsequent dates of its arrival at the same point in the heavens could be found, therefore, by simply making successive additions of an extra day every four years as was done by the Julian calendar, or by counting thirteen extra days after fifty-two years or twenty-five days after one hundred and four years. The latter may have been the method of the Mayas, arriving at a correction more accurate than that of the Julian calendar.

The Planets

The motion of the moon and of all the planets with respect to the stars is always, in the long run, and for the greater part of the time, direct, that is, from west to east. All of the planets, however, at certain parts of their courses decrease their direct motion and come to a standstill, or to a stationary point, among the stars after which they begin to move west or "retrograde" faster and faster till they reach the line joining the earth and sun where this retrograde motion is at a maximum. Venus and Mercury are then between the earth and sun at conjunction, and are lost in the sun's rays. Mars, Jupiter, and Saturn, at maximum retrograde motion, are in the sun-earth line but on the opposite side of the earth from the sun, at *opposition*, and come to the meridian at midnight.

After reaching this position in the sun-earth line, the retrograde motion becomes slower and after a certain interval of time the planet is stationary among the stars for an instant and then resumes its direct motion for a period always much greater than that of its retrogradation.

The middle of the retrograde arc of Mars, Jupiter, and Saturn, as has been said, is always at *opposition*, that of Venus and Mercury at that *conjunction* which is called *inferior conjunction*. The two latter planets may also be in conjunction when on the sun-earth line but beyond the sun, they are then in *direct* motion among the stars and are said to be at *superior conjunction*. Mars, Jupiter, and Saturn, when in the middle of their arcs of direct motion, are beyond the sun and at *conjunction*. As their orbits lie entirely outside of the earth, they can never be at inferior conjunction.

Ptolemy explained these appearances on the theory that each planet moved uniformly in a circle nearly in the plane of the great

circle yearly described by the sun in the celestial sphere, and that this orbit, which he called the *epicycle*, moved uniformly on a circle called the *deferent*. The position of the earth was at a little distance from the center of the deferent and the point of the epicycle that moved on the deferent was also a little out of center.

Risings and Settings of the Planets

Sometimes the watcher notes the *heliacal rising* of an object evidently much brighter than the other stars because at its first appearance it is well within the twilight arc which, at the time of the object's rising, has already extended several degrees above the horizon. After heliacal rising, this object, which is the planet Venus, moves toward the west like the stars but much more rapidly, so that it is moving westward not only from the sun but with respect to neighboring stars; that is, its motion is retrograde. After about two weeks it has moved so far to the west that it is well clear of the twilight arc at rising and its brilliance is greatly increased but its rate of motion is much slower than at its first appearance and, in fact, about equal to the rate of the fixed stars; so that for several days it remains very nearly in the same position among the constellations but still travels westward with them about a degree a day away from the sun. At this point, when it is a little less than 20° west of the sun, it is said to be *stationary*. Then it begins to move toward the east slowly among the stars, its motion being *direct* though it still increases its westward *elongation* or distance from the sun. Its daily motion westward continues to diminish but its brightness increases till about a month after its first appearance when it reaches a maximum far exceeding that attained by any other of the planets, and blazes in the eastern sky an hour before the dawn with such intensity that it often casts a distinct shadow.

From this point it continues, still with direct motion but increasing its distance west of the sun and slowly decreasing in light, until, a little more than two months after heliacal rising, it reaches its *greatest elongation* at a little more than 45° west of the sun, rising about three hours after midnight and still a splendid object well up in the morning sky even when the dawn is well advanced.

For a few days it remains nearly stationary with respect to the sun which, of course, implies that it is following that luminary at its

own pace of about one degree per day with direct motion among the stars. This direct motion slowly increases and continues for many months during which the light of the planet gradually decreases while the planet approaches the sun to pass beyond it.

About eight months from the day of first heliacal rising described above, Venus has returned to a point so near the sun, about 12° west, that it is deep in the arc of dawn, and is no longer seen before sunrise; this takes place when the direct motion is about 1.3° per day so that the planet is approaching the sun at a rate of about three degrees in ten days and its brightness is still as great as that of Sirius.

Though lost to sight for a time, Venus keeps on at about the same rate, describing the 12° to conjunction with the sun in about six weeks, passes it, and, after another six weeks, arrives at a point 12° east of the sun. This is a second heliacal rising but much less spectacular than that first described. When in this position it *follows* the sun in its daily course, rises in full daylight at the eastern horizon about an hour after sunrise and is seen low in the west about an hour after sunset and itself on the point of setting. It is then an evening star.

The planet moves slowly east, but with increasing speed for about six months with a slow increase in brightness; it is higher in the sky at each sunset and at the end of that period is at greatest elongation, just about 45° from the sun and setting about three hours after sunset. Turning at this point where the direct motion is just equal to that of the sun, it begins to move back toward the sun with increasing speed, passing successively through a point where its motion among the stars changes to retrograde; then through a point of greatest brilliancy when it sets about an hour after the end of evening twilight and is very conspicuous, sometimes visible even before the sun has set; then through a stationary point where for a moment its motion westward equals that of the stars and finally to a second point of heliacal setting and a disappearance in the sun's rays, lasting about two weeks, after which it reappears at a heliacal rising such as was described in the first lines of the chapter.

At the middle of this period of invisibility the planet is in conjunction with the sun. The keen eye of the Mayan astronomer in the clear tropical sky could follow the planet as it approached the

sunset horizon in an almost vertical path up to the fourth day before conjunction and pick it up in the morning twilight four days after conjunction; for we know that they reckoned the period of invisibility as eight days. This conjunction is called "inferior conjunction" and is much more striking than that between second heliacal rising and first heliacal setting on account of the great brilliancy of the planet and of the rapidity with which it passes from evening star to morning star.

It is literally a "moving sight" for about four months on account of the rapid changes in its speed and brightness.

The Lunar Series in the Dresden Codex

Some time in December 1911 the late Professor F. W. Putnam showed me the report of the Peabody Museum on Tikal by Professor A. M. Tozzer. When I asked him if the very obvious orientation was explained, he told me that no competent astronomer had attempted it and suggested that I attack the problem.

After some weeks of study it appeared that the conditions did not promise such important results as have been obtained by the study of the Great Pyramid and the Egyptian temples and on my application to Professor Putnam for further information he gave me a copy of Mr. C. P. Bowditch's "The Numeration, Calendar Systems, and Astronomical Knowledge of the Mayas"[1] and lent me a facsimile of the Dresden Codex.

It is easy to imagine the delight with which I learned of a race of priest-astronomers who had a system of numeration which resembles the "Arabic" system but is based on 20 instead of 10 and which furnishes an example of the use of a sign for "zero" at a date certainly earlier than any yet noted in the histories of mathematics.

Very early in my acquaintance with Mr. Bowditch's book I chanced upon the table of the Lunar Series beginning on page 222 and, at the first glance, saw the number 6585.32, conspicuously displayed at the top of the last column on page 223. The idea was at once suggested that the table had to do with the Saros or, at any rate, with a series of eclipses.

A very short study of the Codex showed that the day signs are placed at such intervals that they record not only a series of synodic months with great accuracy, as shown by Mr. Bowditch,[1] but

[1] Cambridge, Massachusetts, University Press, 1910.

also a series of dates on which eclipses may possibly occur, when the sun happens to be near the node of the moon's orbit on the day of new moon. For proof of this compare the upper numbers from the Dresden Codex (column 6 of Bowditch's table [1]) with those in column 1 of Table 11, of Schram's "Table of the Phases of the Moon" [2] and it will be found that the numbers are identical.

The second column of Schram's table shows that, if there is a central eclipse on a given date, there will be a central eclipse somewhere on the earth after 1033, 1211, 1388, and 1565 days, and there may be a central eclipse after 1742 days. The intervals of the pictures in the Codex are 1742, 1033, 1211 thrice repeated, making three periods of 3986 days each.

Solar eclipses can only take place when, on the day of new moon, the sun is near one node of the moon's orbit and astronomers make use of an *eclipse year* which is the period in which the sun passes from one coincidence with the moon's node to the next succeeding coincidence with the same node. After a half of the eclipse year it will be near the opposite node.

The average length of this period of the eclipse year is 346.6201 days, and eleven and a half eclipse years = 3986.131 days. Three times this, that is 34½ eclipse years, are 11958.393 days. The last number of the upper series (pages 51–58 of the Codex) is 11958 days which is not quite so close an approximation to the true value of 34½ eclipse years as the 11960 indicated by the day series is to the true value of 405 synodical revolutions, but near enough to indicate that the upper series of numbers is especially intended to record the circumstances of the eclipse calendar.

It may here be noted that, if there is an eclipse visible in tropical latitudes at a given date, the chance is a little better than one in four that there will be a second eclipse visible in the same region after 3986 days. It is a curious but perhaps not a significant fact that the interval shown on the lower half of pages 51–58 is 6585 days which is exactly the length of the Babylonian Saros.

On May 15, 1912 I noted in the margin of the table of eclipse dates on pages 222–223: "Compare with Oppolzer. What nine eclipses could be observed in this order and at these intervals in Yucatan, say in the latitude of Palenque? The dates would be likely to be given and might give a clue to the calendar."

[1] Bowditch, 1910, pp. 222-223. [2] Schram, 1908, p. 358.

It is of course true that somewhere on the earth at least one eclipse of the sun must occur every 177 days, and it seemed likely enough that the dates which are distinguished in the Dresden Codex by the corresponding pictures were those on which eclipses were visible at some point in the Mayan country, or might have been predicted as likely to be visible by astronomers having as accurate a knowledge of the moon's motion as that indicated by Mr. Bowditch's analysis of the table in this manuscript. It appeared worth while to find whether there was a series of eclipses visible in Yucatan at the intervals corresponding to the pictures. If such a series existed it would be possible to find the dates in our own calendar and from the dates in the codex to determine accurately the correlation of the Mayan Long Count with our time count. To test this hypothesis a table was formed of all the eclipses of the sun which were visible in Yucatan from 12 B.C. to 1520 A.D.

Eclipses of the moon were not included because the fact is known that the ancient Mexicans did not make use of lunar eclipses and also, what is in this case more decisive, the days of lunar eclipses are always about fifteen days earlier, or fifteen days later than the days when solar eclipses may be expected to take place; it is, therefore, impossible that any one of the pictures should fall on the day of a lunar eclipse unless all the others do.

It seemed to be agreed by those whose advice I sought that the date of the lunar series of the Codex would probably be between the beginning of the Christian era and the time of the Spanish Conquest and the table was restricted to the interval between the eclipses of August 31, B.C. 31, and January 2, A.D. 1508 (Julian calendar).

The table was formed by means of the plates of Oppolzer's "Canon" of Eclipses [1] in the following manner, which though not quite accurate, serves to insure the inclusion of all eclipses that could possibly be visible in the region considered.

A circle was drawn on celluloid of a diameter slightly greater than the maximum diameter of the moon's shadow at any possible eclipse, which for the scale of the Oppolzer plates is about 60 millimeters. The center of the circle is indicated by a dot. This dot being placed at a given point on the map, any eclipse track that cuts the perimeter of the circle will be visible at the given point.

[1] Oppolzer, 1887. See Pls. 1 and 2 from Oppolzer with circles in place.

The center was usually placed on the Oppolzer plates about at the position of Tikal, but was sometimes moved to other neighboring points in the Mayan region when the magnitude of the eclipse was small, so as always to include, rather than to exclude, the path of the central line of any eclipse which might be visible anywhere in that region. The dates were then noted of all those tracks any part of which was included in the circle.

Oppolzer's plates show no records of any eclipses unless they are central at some part of the earth. Partial eclipses, of course, occur where the line connecting the centers of the sun and moon does not cut the earth's surface, although some part of the moon's shadow does fall on the earth; such eclipses have no path of central eclipse to be plotted on the charts. But no part of the shadow of such an eclipse can reach so far to the south as the latitude of Yucatan and the eclipse should not be included in our table.

Five hundred and ninety-one eclipses were thus selected for investigation of which about five hundred might have been actually visible in the Mayan region under favorable conditions of weather.

By placing the center of the celluloid disk on the track of central eclipse and sliding it along the map till the Mayan area is most advantageously shown within the circle, the magnitude of the maximum phase of the eclipse at the given point in the area may be estimated. The maximum is 1.0 when the given point coincides with the center of the circle, 0.5 when it is half way from the center to circumference and 0.0 when it is on the perimeter. In the latter case it is doubtful whether the eclipse would be visible at all.

A rough idea of the time of maximum eclipse for a morning eclipse may be obtained by placing the center of the circle on the central track at the position of maximum phase and comparing its distances from the points for "Eclipse central at noon" and "Eclipse begins at sunrise," etc. Assuming that sunrise is at 6 A.M. local mean time (which is never much in error in Yucatan), if the center of the circle, when in position corresponding to greatest phase, is half way from the noon to the sunrise point of the track, the time may be taken as 9 A.M. A corresponding procedure will determine approximately the time of maximum phase for afternoon eclipses by comparing with the noon and sunset points of the central track. Plates 1 and 2 show Plates 91 and 92 of Oppolzer's "Canon" with the circle placed in position to determine

which of the eclipses, whose tracks are shown on the map, were visible in Yucatan.

The data thus found were entered on index cards and copied. Table II (page 14) gives that part of the record corresponding to the observable eclipses of Plates 91 and 92 of Oppolzer's "Canon."

Column 1 contains the current number of the eclipse in Oppolzer's "Canon"; column 2, the date—year, month, and day of the Julian calendar; column 3, the corresponding Julian day taken from Schram's tables; column 4, a rough estimate of the magnitude of greatest eclipse; and column 5, an approximate value of the local mean time of maximum phase. The four columns under the heading "Coincidences" will be explained presently.

A band of paper three inches wide and about 120 feet long, with vertical and horizontal rulings, cut from a roll of cross-section paper (Keuffel & Esser No. V Standard Profile plate A 4×20), was placed on a board 40 inches long with a roller at each end (Pl. 3) so that it could be wound from one roller to the other leaving a length of 34 inches lying exposed on the board for examination; the finer vertical lines were 0.25 inches apart and every tenth line was a heavier ruling.

The heavier rulings, two and one-half inches apart, were numbered consecutively to correspond to Julian days from 1,716,000 to 2,272,000 so that each day should correspond to about $\frac{1}{400}$ of an inch. Upon one of the horizontal lines of the band were carefully plotted points corresponding to the eclipses of the table, the error in plotting being usually less than three days.

On the edge of a separate strip of the same paper covering a length of somewhat more than 12,000 days were plotted points at intervals corresponding to the numbers of days between the pictures of the Codex. This strip may be referred to as the "Picture Strip." As Förstemann has suggested[1] that the eighth eclipse, by a clerical error, is recorded in the Codex 177 days too late, an extra point was included at the date required by his emendation. This point was considered in making the comparisons now to be described.

The edge of the picture strip being placed along the line of

[1] Page 124 of Förstemann's Commentary on the Dresden Manuscript (p. 204 of translation). Papers of the Peabody Museum, V. 4, No. 2, Cambridge, 1906.

TABLE II. — THE ECLIPSES ON OPPOLZER'S "CANON," PLATES 91–92, OBSERVABLE IN YUCATAN

(Copy of p. 22 of Willson's Table of Visible Eclipses)

No	Date		Julian Day	Mag.	Local mean time	Coincidences			
						1	2	3	4
4400	638 IX	13	1,954,343	0.7	8.00 A.M.	. .	. .	. .	. .
4410	642 VII	2	1,955,731	1.0	5.00 P.M.	. .	4	. .	. .
4417	645 V	1	1,956,765	small	9.00 A.M.	6	. .	. .	5
4420	646 X	14	1,957,296	0.2	sunrise	. .	5	. .	6
4429	650 II	6	1,958,507	1.0	7.30 A.M.	. .	6	. .	. .
4436	653 VI	11	1,959,363	0.1	4.00 P.M.	. .	. .	. .	. .
4437	652 XII	6	1,959,651	small	4.00 P.M.	5	5	6	5
4445	656 III	31	1,960,752	0.8	noon	. .	. .	. .	6
4448	657 IX	13	1,961,283	small	9.00 A.M.	. .	4	. .	. .
4453	659 I	28	1,961,785	0.1	sunrise	. .	. .	. .	5
4462	662 XI	16	1,963,173	0.4	3.00 P.M.	. .	. .	. .	. .
4463	663 V	12	1,963,350	0.2	sunset	. .	5	4	. .
4464	663 XI	5	1,963,527	0.1	1.00 P.M.	4	. .	. .	5
4465	664 V	1	1,963,705	0.6	10.00 A.M.	. .	. .	. .	. .
4484	671 VI	12	1,966,303	0.3	7.00 A.M.	4	5	5	. .
4490	674 IV	12	1,967,338	0.2	sunset	6	4	5	5
4498	677 II	7	1,968,370	small	4.00 P.M.	. .	. .	4	. .
4503	679 VII	13	1,969,256	0.0	sunrise	. .	5	. .	. .
4511	682 V	12	1,970,290	0.3	sunset	. .	5	4	4
4517	684 IX	14	1,971,146	0.8	sunset	. .	. .	. .	. .
4158	685 III	10	*1,971,323*	0.1	sunset ×1	7[1]	. .	. .	6
4528	688 XII	28	1,972,712	0.1	sunrise	. .	. .	. .	. .
4529	689 VI	22	1,972,888	0.3	4.00 P.M.	. .	. .	4	. .
4530	689 XII	17	*1,973,066*	1.0	10.00 A.M. ×2	. .	7[1]	4	6
4536	692 X	15	1,974,099	0.15	9.00 A.M. ×3	. .	6	7[1]	. .
4544	696 II	8	*1,975,370*	0.4	4.00 P.M. ×4	7	. .	4	7[1]
4545	696 VIII	3	1,975,487	0.9	10.00 A.M.	. .	. .	. .	4
4556	700 XI	15	*1,977,052*	doubtful	×5	. .	7	. .	. .
4563	703 IX	15	*1,978,086*	0.2	3.00 P.M. ×6	. .	. .	7	. .
4564	704 III	10	1,978,263	0.7	8.00 A.M.	. .	5	. .	4
4572	707 I	8	*1,979,297*	0.8	sunset ×7	5	. .	5	7
4579	710 V	3	1,980,508	total	8.30 A.M.	. .	. .	. .	5
4582[1]	711 X	6	*1,981,069*	0.7	9.30 A.M. ×8	. .	5	. .	. .
4586	713 III	1	1,981,541	0.5	sunrise	. .	. .	. .	4
4596	716 XII	18	1,982,929	0.3	2.30 P.M.	. .	. .	. .	. .
4598	717 XII	7	1,983,283	0.1	noon	. .	. .	. .	5
4599	718 VI	3	1,983,461	0.7	7.30 A.M.	. .	. .	. .	. .
4614	724 VII	25	1,985,705	0.6	sunset	. .	. .	. .	. .
4616	725 VII	14	1,986,059	0.3	sunrise	. .	5	. .	. .
4623	728 V	13	1,987,093	0.5	5.00 P.M.	5	. .	4	4

[1] This series of sevens would be eights if Förstemann's emendation is justified. The fifth eclipse, however, is shown *not* to be visible.

plotted eclipses so that its first plotted point coincided with the first eclipse of the table, it was noted how many of the points coincided with an eclipse on the long strip and this number was recorded in column 1 under the heading "Coincidences," opposite the first eclipse of the table. The picture strip was then slid along till its first point coincided with the second eclipse of the table and the number of coincidences was noted in column 1 opposite the second tabular eclipse.

Continuing this process the numbers of column 1 were found. If the pictures represented eclipses actually visible in Yucatan in the period considered there should be at least one case in which the number 9[1] is recorded — unless, by some mischance, the initial eclipse of the series had been omitted on the long strip.

To guard against this possibility the process was repeated with the *second* picture in coincidence with the first eclipse and the number of coincidences noted in column 2 of the coincidences; and, to make assurance doubly sure, the third and fourth columns of coincidences were filled out for the cases where the third and fourth pictures respectively coincided with the first, second, third, etc., of the plotted eclipses.

No series of 9 was found and only one series of 8 coincidences. This is shown on page 22 of my Table, which is reproduced in Table II. The coincidences begin with the eclipse of March 10, 685 A.D. of the Julian calendar, that is, J. D. 1,917,323.

The fifth eclipse, being doubtful, was carefully computed and the extreme limit of the shadow found to be about parallel to the S. W. coast of Guatemala and probably a few miles off shore so that the series should perhaps be reduced to 7. It may therefore be regarded as highly probable that this method will not give the correlation of the two calendars.

This conclusion was arrived at in the summer of 1913 by an investigation made in the same way but with a paper strip less accurately graduated and on a much smaller scale; the strip shown in Plate 3 was made in January 1914 and gave the same negative results.

Having this improved apparatus at hand it seemed worth while to go a little further into the question of the Maya "Saroid" of

[1] The tenth picture follows the ninth by 708 days and probably does not in any case refer to a visible eclipse since no central eclipse visible in the tropics can be followed in 708 days by an eclipse whose shadow passes over tropical countries.

3986 days as a predicting method. By a slight modification of the method it was easy to add to the list of eclipses those that would have been predicted by an astronomer who knew that he might be in error by one-tenth of a day, corresponding to an error of about 1.3° in the moon's longitude, or one-tenth of a day in the computation of the time.

This added about 400 eclipses to the list, which were plotted on the long strip and the whole series was investigated in the same way as the visible eclipses. In place of the four cases of seven coincidences of visible eclipses, the new layout gave seven cases of seven, five of eight, four of nine, and one case of ten coincidences of predictable eclipses. This last case was the one already considered, beginning March 10, 685. The result of this study was to confirm the opinion that no correlation of the Mayan and Julian Calendars could be found from the lunar series alone.

The Ahau Equation

While engaged in the above research I had carefully avoided everything except the investigation of the *numerical series* and had confined myself strictly to pages 51–58 of the Codex, but after the failure of my first attempt in the summer of 1913, I began the study of other sections of the manuscript, especially pages 24 and 46–50, avoiding in this new attempt all guesses at the relation of the pictures and glyphs and considering the series of numbers alone. Here, of course, Förstemann's discovery that this is a Venus calendar was of the first importance.

In 1914 I computed a table of the dates of inferior conjunction of Venus preparatory to an exhaustive study of the Venus calendar and in 1915 began to study the suspected Mars calendar of pages 43–45. In that year certain results of these studies took a form that promised a solution of the question of the correlation of the two calendars and in August, 1916, it seemed to me that there was a good deal of evidence tending to show that the initial date of the Maya Long Count from 4 Ahau 8 Cumhu was August 29, 3511 B.C. Julian calendar, astronomical reckoning (3512 of the chronologist), corresponding to the Julian day 438,906.

The steps by which this result was reached are described in the following pages. It may be said here that on the above-given date there was a somewhat unusual configuration of the planets which

may account for its selection as the "Mayan Era." In the fall of 1916 I was obliged to give all my time to more pressing work and only recently (1920) have been able to return to the subject.

From the study of pages 51–58 of the Dresden Codex, it appeared that the intervals between the pictures of the Codex alone would not fix the definite series of dates in the Julian calendar to which the days marked by the pictures correspond, so that it would not be possible by this means to determine the Julian day corresponding to the Mayan date 9.16.4.10.8, the date on which it seems probable that the Moon calendar begins. The first date of the calendar itself, which is 3 Cib, is 177 days after 12 Lamat and is the first day on which an eclipse could occur after that date.

The Long Count date, 9.16.4.10.8, 12 Lamat, is equivalent in Arabic numerals to the number 1,412,848 days and an Initial Series expressed by such a number will hereafter be styled the "Mayan day" of a given date. This term may be defined as the number of days elapsed since the Mayan Era, 4 Ahau 8 Cumhu, exactly as astronomers define the Julian day of a given event as the number of days elapsed since the beginning of the Julian period, which commenced January 1, B.C. 4712, astronomical reckoning, or B.C. 4713 according to the chronologists.

If we abbreviate the terms "Mayan day" and "Julian day" by M. D. and J. D., respectively, the problem of determining the relation between the two calendars may be stated as follows: To find the value of A such that M. D. + A = J. D. That is, what is the quantity, A, which must be added to or subtracted from the Mayan day of a given event to give the Julian day of that event?

This constant will hereafter be referred to as the "Ahau Equation" and I now propose to set forth the probability that A = 438,906 and to explain the process by which this number was determined.

As far as the eclipse calendar is concerned, if we assume that it begins with the Mayan day 1,412,848, and the Ahau Equation is taken as 438,906, the corresponding Julian day is 1,412,848 + 438,906, or 1,851,754, which is found by Schram's table to be Octo-
was not visible in Central America. The first picture, 502 days
later—March 15, 359—was the date of an eclipse visible in Yuca-
ber 29, 357 A.D. of the Julian calendar. The eclipse of that date

tan, the sun, an hour after rising, having more than half its surface obscured by the moon.

Before proceeding further, it will be convenient to consider briefly the contents of pages 51a and 52a of the Dresden Codex (Pl. 4).

Beginning at the right, the first column contains two interwritten numbers in the Long Count notation, one in black and the other in red — a method frequently used in the Codex to economize space and, as I believe, usually with the number first to be considered, or of most importance, in black. In this case the black number is M. D. 1,412,848, 12 Lamat, and the symbol for this day appears in the same column below. The second (red) number is 1,412,863, 1 Akbal, and this day also appears in the column below.

In the second column appears the black number 1,412,858 and below, 3 Eznab. M. D. 1,412,858, however, is 9 Eznab, not 3 Eznab and either the Long Count or the Vulgar date is in error. It is probable that the scribe omitted a dot in the uinals and that the correct reading should be M. D. 1,412,878, 3 Eznab; if this emendation is made the three dates so far considered refer to the date of beginning of the eclipse calendar and to dates following by 15 and 30 days respectively.

In regard to the series of the five days, 12 Lamat, 1 Akbal, 3 Eznab, 5 Ben, 7 Lamat, arranged in seven short columns, I reserve comment for the present.

As to the red number in the second column, associated with the day 12 Lamat, the corresponding M. D. is 1,435,828 which is not 7 Lamat but 8 Lamat. Here we have further evidence that the scribe was less careful in his copy or computation of the second column than of the first column. Probably, just as in other cases in the Codex, the special object of the calendar was to give the Vulgar date correctly for the use of the common people, we may then assume that the 7 Lamat is correct, in which case the M. D. should be 1,435,788, 7 Lamat, or this number plus or minus some multiple of 260 days; what the correction should be I cannot now say.

At the top of each column of interwritten numbers appears the symbol of the Mayan Era, 4 Ahau 8 Cumhu, and the whole arrangement appears to be a very suitable and convenient form for

writing a Long Count date in a manuscript, comparable to the Initial Series dates on monuments.

Immediately at the left of the interwritten numbers appears a series of red thirteens which has never been explained.

A comparison with pages 23 and 24 of the Codex Peresianus leads to the query whether the passage before us may not refer to a series of 169 days, read upwards, beginning with 13 Ahau, 13 Ben, 13 Cimi, etc. and ending with 13 Muluc. It may be noticed that the series of 168-day intervals between the eclipse pictures of pages 23 and 24 of the Peresianus may be supposed to begin with 13 Ahau since that date is found in close connection,[1] and the further question must arise whether that series (probably of sidereal months) which begins with 12 Lamat refers to the same date in the Long Count as the 12 Lamat with which the Dresden table of synodic months and eclipse syzygies begins. It is curious if this is merely a coincidence, and this point will receive further consideration. (See page 28.)

Attention is called to the fact that the eight days (Fig. 1) written above the red thirteens, if added to 169, make 177 days which is the principal interval between the eclipse dates on pages 51–58.

Something more will be said later as to the second and third glyphs in this column (Fig. 1). That the dot followed by the bar may be fairly taken as meaning "six," although the form is unusual, is not impossible; see for instance the 4 Lamat at the bottom of the fourth column of Vulgar dates on page 47 of the Dresden and the dot covered by a bar on page 24 of the Peresianus.[2]

The middle part of pages 51a, 52a, below the glyphs, consists principally of a set of multiples of 11,960. In one case there is perhaps an error by the scribe of 100 days and in two cases the number differs by an integral number of tonalamatls from a multiple of 11,960;

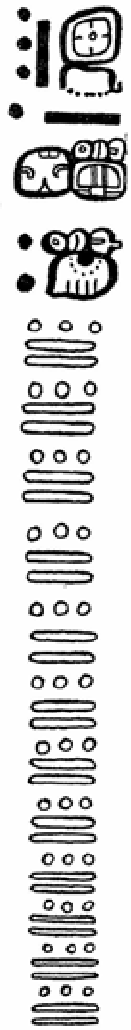


FIGURE 1
Dresden Codex, page 52a.

[1] It is possible that Professor Willson here refers to the blue number thirteen near the center of page 23 between the tails of the two monsters pendent from the Celestial Band. — H. J. S.

[2] Some students will possibly disagree with Professor Willson's reading of this glyph. More probably it is 1 uinal 5 Tuns written in the reverse positions which prevail in the Secondary

in both of these latter instances there is evidence of an alteration of the original number which may be intentional. It will appear hereafter that there are often examples of error in change in the Dresden Codex. It suggests itself that sometimes the number may have been erroneously copied from the wrong line in a table of the equivalent numbers of days in a given series of tonalamatls. This explanation may serve until we can find a plausible reason for the exceptions to the general rule. Of course the Vulgar date, which is the essential thing, is the same for any numbers differing by a multiple of 260.

At the left of the table of multiples of the period is a column which may be called the "Epoch" column and which will be considered later. (See page 25.)

As has been said, the Eclipse calendar, taken by itself, offered no prospect of determining the true value of the Ahau equation and the next subject of study was pages 24 and 46–50 of the Dresden Codex. Page 24 seems to bear somewhat the same relation to the Venus ephemeris that pages 51a and 52a bear to the Lunar ephemeris. It contains a table of multiples of 2920 and, under the three columns of hieroglyphs at the left, are two large numbers which are of the order of magnitude of the dates found on the monuments and one of these numbers may be supposed to be the date of the beginning of the ephemeris for the same reason that has been given for assuming that the lunar ephemeris begins on M. D. 1,412,848. The ephemeris itself begins with the date 1 Ahau 18 Kayab and gives the Vulgar dates of a long series of configurations of the planet with respect to the sun, starting with a "heliacal rising" four days after inferior conjunction and giving as the first following date, 2 Cib, which is 236 days later than 1 Ahau. On this day after its long excursion to westward of the sun, Venus has returned and is just about to be lost in the sun's rays. The second date, 2 Cimi, 90 days later, fixes the time when the planet, having passed through superior conjunction, emerges to the east and begins to be seen as evening star. It continues its motion through a long excursion to the east and returns to the sun

Series on the monuments. 5-1-0 = 1820 days, equivalent to 5 "ritualistic years" of 364 days each. Five such ritualistic years each made up of 13 months of 28 days are recorded on pages 23 and 24 of the Codex Peresianus. Elsewhere we find years of this kind divided into quarters of 91 days each. — H. J. S.

and is lost in its rays after 250 days, on the date 5 Cib recorded in the ephemeris.

The next eight days brings it after four days to inferior conjunction with the sun and after four days more, on the date 13 Kan, to heliacal rising or morning star, the configuration with which the ephemeris began 584 days before.

Five successive periods each reckoned as 584 days are found in the five pages of the calendar, completing an ephemeris giving the configurations for a period of 2920 days. The complete ephemeris records thirteen repetitions of the 2920-day period or 37,960 days in all.

Owing to the eccentricities of the orbits of Venus and the earth, the actual synodical revolutions of Venus are not equal, but follow for many years in the series approximately 580, 587, 583, 583, 587. It seems unlikely that inequalities so great as this were unknown to the Mayan astronomers. But the groups of five revolutions are very nearly equal (amounting to 2920 days).

Page 24 (Pl. 6) contains a series of successive multiples of the period of 2920 days with Vulgar dates affixed, from 1 Ahau (18 Kayab) to the thirteenth, which is again 1 Ahau (18 Kayab) since $13 \times 2920 = 37{,}960$ or exactly two calendar rounds.

Although the days progress in regular order from earlier to later dates it seems likely that this table was meant simply to state that at the beginning and end of a period of 37,960 days Venus is in very nearly the same position with respect to the sun. This number was determined more easily by the addition of days used in counting forward than by the subtractions necessary in counting backward. This table then, as well as the large multiples of 37,960 on the same page all associated with 1 Ahau, may have been used in counting backward as well as forward to find the approximate Mayan day of a given "aspect" of Venus toward the sun and may have served as a table of the "mean motion" of the planet.

The three columns at the left will be explained presently in connection with the description of the Mars calendar. (See page 24.)

The reason for believing that the date of beginning of the Venus calendar is M. D. 1,364,360 is not quite so strong as for assuming the date M. D. 1,412,848 for the beginning of the Lunar Series since the day of the month attached is 18 Zip and not 18 Kayab. The explanation given by Förstemann in his "Commentary" on

this page of the Codex is not convincing on this point and may be compared with that presently to be given. As preliminary to any attempt at connecting the Mayan and Julian calendars, a table of the approximate dates of the inferior conjunctions of Venus with the sun was computed, beginning about 50 B.C. and carried on to the time of the Spanish Conquest.

Before entering upon a critical comparison of the dates of the Venus and Lunar calendars, it seemed well to make a short excursion into other pages of the Dresden Codex to which scant attention had been paid. The most promising field was found on pages 43–45 (Pl. 5a), where there are tables of multiples of 78 and 780 days, the latter number, as had been pointed out by Förstemann, being very nearly the synodic period of Mars.

A table of the configurations of that planet was prepared from the pages of the American ephemeris from 1855 to 1917 and the following mean values were found:

Interval from conjunction to quadrature	283.32 days
Quadrature to first stationary	70.14
First stationary to opposition	36.15
Opposition to second stationary	37.30
Second stationary to quadrature	68.75
Quadrature to conjunction	284.02

Had the dates for a series of seventy-nine years been available, a more accurate set of values could have been obtained, since in that time the earth and the planet return very nearly to the same points of their orbits. The considerable eccentricity and the close proximity of the orbit of Mars cause the length of these intervals to vary greatly in the successive revolutions; the interval from conjunction to quadrature, for instance, may be as small as 240 or as great as 330 days.

Theory indicates that, in the long run, the interval from conjunction to quadrature is the same as from quadrature to conjunction. The interval from quadrature to first stationary is the same as from second stationary to quadrature and from first stationary to opposition the same as from opposition to second stationary and by combining the above data we obtain:

Conjunction to quadrature	283.67
Quadrature to stationary	69.45
Stationary to opposition	36.73

It of course follows that the interval from conjunction to stationary is 353.13 days and that the duration of retrograde motion from stationary before opposition to stationary after opposition is 73.46 days.

I find in my notes the following little table evidently derived from these values.

♂ and ♂	283.67
S and S	69.45
S–S	73.45

Assume ♂ to stationary point	353.12	352		
To S_2 retrograde	73.45	78	76	
S_2 to conjunction	353.12	352		
	779.69	782		
Are the 4 figures, p. 42, Maya retrograde motion?	351			
	78			Conj. at 4 Ahau?
	351			

First stationary to conjunction 352 days.

Morning star 39 days after conjunction January 15, see other book.
+351 (wreathed number in codex).

390 days after conjunction i.e. opposition.

As I now interpret this (having forgotten the circumstances under which the note was made) I believe the first six lines were put down late in 1914 and indicate that the fact that the interval from stationary to stationary point is about 78 days (in the twenty-three synodic revolutions considered, it varies from 60 to 84 days) seemed to favor the supposition that the pages really do refer to Mars. This probably led to a period of intensive study of pages 43–45 which resulted in the note of January 15 fixing the time when the "wreathed number" first appeared upon the scene.

On these pages the arrangement shows a certain likeness to that of the tables of Venus and of the moon; there is a series of four Vulgar dates with their appropriate intervals, covering 78 days in all, accompanied by four pictures and groups of hieroglyphs, and preceded by a table of multiples of the period of 78 days which is associated with the pictures. This table lies to the left of the ephemeris (if it is an ephemeris) and clearly gives the day 3

Lamat as the date on which it begins, in exact correspondence with the Venus and moon tables. At the extreme left of the table of multiples on page 43 is a column which contains the only number that could possibly be supposed to be a date. This number is 9.19.8.15.0 (1,435,980) and, if it is an Initial Series date, must be 12 Lamat, and not 3 Lamat, the day on which the ephemeris begins. This date 3 Lamat, however, appears above the number 9.19.8.15.0 while below is a Ring Number 17.12 (352) and below that the familiar 4 Ahau 8 Cumhu.

It is not likely that the day 3 Lamat is in error since the Vulgar date is very seldom wrongly given and it is therefore hardly possible that the 9.19.8.15.0 to which it is attached is an Initial Series date.

The impression grew with further study and closer comparison with the Venus and Moon pages that here was an ephemeris and table of mean motions of Mars; and, as an ephemeris is essentially a matter of dates, a good deal of attention was given to the one column containing the only number that looks like a date.

Another important feature of the left-hand column is the Ring Number 352 which is very nearly the average number of days between conjunction and stationary point for Mars. After making many combinations and jugglings with the different elements of the column, it seemed to be of some importance that 1,435,980 equals 1841 $\times$ 780, which is an integral number of synodic revolutions of Mars, and also that the day which follows 3 Lamat by 352 days is 4 Ahau. These two facts suggested the hypothesis that the maker of the ephemeris, having selected the Vulgar date at which he should begin his series of days, then counted back, at first by small groups of 780 and then by larger multiples probably obtained by successive additions till he arrived very near the date of the Mayan Era, 4 Ahau 8 Cumhu, in this case 1840 periods, and then added one more which carried him back to a day 3 Lamat 1,435,980 days before the 3 Lamat that began his ephemeris. This process was first thought of as "proving it back to Ahau" or "fixing the Epoch," the Epoch being the first 3 Lamat before 4 Ahau at which Mars was supposed to have the same "aspect" as at the beginning of the ephemeris.

The Ring Number apparently played here the rôle of a negative date, the particular day 3 Lamat recorded in the column and which

was the "Epoch" from which the mean motion of the planet was reckoned, being noted by the Ring Number as "352 days before 4 Ahau."

In accordance with this view the first column may be freely translated as follows:

1. "3 Lamat *is the day of*
2. Mars.
3. 1,435,980 *is the Complete Period to the beginning of the ephemeris from*
4. 3 Lamat *which is the Epoch and which is*
5. 352 days before
6. 4 Ahau *which is our Era*"

This column will henceforth be called the "Epoch" column.

Between the Epoch column on page 43 and the ephemeris on pages 44, 45 of the Dresden Codex we have the table of mean motions of Mars by means of which the complete record of 1,435,980 days may be reckoned and which brings us up to the date 3 Lamat at which the ephemeris begins. Since the Epoch is 352 days before Ahau, and the Complete Period is 1,435,980 days, the initial date of the ephemeris is 1,435,980 minus 352, or M. D. 1,435,628, 3 Lamat.

Then follows the ephemeris, with four pictures corresponding to the Vulgar dates 9 Manik, 2 Cimi, 8 Chicchan, 3 Cimi, which follow the initial 3 Lamat by 19, 38, 57, 78 days, respectively. The symbols of the days are not given but the red numbers 9, 2, 8, 3 leave no doubt as to the intended Vulgar dates.

The first guess was that on that date Mars might be at a stationary point, followed in about 38 days by opposition and 40 days later by another stationary point at the end of the ephemeris, the whole period being 78 days. The inequality of the intervals causes no surprise since the two long periods of the Venus calendar are 236 and 250 days where we should expect each to be equal to 243 days. Attention may be called to the simplicity and completeness of this explanation of these three sections of pages 43–45 in which there are very few clerical errors and in which every number, hieroglyph and picture is as legible as on the day when it was written (if I may use that expression) and which contains the bare essentials necessary for such a planetary table.

Obviously the next step was to examine other portions of the Codex, in the light of the new explanation of the significance of the "Ring Number."

The almost equally simple table on pages 58–60 of the Dresden (Pl. 5b) has the same general form. Column 1 begins with a Vulgar date, 13 Muluc, and there is room above it for a symbol of Mars now lost by the fraying of the upper margin of the page.

Then follow eleven hieroglyphs, then two "Epochs" as indicated by Ring Numbers. Acting on the principle that, in the case of interwritten black and red numbers, the black is usually to be taken first, these Epochs are respectively the dates 1.7.15 and 12.11 before Ahau, both days being 13 Muluc, and the difference between them exactly 260 days.

In the second column are two Complete Periods, namely 9.18.2.2.0 followed by the glyph for Muluc, and 9.12.11.11.0 followed by the date 13 Muluc and the glyph of the month Zip.

Treating these numbers as in the case of pages 43–45 the dates (Complete Periods, minus Epoch) would be 9.18.0.12.9, 13 Muluc, 3 Mol and 9.12.10.16.9, 13 Muluc, 12 Zip, respectively. A table of multiples of 780 follows and page 60 is divided into two distinct portions which may be two ephemerides beginning at the given dates and setting forth the configuration of Mars immediately following. The two dates are 39,520 days apart.

It was noted long afterwards that the headdress of the personage depicted at the left of the picture in the first ephemeris resembles the symbol of Mars which occurs five times on pages 43–45 of this Dresden Codex. A certain vague resemblance of the ungulate beasts in the two ephemerides was recognized from the very first comparison.

Let us now turn back to pages 46–50 (Pl. 6), which, as explained by Förstemann, are unquestionably a very ingenious ephemeris of the configurations of Venus covering a period of 104 years, and which might well serve as a means of determining when the necessary days must be added to the years of 365 days in order to fix the Vulgar date of the solstices and equinoxes.[1] This ephemeris is preceded, on page 24, by a table of mean motions, as in the Mars table, and in the first left-hand column a Ring Number indicates the Epoch is 2200 days before Ahau.

[1] This may account for the fact that there is no *typical* table of the sun in the Codex. Setting the Vulgar date of the equinox forward by two days at each date of Venus morning star, making the interval 2922 days instead of 2920, would have exactly the same effect as the adoption of the Julian calendar which makes the four-year interval 1461 days instead of 1460. (Note that 1460 = one-half 2920.)

In the second column is recorded the Complete Period 9.9.16.0.0 and, below, 1 Ahau 18 Kayab, which is the Epoch, and in column 3 is the Long Count number 9.9.9.16.0, 1 Ahau, 18 Uo. From the Complete Period 9.9.16.0.0 and the Epoch 6.2.0 before Ahau, we compute by the same process as in the case of the Mars calendar 9.9.16.0.0 minus 6.2.0 = 9.9.9.16.0, 1 Ahau, 18 Kayab. Here the month position is not 18 Uo but is the same as that of the Epoch.

The Venus calendar, then, does not deny the conclusions as to the meaning of the Ring Numbers and the Complete Period as inferred from the Mars calendar even if it does not completely confirm them. The only important difference is that the actual date is given as an Initial Series but with an incorrect day of the month.

Pages 51–60 have long been believed to contain a moon series and the passage has been shown by Mr. C. P. Bowditch to give a very accurate value of the Moon's Synodic period and, as explained in the first section of this article, contains an equally accurate series of eclipse dates, while, according to Dr. Guthe,[1] it is a probable indication of a system of months alternately of 30 and 29 days in length with intercalated months of 30 days at certain intervals so that the days of new moon are correctly given to the nearest day throughout the series. An examination of these pages in the light of the hypothesis based on the Mars calendar was next in order.

The Lunar ephemeris seems to indicate a knowledge of moon periods at least as accurate as is shown in the ephemeris of Venus and an equal or perhaps even greater ingenuity in the combination of the different periods.

Pages 51a, 52a, might be expected to conform to what appears in the same position in the Mars calendar and should contain a table of mean motions and an Epoch. I may here anticipate by saying that there are other pages of the Dresden Codex which seem to show the same relation between Ephemeris, table of mean motions, Complete Period, and Epoch, especially for Jupiter and Saturn and perhaps for Mercury.

It has already been stated that the table of mean motions of the moon appears in the successive multiples of 11,960. We do not find the expected Ring Number, which I have called the Epoch,

[1] Peabody Museum, vol. vi, No. 2, 1921, pages 51–60, here referred to, are given in this publication.

in the first column at the left of p. 51a (Fig. 2). There is, however, in that column the usual 4 Ahau 8 Cumhu and at the top of the column, with a nearly erased hieroglyph above it which may have been a general symbol of the planet (moon), appears the expected day 12 Lamat, the same day as that on which the ephemeris begins and a hieroglyph, the meaning of which may be guessed by any reader.[1] May it not be that it takes the place of the usual Ring Number of this column and that it means "The Epoch is eight days *after* 4 Ahau," not eight days before as is usual in this column?

It may be noted that this hieroglyph is associated with the "planet's day," 12 Lamat, just as the Ring Number is in the other planet tables. (See pages 62, 63 and 70, 37a, 43b, and 58 of the Dresden Codex.) As for the number which represents the Complete Period from the Epoch to the beginning of the ephemeris, some reason has already been given for believing that the Initial Series date of the beginning of the ephemeris is correctly given in the right-hand column as 9.16.4.10.8. The Complete Period from a day 12 Lamat eight days after 4 Ahau 8 Cumhu to the date 9.16.4.10.8 would be 9.16.4.10.0 and this might be expected to appear in connection with 12 Lamat and the Epoch symbol (usually a Ring Number) in column 1. The black number actually there is 8.16.4.11.0. I appeal to those familiar with the numerals of the manuscript to determine whether such an error of the scribe is likely or possible. We shall return to this question later. (See page 40.)

If the Complete Period should prove to be 9.16.4.10.0 (1,412,840) and the Epoch should be eight days *after* 4 Ahau, then the ephemeris will begin M. D. 1,412,848, 12 Lamat I Muan. In all other cases the Epoch is *before* Ahau; with one exception there is no Ring Number greater than the 2200 of the Venus calendar. It may be that, rather than use a Ring Number so

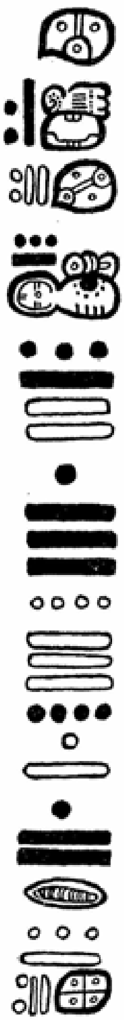


FIGURE 2
Dresden Codex, page 51*a*.

[1] The glyph consists of 8 Kins, that is 8 days, followed by Imix, the first day of the Tonalamatl with a knotted superfix. The Epoch of the Mayan Era is 4 Ahau 8 Cumhu. The next day would be 5 Imix, but the Tonalamatl is considered to begin formally with 1 Imix. — H. J. S.

large as minus 11,952 in this contracted space, it was thought more convenient to use a positive date of Epoch here.

Data for Determining the Ahau Equation

The result of the foregoing discussion was to make it seem fairly probable that, according to the Mayan astronomers, there was an inferior conjunction of Venus with the sun four days preceding M. D. 1,364,360, *i.e.*, M. D. 1,364,356, also a possible eclipse date 48,492 days later, *i.e.*, M. D. 1,412,848 and 22,780 days later some noteworthy configuration of Mars with respect to the sun on M. D. 1,435,628. It was believed that Mars was probably stationary at the latter date.

It would be a comparatively easy matter, if we could be certain that the Mayan dates were correct to a single day, to find on how many occasions a conjunction of Venus at a known Julian date was followed in 48,492 days by a possible Eclipse date as given in Oppolzer's "Canon" of Eclipses and then, for each such case, to compute the position of Mars for the date which followed this eclipse date by 22,780 days. To make sure that no vital omissions were made, it seemed advisable to include all cases where the first interval was exact within three or four days, especially since the dates of the conjunctions and of the "Canon" are given in Greenwich time and the difference in longitude between Greenwich and Yucatan would in many cases change the date by a day. If the Mayan day had been certainly known, no amount of labor would have been too great, but under the circumstances it seemed best to restrict the period covered. Acting on the opinion of experts that M. D. 1,364,356 was not probably earlier than 100 A.D., all Venus conjunctions were included from about the beginning of the Christian Era to 700 A.D. and the value of the interval was taken as 48,492 plus or minus five days, to allow for errors in the approximate computation of the Venus conjunctions and possible inaccuracy of the Mayan astronomical tables.

The first step was to take out the Julian days of the Venus conjunctions, add 48,492 to each, and compare the number thus obtained with the Julian days of the Canon. Those which fell within the required limit of five days before or after an eclipse date were then noted. There were found five cases where a Venus conjunction was followed by an eclipse date in exactly 48,492 days, two

cases where the intervals differed from 48,492 by one day, eight cases where the difference was two days, five where it was four days and four where the difference was somewhat greater than five days. The earliest conjunction fulfilling the conditions was that of June 6, A.D. 12, and the latest that of April 23, A.D. 738.

In all, 54 conjunctions were examined, including 25 for which the interval differed from 48,492 by more than five days.

For each of these conjunctions, the J. D. had been found corresponding to the eclipse syzygy which follows approximately 48,492 days later. Since the J. D.'s of the eclipse dates were presumably less liable to error than those of the conjunctions, the J. D. of the beginning of the Mars calendar was computed by adding 22,780 days to each eclipse date instead of adding 48,492 to the conjunction date, and the corresponding Julian dates were found, from which the place of Mars could be computed for those dates; the accuracy seemed to be such that it would be possible to eliminate the great majority as we need not consider those in which Mars was quite distant from conjunction, opposition, stationary point or quadrature.

The positions of Mars as thus found were carefully scrutinized and, as was anticipated, very few of them were such as to suggest any correspondence with the ephemeris on page 45. Two were within a day or two of opposition but there seemed no reason for a period beginning at opposition and continuing 78 days as recorded by the pictures, though, on account of the Ring Number being 352, it had been hoped and almost expected that Mars would be found in the place it should occupy when stationary about 39 days before opposition.

There were three cases where Mars was within five degrees of quadrature but that seemed not appropriate to the ephemeris pictures and there were four cases in which Mars was 29°, 25°, 13°, and 5° east of the sun, corresponding to periods about 102, 90, 45, and 13 days, respectively, before conjunction with the sun as reckoned from the position in its *geocentric mean orbit*.

The date of the beginning of the Mars calendar for which the elongation 13° E had been computed was March 12, 420 A. D. On computing the actual day of conjunction for this case it appeared that it took place April 20, at about midnight, Yucatan time, or 39 days after the date at which the calendar begins. The

coincidence was sufficiently striking to inspire confidence in the hypothesis that had led to this result.

To summarize the facts:

It was assumed that the Codex indicates that:

1. There was an occurrence of the configuration "Venus morning star" (four days after conjunction)	M. D. 1,364,360
2. There was an eclipse syzygy	M. D. 1,412,848
3. Mars was coming after 38 days to some noteworthy configuration	M. D. 1,435,628

and it was found from the modern tables of the planetary motions that there was conjunction of Venus J. D. 1,803,262.3 and therefore:

1. Venus morning star	J. D. 1,803,266	7 P.M.
2. An eclipse syzygy	J. D. 1,851,754	10 A.M.
3. A conjunction of Mars	J. D. 1,874,573	Midnight.

The hours given are in Yucatan time. For the Mayan calendars we cannot give the fractions of a day, but if to the M. D.'s we add the number 438,906 days, we obtain for the Julian days corresponding to 1, 2, 3, respectively, 1,803,266, 1,851,754, 1,874,534, the latter being 39 days before the conjunction on J. D. 1,874,573.5.

In each case the addition of 438,906 to the Mayan day gives a very close approximation to the correct Julian day and justifies the assumption of that number as the "Ahau Equation," *i.e.*, the constant which must be added to any M. D. to give the equivalent J. D.

It follows that 4 Ahau 8 Cumhu, the zero day of the Mayan Era, must be J. D. 438,906 which corresponds to August 29, 3511 B.C. as reckoned by astronomers. The chronologists who recognize no year zero would give the number of the year as 3512 B.C.

One of the first tests and a very simple one, was to compute the place of the planets at the Era 4 Ahau 8 Cumhu which corresponds to August 29, 3511 B.C.

At that time the sun was in longitude 127° and its Right Ascension 8h. 34m. and declination 18.3° north. Mercury was 22° east of the sun and near greatest elongation; Venus and Jupiter were close together about 4° west of the sun; Saturn was within about 5° of a position exactly opposite to the sun and Mars about 59° west of the sun, very near Regulus.

I do not feel sure how far this is confirmatory of the correctness of the assumed value of the Ahau Equation.

To leave the matter here would not be wholly satisfactory without some further consideration of the rejected solutions, and through the generosity of Mr. Bowditch it was possible to have all those that it seemed desirable to examine more carefully, computed by outside assistance — the results are shown in Table III.

TABLE III. — POSITIONS OF VENUS AND MARS. DIFFERENT HYPOTHESES OF VALUE OF AHAU EQUATION

Ahau Equation	Elongation ♀	Elongation ♂	♂	♂
	°	°	°	°
1. +438,906	5.9 W ♂+4 days	13 E ♂−39 days	134 W	57 E
2. 487,956	11.3 W ♂+6.5	29 E ♂−92	67 W	77 E 4 mos. after ♂
3. 389,856	8.8 W ♂+4	25 W	135 E	27 E
4. 374,087	7.2 W ♂+4.3	24 E	84 W	80 E
5. 394,521	1.6 W ♂+0.8	15 W	180	
6. 421,394	13.6 W ♂+9.5	139 E	7 E	
7. 544,597	10.7 W ♂+7.9	6 W	45 W	
8. 508,392	7.7 W ♂+4.6	9 W	166 E	
9. 361,241	6.5 W ♂+3.5	100 W	27 E	
10. 459,342	5.1 W ♂+2.9	17 E	75 E	
11. 541,673	6.1 W ♂+3.5	55 E	9 W	
12. 410,291	5.0 W ♂+4.7	66 W	63 E	
13. 405,625	12.9 W ♂+7.4	84 W	50 E	
14. 423,127	5.8 W ♂+2.3	60 E	51 W	
15. 426,061	11.7 W ♂+6.8	180	12 E	
16. 441,830	12.7 W ♂+8.3	21 E	34 W	
17. 454,675	13.0 W ♂+7.6	62 W	103 W	
18. 475,111	10.5 W ♂+6.0	109 W	29 E	
19. 528,827	0.3 W ♂+1.8	72 W	57 E	
20. 562,108	0.1 W ♂+0.7	15 E	88 W	
21. 574,954	3.9 W ♂+2.1	89 W	46 E	
22. 577,877	6.5 W ♂+5.5	32 W	107 E	

It seems to be a fair inference that no other dates in the first six centuries of the Christian era are at all likely to show so close an agreement with the intervals of 48,492 days between the date of a heliacal rising of Venus and a possible eclipse date, which is followed after 22,780 days by a noteworthy configuration of Mars,

as those which we have shown to determine the Ahau Equation as 438,906.

Outline of the Typical Maya Planetary Table

From what appears in the foregoing pages it seemed that a reasonable theory had been derived from the relations of the planetary periods alone without any possible bias due to the consideration of glyphs (of which those whose meaning is already *known* can be counted on the fingers) and that it was now fair to consider some conclusions which might be drawn from the hieroglyphs.

The first conclusion is that the hieroglyph of Mars (Fig. 3a) is now known with as much certainty as that of Venus (b) — at any

Figure 3

Celestial symbols: a, Mars; b, Venus; c, Sun and Moon; d, Sun and darkness

rate the hieroglyph of Mars at conjunction with the sun. Again the symbol Kin Men [1] (c) has been connected with eclipses. We have here the symbol Kin Akbal [2] (d) associated with the conjunction of a planet with the sun. We have the pendent figure or inverted figure associated with the conjunction of a planet with the sun. There are other inverted figures in the Codex and conventional inverted figures that are almost glyphs. Have they to do with conjunctions?

One of the early computations in accordance with the new theory was made for the date, corresponding to the picture on page 58 at the end of the Eclipse calendar, which begins at M. D. 1,412,848 and ends 11,960 days later at M. D. 1,424,808, *i.e.*, J. D. 1,863,714.

I have noted before that it is difficult to believe that this picture represents an eclipse that the Mayas would expect to see. Moreover, it represents an inverted figure and has the Venus sign for a

[1] This symbol which Professor Willson calls Kin Men might better be called Kin U, since it is effectively a conventional sun joined with a conventional moon. This same conventional moon appears as the sign for 20 for the simple reason that the month was reduced from 30 to 20 days, with its old name (month and moon) continued. — H. J. S.

[2] Kin Akbal = Sun Darkness, a proper enough ideograph of conjunction when the planet disappears in the blaze of the sun's light.

head (it is strange that Förstemann in his commentary should have mistaken its hands for feet). Now on the given date, 1.13.4.0 days from the beginning (or perhaps 1.13.3.18, as recorded in the upper line), Venus had passed on, twenty days beyond superior conjunction. Does a pendent figure always mean *superior* conjunction? Does the inverted baby attached to the half Venus sign above, mean "Venus now at Superior Conjunction"? These questions it is now fair to ask. And it is fair to go searching over the Codex for more of the same sort.

What of the picture on p. 68 of the Dresden Codex, showing the pendent Mars beast, and the appropriate Mars glyph above? Was Mars then somewhere about conjunction? This we cannot answer yet; not till we know the Mayan day. Now, too, we may look at page 2 of the Tro-Cortesianus Codex where we have the same motif as in the ephemeris of the Mars calendar in the Dresden Codex.[1] Here we begin to associate Mars at conjunction with the stone hatchet, which appears also on pages 44 and 45 of the Dresden Codex. We find also the hieroglyph of Mars on pages 71 and 72 with a stone hatchet; does that mean conjunction? What a prospect of getting at the real meaning of some of these riddles opens itself to us!

But let us get back to work. There are in the Codex other number series that look as if they might be tables of mean motions, followed by sections that suggest the possibility of their being ephemerides and preceded by columns containing 4 Ahau 8 Cumhu, Ring Numbers, large numbers that may well be Complete Periods, and Glyphs that may be the signs of planets.

Notably we have, beginning on page 62a (Pl. 7), a series which had suggested an association with the planet Jupiter. There is a Ring Number 7.2.14.19 (much the largest found anywhere in the Codex) which is approximately 129 $\times$ 398.58 and another number, 136,884, interpolated in the table of mean motions, which is 343 $\times$ 399.08, and the two highest numbers in that table are 91 $\times$ 400 and 364 $\times$ 400 which suggested a period of some multiple of 400 and a correction of that approximate number, in some way not immediately obvious, to the correct value of the synodic period of Jupiter, 398.867 days.

[1] The fourth interval is 19 days instead of 21 but the day numbers which are the same as in the Dresden Codex show that this is a clerical error.

These indications were not of much value but they determined the next step.

The initial columns of the suspected Jupiter table, of which there are four, followed by a single column containing interwritten black and red numbers as in the moon calendar, pages 51a–52a, have some of the characteristics of those already considered. If they do relate to Jupiter and are to be read in the same way as the Epoch columns of the Mars and Venus calendars, the first and second columns, at the bottom of which appear the symbols of the Era, 4 Ahau 8 Cumhu, state that after "Complete Periods" of 8.16.15.16.1 and 8.16.14.15.4 from the respective Epochs 1.4.16 and 6.1, 456 and 121 days before 4 Ahau, some noteworthy configuration of Jupiter occurred or was due to occur. Taking out the Mayan days (Complete Period minus Epoch), and adding to each the Ahau Equation, we find the Julian days and, thence, the Julian calendar dates, which prove to be June 24, B.C. 27 for the first column and May 13, B.C. 27 for the second column, both dates according to astronomical reckoning. This is the only case in the Codex where two dates differing by so short an interval as 42 days are fixed by the initial columns of a planetary table.

Upon computing the places of Jupiter for these dates, it appears that on June 24 it was 16.6° west of the sun, just emerging from his rays and appearing as morning star 23 days after a conjunction which took place on June 1; and on May 13, it was 13° east of the sun and just about to be lost in his rays 19 days before conjunction. This result strengthens the belief that we have the right value of the Ahau Equation.

There is still, however, much to do. There are still left two planets, Saturn, which we may suspect to be considered on Dresden Codex, pages 70–73 (Pl. 9), following immediately after the Jupiter calendar, and Mercury which there is some reason to suppose appears in connection with the thirteen Ring Numbers on pages 71a–73a.[1] In all these cases there appear Ring Numbers in connection with planets and we find Ring Numbers nowhere else; for those on page 31a obviously belong to Jupiter as also in all probability does the Epoch 1.10, on page 45a.

That is, all the planets appear with Ring Numbers and all Ring Numbers appear only with planetary tables.

[1] See page 24.

Having now a good deal of confidence in our value of the Ahau equation, we may conveniently put in the form of a table the results of applying the theory to all the planetary tables except that of Mercury which is apparently treated in a different manner from the others as would seem natural on consideration of its very rapid motion and the great eccentricity of its orbit.

In the intensive study of these number series in the Dresden Codex which seem to deal with the motions of the heavenly bodies, a fairly clear picture develops in the mind, of the mode of growth of astronomical science among the Mayan priesthood. I suppose it must have been the special province of the hierarchy which ruled an intelligent but superstitious race by its ability to predict the position of the heavenly bodies and to advise upon weighty public matters or the private concerns of persons of consequence, in the light of their knowledge of the favorable conjunctions or the unfavorable oppositions, the "aspects of the planets" which would influence mundane affairs in the near or remote future. Such knowledge comes only when a system has been devised by which large numbers can be recorded in a small space and in such a form that they can be easily compared and added.

With such a system at hand,—and these people had it in a perfection only realized in civilized Europe after the introduction of the Arabic numerals in the seventh century of the Christian era,[1]—the Mayas could count the days elapsed between recurrences of the same configurations of the sun and moon and planets and, after a sufficient lapse of time, must have observed the general equality of the periods and, by systematic and long-continued observation, have been able to take into account many of these deviations which are called "inequalities," so that, with the original books from which such manuscripts as the Dresden Codex were presumably copied, a fairly accurate prediction of the state of the heavens could be made for any given day many years in the future.

This manuscript was apparently the *Vade Mecum* of some accomplished astronomer-priest who, when consulted as to the probable success of a projected raid, or important undertaking for

[1] It is now believed that Arabic numerals, which are pretty clearly of Hindu origin, may have had a 7th century origin in India. But there is no good evidence that the Arabs received them before 1000 A.D. Modern European nations may have first come into contact with Arabic numerals about 1200 A.D., but these numerals did not come into general use until after 1400 A.D. — H. J. S.

honor or profit, turned over the pages that we have had under survey, noted down the positions of the planets at the critical period indicated by his client, and then, with a deft hand, reversed the folded screen and opened up those pages which form a large portion of the book and apparently contain information as to the effects of the planets upon the fortunate or disastrous issue of all

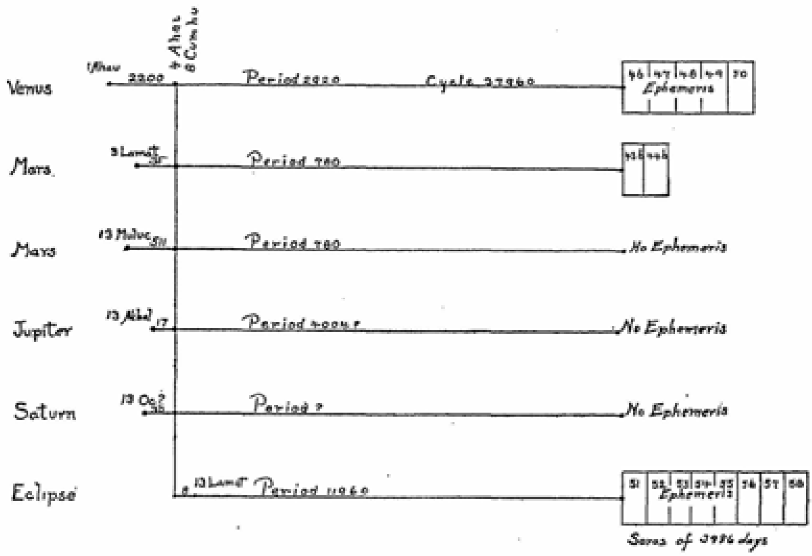


Figure 4

General Scheme of Planetary Tables and Almanacs in Dresden Codex.

sorts of actions connected with all conceivable human experience in any environment.

The general form of the Maya planetary table (Fig. 4) as inferred from those that have been described, is somewhat as follows:

At the right hand is an ephemeris whose form is appropriate to the particular body considered and which consists of a number of pages with hieroglyphs, intervals in days, and Vulgar dates — usually also pictures, the function of which can even now, in a few cases, be inferred with some degree of certainty.

At the extreme left is normally found an initial column, or column containing the glyphs 4 Ahau 8 Cumhu at the bottom, then, reading up, a Ring Number which is the Epoch placed a certain number of days before 4 Ahau, then the Vulgar date of the Epoch, then the

TABLE IV. — INITIAL DATES OF CALENDARS IN THE DRESDEN CODEX

The Text					Corrected
Page in Codex Dr.	Planet	Complete Period	Vulgar date given in text adjacent to Epoch	(Ring Numbers) Epoch (Before 4 Ahau)	Initial Series, Date of beginning of Ephemeris
24	♀	9. 9.16. 0. 0	1 Ahau 18 Kayab	−6.2.0	9. 9. 9.16. 0
51a	☽	8.16. 4.11. 0[1]	12 Lamat	+8	9.16. 4.10. 8
43b	♂	9.19. 8.15. 0	3 Lamat	−17.12	9.19. 7.15. 8
58	♂	9.18. 2. 2. 0	13 Muluc	blk. −1.7.11	9.18. 0.12. 9
58	..	9.12.11.11. 0	13 Muluc Zip?	red −12.11	9.12.10.16. 9
62	♃	8.16.15.16. 1	3 Chicchan 13 Zip	−1.4.16	8.16.14.11. 5
62	..	8.16.14.15. 4	13 Akbal 15 Pop	−6.1	8.16.14. 9. 3
63	..	8.11. 8. 7. 0	3 Chicchan 13 Kankin	−11.15	8.11. 7.13. 5
63	..	8.16. 3.13. 0	13 Akbal 6 Cumhu	−17	8.16. 3.12. 3
63	blk.	10. 8. 3.16. 4	3 Chicchan	−7.2.14.19	10. 1. 1. 2. 5[4]
63	red	10.13.13. 3. 2	13 Akbal	−7.2.14.19	10. 6.10. 6. 3
45a	♃	8.17.11. 3. 0	13 Oc	−1.10	8.17.11. 1.10
70	♄	9.13.12.10. 0	9 Ix	−1.12.6	9.13.10.15.14
70	..	9.19.11.13. 0	9 Ix	−4.10.6	9.19. 7. 2.14
70	..	8. 6.16.12. 0	9 Ix	−4.6	8. 6.16. 7.14
70	..	8. 6.19.10. 0	9 Ix[2]	−10.8	8.16.19. 0.12[5]
70	..	10.17.13.12.12	9 Ix[2] 13 Zip	none	10.17.13.12.12
70	..	10.11. 3.18.[3] 14	9 Ix 13 Yaxkin	none	10.11. 4. 0.14

[1] We should expect to find 9.16.4.10.0.

[2] This is the only error in the Vulgar dates. The Epoch 208 days before Ahau *must* be 4 Eb, 10.17.13.12.12 must be 4 Eb. The scribe has written a red 4 above the Ix, but has not made the full correction.

[3] Sic.

[4] 20 days have been added to make it 3 Chicchan instead of 9 Chicchan.

[5] 20 days have been added to make it 4 Eb instead of 10 Eb.

TABLE IV. — INITIAL DATES OF CALENDARS IN THE DRESDEN CODEX

Data of Calendar		Planetary Places Computed			Remarks
Beginning of Mayan day	Vulgar date of beginning of Ephemeris	Julian day assuming Ahau equation 438,906	Corresponding Julian date	Elongation of Planet	
1,364,360	1 Ahau 18 Kayab	1,803,266	Jan. 27, 225	5.9° S	4 days after inf. ☌
1,412,848	12 Lamat 1 Muan	1,851,754	Oct. 29, 357	0	New moon at node
1,435,628	3 Lamat 3 Tzec	1,874,534	Mar. 12, 420	13° E	39 days before ☌
1,425,849	13 Muluc 3 Mol	1,864,755	June 3, 393	134° W	Nearly stationary 52 days before opposition
1,386,329	13 Muluc 12 Zip	1,825,235	Mar. 22, 285	57° E	338 days after ☌
1,272,465	3 Chicchan 18 Zip	1,711,371	June 24, –27[a]	16.6° W	23 days after ☌ June 1
1,272,423	13 Akbal 16 Pop	1,711,329	May 13, –27	13.0° E	19 days before ☌ June 1
1,233,985	3 Chicchan 8 Pop	1,672,891	Feb. 16, –132	137° E	37 days after ☍ Jan. 10
1,268,523	13 Akbal 11 Yaxkin	1,707,429	Sept. 8, –38	53° W	70 days after ☌ June 30
1,447,605	3 Chicchan 3 Uayeb	1,886,511	Dec. 26, 452	48° W	63 days after ☌ Oct. 24
1,486,923	13 Akbal 1 Kankin	1,925,829	Aug. 19, 560	89° E	Quadrature (nearly)
1,278,390	13 Oc 3 Mol	1,717,296	Sept. 13, –11	23° E	29 days before ☌
1,393,514	9 Ix 12 Kankin	1,832,420	Nov. 22, 304	41.6° W	46 days after ☌
1,435,374	9 Ix 7 Yax	1,874,280	July 2, 419	55.4° E	60 days before ☌
1,201,114	9 Ix 12 Mol	1,640,020	Feb. 17, –222	94.3° W	Quadrature (nearly)
1,274,052	4 Eb 5 Yax	1,712,958	Oct. 28, –23	55.5° W	60 days after ☌ } approximately
1,567,332	4 Eb 5 Pop	2,006,238	Oct. 12, 780	45.8° E	50 days before ☌ } approximately
1,520,654	9 Ix 7 Zip	1,959,560	Dec. 25, 652	137.1° W	

[a] Dates B.C. are given in Astr. Calendar as negative; chronologists who do not use the year zero, use B.C. 28, –133, –39, –12, –223, –24, etc.

Complete Period, a large number which is the count of Bactuns, Katuns, Tuns, Uinals and Kins from the Epoch to the date of beginning of the ephemeris, which has the same Vulgar date as the Epoch — this of course implies that the Complete Period is always a multiple of 260 days.

Between the initial column and the ephemeris is found a table of which it is enough to say here that it always contains a series of multiples of the fundamental period of the ephemeris leading back by equal steps from the zero of the ephemeris till the same Vulgar date is reached,[1] and carried up to intervals of many hundred tonalamatls. Of course the interval is then an integral number of tonalamatls and there is some reason to think that the highest multiples recorded were computed as the number of tonalamatls after which the same configuration occurred as at the Epoch.

Table IV (pp. 38, 39) shows at a glance the facts on which we have based the hypothesis that the value of the Ahau Equation is 438,906 and how the investigation was continued in search of further confirmation:

Column 1 gives the page of the Codex for each of the planets.
Column 2 gives the symbol of the planet, Venus ♀, Moon ☽, Mars ♂, Jupiter ♃, Saturn ♄.
Column 3 gives the "Complete Period" which is always an integral number of Tonalamatls.
Column 4 gives the Vulgar date of the Epoch.
Column 5 gives the Ring Number or number of days by which the Epoch precedes 4 Ahau 8 Cumhu.

These first columns give the exact transcription of the text, except that the Complete Period of the moon, Dresden 51a (Fig. 2), has been assumed to be in error on the ground that some copyist, who meant to repeat the Initial Series 9.16.4.10.8 decreased by eight days and perhaps used the correct date already written in the right-hand column instead of making a straight copy from the original, put one dot too many in the uinals, possibly taking the red eleven instead of the black ten, and one dot too few in the cycles, making the number 8 instead of 9.

This mistake would perhaps be not unlikely if, in copying from an original in which a Ring Number was used, he had endeavored

[1] This is of course the least common multiple of the "Period" and 260. For the Mars Calendar it is 10 + 78 or 780 days, for Venus 15 + 584 or 2920 days.

to save space by using the Epoch 8 days after 4 Ahau instead of 1.13.3.12 (11,952) before Ahau. It will be seen that the normal form, reading up, and following the arrangement of the Mars calendar, would be as indicated: and it is plain to see why, in trying to shift this form to suit a positive epoch, he should find it easier to shorten the column by copying from the date 9.16.4.10.8 already correctly transcribed in the right-hand column. There is evidence of erasure in the red number of this column which suggests that some changes were made in the numbers as originally written down and this, perhaps, supports the suspicion of an error.

As the M. D. 1,412,848, just preceding the ephemeris, and one of the other numbers associated with it are consistent with the attached Vulgar dates on the assumption that they are themselves Initial Series dates, the discussion above has no important bearing on the probability that the moon ephemeris begins at 9.16.4.10.8. 12 Lamat, which was determined upon before any examination of the Epoch column had been considered at all. It was only after the true meaning of Ring Numbers had been investigated that any attempt was made to explain the Epoch column of the moon series.

In column 3 of Table IV, where a black number and a red number occur interwritten, it has been assumed that the black number is to be read with the first Vulgar date and the red with the second; and in column 5, where a black and a red Ring Number are interwritten, it has been assumed that the black Epoch goes with the first Complete Period and the red Epoch with the second.

In the fourth column, 9 Ix twice occurs as a Vulgar date in the Saturn series although there is good reason to believe that 4 Eb should have been written. Indeed, in one case, the scribe had written a red 4 above the day sign although not altering the latter from Ix to Eb; this is the only error in the Vulgar dates in the planetary tables of the Dresden Codex though there are many in the days of the month.

The second section of the table gives in

Column 6. The Initial Series, or Long Count date of the beginning of the Ephemeris corrected for errors in column 3 and 4.

Column 7. Contains the corresponding Maya day.

Column 8. The corresponding Vulgar date and the day of the month.

The third section of the table gives in

Column 9. The Julian day computed as Maya day + 438,906.
Column 10. The corresponding year, month, and day of the Julian date.
Column 11. The elongation of the planet at the given Julian date.
Column 12. Remarks which need no explanation except that ☌ indicates conjunction, ☍ Opposition, □ Quadrature.

The first, second, and third lines in the "Remarks" column summarize the conditions which led to the hypothesis that the Ahau Equation is 438,906.

The sixth and seventh lines give the results of the computation of the two dates for the Jupiter calendar on page 69 which made it seem worth while to undertake the examination of all the available materials on the assumption that the Ahau Equation is 438,906.

The other lines are the result of applying the process to all the pages of the Codex that have the earmarks of planetary tables.

Before going further, the reader should examine the two last columns of the table in order to form an independent judgment as to whether they strengthen the probability of the assumed value of the Ahau Equation.

It may possibly be better to form this judgment by the use of Table V which gives the date of the last two columns of Table IV in such form that they are easily compared with the results of two other assumptions of the Ahau Equation. These were selected as follows: Mr. C. P. Bowditch, in a paper, "Memoranda on the Mayan Calendars, etc." *Am. Anthropologist*, vol. 3, p. 129, 1901, had suggested that the Mayan date 9.0.0.0.0 fell in the year 94 B.C., so that the date of beginning of the Eclipse calendar 9.16.4.10.8 would occur at some date in or near the year 226 A.D.

The preliminary list contained one conjunction followed in 48,494 days by an eclipse syzygy on July 15, 223 A.D. (J. D. 1,802,704), which, compared with the M. D. 1,412,848, gives the Ahau Equation 389,856.

Mr. S. G. Morley had communicated to me his belief that 9.16.4.10.8 is within twenty years and probably within ten years of the year 482 A.D. There was a conjunction in the preliminary list followed in 48,495 days by an eclipse syzygy on February 14, 492 A.D., J. D. 1,900,804 and no other within twenty years of the year 482.

TABLE V. — PLANETARY CONFIGURATIONS AS COMPUTED FROM THE ASSUMED VALUES OF 389,856: 438,906: 487,956 FOR COMPARISON

		I Ahau Equation 389,856	II Ahau Equation 438,906	III Ahau Equation 487,956
		Elongation	Elongation	Elongation
		°	°	°
1.	♀	8.9 W 4 days after ☌	5.9 W 4 days after ☌	11.3 W 6 days after ☌
2.	☽	0 ☌	0 ☌	0 ☌
3.	♂	24.8 W about 3 mos. after ☌	13 E 39 days before ☌	29.2 E 92 days before ☌
4.	♂	134.5 E 34 days after ☍	134 W 52 days before ☍	67.3 W about 5 months before ☍
			(190 days before ☌)	
5.	♂	27.1 E about 3 months after ☌	57 E one-half way ☍ to ☌	77.2 E about 4 months after ☍
6.	♃	35.8 E 48 days after ☌	16.6 W 23 days after ☌	11.9 W 15 days after ☌
7.	♃	3.1 W 4 days after ☌	13.0 E 19 days before ☌	20.9 E 27 days before ☌
8.	♃	113.6 E 50 days after ☍	137 E 37 days after ☍	135.4 E 33 days after ☍
9.	♃	69.5 W about 3 months after ☌	53 W 70 days after ☌	52.2 W 65 days after ☌
10.	♃	49.7 W about 2½ months after ☌	48 W 62 days after ☌	36.7 W 49 days after ☌
11.	♃	77 E about 3 months after ☍	89 E Quadrature East	104.8 E 71 days after ☍
		(about 98 days before ☌)	(about 112 days before ☌)	(128 days before ☌)
12.	♃	18.4 E 24 days before ☌	23 E 29 days before ☌	30.2 E (38 days before ☌)
13.	♄	152.7 W 28 days before ☍	41.6 W 46 days after ☌	37.5 E 44 days before ☌
14.	♄	48.7 W about 2 months after ☌	55.4 E 60 days before ☌	140.2 E 37 days after ☍
15.	♄	160.2 E 18 days after ☍	94.3 W Quadrature W	0.4 E day of ☌
16.	♄	168.2 W 12 days before ☍	55.5 W about 60 days after ☌	21.4 E 24 days before ☌
17.	♄	46.2 W 55 days after ☌	45.8 E about 50 days before ☌	142.2 E 35 days after ☍
18.	♄	107.0 E about 2½ months after ☍	137.1 W about before ☍	122.5 W 63 days after ☌

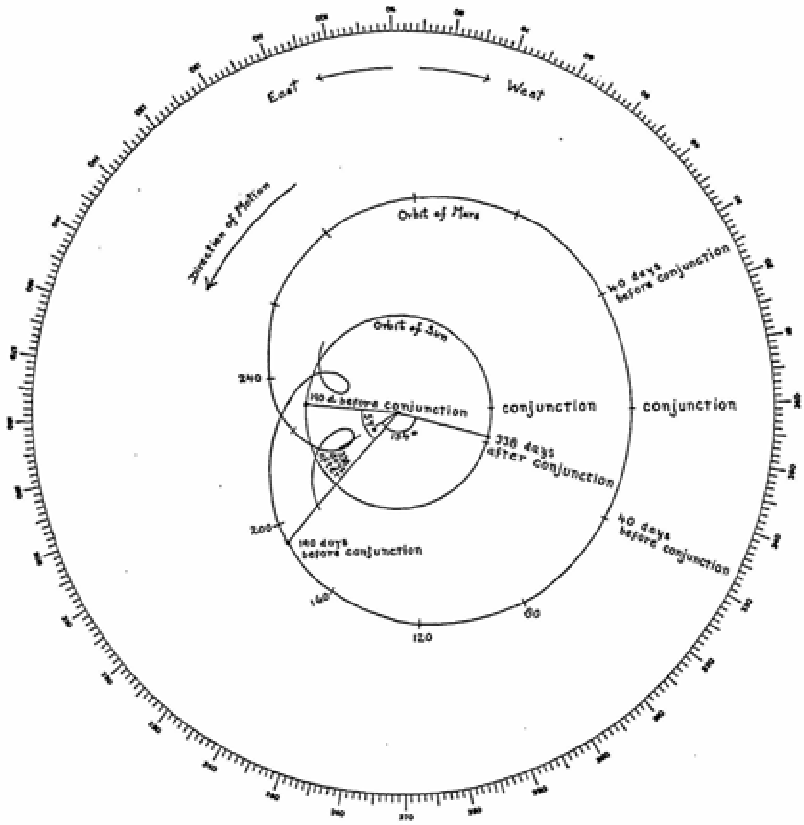


FIGURE 5

Geocentric orbit of Mars (mean planet), showing conditions which obtained June 3, 393 A.D. [13 Muluc]; a, Mars near stationary point 52 days before opposition; b, March 22, 285 A.D. 190 days before conjunction [13 Muluc].

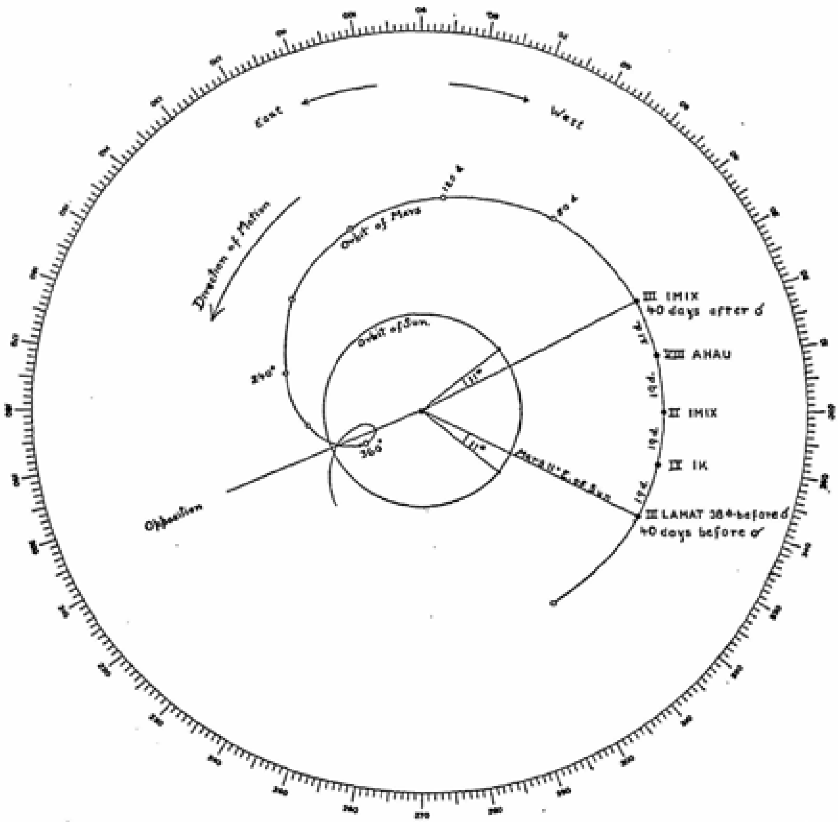


FIGURE 6

Geocentric orbit of Mars (mean planet), showing conditions which correspond to conjunction of April 20, 420 A.D. (Referred to in Dresden Codex, pages 44b, 45b.)

J. D. 1,900,804, M. D. 1,412,848, gives the Ahau Equation *487,956*. Table V gives, in its three sections, the results of each of the assumed values *389,856*, *438,906*, *487,956* for the Ahau Equation, in parallel columns for facility in comparison.

The reader, after examining Table V, might well ask the following question: Do the data in the second section seem to give more evidence of dealing with noteworthy position of the planets than the data in the first or the third section? The writer's answer would be something as follows: Omitting the two first lines dealing with Venus and the moon, which are, of course, in nearly the same relation because this relation is assumed in the original hypothesis, the third line gives an important elongation of Mars at its disappearance, thirty-nine days before conjunction, and consistent with the ephemeris. The first two items of the Jupiter calendar are days when Jupiter is morning star and about to disappear in the sun's rays respectively. The first two items in the Saturn calendar resemble those of the Jupiter calendar in being before and after conjunction by approximately the same interval but this interval is greater than in the case of Jupiter; thus each planet considered has its most important position or configuration as *morning star*. As to the other configurations for Mars,[1] Jupiter, and Saturn, we have elongations approximately 135 degrees east or west of the sun, and elongations approximately 60 degrees east or west of the sun, and for Jupiter and Saturn approximately 45 degrees east or west of the sun and 90 degrees east or west of the sun.

A very curious coincidence is the fact that the date of the second column is exactly 49,050 days after the date of column 1 and 49,050 days before the date of column 3 and it was only after long and anxious consideration that it was decided to be nothing more than coincidence. It is due to the fact that 84 Synodic revolutions of Venus are accomplished in 49,049 days, 123 revolutions of Jupiter require 49,061 days, 130 of Saturn 49,075 days, 63 revolutions of Mars 49,136 days. It seems to the writer, however, that, taking the whole into consideration, there is in the second column much more evidence of the systematic choice of a few noteworthy configurations than in either of the other two.

[1] Figs. 5 and 6 show significant aspects of the planet Mars.

——— Total			△ End	
.... Annular	Eclipse of Sun		○ Middle	● Point at midnight
—·—·— Annular-Total			▲ Beginning	

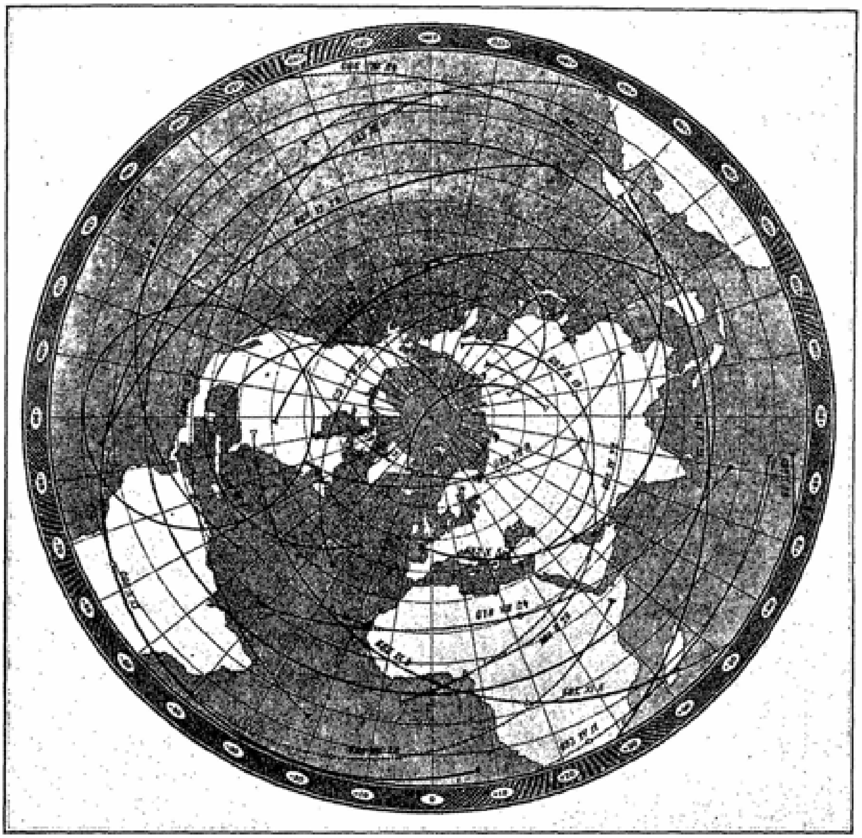


Plate 91 of Oppolzer's "Canon," with circle enclosing solar eclipses visible within the Maya area.

——— Total		△ End		
·········· Annular	ECLIPSE OF SUN	○ Middle	● Point at midnight	
—·—·—·— Annular-Total		▲ Beginning		

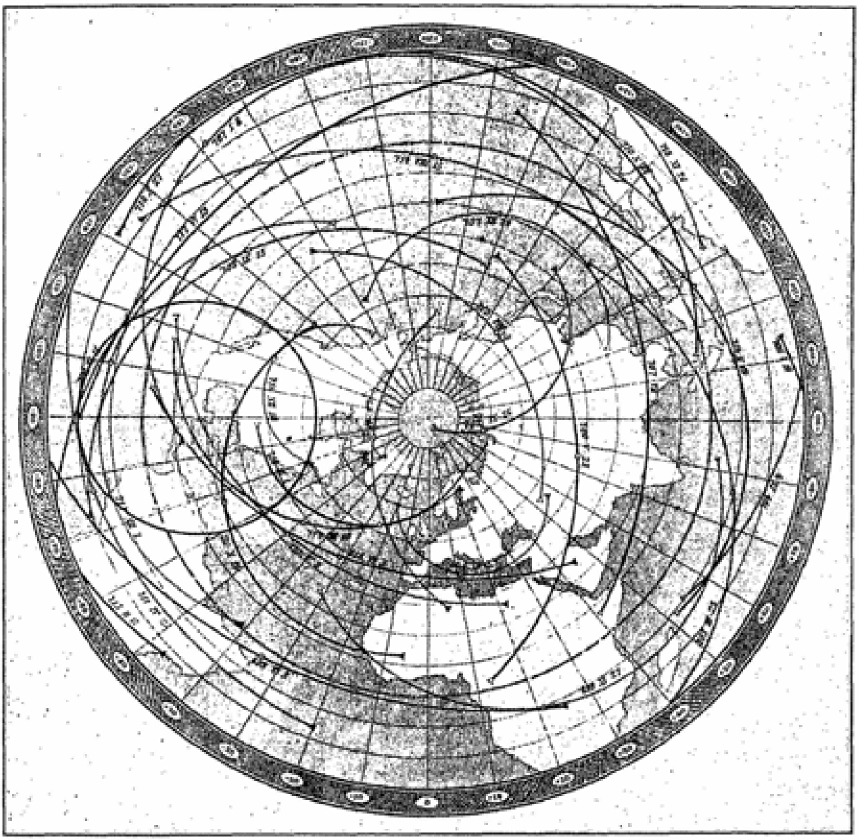
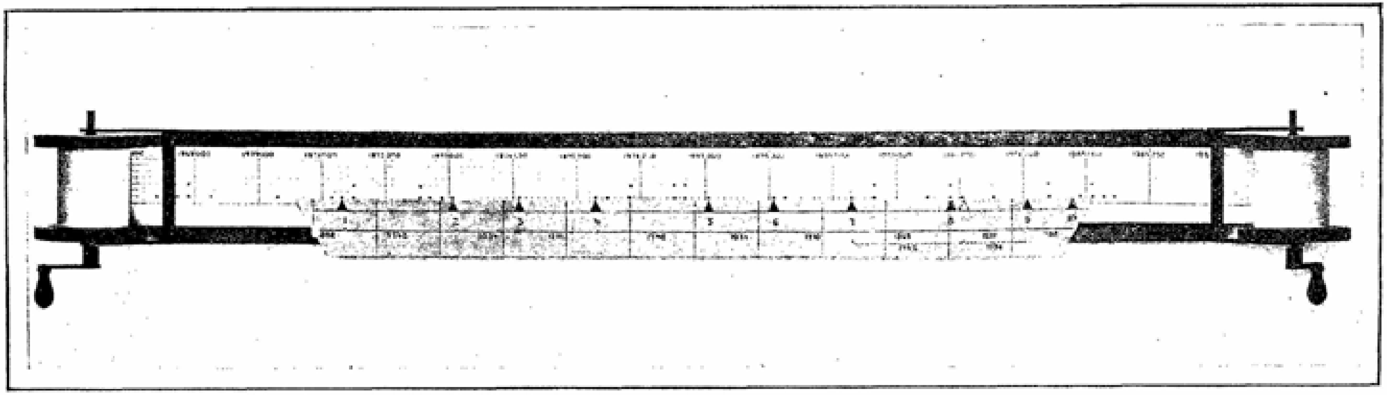
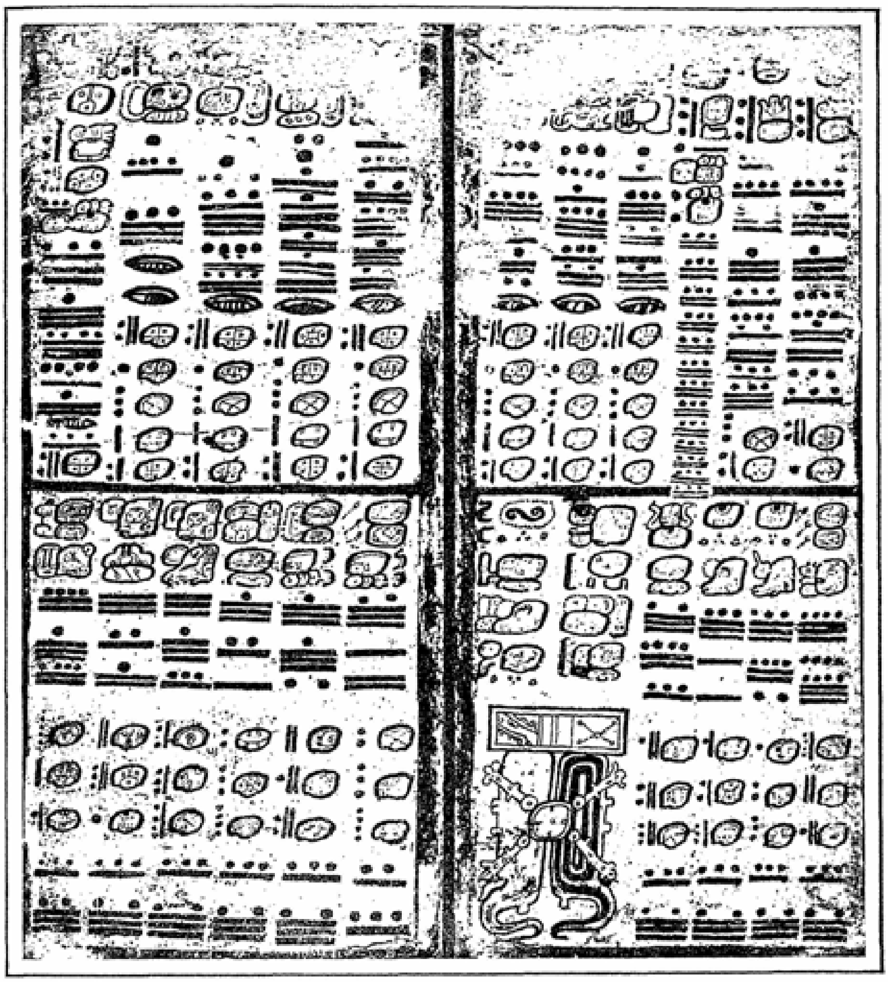


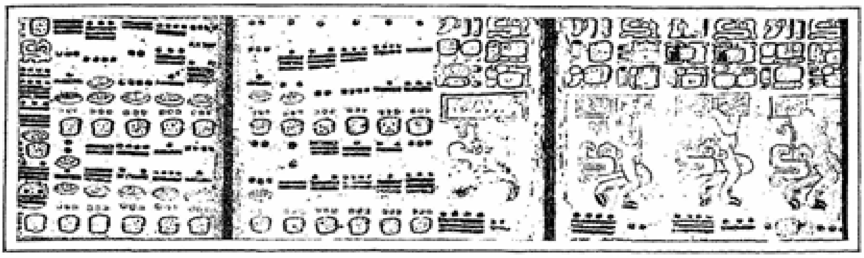
Plate 92 of Oppolzer's "Canon," with circle enclosing solar eclipses visible within the Maya area.



Willson's apparatus for obtaining coincidences between visible eclipses and the Maya record.

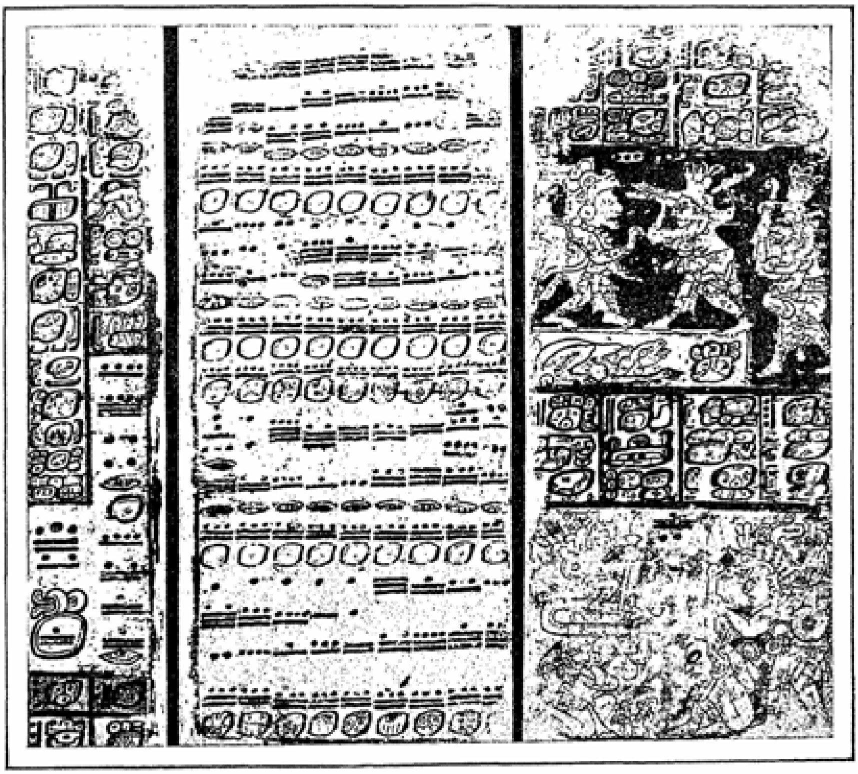


Lunar Table: Dresden Codex, pages 51, 52



43b 44b 45b

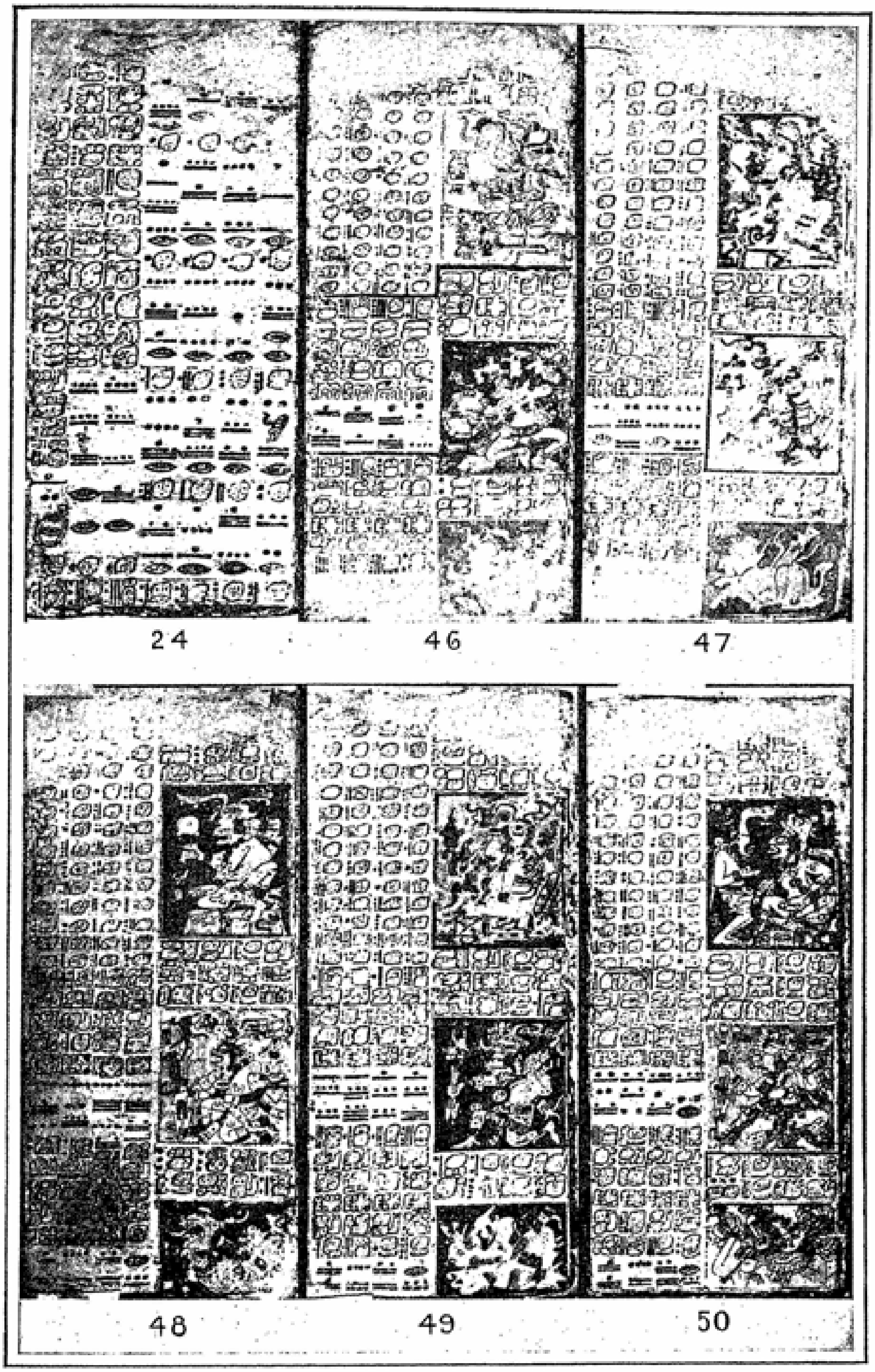
a



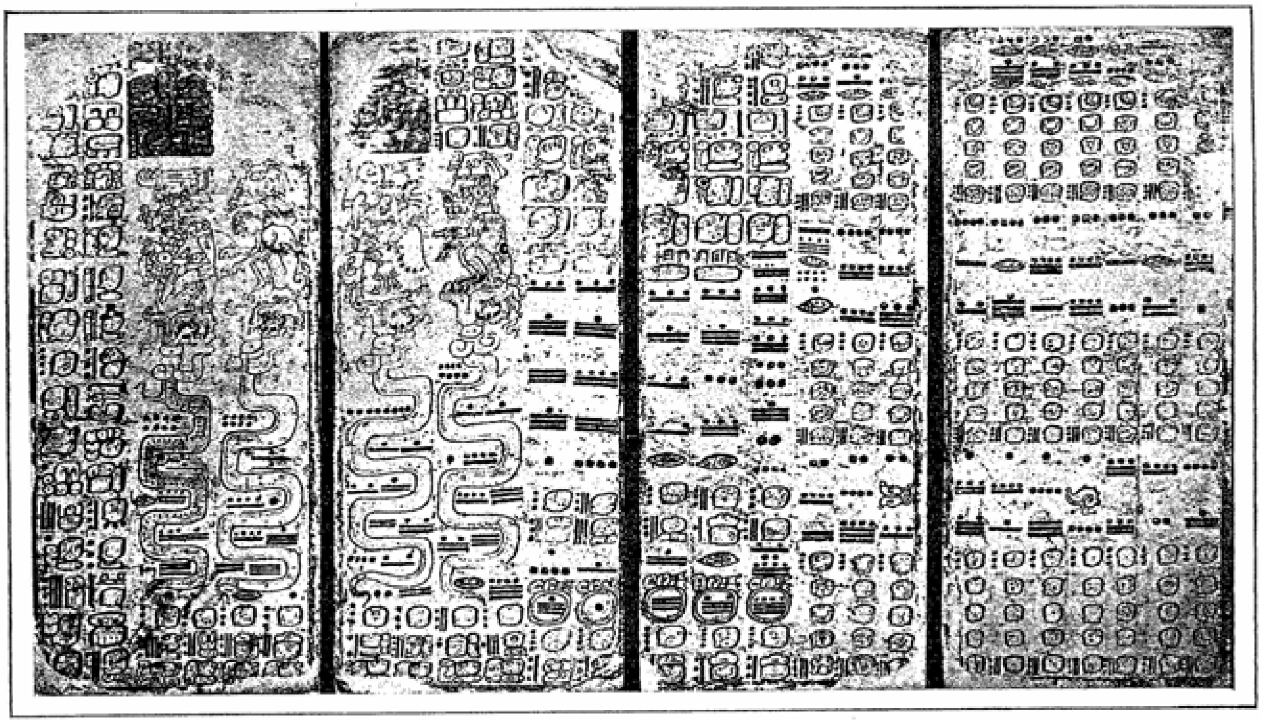
58 59 60

b

(a) Ephemeris of Mars with Pictures of the Mars Beast; Dresden Codex, pages 43*b*–45*b*.
(b) Mars Calendar; Dresden Codex, pages 58–60.

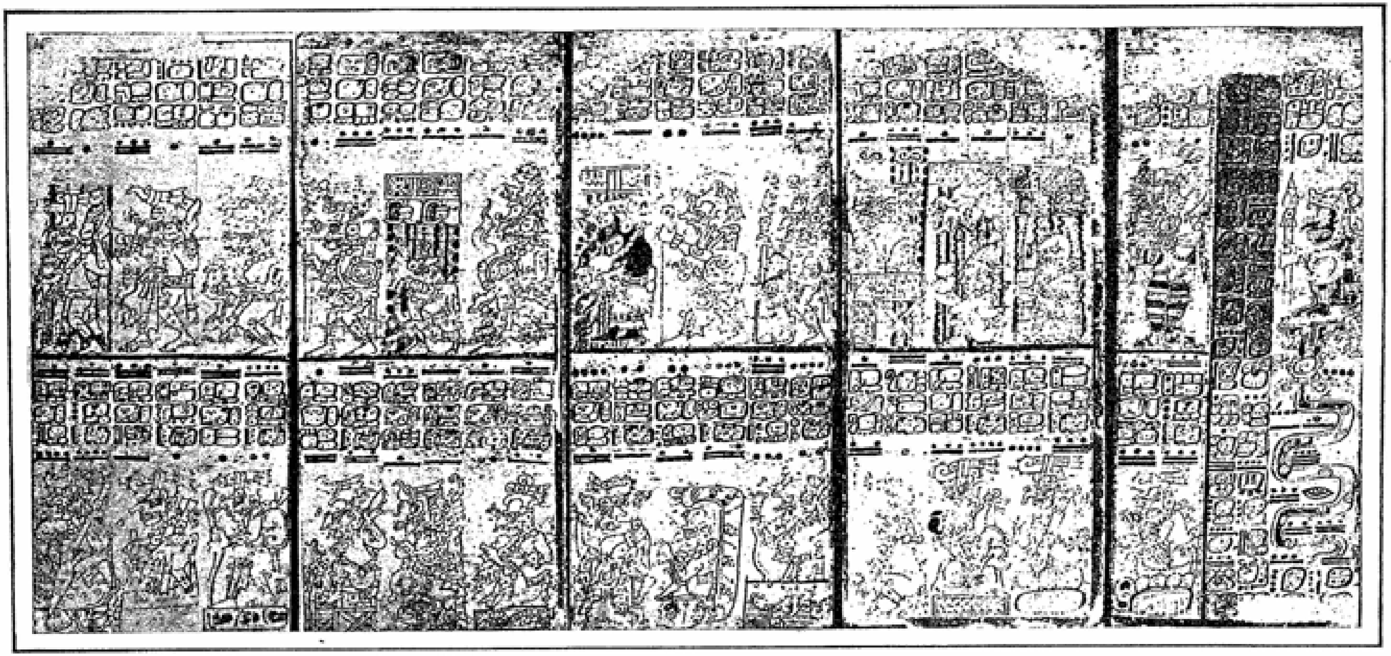


Venus Calendar: Dresden Codex, pages 24 and 46–50. (These pages are continuous in the manuscript.)



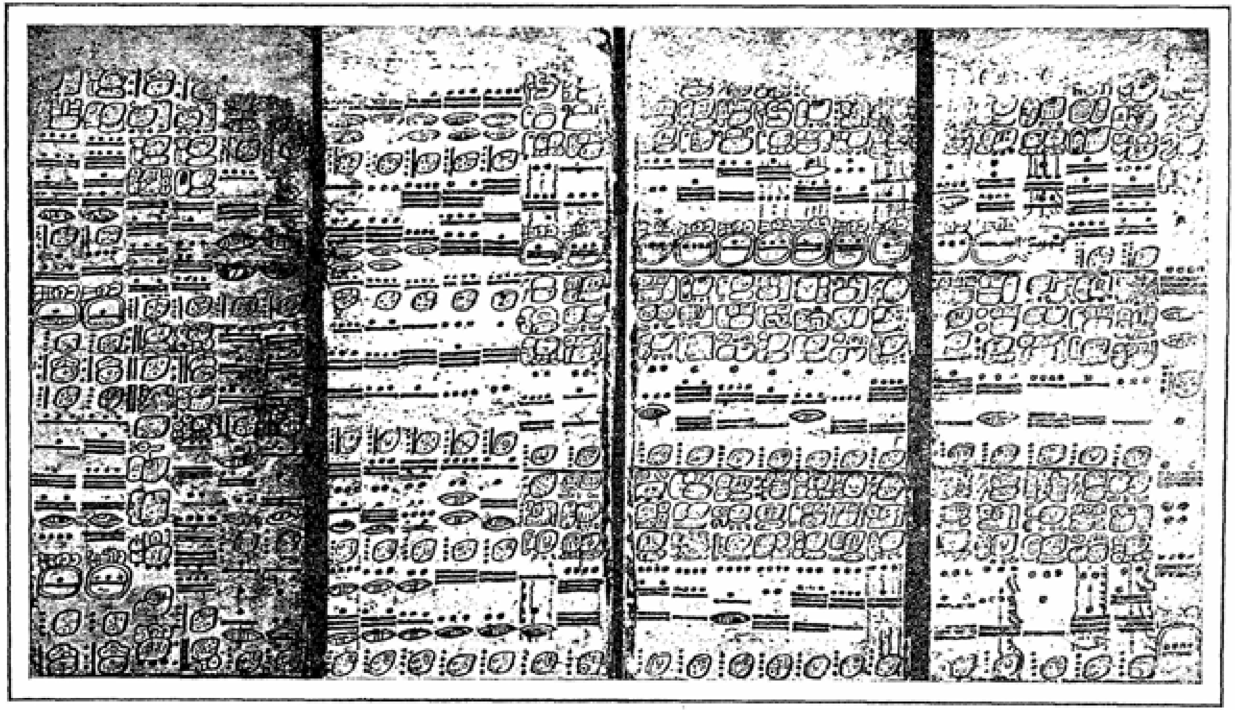
61 62 63 64

Jupiter Calendar: Dresden Codex, pages 61-64. (See Plate 8 for continuation.)



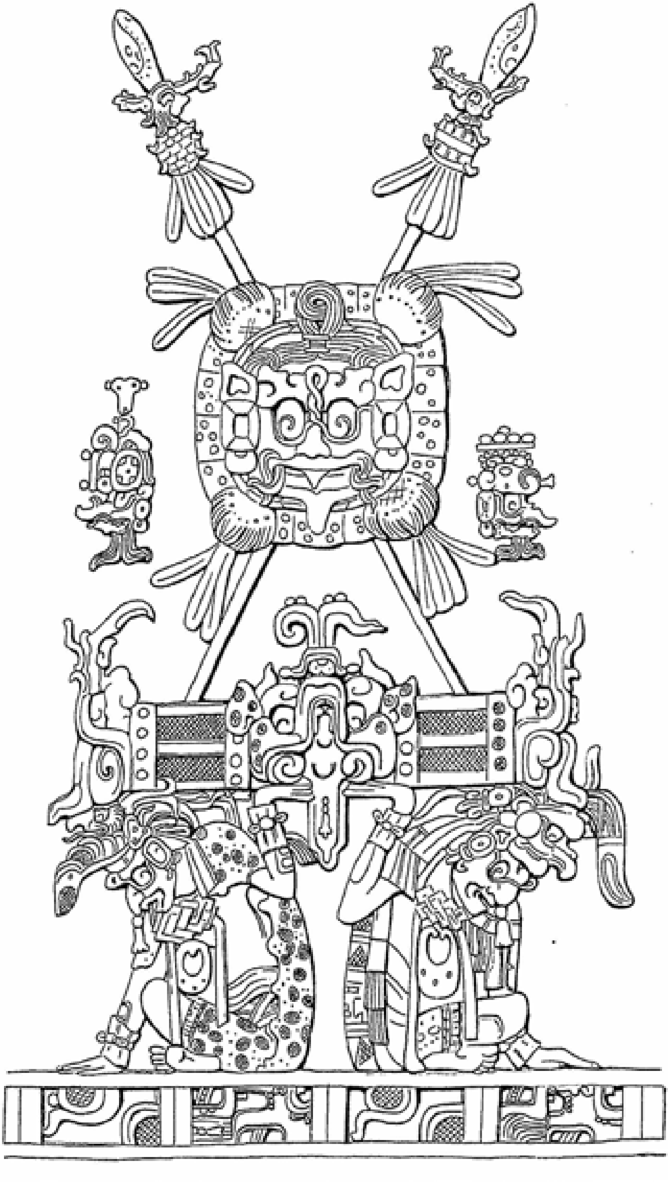
65 66 67 68 69

Jupiter Calendar continued: Dresden Codex, pages 65–69. (See Plate 7.)



70 71 72 73

Saturn Calendar: Dresden Codex, pages 70–73.



DETAIL FROM THE TABLET OF THE SUN, PALENQUE, WITH A SYMBOLICAL DESIGN CONCERNING THE THREE CHRONOLOGICAL ERAS OF THE MAYAS

The face on the shield is the Mundane Era, Oct. 14, 3373 B.C. The hieroglyph at the left is the Historical Era, Aug. 6, 613 B.C., and that at the right is the Era of the Chronicles, Feb. 10, 176 A.D. The altar is supported by the God of the Past.

PAPERS

OF THE

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VOL. VI. — NO. 4

THE REDUCTION OF MAYAN DATES

BY

HERBERT J. SPINDEN

FOUR PLATES AND SIXTY-TWO TEXT ILLUSTRATIONS

CAMBRIDGE, MASSACHUSETTS, U. S. A.
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NOTE

The preparation and publication by the Peabody Museum of the following important paper by Dr. Spinden are the direct results of financial support rendered by a few friends of the Museum who are interested in the advancement of knowledge concerning the remarkable civilization of the ancient Maya people. Preëminent among these friends is Mrs. Charles P. Bowditch, who has continued the generous contributions of her late husband, the distinguished student of Middle American archeology and patron of Maya research. The Museum also makes grateful acknowledgment to Mr. Clarence L. Hay and Mr. John B. Stetson, Jr., for their interest and material aid.

Charles C. Willoughby, *Director*.

Cambridge, Massachusetts
June 23, 1924

PREFACE

THE invention of the Central American calendar in the Seventh century before Christ may be described with all propriety as one of the outstanding intellectual achievements in the history of man. This calendar solved with conspicuous success the great problem of measuring and defining time which confronts all civilized nations. Moreover it required the elaboration of one of the four or five original systems of writing the parts of speech in graphic symbols, and it conjoined with this supplementary invention of hieroglyphs the earliest discovery of the device of figures with place values in the notation of numbers. This time machine of ancient America was distinctly a scientific construction, the product of critical scrutiny of various natural phenomena by a master mind among the Mayas. It permitted a school of astronomer-priests to keep accurate records of celestial occurrences over a range of many centuries, with the ultimate reduction of the accumulated data through logical inferences to patterns of truth.

The measurement of time practically requires an ideal configuration of the universe since time is perceived in the mutual relations of the earth, sun, moon, planets, and stars. But it does not require the theory of Copernicus, let alone an understanding of the higher principles of celestial mechanics. Actually much can be learned about the cosmology of the Mayas in the rich symbolism of their sculptured monuments. The point to note is that, however far this people may have gone in ascribing form and personality to the heavenly bodies,

they did not let mysticism, the eternal foe of science, prevent a logical use of facts observed in careful settings of time and place.

The important thing resulting from the correlation explained in this paper is that we now have a day-for-day chronology for the key civilization of the New World in some respects more accurate than any classical record in the Old World. Especially is the course of art admirably validated. But there is a lack of anecdotal statements, and individuals are submerged in the mass. This restriction on knowledge is not without its compensation. In history that is alive with personalities and events, the effect of glittering detail is often to obscure the generalized evolutions in social structures and esthetic arts and to minimize the importance of economic and mechanical factors which really make civilization possible.

He who seeks his way by night loses the foreland but gains the stars. Even when he cannot recognize the common flowers beneath his feet he sees overhead the marching firmament and the vast perspective of distant suns. The anthropologist groping, if you will, in twilight zones of research is privileged to behold a pageant of human progress stretching far beyond the confines that are called historical. Enormous far-away achievements become visible as points of light and challenge a measurement of their intellectual worth with other human triumphs that are nearby and accepted.

The demonstration of high intellectual productivity and continuity for the American Indian, along lines of striking originality, should overthrow the mystical and romantic theories of Old World origins for New World cultures. These multiple and mutually incompatible theories are based upon the narrow emotional concept of a favored race with creative minds while all the other human races merely have retentive memories. In Central America during a pure stone age — for

not one trace of metal has been found in any of the Mayan cities of the glorious First Empire although a rapid rise in metallurgic art took place subsequently — the Mayas developed arithmetic, astronomy and city planning and swept in advance of anything the Egyptians could do in the sculptural treatment of the human body. They had no beasts of burden and no use of the wheel in mechanics and their economy was based on domesticated plants not known in the Old World before Columbus. Yet the plants and processes which they brought to perfection form the great American heritage and constitute a large proportion of the capital wealth of the world to-day. What standing has the ill-founded Nordic theory, with its nationalistic ramifications, before this new demonstration of brain power in the tropics?

The theory of climatic change in relation to problems of American archeology must now meet the argument that the agricultural arrangements of the Seventh century B.C. are in agreement with the climatic conditions of to-day.

In the preparation of this paper the writer has recognized an opportunity and an obligation — the opportunity of first reconnaissance as of an explorer who bursts into a new land, the obligation of publishing essential details and working tables without great delay so that the new subject matter can be developed under the healthy emulation of international competition, a condition tending always to reduce the personal equation. The first corroborative evidence in ancient inscriptions of the correctness of the correlation herein explained came to light in September 1923. The correlation itself had been published four years before this time, on the merits of the Spanish-Indian record of the Sixteenth century.

Neither space nor time permit a full bibliographic treatment. Several hundred titles have passed under observation, not only in the field of Central American archeology and

history, but in the more general provinces of chronology and primitive astronomy. If a dedication could be made it would be to the pioneers in the Mayan field who made all present efforts possible by laying the broad and sane foundation. Above all others I should name John L. Stephens, Daniel G. Brinton, Charles P. Bowditch, Alfred P. Maudslay, John T. Goodman, Teobert Maler, Desiré Charnay, Eduard Seler, and Ernest Förstemann. Then there is the present generation of Mayan scholars to whom I am immediately indebted in instances too numerous to record.

Herbert J. Spinden.

Boston, Massachusetts
July 12, 1924

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MAYAN DATES

PART I

ESSENTIALS OF THE MAYAN CALENDAR

IT has long been the hope of students of the wonderful civilization of the Mayas that the inscriptions carved upon their temples and monuments which lie scattered through Central American jungles would one day be read with reasonable assurance, at least so far as the outstanding historical and astronomical facts are concerned. In the last few years we have travelled far along the road of success. First, the numerical and calendrical characters in these strange inscriptions were deciphered and proved, partly on hints from early Spanish writers but mostly by reason of the absolutism of mathematics. Next, many numerical statements were shown to be numbers of days counted from a Mayan era far in the past, but usually reaching dates in the present for the builders of the monuments. Thirdly, it was demonstrated in extensive studies that the Mayas had carried the science of astronomy to a high degree of perfection, considering the fact that they made their observations without the use of those instruments of precision which make our own work easy.

The possibility of recovering New World history through the instrumentality of the Central American calendar was perceived by some of the earliest writers on the matters of New Spain, and the complete explanation and coördination of the group of closely related time-counts among the Mayas, Aztecs, Zapotecs, Quichés, etc., may be called the first problem of American archeology. Boturini, Vetia, Humboldt, Bustamente, these are only a few of the names associated with early studies and in later times the subject was approached by a Latin school, mostly made up of French, Spanish, and Mexican scholars, and a German school and an English-American school. The last-mentioned school entered through the door of Mayan archeology whereas the others chose the gateway of the voluminous Aztecan records. Then there has been, without the walls, a romantic school which has sought to derive these remarkable American developments from China and

other parts of the Old World. The writers of this group follow an impressionistic rather than a scientific method.

In the present paper the correlation between the Mayan calendar and our own calendar will be explained, and astronomical evidence from the ancient inscriptions will be presented to prove that the time-counts of the Indians were carried forward logically and without a break from an inauguration of the perfected calendar in 580 B.C., until the autos-da-fé of Bishop Diego de Landa in Yucatan destroyed the collections of Mayan books nearly 2150 years later (1561 A.D.). This same bigoted churchman, while he was waiting to be tried before the Council of the Indies for his cruel and abusive acts, wrote a description of the calendar and ceremonial usages of the Mayas which offsets in a slight measure his holocaust of the instruments of learning and his persecution of native scholars. He provides some necessary facts to be used in connection with other early Spanish records. A structural arrangement of the calendar according to these sixteenth-century sources will be shown to agree with the evidence on early monuments as interpreted and checked up by various archeologists. It will be demonstrated that many ancient calculations deal with the scientific adjustment of a 365-day year to the difficult fraction by which the year of the seasons exceeds this amount, and that others lead exactly to days of astronomical import.

A complete Mayan date is three time-counts in one, but at no point in time do these three counts find a common structural zero. It is a number, a name, and a place in a year. A complete date contains the following statements:

A. The serial number of the day counted from a beginning day far in the past.

B. The position of the day reached by this number in one of the months of an uncorrected 365-day year.

C. The position of this day in a permutation formed of twenty day-names and thirteen numbers each revolving upon the other, so that the same name combined with the same number will return after a cycle of 260 changes.

Mayan dates are written out in a remarkable system of hieroglyphs and numerical notations, peculiar in their fullest developments to the Mayas of the Central American lowlands but found

in a fragmentary and debased form among the Aztecs, Zapotecs, and other tribes of Mexico and Guatemala. No similar system is found anywhere else in the world. Space considerations demand that this exposition be direct, rapid, and without discussion of moot points; but after the calendar of the lowland Mayas has been explained, some attention will be paid to the chronological problem among the tribes on the highlands of Mexico and Guatemala. We will begin with a preliminary examination of the peculiar system of arranging days in a memorable order.

The Essential Permutation

The Mayas designated days by a series of twenty names and a series of thirteen numbers, each revolving like a wheel upon the

FIGURE 1. THE TWENTY DAY-SIGNS
The first example in each case is taken from the inscriptions and the second from the codices.

other, so that the same name was combined with the same number once in 13 times 20 or 260 days. This period is often called by the Aztecan name, tonalamatl, the book of days or of fates, but the Mayan term appears to have been tzolkin, with about the same significance. The tzolkin is generally considered to begin with the day called 1 Imix, but for practical purposes it can begin anywhere, since in this time-machine the next recurrence of the same day always comes exactly 260 positions later. One complete tzolkin and the beginning of another one is shown in the following table. The

numbers are to be read downward in each column in combination with the name at the left, thus: 1 Imix, 2 Ik, 3 Akbal, etc. After 13 Ben, the number is again 1, and the reading is 1 Ix, 2 Men, 3 Cib, etc. The numbers in the horizontal rows belong to days with

TABLE I. — THE TZOLKIN

A Permutation Table Covering the Cycle of 20 Names Counted Continuously with 13 Numbers

	1	2	3	4	5	6	7	8	9	10	11	12	13	1
1. Imix............	*1*	8	2	9	3	10	4	11	5	12	6	13	7	*1*
2. Ik..............	*2*	9	3	10	4	11	5	12	6	13	7	1	8	*2*
3. Akbal...........	*3*	10	4	11	5	12	6	13	7	1	8	2	9	*3*
4. Kan.............	*4*	11	5	12	6	13	7	1	8	2	9	3	10	*4*
5. Chicchan........	*5*	12	6	13	7	1	8	2	9	3	10	4	11	*5*
6. Cimi............	*6*	13	7	1	8	2	9	3	10	4	11	5	12	*6*
7. Manik...........	*7*	1	8	2	9	3	10	4	11	5	12	6	13	*7*
8. Lamat...........	*8*	2	9	3	10	4	11	5	12	6	13	7	1	*8*
9. Muluc...........	*9*	3	10	4	11	5	12	6	13	7	1	8	2	*9*
10. Oc.............	*10*	4	11	5	12	6	13	7	1	8	2	9	3	*10*
11. Chuen..........	*11*	5	12	6	13	7	1	8	2	9	3	10	4	*11*
12. Eb.............	*12*	6	13	7	1	8	2	9	3	10	4	11	5	*12*
13. Ben............	*13*	7	1	8	2	9	3	10	4	11	5	12	6	*13*
14. Ix.............	1	8	2	9	3	10	4	11	5	12	6	13	7	1
15. Men............	2	9	3	10	4	11	5	12	6	13	7	1	8	2
16. Cib............	3	10	4	11	5	12	6	13	7	1	8	2	9	3
17. Caban..........	4	11	5	12	6	13	7	1	8	2	9	3	10	4
18. Eznab..........	5	12	6	13	7	1	8	2	9	3	10	4	11	5
19. Cauac..........	6	13	7	1	8	2	9	3	10	4	11	5	12	6
20. Ahau...........	7	1	8	2	9	3	10	4	11	5	12	6	13	7

the same name which are removed by multiples of 20. Thus, 8 Imix is 20 days after 1 Imix, and 2 Imix is 40 days after 1 Imix.

The hieroglyphs of the twenty named days of the Mayan calendar are reproduced in figure 1, where an example from the ancient inscriptions [1] is followed by an example from the manu-

[1] The ancient inscriptions of Central America can best be studied in the following publications:

Bowditch, C. P., *Enumeration, Calendar System and Astronomical Knowledge of the Mayas.*
Maudslay, A. P., "Biologia Centrali-Americana," *Archeology*, 4 vols., with appendix by J. T. Goodman, *Archaic Maya Inscriptions.*
Morley, S. G., *Inscriptions at Copan; Introduction to the Study of Maya Hieroglyphs.*

The Papers and Memoirs of the Peabody Museum of Harvard University furnish source materials for many cities. The bibliography of this general subject is extensive, and for fuller

scripts.[1] With these day-signs are combined bar-and-dot numerals which run from 1 to 13, to make a graphic record of the 260 combinations of the tzolkin table (for examples see fig. 2). In these numerals a bar is five and a dot one, so that 13 is represented by two bars and three dots. Sometimes a series of faces replace these simple numerals.

A word about permutations in general may not be out of place. These are found the world over as mechanistic devices for deciding fate in terms of time and place. Magicians, gamblers, and calendar-makers join in the casting of lots upon the counting table. Indeed the essential permutation of the Central American calendar finds a close parallel in ordinary playing cards, only the permutation of the

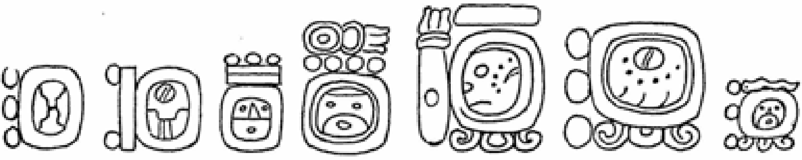


FIGURE 2. DESIGNATIONS IN THE TZOLKIN
Day-signs with numerical coefficients.

calendar runs over five decks, so to speak. But a definite day, stated to occupy a definite position, has a permutation of only fifty-two possibilities depending on thirteen numbers and four names. This is because the number 260 of the tzolkin and the number 365 of the year have a common factor of five which reduces the effective permutation to fifty-two changes in terms of years, or 18980 changes in terms of days. In the cyclic designations of years used by the Chinese, the factors of the permutation are ten and twelve and the effective changes are cut down from 120 to 60 because ten and twelve have two as a common factor. In our own useful cycle of the seven-day week, which is the oldest undisturbed element in our calendar although it goes back only to the second century B.C., we see a permutation of the twenty-four hours of the day with the seven planets in their reputed order in the universe

detail the student is referred to the bibliographies in Morley's *Inscriptions at Copan*, and the present author's *A Study of Maya Art*.

[1] Reference is here made to the three Mayan books which survived the fury of the Inquisition. They are the *Dresden Codex*, the *Peresianus Codex*, and the *Tro-Cortesianus Codex*. All have been published in facsimile. The best commentaries are those of Förstemann although obsolete as regards some matters.

counting inward towards the earth as center. There is no common factor here and seven goes into twenty-four three times with a remainder of three. While the actual order of the planets, as defined above, is Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon, the order set by the permutation for the first hour of each day is Saturn, Sun, Moon, Mars, Mercury, Jupiter, Venus. This order is still preserved in the days of the European week although the beginning has been shifted from Saturn's day — that is, Saturday — to Sunday, and substitutions have been made in some names. Permutations used in magic and gambling may be of things rather than names and numbers: they are found everywhere and constitute the outstanding mechanistic patterns for solving luck.

Mayan Numeration

The Mayas distinguished between ordinary counting and the counting of time units. For ordinary counting their vigesimal scale was as follows:

Mayan Numbers		Arabic Equivalents
	1 hun	1
20 hun	1 kal	20
20 kal	1 bak	400
20 bak	1 pic	8,000
20 pic	1 cabal	160,000
20 cabal	1 kinchil	3,200,000
20 kinchil	1 alau	64,000,000
20 alau	1 hablat	1,280,000,000

The numerical system used in the counting of days was influenced by calendarial considerations. First, the Mayas must have decided upon a formal year with twelve months of thirty days each, or 360 days in all. Then they made a compromise between the construction of their vigesimal system of numbers and the construction of their year. They reduced the calendar month from thirty days to twenty days, so that the number of days in it corresponded to the second degree of their numerical values. Then they took eighteen instead of twenty of these second-degree units of value to make one of the third degree.

Perhaps we can understand this better if we compare our decimal system of numbers with a vigesimal system. In our decimal system

the units of numerical value are ones, tens, hundreds, thousands, etc., and in a straight vigesimal system they are ones, twenties, four hundreds, eight thousands, etc. But after the creation of the numerical calendar and the modification in the straight vigesimal count to correspond with this calendar, the place values which the Mayas used in the counting of days were ones, twenties, three-hundred-and-sixties, seven-thousand-two-hundreds, etc. Both the formal month and the formal year became a round number of days. The Mayas called the twenty-day unit or period by a name which is cognate with moon, thereby indicating that they regarded this twenty-day unit as a reformed month. They also used the picture of the moon to express the value of 20 instead of 29 or 30 days. They called the 360-day unit or period by a word meaning stone, possibly because a stone marker was erected upon its completion in the time count.

They took this word meaning stone as a new base for the construction of names and compounded it with the terms of their straight vigesimal system of numbers which we have already seen. Thus the fourth period or degree of value in the count of days they called katun (kal-tun), literally twenty stone, and the fifth one they called baktun, literally 400 stone. There can be little doubt about the Mayan names for the higher values in their numeration of days although the names themselves have been preserved only in the common count.

Mayan Day Numbers		Arabic Equivalents
	1 kin	1 day
20 kins[1]	1 uinal	20 days
18 uinals	1 tun	360 "
20 tuns	1 katun	7,200 "
20 katuns	1 baktun	144,000 "
20 baktuns	1 pictun	2,880,000 "
20 pictuns	1 cabaltun	57,600,000 "
20 cabaltuns	1 kinchiltun	1,152,000,000 "
20 kinchiltuns	1 alautun	23,040,000,000 "
20 alautuns	1 hablatun	460,800,000,000 "

We will return to the way in which these numbers are written.

[1]English plurals in *s* are commonly used for these Mayan terms.

The Mayan Year

The round of the seasons is an unescapable phenomenon in nature, but the first recognition of the year, as a natural cycle, does not call for a recognition of the number of days in a year or even the number of lunations. Indeed the first coördinations of primitive people, having defective numerical systems, are between the return of a season and the return of the sun to the same point on the horizon at sunrise or sunset (viewed of course from the same spot) or the return of a star or constellation to some obvious relation with the sun. It is an assured fact that heliacal positions of certain stars or constellations, and especially the setting of the star just after the sun or the rising just before the sun, are observed by primitive tribes who have no words for counting higher than ten or twenty.

Among slightly more developed peoples lunations, measured either from new moon to new moon or from full moon to full moon, are used as convenient divisions of the year. But since twelve moons amount to approximately 354 days, there must be an occasional year of thirteen months or the seasons and the moons supposed to coincide with them will become sadly askew. The beginning of the year can, of course, be regulated by reference to the stars or to the sunrise and sunset points. For instance, the first month may begin with the first new moon after the vernal equinox, the first new moon after the heliacal rising of Orion, etc. Regulations of this type usually take place in the middle stage of calendar making.

With the extension of the numerical system, a tendency is disclosed in various parts of the world, to formalize both the month and the year, and the simplest way to do this is to make a 360-day period out of twelve months of thirty days each. Such a year is strictly mathematical: in nature it falls between two stools and reproduces the conditions neither of the moon nor of the sun. Nevertheless there are evidences of its existence in very early times in Egypt and India. Among the Mayas the 360-day year was invented as a unit of numeration, as we have already seen, and the month was reduced to twenty days in a converse proposition, and eighteen instead of twelve of them were required in a conventional year. Later the Mayas became acquainted with the fact that the

year is nearer 365 days than 360 days, if they did not know it already, and they provided an offset of five days, or one-quarter of a reformed month, to make this new adjustment. In this way the vague 365-day year, or haab, came into use and was kept as inviolable as the vague 365-day year of Egypt, but for a different reason. The wonderful calendar in the form that it has come down to us must have been the deliberate invention of some individual who made use of traditional materials. It can hardly have been a

FIGURE 3. THE NINETEEN MONTH-SIGNS OF THE MAYAN YEAR
The first examples are from the monuments and the second ones from the books. The last device is zero.

matter of slow development because its essential structure is arbitrary rather than natural.

We have plenty of proof that the length of the tropical year was very accurately determined by the Mayas and the number of intercalary days nicely calculated over stretches of many centuries. Nevertheless the astronomers of those times realized that any intercalation by the leap-year method to reach the recurrence of the seasons would invalidate their day-count as a common measure of planetary cycles and ecliptic periods as well as of sidereal and tropical years. This is something that some of us find it hard to understand: we, ourselves, have sacrificed every other natural consideration in our calendar to keep the years straight with the seasons. We have no way to mark in common parlance the position of the moon. Although our word month is derived from moon there is no

longer the slightest correlation between the length of the calendarial month and a lunation. The days we interpolate in leap years can be recovered by calculations, but modern astronomers use a day-count comparable to that of the Mayas except that it is expressed in the decimal system. This is the Julian day, not to be confused with the Julian calendar. It was invented by Scaliger in 1582, about the time the Julian calendar was superseded by the Gregorian.

The names of the eighteen months of the Mayan year, and the five extra days, are given below for purposes of convenient reference. The common forms of hieroglyphs for the months (see fig. 3) are recognizably the same in the manuscripts and on the stone monuments.

1. Pop	7. Yaxkin	13. Mac
2. Uo	8. Mol	14. Kankin
3. Zip	9. Chen	15. Muan
4. Zotz	10. Yax	16. Pax
5. Tzec	11. Zac	17. Kayab
6. Xul	12. Ceh	18. Cumhu

19. Uayeb (five additional days)

Since there are twenty named days, and likewise twenty positions in a Mayan month, it follows that every named day occupies the same position for all the months of any year, being advanced five positions for the subsequent year by the intervening five days of the short Uayeb period. The twenty days of the months, then, naturally fall into five sets of four days each, the separate days of each set being able to occupy in turn four positions in the months of four successive years. For instance, in one year, Ik can occupy the zero position in all the months, Manik the fifth, Eb the tenth, and Caban the fifteenth. In the next year, these days will all be offset five positions by the five days of Uayeb which belong in no month. The days are advanced so that Ik falls on the fifth, Manik on the tenth, Eb on the fifteenth, and Caban on zero. In present usage among students of the Mayan calendar, the so-called zero position in the month is regarded as the first position. Whether it really is the first position of the month carrying the appropriate symbol, or the last or twentieth position in the previous month, is a question which will be taken up later; fortunately it is more or less

academic. The highest apparent number which can occur with each month hieroglyph is nineteen (see fig. 4).

The full table of shifts is best shown in tabular form. Strictly this statement only holds true of the ancient usage. In northern Yucatan at the time of the Conquest a general discrepancy of one

FIGURE 4. DESIGNATIONS IN THE HAAB
Month-signs with numerical coefficients indicating positions in the months.

day is apparent and the series of days led by Ik is found in the positions indicated for the series led by Imix, while all the others move up one line.

Days				Possible Positions in the Month			
Ik	Manik	Eb	Caban..........	0	5	10	15
Akbal	Lamat	Ben	Eznab...........	1	6	11	16
Kan	Muluc	Ix	Cauac...........	2	7	12	17
Chicchan	Oc	Men	Ahau...........	3	8	13	18
Imix	Cimi	Chuen	Cib.............	4	9	14	19

Statements such as 9 Ik 15 Ceh, 4 Ahau 8 Cumhu, etc., give the double permutation of the days of the tzolkin counted in combination with the days of the haab or 365-day year. The statement 9 Ik 15 Ceh means that a day Ik combined with the number nine occupies the fifteenth position in the month Ceh. It can occupy this position and three others in this and every other month, besides one position in Uayeb during a long cycle of changes. This larger permutation covers $73 \times 260 = 18{,}980$ days or fifty-two years of 365 days each ($52 \times 365 = 18{,}980$) and is called the calendar round. For this enormous set of changes the reader is referred to the first series of tables in Goodman's Archaic Maya Inscriptions, which gives the layout for each of the fifty-two years of this cycle.

The list of twenty named days commences, as has been said, with Imix, and while this day never can begin a month it does occur wherever the last figure of a number of days counted from any zero or round number is 1. Zero or any round number in this modified vigesimal system is Ahau. Any number with two in its last

place is Ik, etc. The second position in the numerical count, called the uinal or reformed month, never coincides exactly with the named months of the haab or 365-day year, although of the same length. All uinals begin with Imix and end with Ahau and therefore all tuns, katuns, baktuns, etc., also begin with Imix and end with Ahau. But the 365-day years begin with Ik, Manik, Eb, and

TABLE II. — NUMERICAL RELATIONSHIPS IN THE MAYAN TIME COUNT

TZOLKIN	LONG COUNT	HAAB			
Day Names	Position in Uinal	Ik yrs.	Manik yrs.	Eb yrs.	Caban yrs.
Imix	1	19	14	9	4
Ik	2	0	15	10	5
Akbal	3	1	16	11	6
Kan	4	2	17	12	7
Chicchan	5	3	18	13	8
Cimi	6	4	19	14	9
Manik	7	5	0	15	10
Lamat	8	6	1	16	11
Muluc	9	7	2	17	12
Oc	10	8	3	18	13
Chuen	11	9	4	19	14
Eb	12	10	5	0	15
Ben	13	11	6	1	16
Ix	14	12	7	2	17
Men	15	13	8	3	18
Cib	16	14	9	4	19
Caban	17	15	10	5	0
Eznab	18	16	11	6	1
Cauac	19	17	12	7	2
Ahau	20	18	13	8	3

Caban, if we call the zero position of the named months the first position; or with Akbal, Lamat, Ben, and Eznab if we call the position where the month-signs carry the numeral 1 as their coefficient the first position. In Yucatan at the coming of the Spaniards, the year-bearers — explained as the first day of the first month of the year — were Kan, Muluc, Ix, and Cauac. While a shifting of some sort is indicated in this record of the days and their possible positions, this shift clearly did not affect the sequence of the days nor did it seriously affect the recording of dates.

The coördination of numerical relationships for the twenty named days in the long count of days in sequence from a mundane epoch and in the months of the haab or vague 365-day year is best shown in tabular form. The reader is recommended to examine Goodman's tables of the 52 years of the calendar round, and to note that the rows of heavy lined figures which give the coefficients of the day Ahau on all complete units or round numbers extend across the years in the 3rd, 8th, 13th, and 18th positions in the months, and that all the round numbers can end on any one of these positions of Ahau in any month.

The second set of Goodman's tables records the ending days of baktuns, katuns, and tuns in their natural order for only a part of the vast cycle of possible changes. Nearly all Mayan dates are found in the series of 13 baktuns which Goodman calls the 54th Great Cycle. This designation is not much used by modern students, since there is no evidence that it conforms to ancient usage.

Hieroglyphs and Numerical Notation

Some idea of the nature of Mayan hieroglyphs has already been gained from the sets of day-signs and month-signs. In the opinion of the writer, Mayan hieroglyphs are among the best examples of calligraphy; each glyph block is a composition exhibiting remarkable qualities of design. We now know almost to a certainty that some of the signs are ideographic, while others contain phonetic elements which are ordinarily entire syllables rather than separate sounds.

Notation for all higher numbers in the Mayan calculations is of the place-value type, which called for the invention of a zero or place-holding symbol. It can now be shown that the Mayas discovered and developed place-value notation a clear thousand years before it was put in practical use anywhere in the Old World. And place-value notation is the *sine qua non* of modern arithmetic. In this connection it may be noted that our modern decimal system of numbers arranged in degrees of value, which bears the name Arabic, seems to have been invented in India about the seventh century A.D. Some of the figures belong to earlier times, but the place-value scheme was not known to the earlier astronomers of India who flourished in the fifth and sixth centuries.

In Mayan notation, the figures corresponding to the digits are made up of dots which count as one and bars which count as five. Thus one is represented by one dot, two by two dots, five by one bar, six by a bar and a dot, fifteen by three bars, etc. (fig. 5).

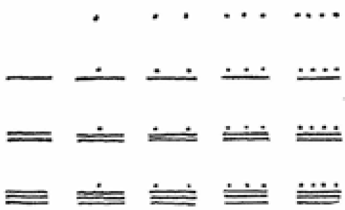


FIGURE 5. BAR-AND-DOT NUMERALS, 1 TO 19

Certain esthetic variations in the numerical notation are seen in the inscriptions. One kind is the use of decorative details to fill out the line when one or two dots are recorded. Often the decorative elements are crescents, but sometimes other devices are seen. Also the bars are decorated,

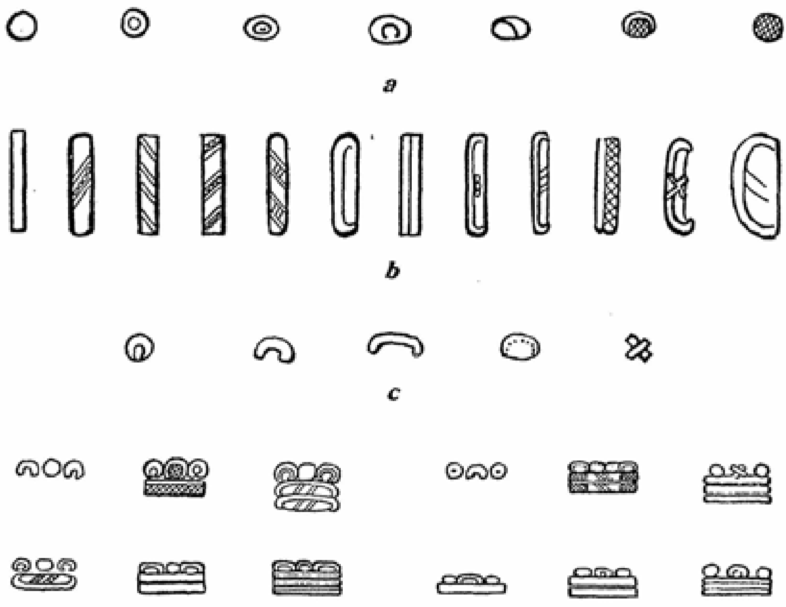


FIGURE 6. ESTHETIC VARIATIONS OF BAR-AND-DOT NUMERALS

a, types of dots; *b*, types of bars; *c*, decorative fillers, not to be counted; *d*, bar-and-dot numerals with decorative fillers.

usually by diagonal lines which may be intended for the wrappings of a bundle. An idea of the decorative treatment of numerals can be obtained from the examples given herewith (fig. 6).

Another and more important variation occurs when the bar-and-dot figures are replaced by the faces of a series of gods. This is seen mostly in initial series inscriptions which will be described elsewhere. Ten or perhaps thirteen gods are represented as the patrons

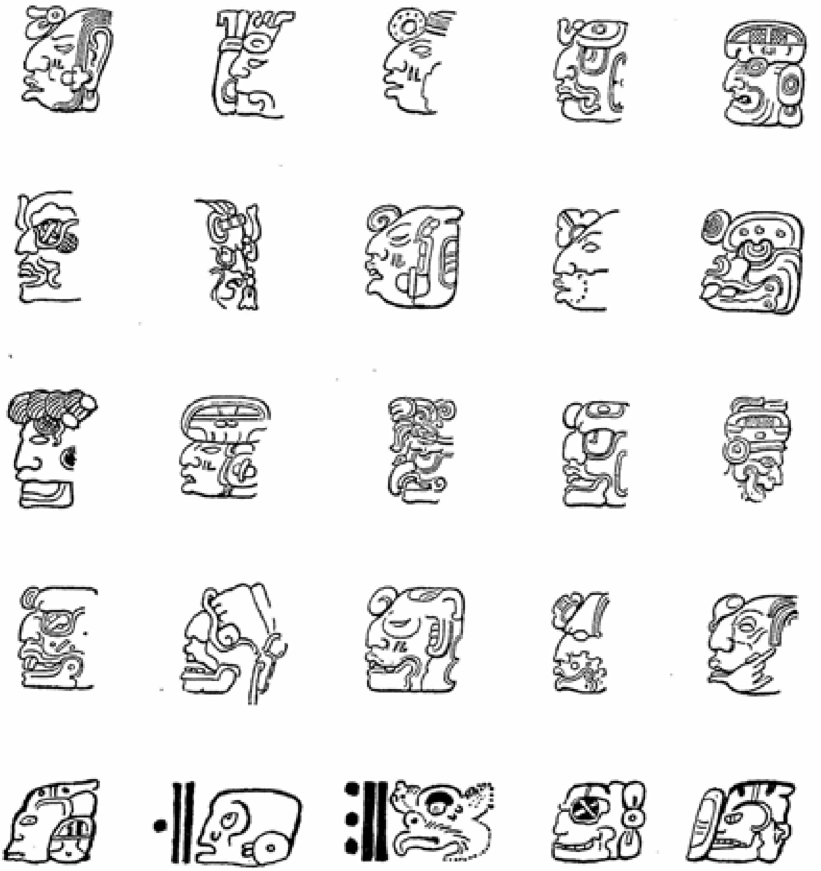


FIGURE 7. NUMERICAL FACES

The first four rows are the numerical faces 1 to 20 arranged in order, 1–5, 6–10, etc. The last row taken from the codices gives faces for 8, 11, 13, 16, and 18. The owl with 13 is a symbol of the Mundane Era.

of special numbers and for cases above fourteen we generally find the faces for four, five, etc., repeated with a symbolism of death, such as a bone for the lower jaw. Most of the faces can easily be identified as those of special gods of the Mayan pantheon. For

instance, four is the Sun God with the kin or sun sign on his face. From the sun are derived the four directions marked on the kin sign, hence the fitness of this god as a patron of four. Five is an aged god with the tun sign as a head-dress. He is almost certainly the special god of the short five-day period at the end of the year, a God of Fire functioning at the New Fire Ceremony. Six is a Sky God with the diagonal cross in his eye; the idea of the four directions plus above and below may be involved. Seven, as we shall see, is probably the special god of the seven ages between the beginning of the Mayan era and the actual inauguration of the historical count. Eight is very clearly the Maize God. Nine is a god with dots upon his cheek. Ten is the Death God. Eleven probably has to do with war or sacrifice; such a god, at least, is frequently pictured in connection with the number eleven in the Dresden Codex.[1] One, two, three, as well as twelve and thirteen, are not so easily identified. Examples of these numerical faces are given in figure 7.

Nothingness or Completion

Consideration of the symbols which fulfill the functions of our zero has been purposely postponed to this time, because these symbols are involved in conceptions rather strikingly different from mere nothingness or emptiness. To the Mayan mind zero was not nothingness but completion, and it seems that this people may have had a truer philosophy of numbers than we ourselves can boast. They registered only elapsed or completed units of time, while we make an illogical use of current units in all our larger measures. On the dials of clocks we count as the Mayas counted, but not so in the calendrical enumeration of days, months, years, and centuries.

But zero is, in effect, the moment of completion in our mathematical processes whether we admit it or not. We have a decimal system with nine digits: what, then, is zero? If we perform the following addition what really happens?

$$\begin{array}{r} 999{,}999 \\ 1 \\ \hline 1{,}000{,}000 \end{array}$$

[1] Usually the dot is placed above the ends of the two bars and there is a possibility that the number is 30 rather than 11, — perhaps referring to the natural month.

FIGURE 8. SHELLS AND THE MOON

In *a* are shells of various types; *b*, representations of the moon; *c*, shells meaning zero in the codices, and moons meaning 20; *d*, various moon and shell signs; the bottom two rows show the moon with 9 or 10 to declare a 29- or 30-day month.

We lift in sequence six degrees of value to a point of completion expressed by a sign which we commonly consider as representing nothingness, and we conclude by putting the figure one in a seventh position. And yet ten is the basis of our numeration and 1,000,000 is a round number.

We can see the application of this principle more clearly when we read the dials on a clock where the zero hour is the point of twelve. Again the completion of the largest units waits on the completion of all those below it. The reading is 11 h. 59 m. 59 sec., and while the hours and minutes may seem from their indicators to be complete we know they are not complete till the second hand reaches 60. Then we actually have 12–60–60 as a new point of departure which we write 12–0–0 and call "twelve o'clock." The next moment is 0 h. 0 m. 1 sec. But in common parlance we call this "one second after 12 o'clock" and we continue to designate seconds and minutes in this fashion as we approach the point of completion of the first hour. The Mayas expressed the temporal zero of their numerical count of days by a number which we transcribe as 13–0–0–0–0,[1] quite comparable to our 12–0–0 for the complete or zero hour. But when we give the numerical position of the day of the month, the month of the year, or the year of the century, we use a system of current units utterly at variance with the logical system of dials. To-day, January 14, 1924, is explained as falling in the twentieth century after Christ, and is written 1–14–'24. Actually only 19 centuries have passed, 23 years, 0 months, 13 days, and, let us say, 10 hours, 45 minutes, and 30 seconds.

The Mayas used zero or completion symbols in connection with month glyphs to indicate the position which rightly or wrongly we transcribe as 0. They also used symbols as place-holders in place-value notation exactly as we use zero, and finally they used ending-signs for completed numerical periods which we call round numbers. For these purposes they employed more than one graphic device.

In a later section an explanation of how the various zero signs may have originated will be offered. At this place it is only necessary to present some of the actual devices and the manner in which they are employed. In the Dresden Codex, the place-holding figure in place-value notation is the conventional picture of a shell, usu-

[1] Probably the Mayas intended to write this 13–20–20–18–20, each position being complete.

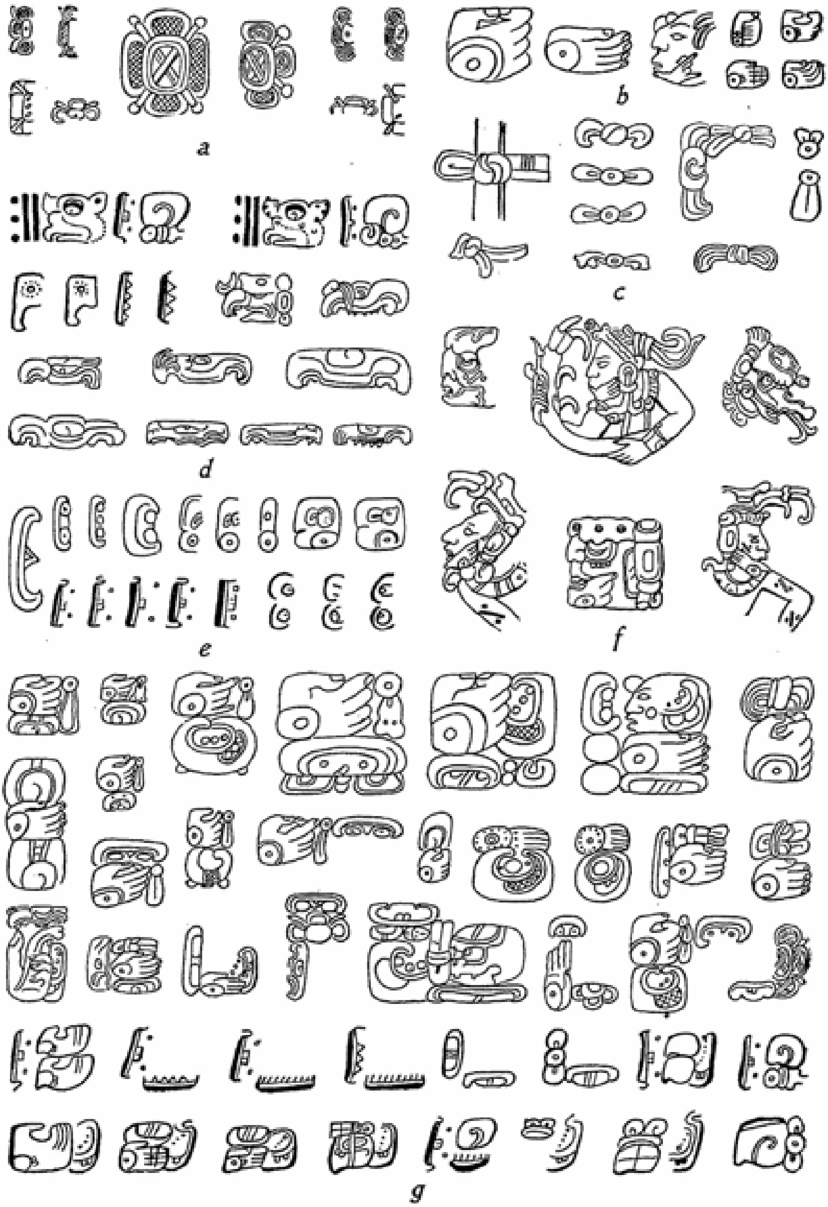


FIGURE 9. SYMBOLS FOR ZERO OR COMPLETION

In *a*, the universality symbol; *b*, the hand; *c*, the knot; *d*, the bird's head of the Mundane Era; *e*, the bracket; *f*, death; *g*, combinations of the above signs with the shell and the moon.

ally of a long narrow shape. This does not occur in exactly the same form in the inscriptions, because here period glyphs are commonly used as indicators of the basic values of the positions, and the zero or completion sign is affixed to these period glyphs in much the same way as the bar-and-dot coefficients are affixed to the day and month glyphs. Also in the codices there is a sign with the numerical value of twenty which belongs to a system of notation by addition, with limited use in magical formulae, and in lunar counts. This sign for twenty is a conventional moon and it has already been stated that the month was reduced from thirty days to twenty days to accord with the second station in vigesimal numeration, and the picture of the moon carried over to the new meaning. The various shells were probably regarded as mere substitutes for the picture of the moon and therefore contain the idea of the completed unit. Some of the shell and moon forms of zero may be compared in figure 8.

Perhaps the most common device for zero or completion in the inscriptions is part of a symbol which in its entirety probably means the round or cycle of the universe. We will not stop at this time to look into this symbolism which is clear enough but which might deflect us from the main thesis. This sign is given in figure 9, where we also see the hand and scroll, so-called, which is probably a hand and shell. The idea of the hand which grasps, like that of the knot which ties up, is connected with completion rather than emptiness or zero. The zero position in months is sometimes indicated by still other signs. Even the tun glyph seems to have been used for this purpose in a few instances.

Place-Value Notation of Numbers

In our first demonstration, we will examine simple cases of the place-value notation used by the Mayas, postponing consideration of the more ornate and elaborate presentations. Near the bottom of page 24 of the Dresden Codex are three adjacent numbers, written as in figure 10.

Obviously, the number at the right is the smallest one. It is written in three positions or degrees of value: at the top is a bar and three dots, which we read as eight, then come two dots for two in the second position, and lastly, at the bottom, a shell for zero.

We read the number before us as eight tuns, two uinals, and zero kins. We can write it as 8–2–0 in a convenient system of transcription. The Mayan numeral in each position is set over into an Arabic number which may run from 0 to 19 and a dash or comma is put between the positions: additions and subtractions are made very much as with the decimal system, care being taken with the second position which is completed with eighteen units instead of the usual twenty. To solve this and the other Mayan numbers into our own system we multiply the separate

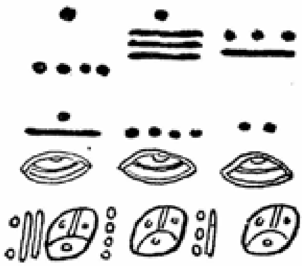


FIGURE 10. PORTION OF A MULTIPLICATION TABLE
Dresden Codex.

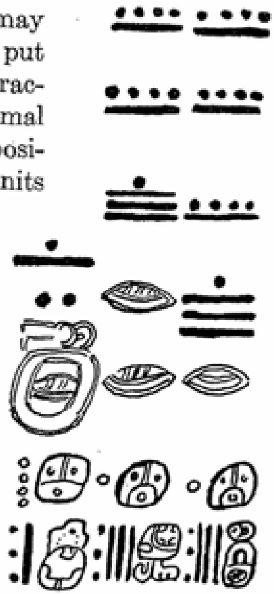


FIGURE 11. TWO LONG NUMBERS AND THEIR DIFFERENCE
Dresden Codex.

numerals by their place values and add the results. The three numbers before us then become:

1 × 7200	7200				
4 × 360	1440	16 × 360	5760	8 × 360	2880
6 × 20	120	4 × 20	80	2 × 20	40
0 × 1	0	0 × 1	0	0 × 1	0
	8760		5840		2920

A very strong indication that our solutions are correct develops when we observe that 5840 is exactly twice 2920, and 8760 is exactly three times 2920. This would not be true if we used any other values for the positions than those of the modified vigesimal system with 360 as the place value of the tun. Now under the three numbers in the original text we see the three days 12 Ahau, 4 Ahau, and 9 Ahau, thus:

8760	5840	2920
12 Ahau	4 Ahau	9 Ahau

If we count forward from 9 Ahau exactly 2920 days on the permutation table (that is eleven complete rounds of the tzolkin and sixty days more), we reach 4 Ahau. Similarly 12 Ahau is found to be exactly 2920 days in advance of 4 Ahau. These three named days occur just 2920 days apart, and the numbers are multiples of 2920. Actually the count started from a day 1 Ahau, which is undeclared but can be recovered from indications we will not touch upon now; next it proceeded to 9 Ahau, 2920 days distant; then to 4 Ahau, 12 Ahau, etc., in the same stride.

Passing over the four upper tiers of bar-and-dot numerals separated by rows of day-signs, which mostly record higher multiples of 2920, we take note of two long numbers and a short one in the lower left-hand corner of the page (fig. 11). The short number has three positions, with a red loop around the lowest position. The other two numbers have five positions.

These numbers are easily reduced in two stages. First, we change the Mayan numerals into Arabic numerals and obtain a parallel statement to the one in the manuscript. Secondly, we reduce the three numbers completely to the Arabic system by multiplying the basic values of the various positions by the figures occupying these positions and then adding the results. Thus:

	9 × 144,000 = 1,296,000	9 × 144,000 = 1,296,000
	9 × 7,200 = 64,800	9 × 7,200 = 64,800
6 × 360 = 2160	16 × 360 = 5,760	9 × 360 = 3,240
2 × 20 = 40	0 × 20 .. 0	16 × 20 = 320
0 × 1 = 0	0 × 1 = 0	0 × 1 = 0
2200	1,366,560	1,364,360

From these statements it is readily seen that the first number is exactly the difference between the other two. Furthermore we learn by consulting the table of calendar rounds that the second number is exactly seventy-two calendar rounds of 18,980 days each, and, since the Mayan era began from a day 4 Ahau 8 Cumhu, the second number in our set would call for a repetition of this calendar-round date if the number was intended to relate to days in the Mayan era. Now if we count back 2200 days from 4 Ahau on the

tzolkin table we come to 1 Ahau, and if we count back the same number in the months of the 365-day year from 8 Cumhu we come to the month position 18 Kayab. In other words, a date 1 Ahau 18 Kayab lies 2200 days before 4 Ahau 8 Cumhu and we find this date given under the second column. This permits a third statement of a kind which will be found very useful since it furnishes a much better basis for associations than do the Arabic numbers.

9–9–16– 0–0, 4 Ahau 8 Cumhu
6– 2–0 subtract
9–9– 9–16–0, 1 Ahau 18 Kayab

Here, to make the subtraction, we must borrow one tun from the third position creating 18 uinals in the second position. Then we subtract two and get a remainder of 16 uinals. Next, we take six tuns from the 16 minus one and obtain 9; the other positions are not affected by the borrowing. The reverse of this process is employed in addition thus:

9–9– 9–16–0, 1 Ahau 18 Kayab
6– 2–0 add
9–9–16– 0–0, 4 Ahau 8 Cumhu

We still have the declaration 1 Ahau 8 Uo under the third column unexplained. At the left of the three columns on page 24 of the manuscript there are five other columns mostly containing high multiples of the 2920 already discussed. For instance the top row of numbers records 37,960, 75,920, 113,880, and 151,840, or 13, 26, 39, and 52 times 2920. But the numbers of the second row from the top do not fall in this category and two of them, we find by experiment, lead from a day 1 Ahau 18 Kayab to a day 1 Ahau 18 Uo. Thus:

9– 9– 9–16–0, 1 Ahau 18 Kayab	9– 9– 9–16–0, 1 Ahau 18 Kayab
1– 5–14– 4–0 add	4–12– 8–0 add
10–15– 4– 2–0, 1 Ahau 18 Uo	9–14– 2– 6–0, 1 Ahau 18 Uo

Setting these statements over into Arabic notation, we reach:

1,364,360, 1 Ahau 18 Kayab	1,364,360, 1 Ahau 18 Kayab
185,120 add	33,280 add
1,549,480, 1 Ahau 18 Uo	1,397,640, 1 Ahau 18 Uo

The difference between these two final numbers is 151,840 or 52 × 2920, a sum which has already received notice. This is also

exactly eight calendar rounds, with the result that 1 Ahau 18 Uo is reached in both statements.

In several adjoining pages in the Dresden Codex, the number 2920 so prominent on page 24 of the manuscript is built up out of additions of 236, 90, 250, and 8, making 584, which is then taken five times to make 2920. Finally, we reach a round or cycle of 37,960 days by taking the stages, explained above, thirteen times. It has been demonstrated that this remarkable passage deals with the planet Venus.

It must be apparent that our transcription of Mayan numbers is correct when so complicated a series as this is consistently solved. We are even able to discover and correct several errors in the statements of month positions. In this connection, it may be said that errors are not infrequent in the Dresden Codex and on the monuments. They are generally self-correcting because the number, the day, and the month position constitutes a triple statement and the agreement of two is logically sufficient to carry against the disagreement of the third. Many of the errors in the Dresden Codex are probably the result of careless copying from an earlier manuscript. The Mayan system of dating carried such a high factor of safety that no special effort was made to correct mistakes of the sculptors who could hardly be expected to understand the higher mathematics of those times. An error occurs in the statement of 4×2920 to the left of the last number given above on page 24 of the Dresden Codex, a bar being drawn in the uinal position where a bar and three dots are called for. But the day-sign below catches up the error. Other multiples of 2920 are correctly recorded.

The Dresden Codex probably dates from the end of the tenth century A.D., but place-value notation occurs on the earliest known object of Mayan art with a contemporaneous date falling close to 100 B.C. Between the carving of the jade figurine from San Andres Tuxtla, commonly called the Tuxtla Statuette, and the writing of the Dresden Codex, the great Mayan civilization rose and declined. While the inscriptions on monuments and temple walls do not follow exactly the simple mode now under discussion, they do not depart from it as far as might be supposed from a first glance at the involved calligraphic texts. Order of a kind is always maintained and we assume that the naïve and unpretentious numbers of the

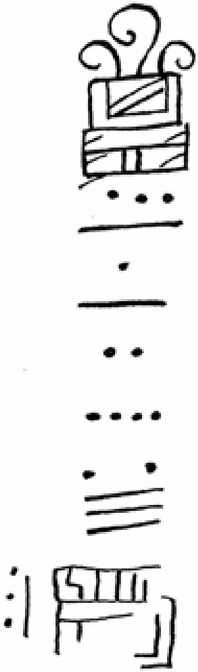
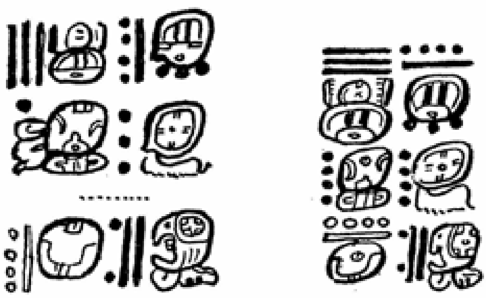
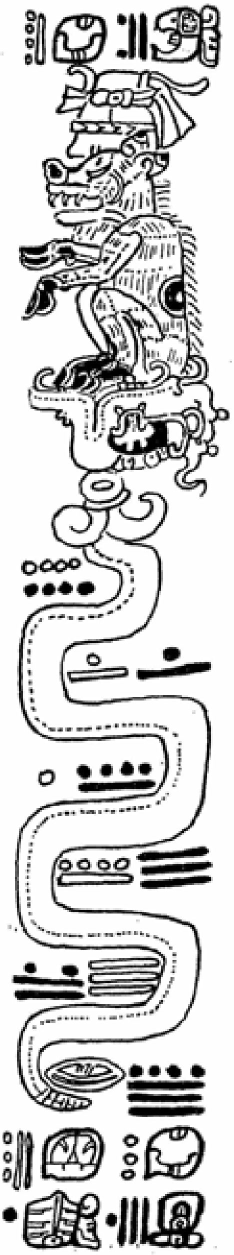


FIGURE 12.
THE NUMBER ON THE STATUETTE OF SAN ANDRES TUXTLA.





a *b* *c*

FIGURE 13. SERPENT NUMBERS AND THE BASES FROM WHICH THEY ARE COUNTED
The first two statements contain errors in the original: they should read, 15–9–9–4.

place-value type were used during all this passage of time in ordinary calculations.

The number on the Tuxtla Statuette (fig. 12) is transcribed thus: 8–6–2–4–17. The figure at the left in our transcription occurs at the top on the original document where a bar and three dots correspond to eight. Next comes one bar and one dot for six, although the space between the two elements is rather wide. The third position carries two dots. Then we have four dots and finally three bars and two dots which represent the number of times that the lowest degree of value is taken. Multiplying the basic values of the positions by the numerals which occur in these positions gives us the following whole number:

$$\begin{array}{rrr} 8 \times & 144{,}000 = & 1{,}152{,}000 \\ 6 \times & 7{,}200 = & 43{,}200 \\ 2 \times & 360 = & 720 \\ 4 \times & 20 = & 80 \\ 17 \times & 1 = & 17 \\ \hline & & 1{,}196{,}017 \end{array}$$

This number of days added to 4 Ahau 8 Cumhu at the epoch of the Mayan era leads to the day 8 Caban occupying the zero position of the month Kankin. We see the bar and three dots for eight in front of a partly erased glyph, but 0 Kankin is not recorded.

Place-value notation of still greater range is found in the so-called serpent numbers of the Dresden Codex which almost certainly have some hypothetical meaning in the ancient astronomy of the Mayas. We give, in figure 13, the second serpent with a red and a black number in its coils on page 62 of the Dresden Codex together with the day and month signs recorded above and below. These numbers reach six positions and are transcribed as follows:

Black Number

$$\begin{array}{rrr} 4 \times & 2{,}880{,}000 = & 11{,}520{,}000 \\ 6 \times & 144{,}000 = & 864{,}000 \\ 9 \times & 7{,}200 = & 64{,}800 \\ 15 \times & 360 = & 5{,}400 \\ 12 \times & 20 = & 240 \\ 19 \times & 1 = & 19 \\ \hline & & 12{,}454{,}459 \end{array}$$

Red Number

$$\begin{array}{rrr} 4 \times & 2{,}880{,}000 = & 11{,}520{,}000 \\ 6 \times & 144{,}000 = & 864{,}000 \\ 1 \times & 7{,}200 = & 7{,}200 \\ 9 \times & 360 = & 3{,}240 \\ 15 \times & 20 = & 300 \\ 0 \times & 1 = & 0 \\ \hline & & 12{,}394{,}740 \end{array}$$

It can be shown that these numbers, when counted from 9 Kan 12 Kayab which is written above, lead to 13 Akbal 1 Kankin and 3

Kan 17 Uo, respectively, which are written below. Furthermore, it can be shown that the 9 Kan 12 Kayab which serves as the point of departure really is 9–15–9–9–4, 9 Kan 12 Kayab, corresponding to 1,407,424 days after the epoch of the Mayan era. Two attempts to write the last four positions of this number contain errors (fig. 13, *a* and *b*). The indications are that the vast numbers of days in the serpent folds were counted into the future, in some astronomical calculation.

Period Glyphs

The order in which hieroglyphs are to be read is, of course, a matter of supreme importance. The single column, reading down, and the single row, reading to the right, are the most primitive presentations. But two column texts are more common on the monuments, usually being introduced by a large glyph which extends across the top of both columns. Here the reading begins at the top and to the left and then proceeds across and down. There are examples of double row texts where the reading is by the same system in blocks of four glyphs, the blocks being arranged in horizontal order. The larger texts nearly always are intended to be read in double columns proceeding from top to bottom (see fig. 14 for patterns). In a few cases where tables of day-signs are being considered, the order is from right to left and this is sometimes true of the arrangements of ascending numbers in multiplication tables.

Now the conventional arrangement of hieroglyphs in a double column seems sufficiently rigid. Nevertheless the period glyphs were probably invented as safeguards against error in position. To be sure these glyphs also have peculiar use and justification in the so-called secondary series — which is a number of days to be added to or subtracted from another number in the body of a hieroglyphic text, and which is customarily written with the degrees of value in reversed order — and also in the abbreviated statement which is termed a period-ending date. But in general we are safe in saying that period glyphs merely assure the basic values of the positions and are therefore not in conflict with place-value notation. They are combined with numerical coefficients which declare how many times the basic value of the position is to be taken.

Period glyphs are of two general types (see fig. 15). One type which has been called the normal type can be described as an arbi-

trary device. Then there is the face type founded on a realistic motive but sometimes containing the normal device as a detail. The periods or place values are called kins, uinals, tuns, katuns, etc., the first word meaning sun or day, the second moon or month, the third stone, the fourth twenty stone, etc.

The kin glyph in the more complete presentation is a portrait of the Sun God in profile view, while in the simplified or normal type it is a graphic element expressing the idea of the four directions

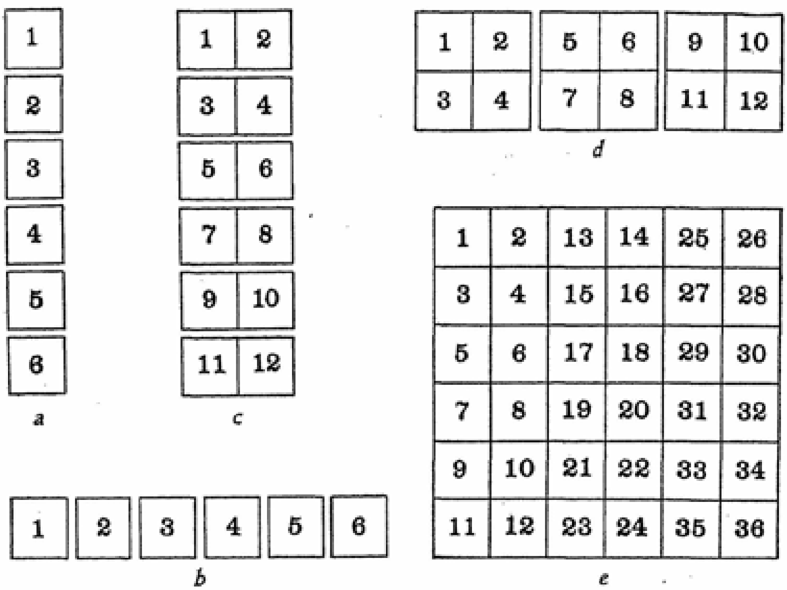


Figure 14. Patterns of the Order in which Glyphs are to be Read

which is associated with the sun. The uinal glyph is a frog, occasionally represented in full but usually only as a conventional head in profile. The use of the frog for this twenty-day period glyph has been explained on linguistic grounds since the word for frog is *uo* and that for the moon or month is *u*. The normal form is a device without obvious explanation resembling the glyph for the day Chuen.

The realistic ideas back of the face types of tun, katun, and baktun glyphs doubtless relate to birds but it is impossible to tell what birds. The bird's head that stands for the 360-day period often

wears the normal sign for this period as a head-dress and carries marks of death, such as a bare bone in the lower jaw. The normal tun has been variously explained as a stone, a drum, or a seat. Or it may represent a round altar. It is drawn in practically identical fashion in many cities over a stretch of many centuries. The word

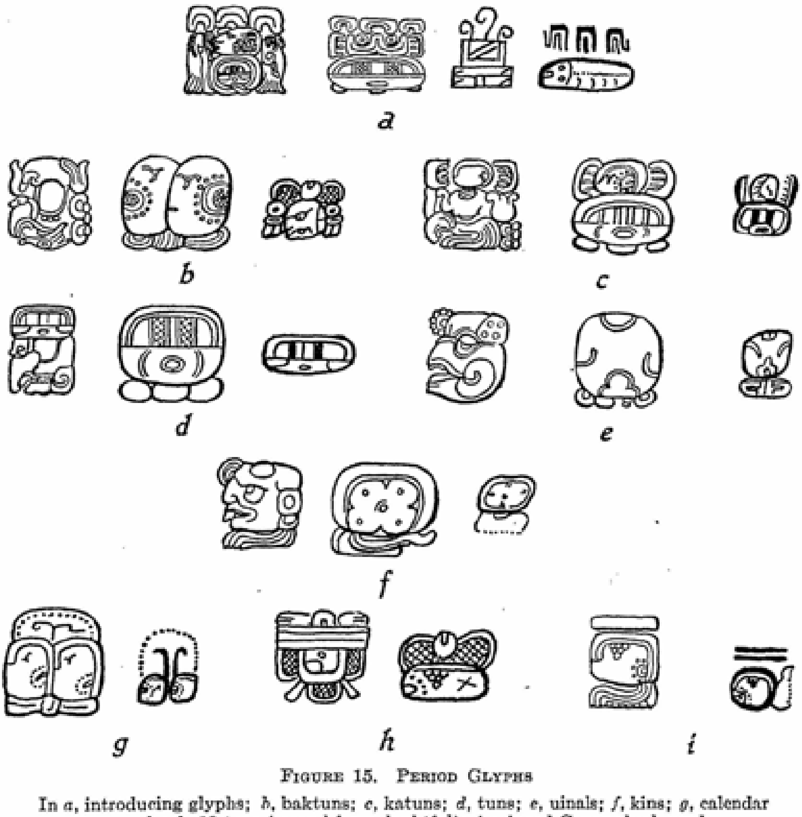


FIGURE 15. PERIOD GLYPHS

In *a*, introducing glyphs; *b*, baktuns; *c*, katuns; *d*, tuns; *e*, uinals; *f*, kins; *g*, calendar rounds: *h*, 10 tuns (second form doubtful); *i*, winged Cauac glyph used for hotuns, etc., with numerical coefficients.

tun means stone and, stones were ceremonially set up at the completion of each 360 days. But 360 days were five days less than a year with the result that the normal tun sign appears by association of this circumstance in the head-dress of the God of the End of the Year, an old man god whom Schellhas calls God N. He was the patron of the number five.

The normal form of the katun glyph shows the tun sign surmounted by other elements. The middle element of the superfix is the day-sign called Cauac meaning rain. It seems that this sign was extended to mean year, a time unit marked off by recurring rainy seasons. On either side is the comb-like element which is believed to signify twenty. In certain introducing glyphs, each comb of the katun superfix is replaced by a fish. In Landa's ill-starred "alphabet" the comb-like element is given the phonetic value *ca* which has been connected with *cay* meaning, fish.[1] It is not impossible, therefore, that the normal form of the katun actually contains a combined phonetic and ideographic record of twenty tuns. The face type is a bird's head in profile surmounted in most examples by the Cauac and comb-like elements.

The baktun glyph of the normal type consists of two enlarged Cauac signs with a knotted element below, while that of the face type consists of a grotesque bird's head with a hand for the lower jaw. In either case we may see a symbolism of the knotting up or grasping of years to form a huge unit. The same symbolism is continued in the higher periods which are of rare occurrence. A glyph which may represent the pictun contains a hand holding a staff with a flower-like detail hanging down from the end.

The introducing glyph, so called because it stands at the head of the initial series dates on the monuments, probably does not represent a pictun or other high time unit. It may simply indicate that a count of time periods will follow and some of the elements, especially a variable central element, may relate the purpose or general significance of this time-count. In a few cases, for instance, the central element is a sign of the planet Venus; in other cases it is the moon, or the day-sign Ik or the head of the Sun God.

Dates in Full and Abbreviated Modes

The inscriptions on Mayan monuments nearly always contain dates and indeed most of them begin with an initial series, which is an elaborate and complete date, and then give a supplementary series, which is a lunar correlation intimately connected with the initial series, and then proceed with one or more secondary series, which is a number of days to be added to or subtracted from the

[1] Bishop Landa attempted to recover the phonetic elements in Mayan writing but seems only to have been furnished by his informants with signs for words containing among other sounds the special ones he asked for.

date of the initial series, and finally record one or more period-ending dates, which are brief declarations of the days when certain round numbers in the long count are completed.

The name initial series, coming from the mere fact that these complete statements usually stand at the beginning of texts, is not entirely satisfactory but has become fixed in usage. They were the first kind of inscription to be deciphered and later their value as contemporary dates was validated by studies of the stylistic sequence of the Mayan monuments. Some initial series were obviously intended to relate to time far in the past and in these cases secondary additions usually reached the present for the builders of the monuments. Nearly all the incomplete or syncopated dates can now be placed in the long count as a result of the manifold associations which have been established.

The decipherment of a complete Mayan inscription means, first, the reading of the number, which is ordinarily easy enough if the text is complete, but which may be rather difficult in some instances where the bar-and-dot numerals are replaced by the faces of gods; secondly, it means the reading of the day and its associated number; and thirdly, the reading of the month and its numerical coefficient. Each of these three readings means three separate calculations from the epoch of the Mayan era, designated 13–0–0–0–0, 4 Ahau 8 Cumhu. That is, the number runs from zero, the tzolkin or essential permutation, from 4 Ahau and the haab, or civil year, from 8 Cumhu. In a perfect date all three counts will agree and from this circumstance restorations are easily accomplished. If the number is complete, the day and month can be restored, and if the day and month are intact, the number can be restored provided the coefficients of two or three of its periods prove legible.

In figure 16 are various declarations of zero in the numerical count of days from inscriptions on stone — in other words, the epoch of the Mayan era. In *a* from Stela C at Quirigua the declaration takes the form of an initial series: at the top is the introducing glyph occupying the space of four ordinary glyphs; then, in the usual double column sequence, we read 13 baktuns, 0 katuns, 0 tuns, 0 uinals, and 0 kins, followed by 4 Ahau 8 Cumhu.[1] Note

[1] It was stated above that the 0 of these transcriptions means completion rather than zero and that this number might be written 13-20-20-18-20.

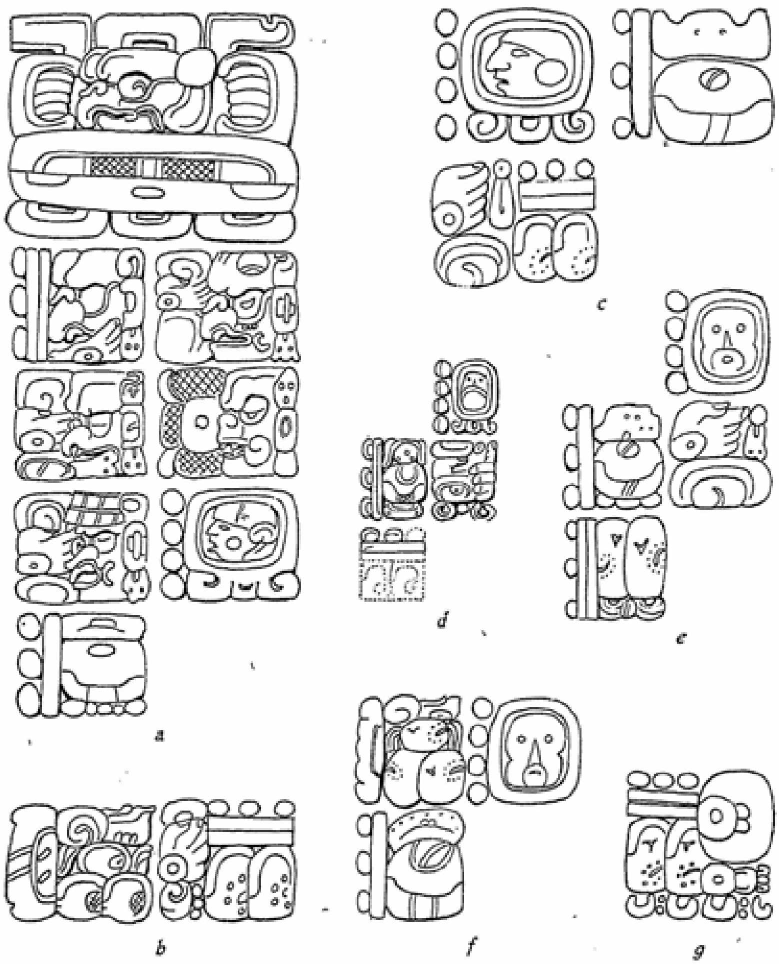


FIGURE 16. DECLARATIONS OF THE EPOCH OF THE MUNDANE ERA, 13-0-0-0-0, 4 AHAU 8 CUMHU

Example *a*, *b*, Stela C, Quirigua; *c*, Altar 2, Piedras Negras; *d*, Stela 3, Copan; *e*, Temple of the Cross, Palenque; *f*, Temple of the Sun, Palenque; *g*, Altar P, Quirigua.

the two signs which are used for zero or completion in the periods, namely, the hand and scroll, or shell, and the cosmic symbol. Farther along in the same inscription is a shorter reference to the epoch of the era.

In other cases the record is shortened to the simple statement of 4 Ahau 8 Cumhu, a hand and shell signifying end of, completion of,

or zero point of, and a baktun glyph with the coefficient 13. This number 13 probably indicates a kind of chronological infinity. Sometimes the statement is even briefer; a bundle of Cauac elements is preceded by a shell as a sign of completion or zero and then comes the declaration of 4 Ahau 8 Cumhu. In the Dresden Codex, 4 Ahau 8 Cumhu is sometimes shown as the epoch of the day-count without classificatory glyphs of any kind.

The way in which this zero is recorded raises interesting problems concerning the number of fifth order units in the next higher order of the time-count. Morley makes a strong effort to prove that twenty baktuns, or periods of 144,000 days, constituted one of the next order. This contention really means that the vigesimal scale might have been used in the formation of the higher place values in spite of the way the zero of the time-count is actually recorded. Goodman arranges baktuns, which he calls cycles, in groups of thirteen to form what he calls a great cycle. Now the number 13–0–0–0–0, 4 Ahau 8 Cumhu, was obviously intended to represent completion of a sort. It was not regarded as absolute zero because in one very clear inscription at Palenque there is recorded a still earlier date under a baktun with the number 12. Also it can be demonstrated without a shadow of doubt that the baktun following 13–0–0–0–0 was written 1–0–0–0–0 instead of 14–0–0–0–0 in Mayan notation and that the succeeding periods of 144,000 days were numbered in order from the same start.

We must imagine that the Mayas during their monument-building age were carrying out the provisions of a calendarial system already long established. Increased knowledge of planetary cycles and efforts at broadcast correlation must have called for quantities of days running far into the past or into the future and in these calculations there can be little doubt but that twenty baktuns were counted for 1 pictun. The serpent numbers in the Dresden Codex show this quite clearly for they run into the sixth position and correctly state the resulting calendar-round dates when we assume that the scale employed in them is purely vigesimal.

The Mayan calendar was doubtless part of a general cosmic conception involving universal relations in time and space and the provinces of divinity. There is a structural great cycle of thirteen baktuns rising from the fact that the terminal day 4 Ahau, in an-

other month position to be sure, repeats after this time. Of course it is true for all the periods from the uinal up that the day repeats after thirteen changes. But in the case of the repetition of 4 Ahau after 13 times 144,000 days, we might imagine that the inventor of the calendar thought this was going far enough. Thirteen by itself seems to have had a connotation of infinity. Goodman sees a neater finish to the chronological problem in a round of 73 times 13 baktuns, which would bring not only the day but the month position back again as a terminal date of a great cycle. He argues that the great wheel of time began from a great cycle 73 ending on a day 4 Ahau 13 Yax and that the great cycle of the era recorded in the inscriptions was really the 54th in order from this far-off beginning. The entire scope of this time-wheel was not less than 374,400 years.

In reality there is no very grave conflict between the arguments of Morley and Goodman since the sequence of days is the same in both cases. It matters very little whether there were 13 baktuns in a great cycle or 20 baktuns in a pictun so far as the uses of actual chronology are concerned. The Mayas of the monumental age possibly thought of 13 baktuns as covering the range of cosmic time but they actually cast their calculations beyond these limits. A few numbers in the inscriptions seem to rise above the fifth order in the count of days but they are either defective or ambiguous. This matter will be discussed more fully in a later section of this paper.

As for Goodman's theory only a few arguments can be mustered in its favor beyond the fact that it is structurally possible. The month position 13 Yax is emphasized in some passages. To be sure the very day 4 Ahau 13 Yax with which Goodman begins his grand era is found in the position 9–15–0–0–0, 4 Ahau 13 Yax at the height of the historic age.

We shall be able to demonstrate a much superior knowledge of the proper leap-year correlation than that contained in the Julian calendar and suggested in Goodman's bissextile count. Nevertheless there is just a possibility that this student of the Mayan calendar came intuitively near the truth. At any rate his words embody a grandiose conception of time:[1] "No fair-minded person, I think, will contend that the Mayas elaborated almost to its con-

[1] *The Archaic Maya Inscriptions*, p. 6.

clusion a design not only susceptible of but inviting the most perfect finish and then wilfully or blindly left it disproportioned and awry. If they did not do this — a thing alien and repugnant to human nature — then their grand era embraces 374,400 years. There are two unmistakable indices pointing to this conclusion. The moment the cycle and great cycle appear upon the scene we know by the unchangeable law governing the calendar that they must go forward until they commence again with the same date from which they started. Such a result in the case of the former requires 949 cycles, and in that of the latter 73 great cycles — each of which reckonings constitutes a period of 374,400 years."

For practical purposes it is no longer deemed necessary to write the numeral 54 in connection with the actual Mayan era.

Initial Series Reduced

The initial series on the Tuxtla Statuette has already been examined: it is recorded in simple place-value numerals without period glyphs but with a simple kind of introducing glyph at the top of the column. The initial series on the Leyden Plate, a thin slab of jadite with a human figure incised on one side and an inscription on the other, has a well-developed introducing glyph and the period glyphs with bar-and-dot coefficients are employed even though the presentation is in a single column (see fig. 17). The number in this initial series reads 8–14–3–1–12. It can be reduced by multiplying the coefficients by the place values implied in the five period glyphs and adding the results to obtain an Arabic number equal to the inscribed Mayan number. Carrying out this process we obtain:

FIGURE 17. INSCRIPTION ON THE LEYDEN PLATE.

$$
\begin{array}{rrcr}
8 \times & 144{,}000 & = & 1{,}152{,}000 \\
14 \times & 7{,}200 & = & 100{,}800 \\
3 \times & 360 & = & 1{,}080 \\
1 \times & 20 & = & 20 \\
12 \times & 1 & = & 12 \\
\hline
 & & & 1{,}253{,}912
\end{array}
$$

Now the day recorded has the numeral one and resembles Eb more closely than any other day form. Below it we see a pretty

TABLE III — DISTANCE OF DAYS IN TZOLKIN FROM 4 AHAU

	1	2	3	4	5	6	7	8	9	10	11	12	13
Imix	101	141	181	221	1	41	81	121	161	201	241	21	61
Ik........	62	102	142	182	222	2	42	82	122	162	202	242	22
Akbal	23	63	103	143	183	223	3	43	83	123	163	203	243
Kan......	244	24	64	104	144	184	224	4	44	84	124	164	204
Chicchan .	205	245	25	65	105	145	185	225	5	45	85	125	165
Cimi	166	206	246	26	66	106	146	186	226	6	46	86	126
Manik....	127	167	207	247	27	67	107	147	187	227	7	47	87
Lamat....	88	128	168	208	248	28	68	108	148	188	228	8	48
Muluc....	49	89	129	169	209	249	29	69	109	149	189	229	9
Oc.......	10	50	90	130	170	210	250	30	70	110	150	190	230
Chuen....	231	11	51	91	131	171	211	251	31	71	111	151	191
Eb.......	192	232	12	52	92	132	172	212	252	32	72	112	152
Ben......	153	193	233	13	53	93	133	173	213	253	33	73	113
Ix........	114	154	194	234	14	54	94	134	174	214	254	34	74
Men......	75	115	155	195	235	15	55	95	135	175	215	255	35
Cib	36	76	116	156	196	236	16	56	96	136	176	216	256
Caban....	257	37	77	117	157	197	237	17	57	97	137	177	217
Eznab....	218	258	38	78	118	158	198	238	18	58	98	138	178
Cauac	179	219	259	39	79	119	159	199	239	19	59	99	139
Ahau.....	140	180	220	0	40	80	120	160	200	240	20	60	100

clear Yaxkin with a strange superfix which is possibly the coefficient. Let us now find what day and month position is reached when 1,253,912 days are added to 4 Ahau 8 Cumhu. Since the day and month positions all come back after 52×365 or 18,980 days we can simplify the number by first removing all the whole calendar rounds. Thus:

$$
\begin{array}{r}
1{,}253{,}912 \\
1{,}252{,}680 \\
\hline
1{,}232
\end{array}
$$

Table IV. — Distances of Days in Haab from 8 Cumhu

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pop	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Uo	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56
Zip	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
Zotz	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Tzec	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Xul	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136
Yaxkin	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
Mol	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
Chen	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196
Yax	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
Zac	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236
Ceh	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256
Mac	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276
Kankin	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296
Muan	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316
Pax	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336
Kayab	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356
Cumhu	357	358	359	360	361	362	363	364	0	1	2	3	4	5	6	7	8	9	10	11
Uayeb	12	13	14	15	16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Now if this is an initial series date, as we have every reason to believe, the day and month positions reached should be just 1,232 days in advance of 4 Ahau 8 Cumhu. First, to obtain the day, we divide by 20 and count the remainder forward from Ahau and to obtain the coefficient of this day we divide by 13 and count the remainder forward from 4. Or we can accomplish both things at once by dividing by 260 and counting the remainder forward from 4 Ahau.

$$1{,}232 \div 260 = 4 + 192$$

We can now count forward 192 positions on the ordinary tzolkin table (Table I) from 4 Ahau, or we can find the same number on a special table devised to give the days reached by various distance numbers after 4 Ahau. On this table (Table III) the numbers follow in sequence on the diagonals, the day-names are at the left and the day-coefficients are at the top. The distance number 192 reaches 1 Eb, in the first column of the table, thus agreeing with the tentative reading from the tablet.

To obtain the month position we divide our number by 365, thus:

$$1{,}232 \div 365 = 3 + 137$$

This remainder can be counted forward from 8 Cumhu on any table of the 365-day year, but perhaps more conveniently on one arranged to depart from 8 Cumhu (Table IV). 137 is found to correspond to 0 Yaxkin and we therefore are justified in assuming that the strange superfix is a symbol for zero or completion.

Two initial series presented in an unusually clear and straightforward manner, with the day and month declarations following immediately after the number, are found on Stela M at Copan and Stela I at Quirigua (fig. 18, *a* and *b*). The reading of the first is 9–16–5–0–0, 8 Ahau 8 Zotz, and that of the second is 9–18–10–0–0, 10 Ahau 8 Zac. The numbers are reduced as follows:

Stela M, Copan

$$\begin{array}{rrr} 9 \times & 144{,}000 = & 1{,}296{,}000 \\ 16 \times & 7{,}200 = & 115{,}200 \\ 5 \times & 360 = & 1{,}800 \\ 0 \times & 20 = & 0 \\ 0 \times & 1 = & 0 \\ \hline & & 1{,}413{,}000 \end{array}$$

Stela I, Quirigua

$$\begin{array}{rrr} 9 \times & 144{,}000 = & 1{,}296{,}000 \\ 18 \times & 7{,}200 = & 129{,}600 \\ 10 \times & 360 = & 3{,}600 \\ 0 \times & 20 = & 0 \\ 0 \times & 1 = & 0 \\ \hline & & 1{,}429{,}200 \end{array}$$

To prove these dates we first subtract the largest possible number of calendar rounds thus:

1,413,000	1,429,200
1,404,520 (74 calendar rounds)	1,423,500 (75 calendar rounds)
8,480	5,700

This means that in these two cases the day and month positions reached by the initial series are 8,480 days and 5,700 days after 4 Ahau 8 Cumhu, provided, of course, that the numbers actually

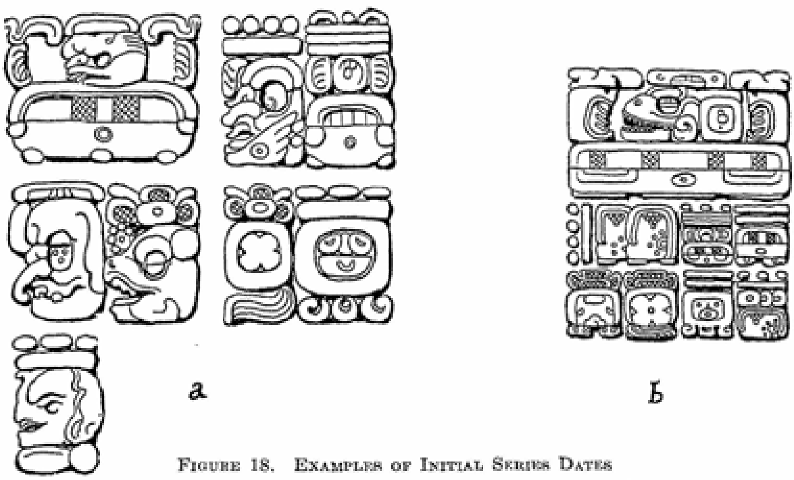
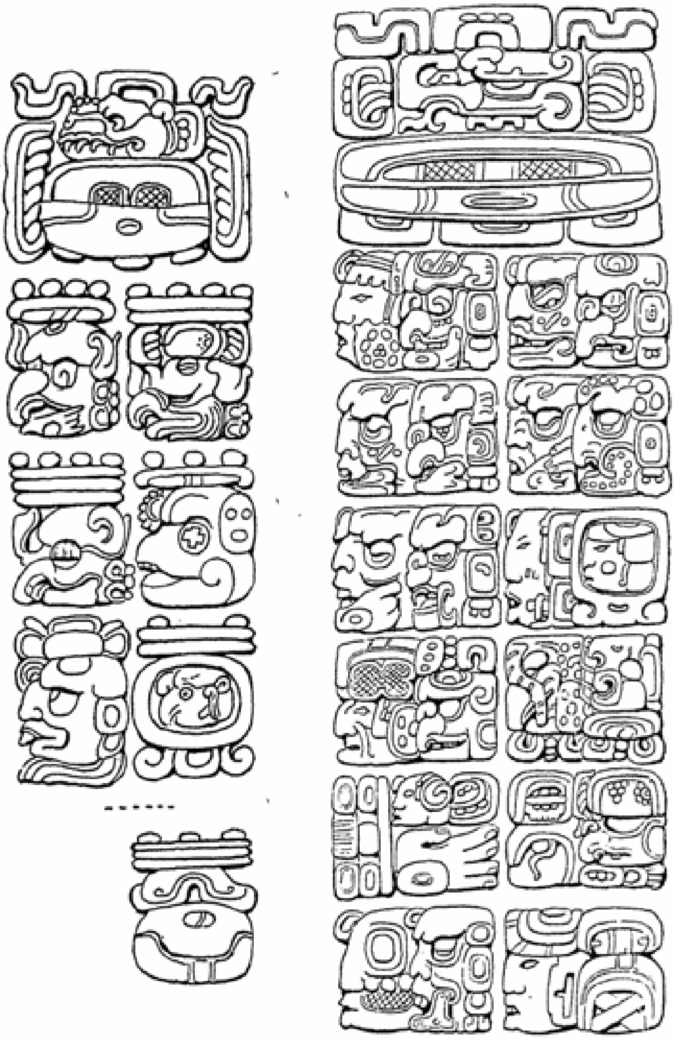


Figure 18. Examples of Initial Series Dates
a, Stela M, Copan; *b*, Stela I at Quirigua.

departed from the epoch of the Mundane Era. Since the kin coefficients are zero, or completion, we know that the resulting days are Ahau. We can find the day and its coefficient in these and other cases by dividing the number in the current calendar round — that is, the number reached when all complete calendar rounds are subtracted — by 260 and counting forward the remainder, on Table III. Similarly we can obtain the month position by dividing by 365 and counting forward the remainder, on Table IV. Thus:

8480 ÷ 260 = 32 + 160	5700 ÷ 260 = 21 + 240
(Table III) 160 = 8 Ahau	(Table III) 240 = 10 Ahau
8480 ÷ 365 = 23 + 85	5700 ÷ 365 = 15 + 225
(Table IV) 85 = 8 Zotz	(Table IV) 225 = 8 Zac



a *b*

FIGURE 19. INITIAL SERIES DATES WITH BAR-AND-DOT NUMERALS AND FACE NUMERALS

a, Stela A, Copan; *b*, Stela F, Quirigua.

The first of these handy tables gives the distances of days in the tzolkin from 4 Ahau, the day of the epoch. The second one gives the distances in days from 8 Cumhu, the month position of the epoch. The records on the monuments are very clearly 8 Ahau 8 Zotz and 10 Ahau 8 Zac and these records are obviously correct.

In another very clear example, Stela A at Copan (fig. 19, *a*), the bar-and-dot coefficients are placed on the top of the period glyphs. We read 9–14–19–8–0, 12 Ahau 18 Cumhu, or, in other words, a day 12 Ahau in the 18th position of the month Cumhu 1,403,800 days after the epoch of the Mundane Era which is 4 Ahau 8 Cumhu. This can readily be proved by the processes explained above.

For initial series in which numerical faces replace the bar-and-dot coefficients the only difficulty is in identifying the faces. Aside from this difference in the form of writing the records are the same. Practice is required and sometimes secondary checks are used. For instance, Goodman, who first demonstrated initial series with face variant numerals, made several bad mistakes in reading, some of which he surely would not have made had he been able to fall back on artistic criteria as to the probable date of the monument. Space can only be given to a single inscription with numerical faces, namely that on the east side of Stela F at Quirigua (fig. 19, *b*). This reads 9–16–10–0–0, 1 Ahau 3 Zip. The face for 9 has a circle of dots on the cheek. That for 16 is the normal face for 6 with a diagonal cross in the eye plus signs of death such as a bare bone for the lower jaw and a symbol consisting of 2 dots separated by a diagonal line on the cheek. Ten is a death's head, while 0 in both cases has the lower jaw formed out of a hand. The day Ahau is preceded by the face for 1, while the month declaration, 3 Zip, in the lower right-hand glyph block, follows the moon glyph with a face for 10. Goodman, Seler, Thomas, Bowditch and Morley have published studies on nearly all the ornate inscriptions, which are now solved without any likelihood of error.

The supplementary series is a group of glyphs in more or less constant order which follows the initial series and probably contains matter relating to the lunar correlation. The months glyph of the initial series frequently follows the last glyph of the supplementary series, a moon glyph with the numeral 9 or 10 placed after or below it.

Secondary Series

In many inscriptions, one or more secondary series follow the initial series, these being intervals of days between stated or suppressed dates. These distance numbers are characteristically written in reversed order with the smallest place value at the top

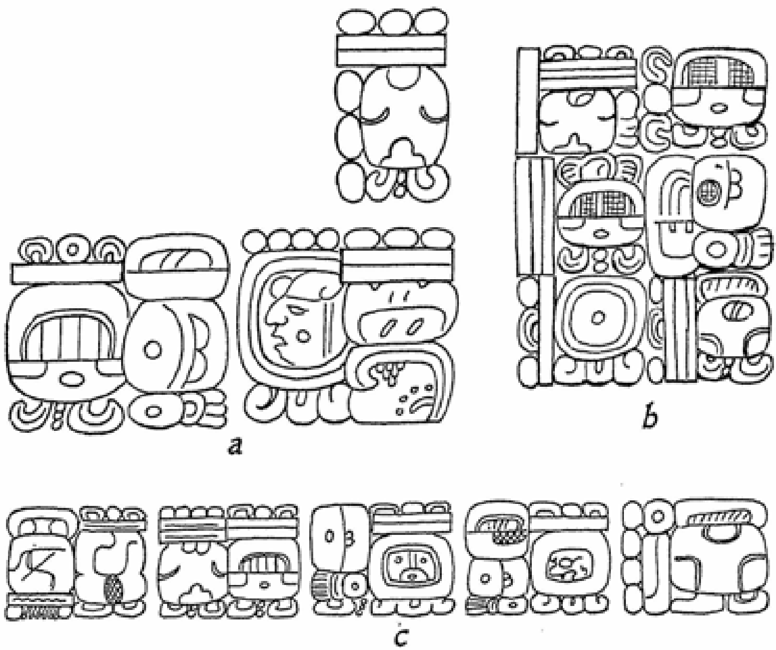


FIGURE 20. SECONDARY SERIES
a, Stela E, Quirigua; *b*, Lintel 21, Yaxchilan; *c*, Hieroglyphic Stairway, Copan.

or left. Very often the kin glyph is suppressed and the kin coefficient is written at the left of the uinal glyph while the uinal coefficient is written at the top. Such a secondary series is seen in figure 20, *a*. The number is 3 kins, 13 uinals, and 6 tuns, which we write 6–13–3; it is added to the initial series on Stela E at Quirigua to reach the next katun ending. The statement may be expressed in the form of an addition thus:

Initial Series	9–14–13– 4–17,	12 Caban 5 Kayab
Secondary Series	6–13– 3	
Resulting date	9–15– 0– 0– 0,	4 Ahau 13 Yax

A similar secondary series on Lintel 21 at Yaxchilan embodies a still longer number also added to an initial series (fig. 20, *b*). In this case the record becomes:

Initial Series	9– 0–19– 2–4,	2 Kan 2 Yax
Secondary Series	15– 1–16–5	
Resulting date	9–16– 1– 0–9,	7 Muluc 17 Tzec

Sometimes the secondary series precedes the two dates for which it serves as an interval. An excellent example of this on the Hieroglyphic Stairway at Copan takes the form in *c*. The first glyph at the right is a kind of introductory or descriptive glyph, next follows 6 kins with the shell form of kin glyph, 14 uinals, and 11 tuns. It connects a day 11 Ahau — really 11 Ahau 18 Zac — with 6 Cimi 7 Tzec in this fashion:

9–14–15– 0–0,	11 Ahau 18 Zac
11–14–6	
9–15– 6–14–6,	6 Cimi 4 Tzec

Many examples of secondary series might be given which do not conform to the types already described. Often the count is backward rather than forward. Or only one date may be recorded in connection with the distance number. In such cases there may be no way of proving whether the count is backward or forward. An interesting secondary series, which must be counted backward follows shortly after the initial series on Stela K at Quirigua. This leading date is 9–18–15–0–0, 3 Ahau 3 Yax, the month declaration not appearing. Then follow two glyphs, doubtless explanatory if we could only read them, and the distance number 10–10 reaching 1 Oc 18 Kayab by counting the distance number backward. The statement must be of unusual significance because it displaces the supplementary series. After the last glyph of this lunar correlation we find a distance declaration 0–0, or nothing, and a declaration of 3 Ahau 3 Yax. It has been suggested that an occult equation is intended in this inscription which can be written as follows:

9–18–15– 0– 0,	3 Ahau 3 Yax
10–10	subtract
9–18–14– 7– 0,	1 Oc 18 Kayab
0– 0	add to first date
9–18–15– 0– 0,	3 Ahau 3 Yax

On Stela J at Quirigua there is another unusual secondary series. In the usual reversed order it states very clearly the number 0–11–13–3, although no reason is forthcoming why 0 katuns should be written. After one explanatory glyph we find the date 12 Caban 5 Kayab, occurring on several other monuments at this city in the position 9–14–13–4–17, 12 Caban 5 Kayab. But experiment discloses that the only satisfactory explanation of the distance number is that it counts from rather than toward this date. It then will reach an unrecorded period-ending date. The statement becomes:

9–14–13– 4–17,	12 Caban 5 Kayab
0–11–13– 3	
9–15– 5– 0– 0,	10 Ahau 8 Chen

The likelihood that this rendering is correct becomes stronger when another similar secondary series on the same monument is found to lead from another well-known date at Quirigua and reach a quarter-katun-ending date which in this case is the one recorded in the initial series. Many of the problems of Mayan numbers have been solved on the trial and error method.

Period-Ending Dates

Many initial series declare round numbers of days, that is, even baktuns, katuns, and tuns. Methods were devised whereby such dates could be recorded in fewer hieroglyphs than are required in the complete numerical statement of the initial series and yet with greater accuracy than exists in the simple calendar-round declaration. We must suppose that even calendar-round dates were intended to occupy definite positions in the count of days, nevertheless they recur at intervals of 52 years and are to that extent doubtful unless some statement or association fixes them in a particular calendar round.

Period-ending dates are those upon which some designated baktun, katun, or tun end and they consist of the day and month declaration — the former by necessity a day Ahau — combined with a baktun, katun, or tun glyph with a numerical coefficient and an ending-sign. This coefficient indicates the serial number of the period in question in the next larger unit of time.

We have already seen examples of period-ending dates in the short statements of 4 Ahau 8 Cumhu, end of 13 baktuns, the zero of the Mayan day-count. There are various ending-signs, especially notable being the hand and shell sign, the bracket sign, and the

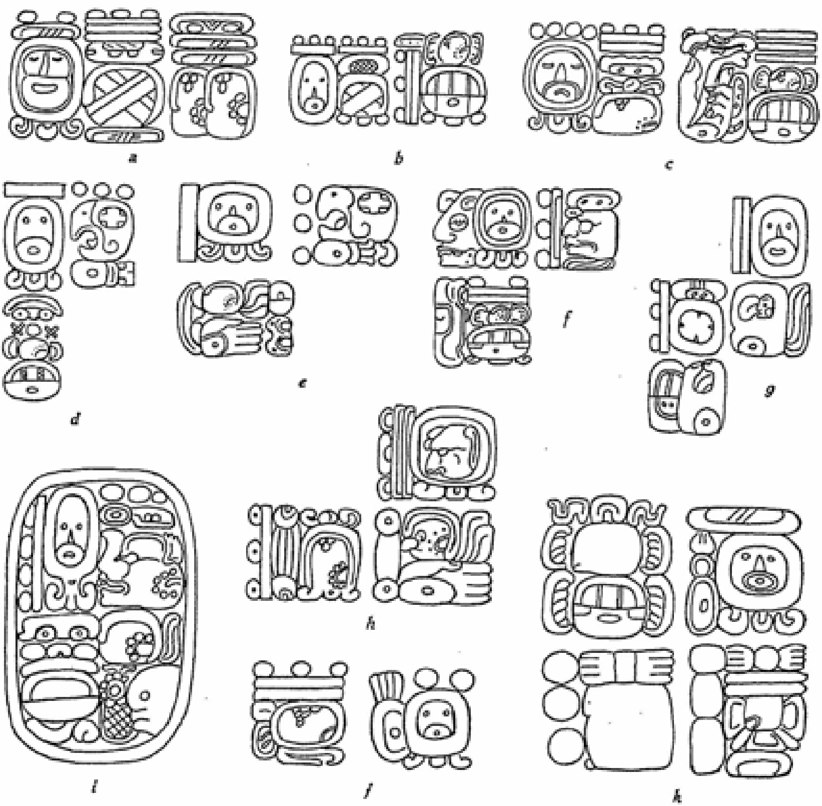


FIGURE 21. EXAMPLES OF PERIOD-ENDING DATES

a, 10–0–0–0–0, 7 Ahau 18 Zip; *b*, 9–13–0–0–0, 8 Ahau 8 Uo; *c*, 9–15–0–0–0, 4 Ahau 13 Yax; *d* and *e*, 10–1–0–0–0, 5 Ahau 3 Kayab; *f* and *g*, 9–12–0–0–0, 10 Ahau 8 Yaxkin; *h*, 9–11–0–0–0, 12 Ahau 8 Ceh; *i*, 9–7–5–0–0, 9 Ahau 3 Zotz; *j*, a tun 13 ending on 2 Ahau; *k*, 9–14–10–0–0, 5 Ahau 3 Mac.

bird's head sign. In the case of baktun and katun endings the ordinary period glyphs are combined with the ending-sign but a special symbol called the hotun symbol is used for the first and third quarters of a katun while another glyph called the lahuntun symbol (see fig. 15, *h*) is employed to record a date on the half

katun or on ten tuns. A winged Cauac symbol is used with tun endings. Various examples of period-ending dates are given in figure 21.

A date which stands at the end of a baktun, katun, or tun will not return till the permutation of possible dates in these positions has been exhausted and this means definition over a long range of time. Since these possible dates comprise four positions in each of the eighteen months plus one position in Uayeb to be occupied by all thirteen Ahaus, the repeat is $13 \times 73 = 949$. That is, there are 949 varieties of baktun, katun, and tun endings. But a tun declared to occupy a definite position in a katun and to end on a definite calendar-round date will not return for 20×949 tuns. Let us take for example the cartouche from the Altar P at Quirigua (fig. 21, *i*) which states that 9 Ahau 3 Zotz ends a 7th tun. Looking through Goodman's table of period-endings we find this date, in its nearest position to the date of the monument, at 9–5–7–0–0, 9 Ahau 3 Zotz. Now, if we look farther, we find that a tun ending on 9 Ahau 3 Zotz returns at intervals of 2–7–9–0–0 thus:

9– 5– 7–0–0,	9 Ahau 3 Zotz
2– 7– 9–0–0	
11–12–16–0–0,	9 Ahau 3 Zotz

But this return does not meet all the conditions since this 9 Ahau 3 Zotz ends a katun numbered 16 rather than 7. A multiple of 2–7–9–0–0 having zero in the third position is necessary and this can only be secured at 2–7–9–0–0–0. In other words $20 \times 949 \times 360$ days or nearly 19,000 years must pass before a designated calendar-round date will end a designated tun.

With such a brief and accurate means of chronological statement at hand we need not wonder that the Mayas gave up the initial series towards the end of the First Empire and depended more and more on period-ending dates.

The U Kahlay Katunob

In the last records of the Mayas we find two kinds of designation of time units not met with, or at least not emphasized, in the ancient inscriptions. Both, however, are perfectly in keeping with the operation of the ancient time machine. One of these late de-

velopments is the U Kahlay Katunob, or record of the katuns, a cycle of thirteen periods of 7200 days each, and the other is the Cuch Haab, or year-bearer, the cycle of which is the old calendar round.

The several brief digests of history, which survived the ruin of Mayan learning, reach back to 176 A.D. Events are referred to as falling in tuns and katuns and it has now been demonstrated that these tuns and katuns are the ancient periods or degrees of value in the numerical system used to count days from the era. The katuns are designated by the day Ahau with which they end and these Ahaus carry the numbers 1 to 13 falling in the order 8, 6, 4, 2, 13, 11, 9, 7, 5, 3, 1, 12, 10, etc., which is, in effect, the designation of the terminal days of a series of katuns in the ancient count, but with the number of days from the era and the month position suppressed. The U Kahlay Katunob, or record of the katuns, has a cycle of 13×7200 or 93600 days. A concordance of the U Kahlay Katunob count with that of the ancient initial series inscriptions has been worked out on the basis that the first katun in the record, a Katun 8 Ahau, is 9–0–0–0–0, 8 Ahau 13 Ceh. This concordance was made possible by the existence in Chichen Itza of an initial series inscription which was placed by Morley in the only available position in the first recorded occupation of the city according to the chronicles. In itself this identification makes a general correlation of European and Mayan time.

In the Mayan chronicles the U Kahlay Katunob is written out in Spanish script. But the original method appears to have been to write the appropriate Ahau with a knotted element or a small serpent, generally without a month declaration. Such records appear in series of katun-ending days in the Temple of the Inscriptions at Palenque and a simple Ahaus without the knot or serpent on pages 2–11 of the Peresianus Codex. This kind of date may also be used in some of the inscriptions of northern Yucatan. We surmise that it had an extensive use in manuscripts, but only the fragmentary passage in the Peresianus Codex gives direct evidence on this score and this passage has not been placed definitely in the long count.

The Cuch Haab

The Cuch Haab, or year-bearer, in Yucatan of the 16th century was the day Kan, Muluc, Ix, or Cauac, standing in the position 1 Pop. To conform with the ancient usage this month position must be changed to 2 Pop. The entire year was designated by its first day and any year called 1 Kan, 2 Muluc, 8 Cauac, etc., would only return after intervals of 52 years since these days were really

FIGURE 22. A PAINTED INSCRIPTION ON A CAPSTONE AT CHICHEN ITZA

the calendar-round dates 1 Kan 2 Pop, 2 Muluc 2 Pop, 8 Cauac 2 Pop, etc. In one way the Cuch Haab system was contradictory to the best traditions of Mayan chronology: it was used to designate current rather than elapsed time. In the U Kahlay Katunob the units of time were named after the last day, in the Cuch Haab after the first day.

Celebrations of first days of the year were held in ancient times according to the codices. One of the most interesting discoveries of Thomas was the parallelism between four pages in the Dresden, two pages of the Peresianus, and four pages in the Tro-Cortesianus Codex given over to the first days of years. In the first manuscript there are thirteen repetitions of the days Eb-Ben, Caban-Eznab, Ik-Akbal and Manik-Lamat, together with pictures of ceremonies. The second day of each set is emphasized in the Peresianus. In the Tro-Cortesianus the days recorded are the next in order, namely Muluc, Ix, Cauac, and Kan. This last presentation is in keeping with the usage in Yucatan at the arrival of the Spaniards. Presumably the year-bearer system was developed by Mexican tribes and introduced among the Mayas by foreign conquerors.

FIGURE 23. A POSSIBLE DATE IN THE CUCH HAAB METHOD ON A CAPSTONE AT DZIBILNOCAC

Most of the historical records of the Aztecs, Zapotecs, etc., follow the year-bearer system. Events are represented in pictures and hieroglyphs attached to the glyph of the year-bearer. No such

manuscripts are known from Yucatan but a few dates pretty clearly of year-bearer type have been recovered. One on a painted lintel at Chichen Itza is reproduced in figure 22. The third and fourth glyphs are 6 Kan 9 tuns and the implication is that the year-bearer 6 Kan is found in a tun 9. This may be either 10-3-8-14-4, 6 Kan 2 Pop, or 11-12-8-13-4, 6 Kan 2 Pop, the latter being the more probable. A second date of a more cryptic type on a painted capstone at Dzibilnocac is reproduced in figure 23. The year is 9 Kan which is bonded with a numeral three. Whether this last signifies the number of a tun or katun or the coefficient of an Ahau in some significant position cannot be decided from this single example.

PART II

MATHEMATICS, MAGIC, AND ASTRONOMY

We are concerned mostly with matters of the calendar, but it should be held in mind that Mayan mathematical records that have come down to our times relate to several distinct operations and problems, and an understanding of these is advisable if the calendar itself is to be understood properly.

Mayan Mathematics

We have already seen how additions and subtractions can be accomplished by a compromise form with vigesimal values built up out of decimal notation. Numbers to be added or subtracted can be arranged as in our decimal system, one number being written directly above another. This kind of presentation is never found in Mayan texts. The nearest approach is where two related numbers are arranged in interlocking orders alternately red and black, either in a simple column or caught in a serpent's folds. Multiplication and division are quick methods of addition and subtraction, and the Mayas probably did not employ either as we understand the processes. But they had multiplication tables. They may have had a glimmering of squares, at least we find $2 \times 260 \times 260$ recorded; that is, a tzolkin of tzolkins, doubled. They were very skilful at reaching common multiples, which they probably achieved by additions. In the following pages an idea of the essential developments in mathematics may be obtained from the examination of cases.

In this paper only the simplest and most direct means will be used in transcribing Mayan numbers, and in reproducing mathematical processes. Short-cuts in carrying out some of the processes have been suggested by the late Charles P. Bowditch and by Raymond K. Morley. Undoubtedly the vigesimal system is capable of interesting applications. The modified vigesimal system of Mayan chronology has limitations and special facilities which must have acted as controls on thought.

Although recorded examples are no longer extant the Mayas undoubtedly made use of the straight vigesimal system in connection with quantities of goods in commerce, tribute, etc., and probably also in censuses of population. The uses of which we have examples are:

First. There are manipulations of the tzolkin to secure magical combinations of days. These manipulations are of astrological

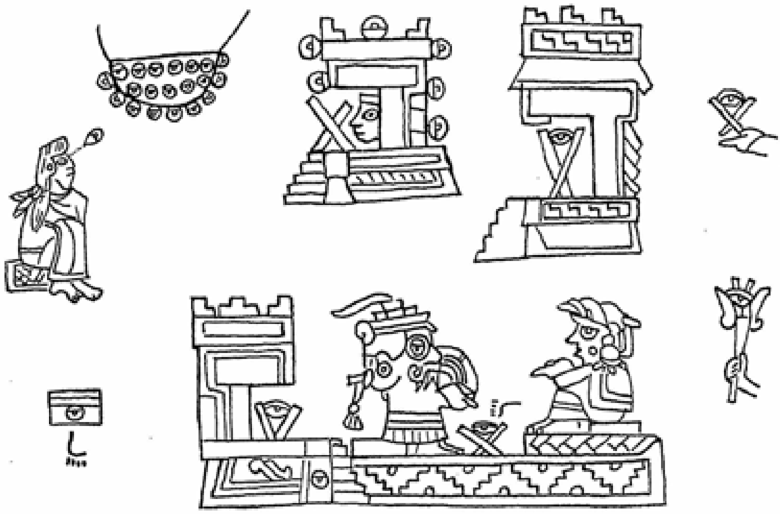


FIGURE 24. OBSERVATION OF THE STARS AS PICTURED IN MEXICAN MANUSCRIPTS

type and are developed in accordance with mechanistic layouts and patterns in which world directions and the patron gods of special numbers are invoked.

Second. There are tabular statements in terms of days and numbers which are in the nature of multiplication tables. The numbers are multiples of a given number and the running correlation with the sequence of days in the tzolkin is a strong check on the correctness of the calculation. The tables are generally calendarial and their purpose is to establish cycles which contain a certain number without a remainder and which also exactly contain the essential permutation of the Mayan calendar. In other words, these tables establish common multiples of two or more periods or groups of days, one of which is always the tzolkin.

Third. There are tabular statements of parts and multiples of

astronomical periods. Sometimes the parts can be pretty clearly identified with the mean intervals in days between the principal aspects or positions of a planet in relation to the sun. The whole

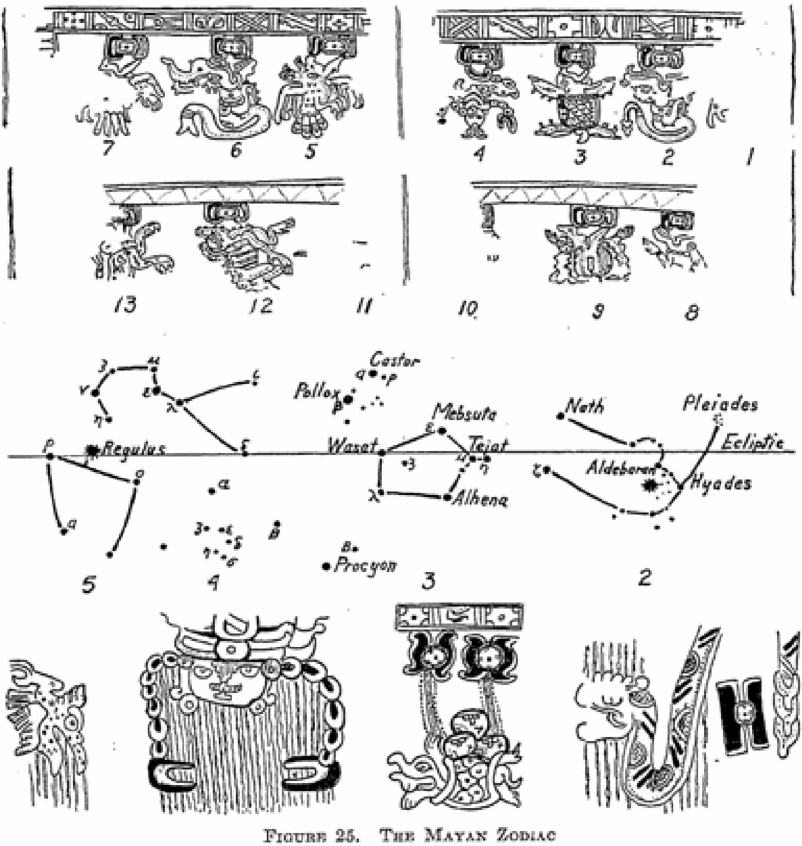


FIGURE 25. THE MAYAN ZODIAC

Upper portion: the Zodiac of the Peresianus Codex, animal figures holding the sun in their mouths associated with 13 sidereal months of 28 days each. Middle portion: possible constellations near the beginning of the Mayan Zodiac, with the Pleiades as the rattle of the snake and the Turtle in Gemini. Lower portion: the signs of the rainy season in the Tro-Cortesianus Codex.

period is then developed by additions till high multiples are reached. Some of the more elaborate tables of this general type have several points of departure in the day-count and are probably intended to serve as generalized statements or as pattern boards of formally related parts which can be adjusted to any given circumstance. In

connection with planetary cycles these are of the type which Bigourdan calls perpetual ephemerides.

Fourth. There is the numerical record of days, counted from the epoch of the Mayan era and containing additions and subtractions. The historical relation of mundane and astronomical events is accomplished in this record.

We have little evidence that the Mayas made use of geometric forms in demonstrations, yet they laid out an astronomical base line at Copan. They surely had some means of registering positions on the celestial sphere, and in this connection observations at the horizon and possibly overhead may have been used. We have pictures of the Mexicans sighting through forked sticks and making observations from temples (fig. 24). We have ample proofs that the conjunctions of planets and constellations were noted. Something akin to a zodiac,[1] but with thirteen divisions instead of the 12 or 28 of the Old World, was probably employed as may be seen by the series of thirteen animals holding the sun sign in their mouths on pages 23–24 of the Peresianus Codex. On the eastern end of the Nunnery at Chichen Itza, several of these animals, found in the same order as above, are combined with the Venus sign. The thirteen-part zodiac was possibly secured from the celestial positions of the sun during thirteen sidereal months, conventionally fixed at twenty-eight days to make a 364-day year. Figure 25 gives the thirteen signs of the Mayan Zodiac as well as a suggestion of the actual configurations of stars used. The series probably started from the vernal equinox. The Pleiades were the rattlesnake's rattle, and the Turtle Stars, associated with the summer solstice, were in Gemini. Even to-day the Indians of Central America are very skilful at telling time by the elevation of the sun, and at night by the dial of stars.

Tzolkin Formulae

Since the tzolkin is such an important factor in Mayan time-counts we are justified in examining its use in magical formulae in the Mayan codices. Among the Mexicans, who adopted the Mayan calendar in principle but who never seem to have acquired any great skill in making calculations, the tonalamatl was known in set forms as far as the determination of good and bad days was con-

[1] See the author's *The Question of the Zodiac in America*, Amer. Anthropologist, 1916.

cerned. But among the Mayas the tzolkin was used in many different ways in condensed presentations.

In the Tro-Cortesianus Codex there are several tzolkin formulae which deal with the planting of maize. In Plate I, *a*, two of these are reproduced in horizontal bands extending across two pages in the manuscript. At the left in each statement is a column of five day-signs with a red numeral at the top. This numeral is the coefficient of each day-sign in the column when its time comes to be counted. At the right, among the pictures, are black and red numerals: the black ones give the number of days to be added and the red ones give the coefficients of the days reached after each addition. These magical patterns can be written out with Roman notation for the red numerals and Arabic notation for the black numerals.

Tro-Cortesianus, p. 27–28*b*	Tro-Cortesianus, p. 27–28*c*
III	XIII
Ik 13 III 13 III 13 III 13	Muluc 13 XIII 13 XIII 13 XIII 13 XIII
Ix	Ix
Cimi	Cauac
Eznab	Kan
Oc	Muluc

If we begin in the first case with 3 Ik and add thirteen days we reach 3 Men and if we add thirteen more we reach 3 Lamat, etc. We find the numerical coefficient of these days recorded but none of the day-signs until we have run the entire line, and then we discover 3 Ix in the second day-sign of the column at the left. The formula is, in fact, an abbreviation of the following table which gives all the days reached when the black distance numbers are added in sequence from each of the five day-signs in the column.

3 Ik	+ 13 =	3 Men	+ 13 =	3 Lamat	+ 13 =	3 Imix	+ 13 =	
3 Ix	+ 13 =	3 Manik	+ 13 =	3 Ahau	+ 13 =	3 Ben	+ 13 =	
3 Cimi	+ 13 =	3 Cauac	+ 13 =	3 Eb	+ 13 =	3 Chicchan	+ 13 =	
3 Eznab	+ 13 =	3 Chuen	+ 13 =	3 Kan	+ 13 =	3 Caban	+ 13 =	
3 Oc	+ 13 =	3 Akbal	+ 13 =	3 Cib	+ 13 =	3 Muluc	+ 13 =	3 Ik

The next tzolkin has a very similar form but begins with a day 13 Muluc. In both cases the pictures have to do with the difficulty of growing maize. In the first picture of the first formula the Rain God plants maize with his digging stick and in the second picture he sees a bird steal the seed. In the third picture the grain has sprouted but a dog is digging it out. In the fourth picture the god

plants more maize while other seeds grow. The second set of pictures shows the Maize God seated on the Caban glyph, which represents the Earth, holding Ik, the Wind, on his hand. In the following picture the Maize God is killed by a bird, next he is attacked but not killed by a dog. A worm attacks the plant in the fourth picture, yet at the last we see the Maize God seated on the Earth and holding out the ripe grain.

A third tzolkin formula likewise concerned with maize is reproduced in Plate I, *b*. Here, in the first picture, the Rain God waters the sprouting maize. Next we see the Maize God attacked by birds and worms. The fourth picture shows the God A [1] talking to God F who may here be a God of Famine, and in the last picture a dog with the maize grain in his eye sits upon the Kan or maize glyph. We are not able, in our present knowledge, to explain all of the symbolism involved in this series of pictures. At the left are two columns of five day-signs, each column having the number thirteen at the top. The calculation proceeds from a day with the coefficient thirteen and reaches the same coefficient again after an addition which amounts to twenty-six, thus:

$$\text{XIII}+9, = \text{IX} + 3, = \text{XII} + 10, = \text{IX} + 2, = \text{XI} + 2 = \text{XIII}$$

This sum must be taken ten times to make 260, and the count goes from the day 13 Imix in column 1 to 13 Manik in column 2 then to 13 Ben in column 1, etc. The major stages are:

13 Imix	+ 26 =	13 Manik	+ 26 =	
13 Ben	+ 26 =	13 Cauac	+ 26 =	
13 Chicchan	+ 26 =	13 Chuen	+ 26 =	
13 Caban	+ 26 =	13 Akbal	+ 26 =	
13 Muluc	+ 26 =	13 Men	+ 26 =	13 Imix

From the pictures which accompany other castings of the tzolkin permutation we learn that nearly all vocations and activities were subject to good and bad combinations of days. Hunting luck is especially emphasized in the Tro-Cortesianus Codex but there are other formulae concerned with raising beans, keeping bees, and weaving cloth, with operating the fire drill and the stone drill, with going on war parties and commercial expeditions, etc. In the Dresden Codex the practical significance of the pictures, which

[1] The names of many Mayan gods being in doubt, a method of designation by letters, suggested by Schelhas, has come into common use. Here the God of Death is called God A.

Passages from Mayan Codices Dealing with Magical Formulae, *a*, Tro-Cortesianus, pp. 27-28: *b*, Tro-Cortesianus, pp. 26-27: *c*, Dresden, pp. 8-9.

usually portray gods, cannot be interpreted so readily. Also the presentation of the formulae is more condensed although the device of a column of day-names at the left with red day-coefficients and black distance numbers is commonly used as above.

The lower two-thirds of pages 8 and 9 of the Dresden Codex (Plate I, *c*) give four condensed tzolkin formulae. The upper pair relate to the numbers 13 and 11 which are figured in connection with a bird's head and a somewhat human face. These numbers may mean 13–0–0–0–0, the point of departure for the long count of days, and 11–0–0–0–0, the baktun of the manuscript. God D, pretty clearly Itzamna the reputed inventor of the calendar, is pictured in both passages in conversation with another deity. In each formula we see black numbers in excess of 20, made by joining bar-and-dot numerals with the conventional moon face.

Page 8*b*	Page 9*b*
VIII	
Manik 26 VIII 26 VIII	Muluc 33 + 32 III
Cauac	Ix
Chuen	Cauac
Akbal	Kan
Men	

In the first example, the two additions of twenty-six amount to fifty-two or one-fifth of a permutation, and the operation is carried out with each of the five days given at the left to reach a complete round. In the second example 32 and 33 amount to 65, or one-fourth of a permutation, and the operation is carried out with four days.

The third and fourth examples in the lower section of Plate 1, *c*, are proved by small additions which are arranged in two columns. In the first case additions of five 9's and 7 make 52, and the repeat is made five times. In the second case the eight numbers only add up to 26 and must be repeated from ten different days. Four deities are pictured but the purposes of the tzolkins are not disclosed.

Page 8*c*			Page 9*c*			
III	XII	VIII	III	III	VI	VIII
Cib	9	9	Cauac	Ben	3	2
Lamat	IV	XIII	Chuen	Chicchan	XI	II
Ahau	9	9	Akbal	Caban	3	4
Eb	IX	III	Men	Muluc	VI	VII
Kan	9	7	Manik	Imix	4	1
					I	III
					7	2

An extensive tzolkin formula is seen on pages 4–10*a* of the Dresden Codex. It extends across the top of seven pages and the pictures of twenty gods are associated with twenty numbers which add up to fifty-two and are repeated in connection with five days in a column. These twenty gods are supposed to be the patrons of the twenty days.

A few especially elaborate tzolkin formulae in the Dresden Codex do not follow very closely the models given above. One is found on pages 31–35*b*. Here the count is really divided into four parts of sixty-five days each and each part consists of the following addition: $9 + 9 + 9 + 2 + 4 + 9 + 4 + 19$. The last number nineteen is emphasized by being drawn three times upon water contained in the folds of a serpent. The days reached by the various additions are declared, instead of being suppressed as is usually the case. In the Tro-Cortesianus Codex, pages 3–6*a*, there is a similar layout associated with hieroglyphs of the four directions and with eighteen instead of nineteen on the coiled serpents holding water.

On pages 33–39*c* of the Dresden Codex is a very full tzolkin with the day-signs as well as their coefficients written out at the end of each addition. It is constructed on 4×65 days but is written out in a single line above no less than twenty pictures showing the Long-nosed God (God B) in various activities. A still more elaborate tzolkin formula is presented on pages 30–33*c* of the Dresden Codex. At the left are four columns with five days in a column, surmounted by the red numeral eleven. The addition proceeds with nine black 13's followed by red 11's. The rows total 117 days and this is the interval between the day-signs. The entire magical pattern covers 20×117 days = 2340 days = 9 tzolkins. The benevolent Long-nosed God is pictured nine times in different activities. There are a few examples of tzolkin without red numbers. One on pages 17–18*b* has a day column with Eb, Kan, Cib, Lamat, and Ahau and the numbers $11 + 7 + 6 + 16 + 8 + 4$. This tzolkin is perhaps intended to run the gamut of all thirteen day-coefficients in connection with the day-signs.

The subject of tzolkin formulae can hardly be exhausted in this brief presentation. We have seen that mundane and celestial operations are pictured in connection with days and numbers. Sometimes the days are those upon which the years begin, that is, they are what the Mayas at the time of the Conquest called year-

bearers. The natural surmise is that the luck pattern in these instances has some relation to the year as a whole. Perhaps other castings were believed to have a coercive action on the gods. For instance in the Tro-Cortesianus Codex, pages 30–31*a*, we see two tzolkins which are pretty clearly concerned with rain. In one the Long-nosed God, who is the Rain God, and an Old Woman Goddess, with spindles in her hair, invert bowls of water; in the other the Long-nosed God is in the center of the panel and at the corners are four Frog Gods with water coming from their mouths: these are associated with the hieroglyphs of the four directions. In other cases some of the added numbers are placed over parts of the body and we are reminded of the pictures of deer in Mixtecan or Zapotecan codices with the twenty days attached to parts of the body. One of the most interesting tzolkin presentations is that of the Tro-Cortesianus codex, pages 75–76, where the arrangement is distinctly cosmogonic. The pattern takes the form of the universality symbol which is used as the sign for zero or completion. The days are first arranged in an inner square with Imix at the west, Ik at the south, Akbal at the east, Kan at the north, and so on through the twenty days. Then the 260 days of the permutation are counted around the edge of the universality symbol, only the days with the coefficients 1 and 13 being represented. In the center of the tableau we see two gods under a conventional tree and in each of the four quarters there are pairs of other gods. Human sacrifice is pictured in the north. This layout is closely paralleled by a page in the Codex Fejervary-Mayer coming from southern Mexico.

Permutations and Common Multiples

The tzolkin formulae just examined are expressed in days but these days are not fixed in months or years. They can occupy seventy-three month positions during the course of fifty-two years, but need not have been cast with these month positions in view. Structurally, the essential permutation, when combined with a 365-day year, divided into eighteen months of twenty days each plus a short extra period of five days, develops a grand cycle of 18,980 days. Each position in the year can be occupied by four different days each with numbers running from one to thirteen. Goodman's tables record the complete set of changes in the calendar round, as has been said.

Another extended permutation combines the tzolkin with the cycle of the planet Venus where eight years of 365 days each are declared equal to five Venus revolutions of 584 days each. This new combination runs through exactly twice the period given above, and equals 104 years of 365 days each. The so-called Venus calendar will receive some attention elsewhere.

The principle involved in these additional uses of the tzolkin is brought out in the simpler cycle of the so-called ritualistic year which consists of 364 days instead of the 365 days of the more accurate civil year. The number 364 has several factors not contained in either 360 or 365 and the ritualistic year may have been chosen primarily for mathematical reasons. This year can be divided exactly into four quarters of ninety-one days each and it contains thirteen just twenty-eight times. Perhaps it was also intended as a measure of sidereal time, especially since it is clearly calculated in the Codex Peresianus in connection with a kind of zodiac. On pages 23–24 of this manuscript we find the ritualistic year divided into thirteen months of twenty-eight days each in connection with pictures of thirteen animals holding the sun in their mouths. Elsewhere the ritualistic year is divided into twenty-eight periods of thirteen days each or into four periods of ninety-one days each. This ritualistic year in groups of five combines with the tzolkin in a reëntering cycle of 1820 days: that is, 5×364 equals 7×260.

The simplest statement of the combined permutation of the tzolkin and the ritualistic year is given on page 32*a* of the Dresden Codex where it takes the form reproduced in figure 26. Here we start at the upper right-hand corner and count toward the left, row by row. We find that 13 Ix is followed in ninety-one days by 13 Chicchan and this in another ninety-one days, by 13 Cib, etc. All the days touched in this permutation have the same coefficient since 91 contains 13 an exact number of times.

13	13	13	13
Manik	Cib	Chicchan	Ix
Chuen	Ahau	Muluc	Eznab
Men	Kan	Ben	Ik
Cauac	Lamat	Caban	Cimi
Akbal	Eb	Imix	Oc

The statement in connection with the zodiacal animals in the

Codex Peresianus is more detailed. The day-coefficients, although repeating in columns, are written out. The count begins as before in the upper right-hand corner and proceeds towards the left; the interval is twenty-eight which may be considered the length of a conventional sidereal month. The permutation begins with 12 Lamat and when twenty-eight days are added to the last station, namely, 10 Ahau in the lower left-hand corner, the cycle reënters at 12 Lamat.

This combined permutation is pretty clearly referred to in the Dresden Codex where a count of 5–1–0, or 1820, is recorded in con-

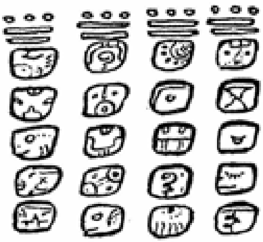


Figure 26. Condensed Permutation Table

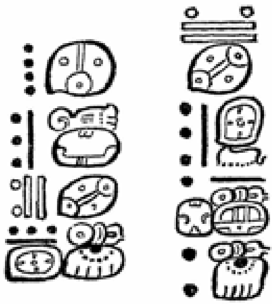


Figure 27. Relations of Ahau and Lamat

nection with 12 Lamat (fig. 27). The first statement reads from top to bottom 4 Ahau 8 Cumhu, 12 Lamat, eight days, knotted Imix. In its nearest position to 4 Ahau 8 Cumhu, the day 12 Lamat occurs at 12 Lamat 16 Cumhu, exactly eight days later. Of course the 4 Ahau 8 Cumhu can be considered to represent the epoch of the Mayan era or any other recurrence.

In the second declaration we see 12 Lamat written at the top of the column, followed by eight kins, one uinal and five tuns, and the last glyph is a knotted Imix with the sign 2. This addition leads to 12 Lamat 11 Cumhu. The two statements can be expressed in relation to the epoch of the Mayan era, as follows:

A.	B.
13–0–0–0–0, 4 Ahau 8 Cumhu	13–0–0–0–0, 4 Ahau 8 Cumhu
8	5–1–8
13–0–0–0–8, 12 Lamat 16 Cumhu	13–0–5–1–8, 12 Lamat 11 Cumhu

The second statement offers no explanation of the numeral 2 in connection with the knotted Imix. Förstemann believed this to be

the symbol of the calendar round. Of course, the conditions repeat at intervals of a calendar round. The following is a typical statement of the possible relationships:

13–0– 0–0–0,	4 Ahau 8 Cumhu
5–1–8	
13–0– 5–1–8,	12 Lamat 11 Cumhu
5– 5–8–0,	2 calendar rounds
13–5–10–9–8,	12 Lamat 11 Cumhu

We shall see this period of 5–1–0, plus 8 for the difference between a day Ahau and a day Lamat, used in very important passages in the ancient inscriptions at Palenque which need not be discussed at this time.

The Table of Mars

Our best chance of understanding Mayan hieroglyphs is to establish the significance of the concomitant numbers. It has been stated that there are astronomical tables in the Dresden Codex which obviously cover mean synodical revolutions of planets, divided into mean intervals between significant aspects or positions in relation to the sun and earth. The tables of Venus and those of the movements of the moon are highly satisfactory and other passages in this wonderful manuscript are believed to treat of Mars, Jupiter, Saturn, and Mercury. A new field of study will open with the day-for-day correlation of the Mayan and Gregorian time-counts. But the planetary tables of the Dresden Codex, compiled after two thousand years of observation had been garnered in books, take a somewhat abstract form. That is, they give patterns of relationship not necessarily expressed in terms of current data and we will therefore have to discover actual statements of contemporary astronomical events in some of the earlier inscriptions. In the matter of the Dresden Codex, calendrical questions are given a wide play and permutations and common multiples are arranged in reëntering cycles.

An interesting table, not too long for easy description, is found on pages 43–45*b* of the Dresden Codex. At the right are four grotesque monsters hanging from the sky and under them is an addition of black numerals leading to red day-coefficients after the fashion of the tzolkin formulae. The day-signs are all suppressed

but they can be restored from the multiplication table that follows. We know the count proceeds from a day 3 Lamat and reaches a day 3 Cimi, 78 days distant.

III + 19 = IX + 19 = II + 19 = VIII + 21 = III
Lamat) (Manik) (Cimi) (Chicchan) (Cimi)

The construction of 78 having been demonstrated in this way the table proper (fig. 28) proceeds from 3 Lamat (declared in

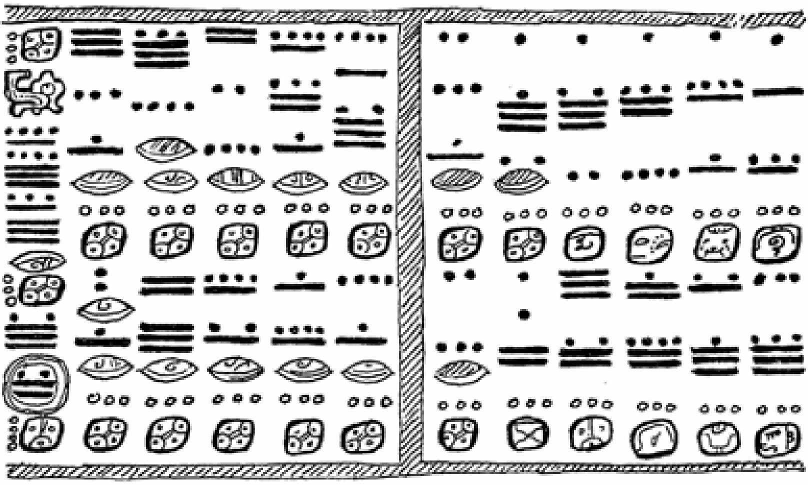


FIGURE 28. THE TABLE OF MARS
Dresden Codex.

the upper left-hand corner) by a distance number written in the lower right-hand corner. This number has three bars and three dots, that is, eighteen, in the bottom position and three dots in the second position. It is, therefore, 78; and under it is written the day 3 Cimi. In other words we have the same number and the same day that was recorded in the addition under the grotesque monsters.

From this base the multiplication table proceeds toward the left for five multiples, then in the upper row for four more multiples and then back to the lower row for the tenth multiple. All the

numbers have the right day, counting accumulatively from 3 Lamat. The first part of the table is therefore:

78, 3 Cimi	$6\times78=468$, 3 Cib
$2\times78=156$, 3 Kan	$7\times78=546$, 3 Ix
$3\times78=234$, 3 Ik	$8\times78=624$, 3 Eb
$4\times78=312$, 3 Ahau	$9\times78=702$, 3 Oc
$5\times78=390$, 3 Eznab	$10\times78=780$, 3 Lamat

When 780 is reached the day is again 3 Lamat since 780 is exactly three times 260. All the days have the coefficient three: this is because 78 contains thirteen without a remainder. The number 780 is next multiplied up to five times, 3 Lamat always being reached.

780, 3 Lamat
$2\times780=1560$, 3 "
$3\times780=2340$, 3 "
$4\times780=3120$, 3 "
$5\times780=3900$, 3 "

Next follow several numbers, four of which must be amended if we are to have multiples. Three are a tzolkin out of the way and while they reach 3 Lamat they are not multiples of 780. First we have a number written 13,000 but perhaps 13,260 was intended; this would be 17×780. Next comes $20\times780=15{,}600$. A number recorded as 30,940 follows which may have been intended for $40\times780=31{,}200$, just 260 days ahead. Sixty-nine thousand six hundred may have been written for 62,400 by putting a dot too many in the katun position. The last suggested correction leads to $93\times780=72{,}540$ in place of the 72,800 actually recorded, which is 260 days ahead. All the rest of the numbers are multiples and include:

$140\times780=109{,}200$
$168\times780=131{,}040$
$184\times780=151{,}320$

The errors, if they are errors, would seem to indicate mental calculation by tzolkins without copy, because only one is really typographical.

Besides these multiples the long number which stands in the column at the extreme left (fig. 28) records $1841\times780=1{,}435{,}980$. It is not exactly an initial series date since it is counted from a

day 3 Lamat 1 Uayeb lying 352 days (the so-called ring number at the bottom of the column) before the epoch of the Mayan era which is 4 Ahau 8 Cumhu.

This passage is supposed to relate to the planet Mars, because of the prominence of the number 780, and the grotesque monsters are called Mars beasts, the head of which becomes a hieroglyph. The mean period of the apparent revolution of Mars is 779.94 days, which is indeed very close to this prominent number. But 780 days also equal exactly three tzolkins.

Mars has an orbit outside that of the earth, and therefore is much nearer to the earth and consequently much brighter when the earth stands between it and the sun than it is at any other time. It is then a full disk in opposition. At superior conjunction Mars is much farther off than Venus in the same situation. The sidereal revolution of this planet requires 687 days.

The nearest concordances between the tropical year and the Mars year are as follows:

I	$32 \times 365.25 = 11688$ days	$15 \times 780 = 11700$ days
II	$47 \times 365.25 = 17166.75$ "	$22 \times 780 = 17160$ "
III	$79 \times 365.25 = 28854.75$ "	$37 \times 780 = 28860$ "

It will be observed that the third correlation is formed on the sum of the first two. Finer calculation reduces the difference in the last example to about five days between 79 tropical years and 37 apparent revolutions of Mars. But 42 sidereal revolutions of Mars consume $42 \times 687 = 28854$ days, which is also very close. This means that the sun, the earth and Mars return to the same relative positions once every 79 years, and in this term we find the natural cycle of the Mars calendar. No evidence is on record that the Mayas took notice of this natural cycle and we may find the reason of this in the fact that 780 already contained their calendrical permutation of 260 days an even number of times. After all it seems to have been the effort of the Mayas to bring planetary cycles into some easy relationship with the basic permutation of the tzolkin which was their common measure of all astronomical time units.

The question arises, what are the outstanding movements or appearances of Mars which would give measuring points to primitive observers. The occurrence of a period of 78 days, just one-

tenth of the entire period of the revolution, in connections with calculations referring to Mars led Willson to suggest that this 78 days was intended for the period of retrogradation. The ring number of Mars is 352 and it happens that 352 days comes pretty close to being the time used by the planet in travelling from the stationary point at the end of retrograde movement to superior conjunction, and again from superior conjunction to the second stationary point. He obtained the following table from an examination of the configurations of Mars for 23 synodical revolutions, remarking that a longer period would give somewhat more accurate averages.

Configurations of Mars and Divisions in Dresden Codex

Conjunction to quadrature	283.67		
Quadrature to stationary	69.45	353.12	352 (351)
Stationary to opposition	36.73		
Retrograde motion		73.45	76 (78)
Opposition to stationary	36.73		
Stationary to quadrature	69.45	353.12	352 (351)
Quadrature to conjunction	283.67		
Complete synodic revolution		779.69	780

The correspondence here is very close, which is all the more remarkable because actually the times which are given above in the mean vary widely. Stationary to stationary, the total period of retrograde motion, runs from 60 to 84 days, and the interval from conjunction to quadrature runs from 240 to 330 days. Dealing with such erratic data as these we must wonder at the Mayan astronomers reaching such accurate averages, if, indeed, the explanation is correct. After all the strongest reason for supposing that Mars is under consideration is a general parallelism to the passages in which Venus and the moon are treated.

The Lunar Correlation

The table of numbers on pages 51 to 58 of the Dresden Codex shows, even when studied abstractly, a truly marvelous accuracy in observations of the moon. The movements of this satellite are correlated with the tzolkin and a reëntering cycle is found in which days and groupings of lunations repeat. In this cycle 405 lunations are correlated with 46 tzolkin or 11,960 days. By modern astronomical calculation 405 lunations equal 11,959.88845+ days.

The discrepancy is so small that the cycle can be used eight times in succession before a single day's error accumulates. Moreover, the table is so arranged that the count can begin with any one of three days which are found in succession in the tzolkin. If the count is carried from 12 Lamat for eight rounds, it can then be moved forward to 11 Manik to offset the error of one day which has accumulated by this time, and after eight rounds at this base it can be advanced one day more to 10 Cimi which will serve for another eight cycles. In other words this table, which clearly begins with 12 Lamat as we shall see, covers the moon's movements for nearly 800 years with entire accuracy so far as the terminal dates of the lunar-tzolkin cycle are concerned. To be sure, this statement rests upon modern determinations of the length of the lunation, and it might be argued that this astonishing correspondence does not constitute proof that the Mayas were aware of the degree of accuracy involved in this application of their lunar table.

Before discussing this point let us examine more attentively the construction of the table. The lunations which we recover in numbers and day-signs are presented in groups of five and six, the former recorded as 148 days and the latter as either 177 or 178 days. This means that the Mayas had the means of approximating the times of the moon, actually consisting in synodic revolutions of 29.53058877315 days, by manipulating blocks of 5×29.6, 6×29.5 and 6×29.66667 days. The table shows that they used nine groups of the first type, 54 of the second and seven of the third to make up the total of 405 revolutions, the allocation being somewhat irregular.

The count begins on page 53 of the Dresden Codex after a multiplication table which will be considered presently, and proceeds to page 58 in the upper half of the manuscript. Then it passes to the lower half of page 51 and continues to page 58.[1] Nine pictures interrupt the count and a tenth is given at the end. This passage can be regarded as a single strip for purposes of study. At the bottom of the strip we find a series of numbers, which are the numbers of days in the various groups of lunations, written in red and black numerals.

[1] See Förstemann, *Commentary on the Dresden Codex*, pp. 200–15; Bowditch, *Mayan Numeration, Calendar Systems and Astronomy*, pp. 211–25; Guthe, *A Possible Solution of the Number Series on Pages 51 to 58 of the Dresden Codex*.

Above these are the three lines of day-signs already referred to in connection with the three shifts in the lunar-tzolkin cycle. At the beginning of the strip the initial day-signs are, from top to bottom, 6 Kan, 7 Chicchan, 8 Cimi. Under these three day-signs we have the number 177 and this is also the interval between these first days in each row and the second days which are 1 Imix, 2 Ik, 3 Akbal respectively. But it must be pointed out that the table actually begins from the three final days in each row which are 10 Cimi, 11 Manik, and 12 Lamat, 178 days before the days 6 Kan, 7 Chicchan, and 8 Cimi. We have every reason to believe that the day 12 Lamat is regarded as the initial day of the entire table because this day is involved in high multiples of the 11,960-day cycle.

There is an upper line of numbers which gives an accumulative count in black numerals. This count is not exactly in agreement with the day-signs; it runs parallel up to the 22d group but with the 23d group records 3986 days while the day-signs register 3987 days. The upper numbers for groups 24–46 register another 3986 and those for groups 47–69 repeat the interval. Therefore, the total amount reached in the upper row of numbers is 11,958. The total reached by the lower line of numbers is 11,959 and the total reached by the day-signs, if these are made to count from the last member, is 11,960 but here it must be noted that the first interval becomes 178 to achieve this reëntry. What is the explanation of these curious adjustments?

The lunations are not grouped in this table of the Dresden Codex to form years of the luni-solar type, nor are they grouped to form the nearest approximations to tuns. But they are grouped very cleverly to form close approximations to ecliptic intervals. Undoubtedly the Mayas could predict eclipses, because the intervals which they emphasize in the lunar table are precisely the intervals which are found to intervene between eclipses either of the sun or of the moon. Eclipses of the sun occur at the time of the new moon and eclipses of the moon occur at the time of the full moon, which means that intervals applicable to either occur at a fifteen-day offset. To be sure eclipses of the sun have a narrow path of shadow, and fewer solar than lunar eclipses are visible from one spot on the earth's surface. The common intervals are 177 and 178 days or 502 days which is composed of 177+177+148, and these appear

constantly in the lunar table of the Dresden Codex. The Mayas express with entire accuracy the famous classical period of the Saros (223 lunations = 6585 days), after which eclipses generally recur, but they paid more attention to the period of 3986 or 3987 days (135 lunations = 3986.63 days), because it was a third of their major cycle of 11960 days which exactly contained the tzolkin. This ecliptic period of 3986 or 3987 days is called by Professor Willson the Mayan Saroid.

In connection with the long lunar table there is on pages 51*a* and 52*a* a multiplication table for 11960 counted from the day 12 Lamat but also applicable to four other days with essential intervals from 12 Lamat of 15 days. These are: 12 Lamat+15=1 Akbal+15=3 Eznab +15=5 Ben + 15 = 7 Lamat. Each of the five days is repeated seven times in a row and perhaps the intention is that each of the five designated days can stand at different places in the historical record. Above the block of day-signs are interlocking red and black numbers which are in most cases exact multiples of 11960. At the top of the page a double row of hieroglyphs is mostly erased.

Before considering the long numbers recorded on either side of the multiplication table let us look at the multiples. We have seen that the black numbers in the lunar table reached 11958 (3×3986) while the day-signs formed a reëntering series at 11960 which in Mayan notation is 1–13–4–0. Now the first term in the so-called multiplication table is 1–18–5–0 which equals 11960+1820. If a mistake, the error is 5–1–0, an exceedingly important interval; probably, therefore, the record is exactly as intended. The interlocking appears to be for condensation solely. The uncorrected table reads:

1st term		1–18– 5–0	11960+1820
2d	"	3– 6– 8–0	2×11960
3d	"	4–19–12–0	3×11960
4th	"	6–12–16–0	4×11960
5th	"	8– 6– 2–0	5×11960
6th	"	9–19–12–0	6×11960+120
7th	"	1– 6–11–10–0	16×11960
8th	"	1– 8– 4–14–0	17×11960
9th	"	1– 9–18– 0–0	18×11960
10th	"	2–11–11–11–0	31×11960+260
11th	"	3– 4–15–12–0	39×11960

The long numbers on pages 51*a* and 52*a* are placed on either side of the multiplication table. At the left (fig. 29) is a red number interlocking with a black one in a single column and on the right we find two red numbers interlocking with two black numbers in two columns as well as a peculiar column of thirteen red 13's. We will begin with the four numbers in this second group which are of the initial series type counted from 4 Ahau 8 Cumhu. Two typographical corrections are necessary to get a layout which reaches the four indicated days. It will be observed that we have here four of the five days appearing in connection with the multiples of 11960, the month positions being recovered in each case by calculation. We assume that the fifth day below the multiplication table was also tied into the long count but are unable to recover its position. The fourth date in the series above is exactly 60 Mayan years from the first one. For three numbers, the interval is still the 15 of the unplaced day-signs while in the other case it is 15 plus an exact number of tzolkins.

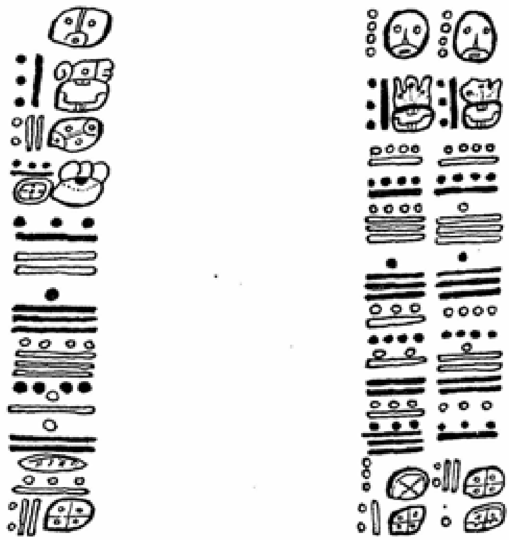
9–16–4–10– 8,	12 Lamat 1 Muan
15	
9–16–4–11– 3,	1 Akbal 16 Muan
15	
9–16–4–11–18,[1]	3 Eznab 11 Pax
3–0–13–10	
9–19–5– 7– 8,[2]	7 Lamat 1 Muan

The third column in from the right has thirteen red 13's, one above the other and this is topped by a secondary series of 5–1–8 and a knotted Imix glyph carrying this numeral 2. The calculation here is probably related to that of the single column at the right of the multiplication table. At the top of the last mentioned column 4 Ahau 8 Cumhu is recorded, next comes 12 Lamat and a secondary series of eight days with a knotted Imix, 12 Lamat is just eight days after 4 Ahau and the knotted Imix possibly means a tzolkin-planetary cycle. Another declaration of 12 Imix is seen at the bottom of the column. The two long numbers are probably intended for 8–16–4–8–0 and 10–19–6–1–0 although slight emendations are necessary to secure these readings.

[1] Written 9–16–4–10–18, a dot wanting in the uinal.
[2] Written 9–19–5–7–8, 3 dots too many in the tun.

1.		2.	
13- 0-0-0-0,	4 Ahau 8 Cumhu	13- 0-0-0-0,	4 Ahau 8 Cumhu
8-16-4-8-0 [1]		10-19-6-1-8 [2]	
8-16-4-8-0,	4 Ahau 3 Zip	10-19-6-1-8,	12 Lamat 6 Cumhu
8			
8-16-4-8-8,	12 Lamat 11 Zip		

While these long numbers reach the day 12 Lamat and imply the epoch of a special era eight days removed from the original 4 Ahau



a *b*

FIGURE 29. DATES IN THE LUNAR TABLES

Dresden Codex.

8 Cumhu that serves as zero for the Mayan day-count (see page 63), they do not have any immediate relationship to the interval 11960. This interval does occur, however, between emphasized dates in the codices some of which also appear in the inscriptions on ancient monuments.

[1] Written 8-16-4-10-0.

[2] Written incorrectly unless the black dot under 6 tuns which has been repainted red is intended for the uinal as is probably the case.

Other Important Tables

Some mention has already been made of the wonderful pattern table of relationships for the movements of Venus and the permutations of Mayan time-counts. This table is recorded on page 24 and pages 46–50 (which are really consecutive). The interval is 2920 and the calculation is made from 1 Ahau. We have already examined the Mars table with 78 and 780 counted from 3 Lamat, and there is another with the same interval counted from 13 Muluc as well as the lunar table with 11960 counted from 12 Lamat. Tables of multiples and long numbers which are mostly concerned with the so-called ritualistic year of 364 days are found as follows:

31a–32a	interval	91	beginning	day	13 Akbal
62–64	"	91	"	"	13 "
45a	"	364	"	"	13 Oc

Besides these there are tables which Willson believes are concerned with the planets Mercury, Jupiter, and Saturn.

Enough has been given to show that the Mayas were interested in recording astronomical periods and in measuring astronomical time by an unswerving permutation.

PART III

THE CORRELATION OF NEW AND OLD WORLD CHRONOLOGY

THE only people in the New World possessing an accurate system of registering time were the Mayas of the Central American lowlands. Their history must therefore provide the standard section of time relations in ancient America to which the history of other nations must ultimately be referred. It becomes a problem of great importance to link the Mayan chronology of the New World to the already correlated systems of measuring time in the Old World in such a fashion that universal time levels may be established in the general history of man.

The greatest period of Mayan civilization came to an end many centuries before the coming of the Spaniards. We find a mass of dates on monuments in numerous deserted cities whose very names are unknown. There had been a Renaissance and that too had failed. While the Mayas had reduced much of their learning to books which existed in quantity at the coming of the Spaniards, only three, and those in a fragmentary condition and without any commentary, escaped the blind zeal of the priests who tried to root out every trace of the ancient culture. Fortunately a few educated Mayas brought together some fragments of ancient history and ceremonial matter in the Books of Chilam Balam, written in Mayan words but Spanish script.[1]

Bases of Correlation

In our effort to effect a correlation of the Mayan calendar with our own we must begin with tenuous indications: we must clarify a confused record and rebuild a time machine of marvelous and intricate parts. The ancient documentation is accurate enough

[1] There are five historical digests of unequal merit in the Books of Chilam Balam of Mani, Tizimin and Chumayel. The last volume contains three digests in addition to scattered statements. Then there is the Chronicle of Nakuk Pech, a much confused account in Maya of the Conquest, the Xiu Manuscript or Chronicle of Oxkutzcub, and the account of the bigoted Landa which probably is based on material collected by various priests. Other matter is contained in the histories of Herrera, Cogolludo, etc.

so far as relative dating of monuments for a period far in the past is concerned. But it must be moored fast to our own history through the much more doubtful documentation of the 16th century. It is true that a few double-dated records with accuracy above reproach would accomplish our purpose, but such double dates as do exist are not above reproach.

No single line of evidence should be deemed sufficient to decide this all important question. It must be decided on a harmonious coördination of:

(1) Cultural developments and especially artistic sequences in sculpture and architecture throughout the range of Mayan history.
(2) Inscribed dates on monuments of the First Empire.
(3) Traditional history in the Books of Chilam Balam.
(4) Astronomical statements.

The careful examination of stylistic criteria in sculpture already has validated the contemporaneous and therefore historical character of many inscribed dates since the time when the writer proved that the stylistic order of practically all Copan monuments agrees with the sequence of the final dates.[1] By the touch stone of art it has been possible to place many calendar-round dates in their proper position in the long count. The relative chronology of the cities of the First Empire is now upon a very certain basis as a result of cross-referencing studies.[2] After the close of this brilliant period, dates were no longer commonly inscribed. It is still possible to indicate the course of change in the art although not in terms of years.

As for the last two lines of evidence there is in the Books of Chilam Balam a meager but dependable series of historical facts reaching back to 176 A.D. and almost certainly overlapping with the inscribed record. Analysis of the calculations in the Dresden Codex forces the conclusion that the Mayas were fine astronomers. Their calculations must somewhere reveal a combination of astronomical facts capable of being placed in the chronological scale.

[1] First published in a table dated July 25, 1910, presented at the 15th International Congress of Americanists, Mexico City, 1910, amplified in a *Study of Maya Art*. 1913.

[2] Attention is called to S. G. Morley's inscriptional and artistic analysis in his *Inscriptions at Copan* (Carnegie Institution of Washington), 1920; to the present author's *Recent Progress in the Study of Maya Art*, 19th International Congress of Americanists, Washington, 1917; and to S. K. Lothrop's *Tulum, an Archeological Study of the East Coast of Yucatan*, Carnegie Institution of Washington, 1924.

Most of the attempts at correlation in the past have been made by following out a single line of evidence and in several cases these earlier correlations were based on assumptions long since proved erroneous. Mention may be made of the correlations of Perez, Carrillo, Valentini, Brinton and Thomas who dealt with little more than the historical material in the Books of Chilam Balam, and of Goodman, Seler, Bowditch and Förstemann who considered also the material in the inscriptions. More recently Lehmann has attempted the placing of Mayan dates by reference to the archeology and traditions of Mexico, and Willson has given us an explanation of the astronomical possibilities revealed in his study of the Dresden Codex.

Structural Correlation of the U Kahlay Katunob

Of another type is Morley's fundamental correlation [1] between the ancient inscriptional system and the U Kahlay Katunob, or record of the katuns, found in the Books of Chilam Balam, which was used with some modification by the writer. The correlation suggested by Morley is distinctly of the mechanistic type, controlled by the supposition that the initial series date at Chichen Itza — the only such date found at any city mentioned by name in the chronicles — was of contemporaneous import and that it fell during the first recorded occupation of that city in the historical synopsis.

Now Chichen Itza was "discovered" or "learned about," say the Books of Chilam Balam, in a Katun 8 Ahau or 6 Ahau, the first coming one round of katuns after the initial date in the digests. It was abandoned in a Katun 1 Ahau, or possibly a little later, after a residence of at least 120 years. The old style date on the Tablet of the Initial Series read 10–2–9–1–9, 9 Muluc 7 Zac falls in a katun which will close as 10–3–0–0–0, 1 Ahau 3 Yaxkin. On the theory that the number and the month of the long count are suppressed in the U Kahlay Katunob this is Katun 1 Ahau. The only Katun 1 Ahau of the residence at Chichen Itza lies just before the abandonment of the city and the evidence indicates that many cities were abandoned at about this time. This arrangement

[1] *The Correlation of Maya and Christian Chronology.* Am. Journal of Archaeology, 1910, XIV, pp. 193–204.

furnishes a general correlation of European and Mayan time accurate within the length of a katun but it is not a day-for-day arrangement unlocking the deeper mysteries of Mayan inscriptions.

In his original publication in 1910 Morley was unable to see his way clear as regards a number of really important points. For instance he says:

"Katuns were named after the days with which they began, or as some contend, after the days with which they ended. This difference of opinion is merely a quibble as to the starting point and does not affect the sequence of the katuns which is the same in either case. In this discussion, katuns are regarded as having been named after the days with which they began."

We know now that katuns were named after their ending days, a fact that inevitably follows from the original use of the katun as the fourth degree in a notation system devoted to the counting of elapsed time from a definite starting point. Properly the definition of Morley permits a maximum chronological displacement of 7200 days but he achieved sharper statements in a few instances. A date was reached for Stela 9 of Copan, 9–6–10–0–0, 8 Ahau 13 Pax, "between the years 284 and 304 A.D. depending on what tun of Katun 13 Ahau coincided with the year 1536." On the basis of the much discussed date that records the death of Ahpula Napot Xiu he reached 294 A.D. for the dedication of the Copan monument named above. While the death of Ahpula Napot Xiu pretty clearly belongs in 1545 rather than 1536, it must be admitted that long-range marksmanship enabled Morley to hit close to the target. Nevertheless, real precision was wanting, and no effort was made towards a correlation of the Gregorian day and the Mayan day.

Indeed, in a more recent survey of the question of correlation, Morley doubts that a day-for-day correlation can be achieved. He says: "These native records are more or less contradictory, especially in regard to the exact Maya equivalents for specific days in the Christian Era, for which reason it appears hazardous to push this evidence to the point of deriving from it a correlation for which accuracy is claimed to the very day. This is attempting to read the vernier-scale of our instrument more accurately than the instrument was built to register."

The answer to this contention is that the vernier-scale of the Mayan calendar is essentially one of specific days and any loose

correlation of the larger time units inevitably hangs on the inviolability of the day-count. To be sure there are contradictory statements and a decision must be rendered on the weight of evidence. The method pursued in the following demonstration will be to establish a broad focus on larger units of time and follow this by a sharp focus on definite days. It will be shown that all the problems of correlation narrow down to a very few structural possibilities determined by:

(1) Statements concerning the closing of Mayan katuns of the U Kahlay Katunob in European years.

(2) Statements involving the position of Mayan days of the tzolkin, and months of the haab in European years.

Two assumptions are made, both of which are clearly indicated in matter that has already been presented. One of these is that the Mayan haab was a vague year with the months slowly displaced in the seasons at the rate of slightly less than one day in four years. This axiomatic assumption follows from the fact that solar, lunar, and planetary matters are all treated in Mayan calculations and the periods are expressed in numbers of days allocated in months of the haab. Any leap-year intercalation invalidates a day-count for other matters than the tropical year. The second assumption is that the permutation of the tzolkin, and the succession of haabs was continuous from ancient times to the Spanish Conquest and that the katuns of the U Kahlay Katunob were units of a numeration system also counted continuously. This means that the ancient calendar was maintained through all disguises exactly as the count of the Christian Era is maintained when such an ambiguous short-hand designation as June 1, '24 is used in dating. The downward shifting in the month of day positions can be explained without assuming that there was an actual dislocation in the numerical record, such as took place in the European calendar at the Gregorian reformation. The correlations developed by the writer on the basis of these assumptions and a critical scansion of all available historical statements was announced in 1919 and the astronomical proofs of its correctness were developed long afterwards, beginning with September, 1923. This means that there has been no qualification of results.[1]

[1] The correlation explained below was presented at the Boston Meeting of the American Association for the Advancement of Science in 1919, and a digest of the findings published in the Journal of the National Academy, under date of Dec. 23, 1919.

Statements Regarding Katuns

We will begin our specific examination with statements that connect definite katuns in the U Kahlay Katunob with the European system of dating. These are seldom very exact, but in the aggregate the indications are extremely important.

Katun 2 Ahau. The Chronicle of Nakuk Pech (pp. 226–227) reads: "Thus the land was discovered . . . in 1517. In this year the katun ended, and then ended the placing of the town stone, for at each twentieth stone they came to place the town stones. . . ."

The Book of Chilam Balam of Tizimin states that the coming of foreigners to Yucatan was in (or after) the 13th tun of Katun 2 Ahau. According to the arrangement that will be submitted presently, the end of Katun 2 Ahau was a day 2 Ahau 3 Pop immediately following 1 Cauac 2 Pop, the first day of the year 1 Cauac, 1516–17. Katun 2 Ahau came to an end in 1516 rather than 1517 but in a Mayan year which partly coincided with 1517. The first persons known to have reached Yucatan were the shipwrecked sailors from Valdivia's ship, and the priest Geronimo de Aguilar. This shipwreck was near the end of 1511.

Katun 13 Ahau. The death of a certain chieftain or sorcerer, Ahpula Napot Xiu, is referred to four times in the Books of Chilam Balam, thrice as having taken place in this katun and once as having occurred in Katun 11 Ahau. This event will be discussed later after more evidence has been put on the table.

In the Chronicle of Chumayel we find the statement: "Katun 13 Ahau, first appeared the ships of the strangers at Campeche." This may refer to the base established by Montejo at Campeche in 1531 from which he attempted to conquer Yucatan.

Katun 11 Ahau. Nakuk Pech says: "The fifth division of Katun 11 Ahau was placed when the Spaniards arrived and settled the city of Merida" — which they did on Jan. 6, 1542. He also states that this was in a year 13 Kan. Now these two statements of Nakuk Pech are in complete agreement with the restored calendrical layout and they raise a rock of assurance.

In the various chronicles the permanent occupation of Yucatan by the Spaniards is stated to have taken place in Katun 11 Ahau and in one passage in the seventh tun of this katun. We have

already been told that the foundation of Merida took place in the 6th tun. Within a year after this date the country was completely in control of the Spaniards. Says the Chumayel Manuscript: "This year 1542 it was wherein was founded the district of Tihoo (Ichcaanziho) Katun 11 Ahau it was, and the first ruler was Don Francisco Montejo, the Adelantado. Then the towns were given to the strangers, the strong men; in the year 1542 the tribute began, 1545 was the year when the fathers came . . . it happened four years after the strangers came and then also began baptism . . . and the towns were divided."

Landa makes a definite statement which is wrong as it stands. We may imagine that he misunderstood a reference to the first hotun of Katun 11 Ahau. He writes: "The Indians say, for example, that the Spaniards first arrived at the city of Merida in the year of the nativity of our Lord 1541, which was precisely the first year (sic!) of the era of Buluc Ahau (11 Ahau) . . . and that they arrived in the very month of Pop, that is the first month of this year." This arrival preceded the founding of Merida by several months.

Katun 9 Ahau. Out of the confusion comes a gratifyingly close check on the coming of Bishop Toral. According to a letter in the Cartas de Indias he took office on August 15, 1562. We find in the Annals of Tecamachalco that he dispatched a letter to his old companions on Aug. 20, 1562. The arrival was shortly after the completion of the 6th tun instead of within this tun as the Mani MS. avers. But this would make Katun 11 Ahau end in 1556 in agreement with the ending of Katun 13 Ahau in 1536. Toral stopped the hanging of Indians and the autos-da-fé of Landa too late to save the precious relics. His coming is confused somewhat with the arrival of the first priests in 1545.

Katun 7 Ahau. Still other references in the Mayan chronicles place the death of Landa in Katun 7 Ahau. This fell on April 29, 1579, and was safely within Katun 7 Ahau if Katun 9 Ahau ended in 1575.

Katun 3 Ahau. Skipping the next katun we find from Villagutierre's History of the Conquest of the Province of the Itza that when certain priests arrived to convert the Indians of Tayasal in 1618 that Katun 3 Ahau was still running. Avendaño's journal contains references to the maintenance of considerable knowledge

of the ancient time-counts among the refugee Itza, their statements placing the abandonment of Chichen Itza in Katun 8 Ahau before the coming of the Spaniards.

Morley discusses the references epitomized above at great length. But in the last analysis there is a difference of one tzolkin between the structural necessities of Morley's arrangement and the one reached in the present thesis. The delimitations achieved by these references to katun endings and events in katuns work practically as well for one arrangement as it does for the other. One difference is in regard to Katun 2 Ahau which ended in a Mayan year corresponding in part to 1517, although the event itself took place in 1516. The main point, as we shall see, is that no evidence points to the year 1539 for the ending of Katun 13 Ahau nor is there any record of other katuns ending at intervals of 7200 days from a base in 1539. On the other hand there is plenty of evidence for their ending at this interval from a base in 1536. Our broad focus places the end of Katun 13 Ahau, then, in the year 1536, and we will now attempt a sharper definition on the theory that the particular Katun 13 Ahau of 1536 was 12–9–0–0–0, 13 Ahau 8 Kankin, in the designation of the ancient calendar as indicated by the arrangement which makes 9–0–0–0–0, 4 Ahau 13 Ceh, the epoch of the U Kahlay Katunob.

Year-Bearer Statements

The year-bearer or Cuch Haab was a day Kan, Muluc, Ix or Cauac falling on 1 Pop. In the ancient usage this would have been 2 Pop so any year-bearer statement implies a calendar-round date, 13 Kan 2 Pop, 7 Cauac 2 Pop, etc. The first days of years appear to have been celebrated by special ceremonies at the time the codices were compiled but the employment of these days to designate the current year was probably due to the influx of a Mexican custom. Year-bearer data can be translated in 52 year stages back (or up) to the table given below which covers one complete round. The record is full and free from doubts.

Merida is distinctly stated to have been founded on Jan. 6, 1542, in a year 13 Kan, which began, of course, in 1541, and there are statements in both the Tizimin and Mani Manuscripts that another year 13 Kan came fifty-two years later in 1593. The Chumayel

says 1537 was a year 8 Cauac. A year 7 Cauac is also said by Cosme de Burgos to have corresponded to 1392. The priests came in a year 3 Cauac equalling 1544. Finally there are several passages in the Mayan chronicles which record sequences of from 13 to 53 years. All these sources are in essential agreement and enable us to reconstruct a complete year-bearer cycle.

TABLE V. — MAYAN YEAR-BEARERS IN THE SIXTEENTH CENTURY

1 Kan	1529–30	Muluc	1542–43	Ix	1555–56	Cauac	1568–69
2 Muluc	1530–31	Ix	1543–44	Cauac	1556–57	Kan	1569–70
3 Ix	1531–32	Cauac	1544–45	Kan	1557–58	Muluc	1570–71
4 Cauac	1532–33	Kan	1545–46	Muluc	1558–59	Ix	1571–72
5 Kan	1533–34	Muluc	1546–47	Ix	1559–60	Cauac	1572–73
6 Muluc	1534–35	Ix	1547–48	Cauac	1560–61	Kan	1573–74
7 Ix	1535–36	Cauac	1548–49	Kan	1561–62	Muluc	1574–75
8 Cauac	1536–37	Kan	1549–50	Muluc	1562–63	Ix	1575–76
9 Kan	1537–38	Muluc	1550–51	Ix	1563–64	Cauac	1576–77
10 Muluc	1538–39	Ix	1551–52	Cauac	1564–65	Kan	1577–78
11 Ix	1539–40	Cauac	1552–53	Kan	1565–66	Muluc	1578–79
12 Cauac	1540–41	Kan	1553–54	Muluc	1566–67	Ix	1579–80
13 Kan	1541–42	Muluc	1554–55	Ix	1567–68	Cauac	1580–81

Tentative conclusions so far reached are:

(1) That the Katun 13 Ahau of the Conquest was 12–9–0–0–0, 13 Ahau 8 Kankin of the long count according to the structural correlation of katuns.

(2) This Katun 13 Ahau came to an end in 1536, according to the general evidence of references to katuns.

(3) That the year-bearer was a day Kan, Muluc, Ix, or Cauac in the position 2 Pop in the ancient usage and 1 Pop in that of the 16th century.

(4) That the year 7 Ix corresponded to 1535–36 and the year 8 Cauac corresponded to 1536–37, according to the general evidence on year-bearers which is very full and satisfactory.

We are now in a position to bring the statements of year-bearers into formal relationship with the katun declaration in a table which fully justifies our method. It shows that 12–9–0–0–0, 13 Ahau 8 Kankin fell in the second half of the year 7 Ix and therefore pretty safely in 1536. Table VI is extended from the year 7 Ix in which Katun 13 Ahau fell, to the year 4 Kan in which the death of Ahpula Napot Xiu is stated to have occurred.

TABLE VI. — MAYAN YEAR-BEARERS AND THE LONG COUNT

Long Count — Old Nomenclature			Event	New Nomenclature	
12-8-19- 4-14,	7 Ix	2 Pop	Beginning of Year 7 Ix	7 Ix	1 Pop
13- 6					
12-9- 0- 0- 0,	13 Ahau	8 Kankin	End of Katun 13 Ahau	13 Ahau	7 Kankin
4-19					
12-9- 0- 4-19,	8 Cauac	2 Pop	Beginning of Year 8 Cauac	8 Cauac	1 Pop
1- 0- 5					
12-9- 1- 5- 4,	9 Kan	2 "	" " " 9 Kan	9 Cauac	1 "
1- 0 -5					
12-9- 2- 5- 9,	10 Muluc	2 "	" " " 10 Muluc	10 Muluc	1 "
1- 0- 5					
12-9- 3- 5-14,	11 Ix	2 "	" " " 11 Ix	11 Ix	1 "
1- 0- 5					
12-9- 4- 5-19,	12 Cauac	2 "	" " " 12 Cauac	12 Cauac	1 "
1- 0- 5					
12-9- 5- 6- 4,	13 Kan	2 "	" " " 13 Kan	13 Kan	1 "
1- 0- 5					
12-9- 6- 6- 9,	1 Muluc	2 "	" " " 1 Muluc	1 Muluc	1 "
1- 0- 5					
12-9- 7- 6-14,	2 Ix	2 "	" " " 2 Ix	2 Ix	1 "
1- 0- 5					
12-9- 8- 6-19,	3 Cauac	2 "	" " " 3 Cauac	3 Cauac	1 "
1- 0- 5					
12-9- 9- 7- 4,	4 Kan	2 "	" " " 4 Kan	4 Kan	1 "
2-17					
12-9- 9-10- 1,	9 Imix	19 Zip	Death of Ahpula Napot Xiu	9 Imix	18 Zip

Landa's Typical Year

Our next step will be to place days designated in the Mayan tzolkin in definite positions in European years and to demonstrate as well the positions of Mayan months in these years. Unfortunately calendar-round dates in the Mayan system which are definitely stated to correspond to dates in European chronology are few and doubtful. We find, however, a complete European year correlated with a complete Mayan year in Landa's Relation and while this European year is not designated the Mayan equivalent carries 12 Kan in the position 1 Pop. This 12 Kan is a year-bearer and we see by the table of year-bearers that it gave its name to a Mayan year beginning in 1553 and running over into 1554.

Landa came to Yucatan in 1548 and was called to Spain shortly after the arrival of Bishop Toral in 1562 for trial before the Council of the Indies. While in Spain he compiled his account of the native ceremonies and history. One might wish to give credit for the preservation of this necessary evidence in the reconstruction of American chronology to a more amiable scholar than that im-

placable Landa whose saturnine fanaticism cost the world so dear. But let us be duly thankful for this one recompense. It will be seen that 1553–54 is a most likely time for the collating of the calendar, late enough for the priests to have gained a safe knowledge but before their sinister activities were put in motion. The presence in Yucatan at about this time of a very good and great man, the first Auditor, Thomas Lopez, who established humane laws and corrected abuses in the name of the Audience of the Confines, suggests he may have been responsible for the collecting of ethnological data.

Landa's typical year begins on January 1 with a day 6 Ben 10 Chen (6 Ben 11 Chen in the ancient usage). The months of the Mayan haab are found as follows:

TABLE VII. — POSITIONS OF MAYAN MONTHS IN 1553–54

First day of Pop	July 16	First day of Zac	Feb. 1
" " " Uo	Aug. 5	" " " Ceh	Feb. 21
" " " Zip	Aug. 25	" " " Mac	Mar. 13
" " " Zotz	Sept. 14	" " " Kankin	April 2
" " " Tzec	Oct. 4	" " " Muan	April 22
" " " Xul	Oct. 24	" " " Pax	May 12
" " " Yaxkin	Nov. 13	" " " Kayab	June 1
" " " Mol	Dec. 3	" " " Cumhu	June 21
" " " Chen	Dec. 23	" " " Uayeb	July 11
" " " Yax	Jan. 12	Last " " Uayeb	July 15

Careful study of this specimen calendar discloses the fact that a current Mayan year was recorded intact, namely the year 12 Kan. Since this was not conterminous with the European year it was cut into two parts, the second part being correlated with the portion of the European year running from January 1 to July 15 and the first part with the rest of this same European year.

Morley, while inclined to accept the method of placing Landa's typical year by its year-bearer, insists that the correlation may be defective. He bases this opinion on a single calendar-round date which will be discussed presently. But an additional circumstance should remove this doubt. In connection with the orderly presentation of the days of the Mayan tzolkin occupying stated positions in Mayan and European months, Landa gives a cycle of seven letters which correspond to the days of the week, Sunday being marked by a capital A and the other days by the lower case

letters b–g. The year-bearer 12 Kan has the letter A and therefore corresponds to Sunday, July 16, 1553. For the rest of the European year the week days actually fall as recorded. But we have already seen that the year 12 Kan ran from July 16, 1553, to July 15, 1554, the part corresponding to 1554 being placed before the part corresponding to 1553. This cutting and patching process gave a record of Mayan days equivalent to the European year except that the last day of Uayeb was a day 12 Lamat which is followed in the table by 12 Kan, an impossible situation. If we turn from 11 Eb on December 31 at the end of Landa's table back to 12 Ben on January 1 at the beginning we have two days which are really in sequence. For 12 Lamat as the last day of Uayeb terminates a year beginning with 12 Kan. Now the count of Landa's European year is continuous from January 1 to December 31 in the week day letters as in the days of the months. But with the day 11 Eb on December 31 being A or Sunday, the day 12 Lamat which follows it in the Mayan calendar cannot also be Sunday. This day Sunday had belonged to January 1, which preceded rather than followed the December 31 of the table. In other words the week day letters disclose the fact that a Mayan year 12 Kan, July 16, 1553 to July 15, 1554, was set over against an almanac of the current European year 1553.

Running the days of the Mayan tzolkin under a definite year-bearer in terms of the week days and month positions of a definite European year gives a hard and fast correlation in the light of the correlations already established between the ancient and new designations of katuns and between katuns and year-bearers. The index of this correlation is 12 Kan 2 Pop, the first day of Landa's typical year equals 12–9–17–9–4, 12 Kan 2 Pop, in the Mayan long count and also equals Sunday, July 16, Julian calendar, or Sunday, July 26, Gregorian calendar.

The only other known date which might be said to compete with this determination is the record of 11 Chuen 18 Zac as Feb. 15, 1544. This occurs in untranslated portions of the Tizimin and Mani Manuscript and according to it the year-bearer 12 Kan would equal July 10, 1553, instead of July 16, 1553, Julian calendar. It is apparent that we cannot leave the disordered material without further scrutiny tedious as the effort may become.

The Problem of Intercalation

Intercalation is the rock upon which many a fine thesis in chronology has been wrecked. The idea of regulating the calendrical year was very much to the fore in Europe in the years preceding the reform of Pope Gregory in 1582. Landa was astonished that the Indians of Yucatan should know the true length of the year and naïvely concluded that they must have a system of intercalation. Landa says:

"They have a year as perfect as ours of 365 days and six hours. They divide it into two kinds of months, one of thirty days which they call *u*, that is to say, moon, which they count from the time it comes out new until it no longer is visible. They have another kind of month of twenty days which they call *Uinal-hun-ekeh;* of these the entire year has eighteen and in addition the five days and six hours." Landa also says the first day of the year 1 Pop always fell on July 16.

Now neither Landa, nor Aguilar, nor any other writer on Yucatan ever explained how the intercalations were made that kept 1 Pop on July 16 nor does any of the later writers take the slightest note of the ten-day discrepancy that would be created by the Gregorian reformation of 1582 if 1 Pop really had been fixed. Aguilar, writing in 1613, and Cogolludo, more than half a century afterward, both follow the unadjusted indications of Landa who died before the reformation was consummated.

As a matter of fact there was no actual intercalation in the Central American calendar, only a very accurate marginal allowance. We are forced to the conclusion that the Mayan calendar ceased to function about the time Landa was hanging Indians and burning books in the name of the Inquisition. The year-bearer designations were continued for some time, the katuns became stereotyped into twenty-year periods, and the months were frozen into the European year. Pretty much the same thing seems to have happened with the calendar of the Tzentals and Tzotzils, associated tribes of the Mayan stock living in Chiapas and Tabasco. Out of the 18 months of their year seven are in obvious correspondence to the month names of the Mayas of Yucatan and these months come in exactly the same order namely: Yaxkin and Yashquin, Mol and Mush, Chen and Tzun, Zac and Sisac, Mac and Mac or

Moc. This calendar is still maintained but the first of Chen or Tzun is in constant conformity with January 1. In Yucatan Chen was frozen into the position December 23 corresponding to its position in the Julian calendar in 1553. It can be seen from this that originally Chen of the Mayas and Tzun of the Tzentals and Tzotzils must have been close together and may have coincided exactly.

Among other Mayan tribes, like the Cakchiquels and Quichés of the Guatemalan highlands, the native months did not become frozen in the European year. We have perfectly consistent calendars of 1685 and 1722 for the Quichés and Cakchiquels. In the document of 1685 there is an accurate statement of the operation of the Central American calendar which I cannot forbear to quote:

"Because since neither the Mexicans nor these (the Mayan tribes of Guatemala) understood leap year day . . . they drew apart and became different from our calendar, and as neither these nor the Mexicans ever commenced their year on the first of our February, each four years they lost a day; that is in the year 1681, '82, '83, and '84 the year of the Indians of this kingdom commences on the first of February and that of 1685 will commence on the 31st of January and that of 1805 will commence on the first of January, and four years thence on the 31st of December, etc."

There is practical unanimity in available records that the month Pop, in the usage of Yucatan, began on July 16 but this unanimity probably goes back to a single source of information which may have been Landa's typical year. This unanimity sets up our principal difficulty since it seems to support the intercalation thesis. For if the first day of a vague year was July 16 in 1553–54 it must have been July 20 in 1536 and July 9 in 1582 when the European calendar dropped ten days to pass into Gregorian style. In 1584 it must have stood at July 18 and in 1592 apparently reëstablished at July 16. Perhaps this circumstance of apparent repetition, coming at a time when the calendar was passing out of memory, was largely responsible for the months of the Mayan year becoming frozen into fixed positions in the European calendar.

One repeated example may be consulted at the end of the Tizimin and likewise in the Kaua, Tekax and Nah Manuscripts. On the side of the European calendar the fullest form is in the Kaua where an unidentified year is reproduced with week day indications

and with Mayan designations sandwiched in between saints' days. January 1 is Sunday and also 11 Oc. Yax begins on January 12 with 8 Imix and Pop starts after the Uayeb on 11 Cimi. Of course these days are impossible in the pre-Spanish system. But the possible year-bearers are emphasized throughout and in the Tizimin variant after June 14, we read *Hoil Ix, uhun te Pop,* that is, 5 Ix first of Pop. This may be an attempt to fix the true position of Pop for the year 5 Ix corresponding to 1715. The same remark, however, is given in two other places after possible year-bearer days. It may be added that the year-bearers were correctly designated down to the end of the 18th century.

The Death of Ahpula Napot Xiu

Reference has already been made to statements concerning the death of a member of the Xiu family called Ahpula Napot Xiu. This occurs in four variants in the Mayan chronicle, three being

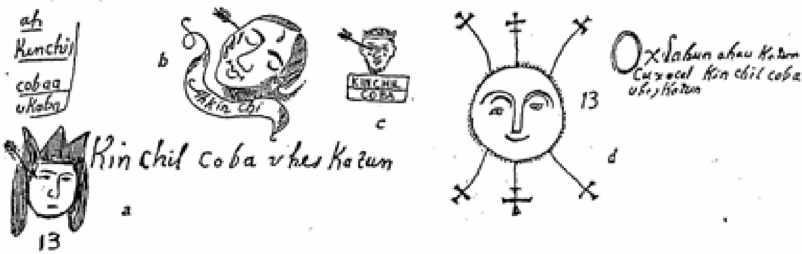


FIGURE 30. OCCULT REFERENCES TO THE END OF KATUN 13 AHAU IN 1536, A.D. Books of Chilam Balam.

in practical agreement. The event is tied in with Katun 13 Ahau and the European year 1536: it is also stated to have taken place on a day 9 Imix 18 Zip (which must be amended to 9 Imix 19 Zip for the ancient calendar) and in a year 4 Kan. Now the date 9 Imix 19 Zip occurs in a year that begins with 4 Kan 2 Pop but this year corresponds to 1545, not 1536.

It appears that two events are confused in this record. We have reason to believe that Katun 13 Ahau ended in 1536. The 13 heads labeled with different names which Cogolludo reproduces as the ambassadors of the Xiu family who were waylaid by a treacherous chief of the Cocom family constitute an esoteric

wheel of katuns as has been demonstrated by Brinton and Morley. The head labeled Kin Chil, identified as Napot Xiu, is the head for Katun 13 Ahau (fig. 30). If a man of this name actually was killed, it was probably in connection with the revolution of 1546, and a passage in Nakuk Pech gives color to the theory that the revolution may have been preceded by reprisal of some of the die-hard Mayan chiefs against the Xius who had sided with the Spaniards.

Thomas, Bowditch, and Morley have attempted to use the date 9 Imix 19 Zip under the Cuch Haab 4 Kan, but forced into the European year 1536 against the heavy weight of evidence as regards year-bearers. Bowditch did not mention his correlation based on these circumstances in his later writings, but a recent English writer, Richard C. E. Long, has accepted Bowditch's correlation and has proceeded to cast over the ancient records on the basis of Sept. 11, 1536 equalling 13–2–13–3–1, 9 Imix 19 Zip. He finds a few astronomical coincidences but nothing out of the proportion of pure chance.[1] Joyce has made use of a somewhat similar arrangement.[2]

Goodman's Multiple Calendar Theory

Goodman held that more than one calendar was in vogue in northern Yucatan and that discrepancies in the record are to be explained as dates in different systems. In the introduction to his classical presentation of the Mayan long count he says:

"Another source of confusion in the Yucatec chronicles quite as misleading as the mutilations and errors, is the fact that in different ones time is computed from at least three and probably four separate starting points. I think it likely that each of the four ruling houses — the Itzas, Cocoms, Xius, and Chels had a chronology of its own though using a common annual calendar."

In a later paper Goodman repeats the assertion that there was more than one calendar in northern Yucatan and even goes as far as to specify two calendars. One of these he ascribes to the Xius of Mani and another to the Itzas, Cocoms and Chels. He considers that the calendar of the Xius may be tied in with the ancient

[1] Long's articles have appeared in *Man* during recent years.
[2] *Mexican Archaeology*, Appendix III.

Mayan long count of the inscriptions and indirectly effects a correlation.

But is the position taken by Goodman defensible on logical grounds when he contends that the annual calendar or haab, designated by its initial day, was constant, while the tun-ending and katun-ending days were variable among the principal houses and provinces in Yucatan? To be sure there is evidence which has to be adjudicated in some fashion or else thrown out of court. But the Mayan calendar is a machine with wheels of time which operate mechanically. The evidence that exactly fits into this machine has a value quite out of proportion to the total amount of evidence. There is one way to be right and many ways to be wrong. The year-bearer method of naming vague years of 365 days each involves, as we have seen, the calendar round of the classical Mayan calendar. The tun-ending and katun-ending dates involve the long count. In both cases we see wheels of time that turn steadily and click off day after day. No effort was made by the Mayas to interpolate a leap-year correction, so there was no opportunity for divergence leading to separate calendars for different ruling houses.

The correlation suggested by Goodman between his Xiu calendar and the ancient calendar of the Mayan inscriptions agrees with a passage in the Xiu Manuscript, where the ending days of certain tuns are placed under year-bearers and these stated to correspond to certain years in the European calendar. So far as the year-bearers are concerned the correspondence is close enough. But if the ending days of these tuns are related to the long count in the manner suggested then all Mayan dates in the pre-Spanish period will have to be moved one U Kaylay Katunob cycle nearer the present. In other words, the particular Katun 13 Ahau that fell at the time of the Spanish Conquest will have to equal 11–16–0–0–0, 13 Ahau 8 Xul instead of 12–9–0–0–0, 13 Ahau 8 Kankin.

The series of thirteen years in the Xiu Manuscript, or Chronicle of Oxkutzcab, is full of obvious errors.[1] There are only two minor mistakes in the list of year-bearers but in the statements of the tun endings under these year bearers the month positions are correctly given in only three out of thirteen instances. This condition would seem to show that the scribe was unfamiliar with the material before him. The statement made at the end of the presen-

[1] See Morley, *Inscriptions at Copan*, pp. 471, 507.

tation has been translated as follows: "Now on the 29th of May in the year 1685 I have copied this from an ancient book, namely in characters as they are called, Anares. I, Don Juan Xiu."

Except for the tun-ending statements the entries are similar to those in several other early documents written in Mayan words but Spanish script. We need not understand that the manuscript as a whole is a translation. It is quite obvious, for instance, that the names of the Spanish priests who came in 1545 could not have been translated from Mayan hieroglyphs. Approximately the same list is given by Nakuk Pech. We may be permitted to form the hypothesis that our Juan Xiu actually had before him an ancient pre-Colombian historical codex covering a section of the long count when Uxmal, Chichen Itza and Mayapan were still flourishing cities, and that he naïvely identified the recognizable year-bearers with those of the same name and number falling in the first years of the Conquest and naïvely adjusted to this calendrical mechanism the known events of the years in question.

At first glance Goodman's correlation, strengthened by such documentary evidence, might seem a difficult one to disprove and explain away, but it happens that while a katun ending on 13 Ahau is found every thirteen katuns in the long count, it is not found under the same year-bearer. This is because the U Kahlay Katunob cycle is $13 \times 20 \times 360 = 93{,}600$ days while five calendar rounds are $5 \times 52 \times 365 = 94{,}900$ days. Starting even, the next closest approximation of two cycles opens a gap of 1300 days or over $3\frac{1}{2}$ years. In other words, if the particular Katun 13 Ahau mentioned above was 11–16–0–0–0, 13 Ahau 8 Xul, it fell in a year 11 Ix but if it was 12–9–0–0–0, 13 Ahau 8 Kankin it fell in a year 7 Ix. But in the annual calendar which Goodman admits was the same in all Yucatan the year 11 Ix was 1539–40, while the year 7 Ix was 1535–36. Goodman makes Katun 13 Ahau of his Xiu calendar end as we have seen on a day 13 Ahau 8 Xul under the year-bearer 11 Ix. On the basis of Landa's tabulation of a complete Mayan year he makes this month position equal Oct. 30, 1539, Julian calendar, omitting a four-day allowance for leap years leading more exactly to Nov. 3, 1539, Julian calendar, or Nov. 13, 1539, Gregorian calendar. On the other hand, he states that in the calendar of the Itzas, Cocoms, and Chels a Katun 11 Ahau "began" on Dec. 25, 1536. He gives us no inkling how or where he

obtained evidence for this assertion and we are compelled to recast the facts which determined his opinion.

The end of any Katun 13 Ahau would, of course, be a day 13 Ahau and Goodman's use of "began" for "ended" merely means the fallacy of considering the katun a measure of current time instead of elapsed time. In the year 1536 a day 13 Ahau occurred once in the month position 8 Kankin and again 260 days later in the month position 3 Chen. This latter position according to the typical year of Landa's table without correction was December 25, and the earlier occurrence was April 9, both in Julian time. The trick which Goodman played upon his own logic becomes clear when this is pointed out. In order to maintain the annual calendar he had, of course, to make his structural correlation with the long count at intervals of 260 days. Actually to reach the correct statement of the two days 13 Ahau 8 Kankin and 13 Ahau 3 Chen in the year 1536 he should have allowed four days for the departure of the vague year from Landa's base. Goodman floundered between two structural possibilities of correlation which are really 13 katuns apart, and then made a minor shift in one case of something over three and a half years to recover the year-bearer and the calendar-round date and in the other case of one tzolkin to recover the day. The two basic possibilities are:

Long Count		Katun Count	Year-Bearer Count
11–16–0–0–0,	13 Ahau 8 Xul	8 Ahau	11 Ix
12– 9–0–0–0,	12 Ahau 8 Kankin	8 Ahau	7 Ix

The two calendars can be related in the last lines of the following statements in true dates of the Gregorian year.

A. Goodman's Xiu Calendar.

11–16–0– 0–0,	13 Ahau 8 Xul,	Jan. 14, 1280
13–0– 0–0	add one round of katuns	
12– 9–0– 0–0,	13 Ahau 8 Kankin,	April 22, 1536
3–11–0	add 5 tzolkin	
12– 9–3–11–0,	13 Ahau 8 Xul,	Nov. 13, 1539

B. Goodman's Itza, Cocom and Chel Calendar.

11–16–0– 0–0,	13 Ahau 8 Xul,	Jan. 14, 1280
13–0– 0–0	add one round of katuns	
12– 9–0– 0–0,	13 Ahau 8 Kankin,	April 22, 1536
13–0	add one tzolkin	
12– 9–0–13–0,	13 Ahau 3 Chen,	Jan. 5, 1537

Goodman effects syncopations of the time count for in the first case two positions of 13 Ahau 8 Xul really 260 haabs apart are treated as identical while in the second case two occurrences of 13 Ahau a tzolkin apart are treated as identical. The reasons for the last shift are not clear from the record. By his Xiu calendar the katuns of the early 16th century must depart from the year 1539, while under the Itza, Cocom, and Chel calendar they depart from the year 1536, or with the tzolkin shift, from very early in 1537. It may be added that Sr. Juan Martinez has also arrived at Goodman's Xiu correlation on the basis of the Xiu Manuscript while Morley has considered and rejected it. The rejection is made on very sound logic because otherwise dates at cities known to have been abandoned at the arrival of the Spaniards will be placed in years considerably later than the Conquest.

Morley's Correlation by Delimitation

With a pessimism which the obliquity of available evidence goes far to justify Morley decries the possibility of a day-for-day correlation. But by a process of delimitation he achieves what he considers accuracy within forty-eight days for the terminal dates of katuns during the Spanish Conquest. The number of historical statements upon which he depends to establish this delimitation is too small to permit any factor of safety.

He places the ending of Katun 13 Ahau between Dec. 15, 1536 and Feb. 1, 1537 and for convenience of reference chooses within this range of forty-eight days the date Dec. 24, 1536 as the one on which Katun 13 Ahau came to an end. In making this choice he falls into Goodman's trap, since this writer states Katun 11 Ahau "began" on Dec. 25, 1536. But instead of accepting Goodman's presumed position of 11–16–0–0–0 for the ending day of this Katun 13 Ahau in the long count Morley holds to the position 12–9–0–0–0, 13 Ahau 8 Kankin. The essential equation established by Morley's line of argument is, therefore, 12–9–0–0–0, 13 Ahau 8 Kankin equals Dec. 24, 1536, Julian calendar. He presents no evidence to show that the month Kankin fell at this time of the year and falls back upon the weak explanation that two or more calendars were functioning in Yucatan at the same time. In this explanation and in the selection of December 24, he shows himself under the influ-

ence of the earlier Mayan scholar. But Morley cannot accept the full responsibility of Goodman's argument which leads directly to the correlation on the basis 11–16–0–0–0, 13 Ahau 8 Xul, because this correlation would make a considerable number of inscribed dates fall after the coming of the Spaniards. Under date of Mar. 14, 1920, Morley stated his position in the following words:

"I believe that a Katun 13 Ahau of the katun sequence of the Books of Chilam Balam, Itza tradition, ended on a day 13 Ahau 8 Kankin which fell between December 16, 1536 and Feb. 1, 1537. I believe this in spite of the statement of Landa that Kankin fell in the month of April. I believe that the 13 Ahau 8 Xul, Xiu tradition fell in 1538."

But there is not the slightest evidence that Kankin fell in December at the time of the Spanish Conquest and on the other hand the evidence is abundant that this month came in April. The fallacy of the two calendars, one basically Mayan and the other basically Mexican, must be attacked at the source. We will therefore shift our attention to the calendrical methods of the highland peoples.

Unity of the Central American Calendar

It has long since been recognized that a scheme of permutation with thirteen numbers and twenty names combined with eighteen months of twenty days each and five extra days controlled the calendar among all the civilized nations of Mexico and Central America. It has also long been recognized that the lists of day names, although expressed in several distinct languages, were in remarkable conformity as regards meaning. Day-names in several languages of the Mayan stock, including Quiché Cakchiquel and Tzental are generally cognate with those of the Maya. For the Mexican or Nahuan group of languages lists of similar meaning in identical order are known from such classical centers of Aztecan culture as Tenochtitlan, Texcuco and Tlaxcala in addition to the colony of Meztitlan on the Huaxtecan border, the Pipil of Guatemala and the Nicarao of Nicaragua. Other languages represented by lists of day-names are Zapotecan, Tarascan and Matlatzincan, the last named belonging to the Chiapaneco-Otomi stock. The Totonacs and Mixtecas doubtless had the calendar and possibly the

Otomi. For the Chiapanecas there remains the evidence of two lists of the eighteeen months and five epagomenal days.

Several animals which gave their names to days belong especially in the wet lowlands (see fig. 31 for Imix and Cipactli as the crocodile). The historical record for tribes other than the Mayas of the humid tropics indicates that the calendar was distributed when the Mayan cities were at the crest of brilliancy. Herrera says the Guatemalan tribes had records going back 800 years and Torquemada makes a like statement about the Totonacs. The first glimmerings of Toltecan history hardly antedate the year 1 Acatl of 687 A.D., although it may be the intention in the Annals of Quauhtitlan to

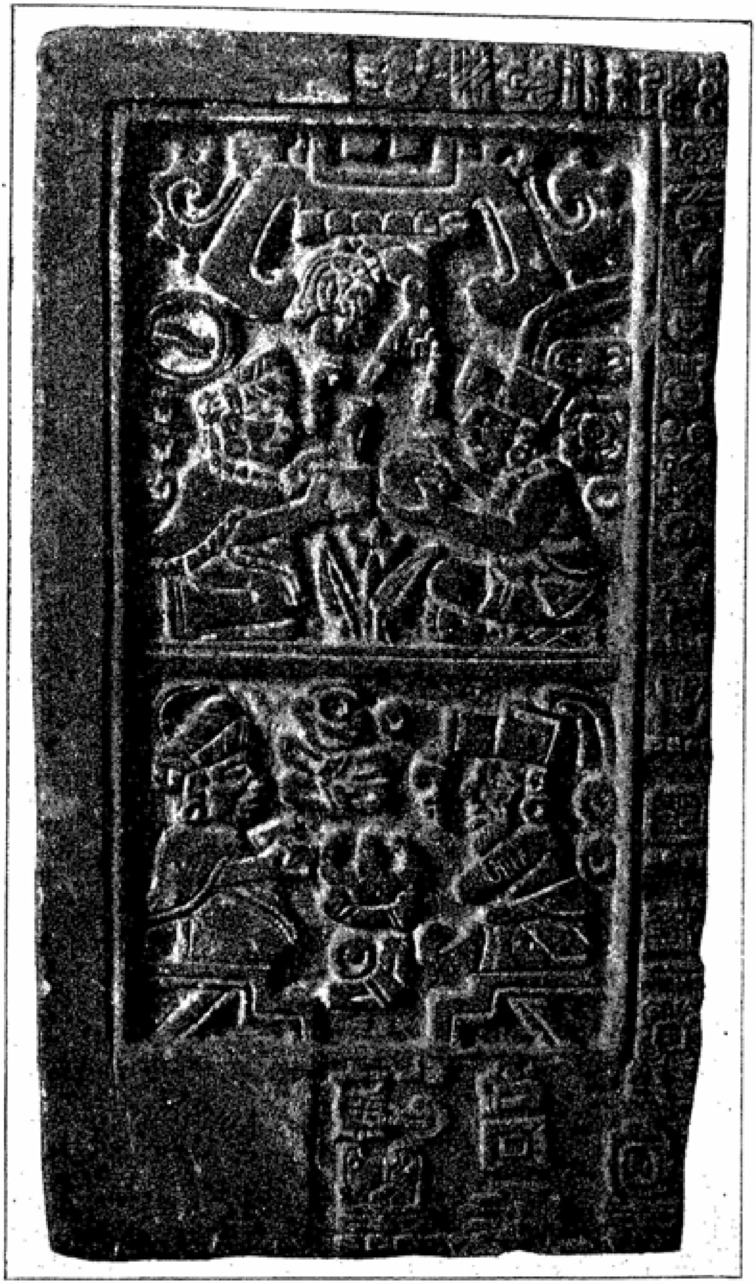
FIGURE 31. IMIX AND CIPACTLI
First detail: Imix on Altar T, Copan, with the crocodile; second detail, characteristic Mexican Cipactli head.

place the fabled coming out from the Seven Caves just seven times 52 years before this date, or in 323 A.D. — a position before the eight centuries already mentioned for the Totonacs.

Says Torquemada, "These Totonacs, situated in Mizquihuacan, were governed by a sole chief and they exhausted in nine ages and a like number of ruling lords the time of eight hundred years, each one of the rulers governing eighty years, neither more nor less." The Mayan katuns of nearly twenty years are called reigns and represented in late documents by crowned heads. Ordoñez speaks of the same thing among the Tzental. For the Totonacs the temporal rules covered four katuns.

Oxomoco and Cipactonal, the Adam and Eve of the Mexicans, introduced the counting of time among the highland tribes of Mexico and kept a record in twenty-year periods with much exactness, according to the Annals of Quauhtitlan, but the development of the calendar is also associated with the great Quetzalcoatl who ruled in Tula toward the end of the 9th century.

Now this Toltec-Totonac bond is especially interesting since Totonacan decoration was freely borrowed for the temples of



A Fine Zapotecan Tablet with Bar-and-Dot Numerals and Artistic Influences from the Mayas. Original in the National Museum, Mexico.

Teotihuacan. We learn further from Torquemada that the Teochichimecas, by which term we may understand Toltecs, swept down and conquered the Totonacs whose first ruler had just been succeeded by his son Xatontan. This first ruler is called Umeacatl

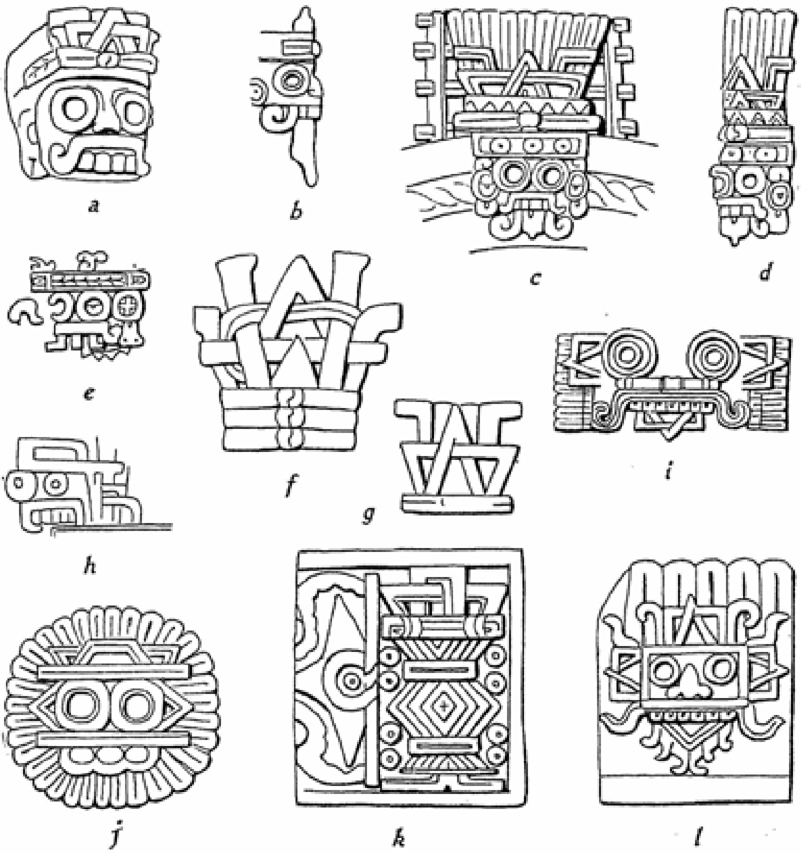


FIGURE 32. THE MAYAN ORIGIN OF TLALOC AND THE IMBRICATED YEAR SYMBOL
a–g, Copan; *h*, Yaxchilan; *j*, Piedras Negras; *i* and *l*, Uxmal; *k*, Chichen Itza.

which is the calendrical term 2 Acatl and it is on the day and year 2 Acatl that the 52 year cycles of the Mexicans begin.

No hieroglyphic inscriptions have been found at Teotihuacan but at Xochicalco there are records pretty clearly of calendrical import although it seems doubtful if they will ever be read. They

follow the pattern of the Zapotecan inscriptions which use bar-and-dot numerals in connection with glyphs of days and possibly in other connections. A very fine Zapotecan inscription is reproduced in Plate 2, perhaps the finest one extant. Monuments like the Mayan stelae are found at Monte Alban, the indications of art pointing to a period subsequent to the first Mayan cities but before the time of the temples of Mitla. Indeed the morphology of design motives furnishes the strongest proofs of the dependency of Zapotecan, Totonacan and Toltecan culture upon the Mayan. In figure 32 Tlaloc, the Aztecan Rain God, is shown to be derived from a Mayan divinity of the annual rains, associated with the imbricated year symbol (see also fig. 33).

The Aztecan Correlation

The earliest attempts to solve the riddles of the Central American calendar were made by the examination of Aztecan material and the prestige of Tenochtitlan in the history of Mexico has led many writers to assume that the calendar originated on the highlands. But such is clearly not the case. The inscriptional record in the Valley of Mexico covers a brief period.

A correlation of the Aztecan year with the present time count was effected by Eduard de Jonghe although certain advances in the problem must be credited to Seler. The present writer arrived by an independent examination of source materials at the same result. The earlier attempts at correlation were mostly wrecked on the day 1 Cipactli. It was thought that this day, which is the reputed first day of the tonalamatl was also the beginning day of the year.

The Aztecan year is stated to have begun with the month Atlacaualco in the majority of early authorities but structurally the first day of Toxcatl was the year-bearer and the formal New Year's day. There was no actual intercalation of leap-year days with the result that the short calendrical year advanced in the seasons at the rate of approximately one day in four years. The tonalamatl, or permutation of 13 numbers and 20 names, was counted continuously in exactly the same way as the Mayan tzolkin and was tied in with the months in a fifty-two year cycle and with the revolutions of Venus in a one-hundred-and-four-year cycle. It was also as a magical pattern.

The evidence leading to the day-for-day correlation of the Mexican calendar is not extensive. The best item is the double dating for the final conquest of Tenochtitlan with the surrender of Quauhtemoc. This event took place on Aug. 13, 1521 or 1 Coatl in the year 3 Calli; more exactly 1 Coatl was in the month position 3 Xocouetzi. Other items are double datings for the entrance of the Spaniards into Tenochtitlan as Nov. 9, 1519 corresponding to 10 Quecholli; for the massacre of the Mexican nobles by Alvarado on the feast of Toxcatl, that is, May 21, 1520, corresponding to 7

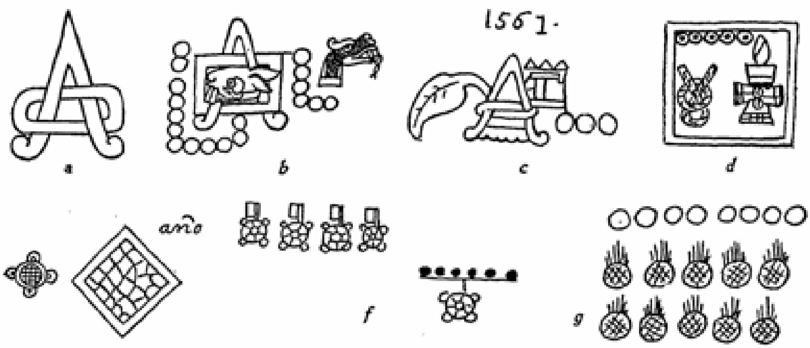


FIGURE 33. THE YEAR SYMBOLS OF THE MEXICANS

In *a*, the imbricated year symbol; *b*, a day 5 Coatl in a year 12 Tochtli; *c*, the leaf *xihuitl*, combined with the year 3 Calli; *d*, the year symbol of rope with 5 Tecpatl; *e*, mosaic of turquoise, *xihuitl*, as year symbol; *f*, $4 \times 20 + 6$ days; *g*, $10 \times 400 + 8$ years.

Cozcaquauhtli 19 Toxcatl; for the flight of the Spaniards on the Noche Triste, June 30, 1520, corresponding to 8 Cozcaquauhtli 19 Tecuilhuitontli. The actual statements for some of these events are incomplete or exhibit various discrepancies in different early authorities — but the record as a whole is capable of being adjusted to a functioning calendar. Also there are various concordances in terms of European months for the beginning days of Aztecan months. When these are arranged according to the European years in which the concordances were made it is found that the European leap-year intercalations explain the apparent differences.

The Aztecan year-bearers, giving their names to the current years, were structurally the first days of Toxcatl as Seler was the first to show. But there is no evidence that the five epagomenal

days of the nemontemi actually stood before Toxcatl in the usage of the sixteenth century. De Jonghe thinks the position of these days was determined by the tonalamatl and that the nemontemi were introduced after the third day of the month Panquetzaliztli, so as to precede the days 1 Cipactli, 2 Miquiztli, 3 Ozomatli and 4 Tochtli in the years 1 Acatl, 2 Tecpatl, 3 Calli and 4 Tochtli respectively. This is following the ignis fatuus, 1 Cipactli, which has led so many others to disaster. Perhaps the Aztecan calendar like the Mayan was founded upon a double base, and one of the months originally stood at an astronomically important point in the tropical year while another month, also used for beginnings, occupied a station of vocational importance. The best evidence puts the five-day period just before Atlacaualco in the usage of 1519, but the indications are not entirely conclusive.

Two dates in the Annals of Tecamachalco falling in the years 1575 and 1576 are extremely interesting in connection with the earlier record. The original text is in a corrupt Mexican dialect. In the first entry certain church dignitaries are stated to have arrived on Friday Sept. 4, 1575 O. S. The year was 5 Acatl and the day was Itzcuintli three days before the termination of the month Ochpaniztli on a day 2 Acatl. Now in any year 5 Acatl on the Aztecan model the month Ochpaniztli must begin on 8 Acatl and have 12 Itzcuintli in its eighteenth position while 2 Acatl would be three days distant as the first day of the month Teotleco. Of course this situation would only be found at intervals of fifty-two years. In 1519 the month position 18 Ochpaniztli equalled September 18 in the Julian calendar but by 1575 it had advanced to September 4, through the failure of the Mexican calendar to intercalate fourteen days. In other words the record is exactly as it should be.

The second statement combines Aztecan and European dates and mentions Feb. 1, 1576 and 4 Tecpatl in a year 6 Tecpatl and adds that the month Quauhuitleua — equivalent to Atlacaualco — will be completed on 11 Tecpatl.[1] In other words the statement means that 4 Tecpatl 1 Atlacaualco and 11 Tecpatl 1 Tlacaxipehualixtli are in a year 6 Tecpatl. The European date is not quite accurate according to my calculation, for 4 Tecpatl in

[1] In both statements the days which begin months are referred to as ending them. It may be an exclusive manner of counting.

this place would equal January 31 rather than February 1. But the really important point is that this date was probably intended for a New Year's declaration. If so, we may assume that the five unlucky days of the nemontemi preceded Atlacaualco. It appears that both of these double-dating records in the chronicle of Tecamachalco were interpolated by some person skilled in the ancient calendar. Elsewhere Spanish month names are used in the document and the Aztecan year-bearers are given as exact equivalents of European years. Also in connection with the first entry we

TABLE VIII. — YEAR-BEARER CORRELATION, MAYAN AND AZTECAN CALENDARS

Mayan		European			Aztecan	
Year-Bearer		Date	Year	Date	Year-Bearer	
4 Ix	2 Pop	Aug. 2	1519	May 14	1 Acatl	1 Toxcatl
5 Cauac	2 "	" 3	1520	" 13	2 Tecpatl	1 "
6 Kan	2 "	" 3	1521	" 13	3 Calli	1 "
7 Muluc	2 "	" 3	1522	" 13	4 Tochtli	1 "
8 Ix	2 "	" 3	1523	" 13	5 Acatl	1 "
9 Cauac	2 "	" 2	1524	" 12	6 Tecpatl	1 "

find the year 1575 of the Christian era written out in Aztecan terms, together with a statement of the golden number and other calendrical data.

Mexican and Mayan year-bearers can easily be brought into agreement. The Mexican ones were Calli, Tochtli, Acatl and Tecpatl falling in the first position of the month Toxcatl, and the Mayan ones were Kan, Muluc, Ix and Cauac, on 2 Pop in the ancient Mayan calendar of months, or on 1 Pop in the later Yucatan system. The Mayan year-bearers come one day later in the permutation than the Aztecan so that, other things being equal, the Mayan year-bearers should have a number one in advance of the Mexican. That is, a year 3 Calli should equals a year 4 Kan. We find that this relationship does hold true for equivalent months but it happens that Toxcatl comes 80 days before Pop and as a result 4 Calli as a Mexican year designation equals 6 Kan as a Mayan year designation. In terms of the Gregorian year the following year-bearer correlation covers the first few years after

the advent of the Spaniards; for Julian dates ten days should be subtracted.

To illustrate the day and month correlation (except for the months affected by the advanced position of the five epagomenal days in the Aztecan year) we need only examine the layout of a few days. It will be noted that 5 Akbal, 6 Kan, etc., are equivalent in the Mayan tzolkin to 5, Calli, 6 Cuezpalin, etc., in the Aztecan tonalamatl.

Table IX. — Day and Month Correlation, Mayan and Aztecan Calendars

Mayan 1521			Old Mayan		Aztecan 1521		
			4 Ik	0 Pop			
5 Akbal	0 Pop	Aug. 2	5 Akbal	1 "	5 Calli	1 Tlaxochimaco	Aug. 1
6 Kan	1 "	" 3	6 Kan	2 "	6 Cuezpalin	2 "	" 2
7 Chicchan	2 "	" 4	7 Chicchan	3 "	7 Coatl	3 "	" 3
8 Cimi	3 "	" 5	8 Cimi	4 "	8 Miquiztli	4 "	" 4
9 Manik	4 "	" 6	9 Manik	5 "	9 Mazatl	5 "	" 5

This correlation means that the tzolkin and the tonalamatl are one day out of exact conformity, that the beginning of the months are also one day out and that the Aztecan year-bearers fall four months (80 days) earlier in the year than the Mayan year-bearers. Waiving the one-day discrepancy this should bring 14 out of 18 months of the Aztecan month into conformity with the Mayan ones. Actually, however, the proportion of conformity is further reduced by the fact that the civil Mexican year was advanced eighty days before Toxcatl and made to begin with Atlacaualco. The correlation of Mayan months on the model of the ancient calendar and of Aztecan months as used at the time of the Conquest is exact for ten out of the eighteen months of the year in the adjoining table.

Although the Mexican calendar was thus in close conformity with the Mayan sharp definition of events is seldom met with in Aztec records. Only a few examples of Aztecan month glyphs are known and these are more in the nature of pictures than hieroglyphs. Usually events are connected with a day of the tonalamatl under a year-bearer but since the same day, more often than not, appears twice a year this method is ineffective. The declaration

of a day in a definite position in a month is practically unknown in Aztecan documents nor is there any means of distinguishing between calendar rounds. These defects also appear in documents from the Mixtecan and Zapotecan regions which on the score of workmanship are much superior to those known to be Aztecan.

TABLE X. — CORRELATION OF MAYAN AND MEXICAN MONTHS IN THE GREGORIAN CALENDAR FOR THE YEAR 1521

Mayan			Mexican		
Number	Initial Day	Date	Number	Initial Day	Date
1	0 Pop	Aug. 1	9	1 Tlaxochimaco	Aug. 1
2	0 Uo	" 21	10	1 Xocouetzi	" 21
3	0 Zip	Sept. 10	11	1 Ochpaniztli	Sept. 10
4	0 Zotz	" 30	12	1 Teotleco	" 30
5	0 Tzec	Oct. 20	13	1 Tepeilhuitl	Oct. 20
6	0 Xul	Nov. 9	14	1 Quecholli	Nov. 9
7	0 Yaxkin	" 29	15	1 Panquetzaliztli	" 29
8	0 Mol	Dec. 19	16	1 Atemoztli	Dec. 19
9	0 Chen	Jan. 8	17	1 Tititl	Jan. 8
10	0 Yax	" 28	18	1 Izcalli	" 28
....	....	....	....	1 Nemontemi	Feb. 17
11	0 Zac	Feb. 17	1	1 Atlacaualco	" 22
12	0 Ceh	Mar. 9	2	1 Tlacaxipehualiztli	Mar. 14
13	0 Mac	" 29	3	1 Tozoztontli	April 3
14	0 Kankin	April 18	4	1 Uei Tozoztli	" 23
15	0 Muan	May 8	5	1 Toxcatl	May 13
16	0 Pax	" 28	6	1 Etzalqualiztli	June 2
17	0 Kayab	June 17	7	1 Tecuilhuitontli	" 22
18	0 Cumhu	July 7	8	1 Uei Tecuilhuitli	July 12
	0 Uayeb	" 27		....	....

Cakchiquel and Quiché Time-Counts

Our information on the calendar among the Cakchiquel and Quiché tribes of the Mayan stock, inhabiting the highlands of Guatemala, is drawn from several sources. Two calendars have come down to us, one from the Cakchiquels dated 1685 and one from the Quichés dated 1722. But by far the most important sources are native chronicles. The chronicle of the Cakchiquels is called the Annals of the Cakchiquels or the Annals of Xahila and that of the Quichés is the Popul Vuh. These two documents contain a mass of legend and some legitimate history. Many of the historical characters have calendrical names; that is to say,

they are called by the calendrical name of the day on which they were born. The prevalence of such names leads us to believe that a calendar following the Mayan model was in use among these tribes for many centuries before the coming of the Spaniards. An analysis of the genealogies contained in these books carries us back only eight generations, but Herrera speaks of pictographic records covering 800 years. In the Annals of the Cakchiquels historical dates are rare until near the close of the fifteenth century and none of them can be definitely placed before the occurrence of a certain revolt at Iximche on a day 11 Ah. Beginning from this day the subsequent days are counted in order in the form of a long count, which is different from that of the Mayas in that it combines a straight vigesimal numeration with the fundamental cycle of 20 names and 13 numbers.

The count begins, as we have said, from a zero day 11 Ah. The first actual day is, therefore, 12 Yix. Since the numeration is strictly vigesimal, the positions or periods of local values are 1's, 20's, 400's, 8000's. The day Yix with numbers running from one to thirteen in a definite but peculiar sequence is the initial day of all the numerical positions or periods and the day Ah is always last. The patterns of a year can be constructed on a tzolkin table extended seven more columns with 11 Yix at the head of column 1, 6 Yix in column 2, etc. The day-names recur in horizontal rows while the day-coefficients of column 1 do not reach a repeat before column 14. The twenty columns of this table constitute a unit of the third order which is called *a* possibly because it necessarily ended on a day Ah (equivalent to the Mayan Ben and the Aztecan Acatl). We at once think of the Mayan method of designating tuns and katuns by the day Ahau with which they end. The terminal days of the 400-day periods likewise fall in a peculiar cycle of thirteen as do the terminal days of the next larger period of $20 \times 20 \times 20$ or 8000 days.

This system of counting time was the one to which the term *may k'ih*, the revolution or recurrence of days, was applied by the Cakchiquels. The day was called *k'ih* meaning sun. The twenty-day period was *vinak* meaning man, which was likewise the ordinary numerical term for twenty. The 400-day period was *ah* and the 8000-day period was called *may*, meaning the revolution or recurrence. This combination of straight vigesimal count with the

permutation is hardly less serviceable than the long count of the Mayas, but it does not give so vivid a picture of time.

We can convert the Cakchiquel count directly into vigesimal notation and hence into our decimal notation and we can establish a correlation with other chronologies by using several definite records of events in the Annals of the Cakchiquels in cases where the European days are known or stated.

(*a*) "On the day 9 Ah was completed the fourth year of the third cycle after the revolt. . . . On the day 2 Tihax . . . the wife of Tonatiuh was drowned." This entry refers to the destruction of the first capital of Guatemala, when Beatriz de la Cueva, wife of Pedro de Alvarado, was drowned with her ladies-in-waiting. The date was Saturday, Sept. 10, 1541.

(*b*) "Died the chief Don Francisco Ahpozotzil . . . on the day 1 Can, a Monday, the 14th day of the month October."

(*c*) "On the day 6 Ah was completed the 18th year (*a*) of the third cycle. . . . In the 13th month (*vinak*) the day of St. James occurred as the day 1 Tziquin. . . . On that day was inaugurated . . . the Emperor Don Feliphe." The Emperor Charles I renounced the crown in favor of his son Philip II in January, 1556, but the proclamation in Guatemala was not made till July 26, 1557, when the change of sovereign was memorialized by a ceremony.

(*d*) "The day of St. Francis, the day 7 Camey."

(*e*) "On the day 13 Ah was completed the third cycle . . . in the year 1558."

These facts and dates transposed into a vigesimal and decimal count (the former not to be confused with the long count of the Maya, since here the third period has a value of 400 instead of 360 days) form the following table:

Table XI. — Correlation of Cakchiquel and European Days

Cakchiquel Day		Vigesimal Number	Decimal Number	European Day
(*a*)	9 Ah	2– 4– 0– 0	17600	. . . . . .
	2 Tihax	2– 4– 2– 5	17645	Sept. 10, 1541 O. S.
(*b*)	1 Can	2–16–19–12	22792	Oct. 14, 1555
(*c*)	6 Ah	2–18– 0– 0	23200	. . . . . .
	1 Tziquin	2–18–12– 2	23442	July 25, 1557
(*d*)	7 Camey	2–18–15–13	23513	Oct. 4, 1557
(*e*)	13 Ah	3– 0– 0– 0	24000	1558

From 2 Tihax (*a*) to 1 Can (*b*) there were 5147 days. Between Sept. 10, 1541 and Oct. 14, 1555, there were also exactly 5147 days, counting the leap-year days of 1544, '48 and '52. From 1 Can (*b*) to 1 Tziquin (*c*) there were 650 days and there were also exactly 650 days from Oct. 14, 1555 to July 25, St. James Day, 1557, counting the leap-year day of 1556. Finally, the 71 days from 1 Tziquin (*c*) to 7 Camey (*d*) exactly equals the time between St. James Day and St. Francis Day. These correspondences establish beyond all doubt the correlation between the European and Cakchiquel count both as regards the *ch'ol k'ih,* cognate of our familiar tzolkin, and the running record of days from the Revolt of Iximche.

The correspondences between the Aztecan month names and the names used in the Cakchiquel calendar of 1685 and in the Quiché calendar of 1722 are surprisingly close in several instances and show important ceremonial connection between Mexico and Guatemala. The Aztecan Tlacaxipehualiztli was shortened into Tacaxepual and Tequexepual respectively and it began the year of the Cakchiquels. The ceremony of dancing in the flayed skins of captives was known as far south as Salvador and indeed appears to have been introduced into the Valley of Mexico from the south.

Similarly the Aztecan Izcalli was borrowed to make the Cakchiquel Yzcal. In other cases the connections are hardly less obvious. Several pairs of Aztec months are distinguished by the adjective Uei, great, applied to the second members. In the Cakchiquel and Quiché the first member of such a pair is classified by the adjective *nabei* or *nab* and the second one by *rucan* or *ucab.* In the cases of the Aztecan Pachtli and Uei Pachtli the southern classifiers are used with Pach, obviously borrowed. Also the Mexican Tozoztontli and Uei Tozoztli are represented by Nabei Tumuzuz and Rucan Tumuzuz in the Cakchiquel calendar and here Tumuzuz may be a poor rendering of Tozoz. In the cases of the Aztecan Tecuilhuitontli and Uei Tecuilhuitl — the Little and Great Feast of the Lords — the Cakchiquel and Quiché terms are built on Mam. Here the etymology appears to have been followed since *mam* means grandfather. The etymology may be followed in other terms where there was no direct borrowing; for instance, the Aztecan month name Quecholli refers to a bird as does Tziquin of the southern peoples. All of the correspondence noted above fall in natural order as may be seen from the following list.

TABLE XII. — COMPARISON OF AZTECAN AND CAKCHIQUEL MONTH NAMES

Aztec, 1519	Cakchiquel, 1685
2 Tlacaxipehualiztli	1 Tacaxepual
3 Tozoztontli	2 Nabei Tumuzuz
4 Uei Tozoztli	3 Rucan Tumuzuz
5 Toxcatl	4 Cibixiz
6 Etzalqualiztli	5 Vihum
7 Tecuilhuitontli	6 Nabei Mam
8 Uei Tecuilhuitl	7 Rucab Mam
9 Tlaxochimaco	8 Liginga
10 Xocouetzi	9 Nabei To gig
11 Ochpaniztli	10 Rucac To gig
12 Teotleco (Pachtli)	11 Nabei Pach
13 Tepelhuitl (Uei Pachtli)	12 Rucan Pach
14 Quecholli	13 Tziquin gih
15 Panquetzaliztli	14 Cakam
16 Atemoztli	15 Ybota
17 Tititl	16 Katic
18 Izcalli	17 Yzcal
1 Atlacaualco	18 Pariche

There is also exact agreements between the days and the places they occupy in any particular year for the Aztecan, Quiché and Cakchiquel calendars when stated for the same European year. The only apparent discrepancy is for months affected by the different positions of the five epagomenal days. For the Cakchiquel and Aztecan calendars this discrepancy affects only one month, the Mexican year beginning twenty days earlier than the Cakchiquel year.

Although the Cakchiquels and Quichés were neighbors, with similar language and practically identical calendars so far as the day-names are concerned, yet they began their years with different months and consequently interpolated the five-day period at different times. The day records are completely in accord but some of the months are displaced five days. The first month of the Quiché year corresponds to the fifth of the Cakchiquel and the sixth of the Mexican year.

After this irrefutable evidence of widespread conformity in the Central American calendar surely there remains no basis for the multiple calendar theories of Goodman and Morley as regards Yucatan. Even the discrepancy of a single day in the essential permutation is susceptible to an explanation which will be given in another place.

The Reduction of Mayan Dates and Calculations

Having established a general correlation between Mayan and Gregorian time both as regards the annual calendar and the chronological record of elapsed days from an arbitrary beginning day we are now in a position to transform the dates on the ancient monuments into their equivalents in our own system of record.

TABLE XIII. MAYAN AND GREGORIAN DATES OF EVEN KATUNS

Baktun 13			B.C.	Baktun 2			B.C.
13- 0-0-0-0	4 Ahau	8 Cumhu	Oct. 14, 3373	2- 0-0-0-0	2 Ahau	3 Uayeb	April 20, 2584
13- 1-0-0-0	2 "	8 Mac	July 1, 3353	2- 1-0-0-0	13 "	3 Kankin	Jan. 5, 2564
13- 2-0-0-0	13 "	8 Mol	Mar. 18, 3333	2- 2-0-0-0	11 "	3 Chen	Sept. 23, 2545
13- 3-0-0-0	11 "	8 Zip	Dec. 3, 3314	2- 3-0-0-0	9 "	3 Zotz	June 10, 2525
13- 4-0-0-0	9 "	13 Pax	Aug. 21, 3294	2- 4-0-0-0	7 "	8 Kayab	Feb. 25, 2505
13- 5-0-0-0	7 "	13 Zac	May 8, 3274	2- 5-0-0-0	5 "	8 Ceh	Nov. 13, 2486
13- 6-0-0-0	5 "	13 Xul	Jan. 23, 3254	2- 6-0-0-0	3 "	8 Yaxkin	July 31, 2466
13- 7-0-0-0	3 "	13 Pop	Oct. 10, 3235	2- 7-0-0-0	1 "	8 Uo	April 17, 2446
13- 8-0-0-0	1 "	18 Kankin	June 27, 3215	2- 8-0-0-0	12 "	13 Muan	Jan. 2, 2426
13- 9-0-0-0	12 "	18 Chen	Mar. 14, 3195	2- 9-0-0-0	10 "	13 Yax	Sept. 19, 2407
13-10-0-0-0	10 "	18 Zotz	Nov. 29, 3176	2-10-0-0-0	8 "	13 Tzec	June 6, 2387
13-11-0-0-0	8 "	3 Cumhu	Aug. 16, 3156	2-11-0-0-0	6 "	18 Cumhu	Feb. 21, 2367
13-12-0-0-0	6 "	3 Mac	May 3, 3136	2-12-0-0-0	4 "	18 Mac	Nov. 8, 2348
13-13-0-0-0	4 "	3 Mol	Jan. 18, 3116	2-13-0-0-0	2 "	18 Mol	July 26, 2328
13-14-0-0-0	2 "	3 Zip	Oct. 7, 3097	2-14-0-0-0	13 "	18 Zip	April 12, 2308
13-15-0-0-0	13 "	8 Pax	June 24, 3077	2-15-0-0-0	11 "	3 Kayab	Dec. 30, 2289
13-16-0-0-0	11 "	8 Zac	Mar. 11, 3057	2-16-0-0-0	9 "	3 Ceh	Sept. 16, 2269
13-17-0-0-0	9 "	8 Xul	Nov. 26, 3038	2-17-0-0-0	7 "	3 Yaxkin	June 3, 2249
13-18-0-0-0	7 "	8 Pop	Aug. 13, 3018	2-18-0-0-0	5 "	3 Uo	Feb. 18, 2229
13-19-0-0-0	5 "	13 Kankin	May 1, 2998	2-19-0-0-0	3 "	8 Muan	Nov. 6, 2210

Baktun 1			B.C.	Baktun 3			B.C.
1- 0-0-0-0	3 Ahau	13 Chen	Jan. 16, 2978	3- 0-0-0-0	1 Ahau	8 Yax	July 24, 2190
1- 1-0-0-0	1 "	13 Zotz	Oct. 3, 2959	3- 1-0-0-0	12 "	8 Tzec	April 10, 2170
1- 2-0-0-0	12 "	18 Kayab	June 20, 2939	3- 2-0-0-0	10 "	13 Cumhu	Dec. 26, 2151
1- 3-0-0-0	10 "	18 Ceh	Mar. 7, 2919	2- 3-0-0-0	8 "	13 Mac	Sept. 12, 2131
1- 4-0-0-0	8 "	18 Yaxkin	Nov. 23, 2900	3- 4-0-0-0	6 "	13 Mol	May 30, 2111
1- 5-0-0-0	6 "	18 Uo	Aug. 10, 2880	3- 5-0-0-0	4 "	13 Zip	Feb. 15, 2091
1- 6-0-0-0	4 "	3 Pax	April 27, 2860	3- 6-0-0-0	2 "	18 Pax	Nov. 2, 2072
1- 7-0-0-0	2 "	3 Zac	Jan. 12, 2840	3- 7-0-0-0	13 "	18 Zac	July 20, 2052
1- 8-0-0-0	13 "	3 Xul	Sept. 30, 2821	3- 8-0-0-0	11 "	18 Xul	April 6, 2032
1- 9-0-0-0	11 "	3 Pop	June 17, 2801	3- 9-0-0-0	9 "	18 Pop	Dec. 23, 2013
1-10-0-0-0	9 "	8 Kankin	Mar. 4, 2781	3-10-0-0-0	7 "	3 Muan	Sept. 10, 1993
1-11-0-0-0	7 "	8 Chen	Nov. 19, 2762	3-11-0-0-0	5 "	3 Yax	May 28, 1973
1-12-0-0-0	5 "	8 Zotz	Aug. 6, 2742	3-12-0-0-0	3 "	3 Tzec	Feb. 12, 1953
1-13-0-0-0	3 "	13 Kayab	April 23, 2722	3-13-0-0-0	1 "	8 Cumhu	Oct. 30, 1934
1-14-0-0-0	1 "	13 Ceh	Jan. 8, 2702	3-14-0-0-0	12 "	8 Mac	July 17, 1914
1-15-0-0-0	12 "	13 Yaxkin	Sept. 26, 2683	3-15-0-0-0	10 "	8 Mol	April 4, 1894
1-16-0-0-0	10 "	13 Uo	June 13, 2663	3-16-0-0-0	8 "	8 Zip	Dec. 20, 1875
1-17-0-0-0	8 "	18 Muan	Feb. 28, 2643	3-17-0-0-0	6 "	13 Pax	Sept. 6, 1855
1-18-0-0-0	6 "	18 Yax	Nov. 15, 2624	3-18-0-0-0	4 "	13 Zac	May 24, 1835
1-19-0-0-0	4 "	18 Tzec	Aug. 2, 2604	3-19-0-0-0	2 "	13 Xul	Feb. 8, 1815

BAKTUN 4

				B.C.
4- 0-0-0-0	13 Ahau	13 Pop	Oct. 26,	1796
4- 1-0-0-0	11 "	18 Kankin	July 14,	1776
4- 2-0-0-0	9 "	18 Chen	Mar. 31,	1756
4- 3-0-0-0	7 "	18 Zotz	Dec. 17,	1737
4- 4-0-0-0	5 "	3 Cumhu	Sept. 3,	1717
4- 5-0-0-0	3 "	3 Mac	May 22,	1697
4- 6-0-0-0	1 "	3 Mol	Feb. 6,	1677
4- 7-0-0-0	12 "	3 Zip	Oct. 24,	1658
4- 8-0-0-0	10 "	8 Pax	July 11,	1638
4- 9-0-0-0	8 "	8 Zac	Mar. 28,	1618
4-10-0-0-0	6 "	8 Xul	Dec. 13,	1599
4-11-0-0-0	4 "	8 Pop	Aug. 30,	1579
4-12-0-0-0	2 "	13 Kankin	May 17,	1559
4-13-0-0-0	13 "	13 Chen	Feb. 1,	1539
4-14-0-0-0	11 "	13 Zotz	Oct. 19,	1520
4-15-0-0-0	9 "	18 Kayab	July 6,	1500
4-16-0-0-0	7 "	18 Ceh	Mar. 24,	1480
4-17-0-0-0	5 "	18 Yaxkin	Dec. 10,	1461
4-18-0-0-0	3 "	18 Uo	Aug. 27,	1441
4-19-0-0-0	1 "	3 Pax	May 14,	1421

BAKTUN 5

				B.C.
5- 0-0-0-0	12 Ahau	3 Zac	Jan. 29,	1401
5- 1-0-0-0	10 "	3 Xul	Oct. 17,	1382
5- 2-0-0-0	8 "	3 Pop	July 4,	1362
5- 3-0-0-0	6 "	8 Kankin	Mar. 20,	1342
5- 4-0-0-0	4 "	8 Chen	Dec. 6,	1323
5- 5-0-0-0	2 "	8 Zotz	Aug. 23,	1303
5- 6-0-0-0	13 "	13 Kayab	May 11,	1283
5- 7-0-0-0	11 "	13 Ceh	Jan. 26,	1263
5- 8-0-0-0	9 "	13 Yaxkin	Oct. 13,	1244
5- 9-0-0-0	7 "	13 Uo	July 1,	1224
5-10-0-0-0	5 "	18 Muan	Mar. 17,	1204
5-11-0-0-0	3 "	18 Yax	Dec. 3,	1185
5-12-0-0-0	1 "	18 Tzec	Aug. 20,	1165
5-13-0-0-0	12 "	3 Uayeb	May 7,	1145
5-14-0-0-0	10 "	3 Kankin	Jan. 22,	1125
5-15-0-0-0	8 "	3 Chen	Oct. 9,	1106
5-16-0-0-0	6 "	3 Zotz	June 27,	1086
5-17-0-0-0	4 "	8 Kayab	Mar. 14,	1066
5-18-0-0-0	2 "	8 Ceh	Nov. 29,	1047
5-19-0-0-0	13 "	8 Yaxkin	Aug. 16,	1027

BAKTUN 6

				B.C.
6- 0-0-0-0	11 Ahau	8 Uo	May 3,	1007
6- 1-0-0-0	9 "	13 Muan	Jan. 19,	987
6- 2-0-0-0	7 "	13 Yax	Oct. 6,	968
6- 3-0-0-0	5 "	13 Tzec	June 23,	948
6- 4-0-0-0	3 "	18 Cumhu	Mar. 10,	928
6- 5-0-0-0	1 "	18 Mac	Nov. 26,	909
6- 6-0-0-0	12 "	18 Mol	Aug. 14,	889
6- 7-0-0-0	10 "	18 Zip	May 1,	869
6- 8-0-0-0	8 "	3 Kayab	Jan. 16,	849
6- 9-0-0-0	6 "	3 Ceh	Oct. 3,	830
6-10-0-0-0	4 Ahau	3 Yaxkin	June 20,	810
6-11-0-0-0	2 "	3 Uo	Mar. 7,	790
6-12-0-0-0	13 "	8 Muan	Nov. 22,	771
6-13-0-0-0	11 "	8 Yax	Aug. 9,	751
6-14-0-0-0	9 "	8 Tzec	April 26,	731
6-15-0-0-0	7 "	13 Cumhu	Jan. 13,	711
6-16-0-0-0	5 "	13 Mac	Sept. 29,	692
6-17-0-0-0	3 "	13 Mol	June 16,	672
6-18-0-0-0	1 "	13 Zip	Mar. 3,	652
6-19-0-0-0	12 "	18 Pax	Nov. 19,	633

BAKTUN 7

				B.C.
7- 0-0-0-0	10 Ahau	18 Zac	Aug. 6,	613
7- 1-0-0-0	8 "	18 Xul	April 24,	593
7- 2-0-0-0	6 "	18 Pop	Jan. 9,	573
7- 3-0-0-0	4 "	3 Muan	Sept. 26,	554
7- 4-0-0-0	2 "	3 Yax	June 13,	534
7- 5-0-0-0	13 "	3 Tzec	Feb. 28,	514
7- 6-0-0-0	11 "	8 Cumhu	Nov. 16,	495
7- 7-0-0-0	9 "	8 Mac	Aug. 3,	475
7- 8-0-0-0	7 "	8 Mol	April 20,	455
7- 9-0-0-0	5 "	8 Zip	Jan. 5,	435
7-10-0-0-0	3 "	13 Pax	Sept. 22,	416
7-11-0-0-0	1 "	13 Zac	June 9,	396
7-12-0-0-0	12 "	13 Xul	Feb. 24,	376
7-13-0-0-0	10 "	13 Pop	Nov. 12,	357
7-14-0-0-0	8 "	18 Kankin	July 30,	337
7-15-0-0-0	6 "	18 Chen	April 16,	317
7-16-0-0-0	4 "	18 Zotz	Jan. 2,	297
7-17-0-0-0	2 "	3 Cumhu	Sept. 19,	278
7-18-0-0-0	13 "	3 Mac	June 6,	258
7-19-0-0-0	11 "	3 Mol	Feb. 21,	238

BAKTUN 8

				B.C.
8- 0-0-0-0	9 Ahau	3 Zip	Nov. 7,	219
8- 1-0-0-0	7 "	8 Pax	July 26,	199
8- 2-0-0-0	5 "	8 Zac	April 13,	179
8- 3-0-0-0	3 "	8 Xul	Dec. 29,	160
8- 4-0-0-0	1 "	8 Pop	Sept. 15,	140
8- 5-0-0-0	12 "	13 Kankin	June 2,	120
8- 6-0-0-0	10 "	13 Chen	Feb. 17,	100
8- 7-0-0-0	8 "	13 Zotz	Nov. 5,	81
8- 8-0-0-0	6 "	18 Kayab	July 23,	61
8- 9-0-0-0	4 "	18 Ceh	April 9,	41
8-10-0-0-0	2 "	18 Yaxkin	Dec. 25,	22
8-11-0-0-0	13 "	18 Uo	Sept. 12,	2
				A.D.
8-12-0-0-0	11 "	3 Pax	May 30,	18
8-13-0-0-0	9 "	3 Zac	Feb. 14,	37
8-14-0-0-0	7 "	3 Xul	Nov. 1,	57
8-15-0-0-0	5 "	3 Pop	July 19,	77
8-16-0-0-0	3 "	8 Kankin	April 5,	97
8-17-0-0-0	1 "	8 Chen	Dec. 22,	116
8-18-0-0-0	12 "	8 Zotz	Sept. 8,	136
8-19-0-0-0	10 "	13 Kayab	May 26,	156

Baktun 9			A.D.
9- 0-0-0-0	8 Ahau	13 Ceh	Feb. 10, 176
9- 1-0-0-0	6 "	13 Yaxkin	Oct. 29, 195
9- 2-0-0-0	4 "	13 Uo	July 17, 215
9- 3-0-0-0	2 "	18 Muan	April 3, 235
9- 4-0-0-0	13 "	18 Yax	Dec. 18, 254
9- 5-0-0-0	11 "	18 Tzec	Sept. 5, 274
9- 6-0-0-0	9 "	3 Uayeb	May 23, 294
9- 7-0-0-0	7 "	3 Kankin	Feb. 8, 314
9- 8-0-0-0	5 "	3 Chen	Oct. 26, 333
9- 9-0-0-0	3 "	3 Zotz	July 13, 353
9-10-0-0-0	1 "	8 Kayab	Mar. 30, 373
9-11-0-0-0	12 "	8 Ceh	Dec. 15, 392
9-12-0-0-0	10 "	8 Yaxkin	Sept. 1, 412
9-13-0-0-0	8 "	8 Uo	May 19, 432
9-14-0-0-0	6 "	13 Muan	Feb. 3, 452
9-15-0-0-0	4 "	13 Yax	Oct. 22, 471
9-16-0-0-0	2 "	13 Tzec	July 9, 491
9-17-0-0-0	13 "	18 Cumhu	Mar. 27, 511
9-18-0-0-0	11 "	18 Mac	Dec. 12, 530
9-19-0-0-0	9 "	18 Mol	Aug. 29, 550

Baktun 10			A.D.
10- 0-0-0-0	7 Ahau	18 Zip	May 17, 570
10- 1-0-0-0	5 "	3 Kayab	Jan. 31, 590
10- 2-0-0-0	3 "	3 Ceh	Oct. 19, 609
10- 3-0-0-0	1 "	3 Yaxkin	July 6, 629
10- 4-0-0-0	12 "	3 Uo	Mar. 23, 649
10- 5-0-0-0	10 "	8 Muan	Dec. 8, 668
10- 6-0-0-0	8 "	8 Yax	Aug. 25, 688
10- 7-0-0-0	6 "	8 Tzec	May 13, 708
10- 8-0-0-0	4 "	13 Cumhu	Jan. 28, 728
10- 9-0-0-0	2 "	13 Mac	Oct. 16, 747
10-10-0-0-0	13 "	13 Mol	July 3, 767
10-11-0-0-0	11 "	13 Zip	Mar. 20, 787
10-12-0-0-0	9 "	18 Pax	Dec. 5, 806
10-13-0-0-0	7 "	18 Zac	Aug. 22, 826
10-14-0-0-0	5 "	18 Xul	May 9, 846
10-15-0-0-0	3 "	18 Pop	Jan. 24, 866
10-16-0-0-0	1 "	3 Muan	Oct. 11, 885
10-17-0-0-0	12 "	3 Yax	June 29, 905
10-18-0-0-0	10 "	3 Tzec	Mar. 16, 925
10-19-0-0-0	8 "	8 Cumhu	Dec. 1, 944

Baktun 11			A.D.
11- 0-0-0-0	6 Ahau	8 Mac	Aug. 18, 964
11- 1-0-0-0	4 "	8 Mol	May 5, 984
11- 2-0-0-0	2 "	8 Zip	Jan. 22, 1004
11- 3-0-0-0	13 "	13 Pax	Oct. 9, 1023
11- 4-0-0-0	11 "	13 Zac	June 26, 1043
11- 5-0-0-0	9 "	13 Xul	Mar. 13, 1063
11- 6-0-0-0	7 "	13 Pop	Nov. 28, 1082
11- 7-0-0-0	5 "	18 Kankin	Aug. 16, 1102
11- 8-0-0-0	3 "	18 Chen	May 3, 1122
11- 9-0-0-0	1 "	18 Zotz	Jan. 18, 1142
11-10-0-0-0	12 Ahau	3 Cumhu	Oct. 5, 1161
11-11-0-0-0	10 "	3 Mac	June 22, 1181
11-12-0-0-0	8 "	3 Mol	Mar. 9, 1201
11-13-0-0-0	6 "	3 Zip	Nov. 24, 1220
11-14-0-0-0	4 "	8 Pax	Aug. 11, 1240
11-15-0-0-0	2 "	8 Zac	April 28, 1260
11-16-0-0-0	13 "	8 Xul	Jan. 14, 1280
11-17-0-0-0	11 "	8 Pop	Oct. 1, 1299
11-18-0-0-0	9 "	13 Kankin	June 18, 1319
11-19-0-0-0	7 "	13 Chen	Mar. 5, 1339

Baktun 12			A.D.
12- 0-0-0-0	5 Ahau	13 Zotz	Nov. 21, 1358
12- 1-0-0-0	3 "	18 Kayab	Aug. 8, 1378
12- 2-0-0-0	1 "	18 Ceh	April 25, 1398
12- 3-0-0-0	12 "	18 Yaxkin	Jan. 11, 1418
12- 4-0-0-0	10 "	18 Uo	Sept. 28, 1437
12- 5-0-0-0	8 "	3 Pax	June 15, 1457
12- 6-0-0-0	6 "	3 Zac	Mar. 2, 1477
12- 7-0-0-0	4 "	3 Xul	Nov. 17, 1496
12- 8-0-0-0	2 "	3 Pop	Aug. 5, 1516
12- 9-0-0-0	13 "	8 Kankin	April 22, 1536
12-10-0-0-0	11 "	8 Chen	Jan. 7, 1556
12-11-0-0-0	9 "	8 Zotz	Sept. 25, 1575
12-12-0-0-0	7 "	13 Kayab	June 12, 1595
12-13-0-0-0	5 "	13 Ceh	Feb. 27, 1615
12-14-0-0-0	3 "	13 Yaxkin	Nov. 14, 1634
12-15-0-0-0	1 "	13 Uo	Aug. 1, 1654
12-16-0-0-0	12 "	18 Muan	April 18, 1674
12-17-0-0-0	10 "	18 Yax	Jan. 3, 1694
12-18-0-0-0	8 "	18 Tzec	Sept. 21, 1713
12-19-0-0-0	6 "	3 Uayeb	June 8, 1733

Baktun 13			A.D.
13- 0-0-0-0	4 Ahau	3 Kankin	Feb. 23, 1753
13- 1-0-0-0	2 "	3 Chen	Nov. 10, 1772
13- 2-0-0-0	13 "	3 Zotz	July 28, 1792
13- 3-0-0-0	11 "	8 Kayab	April 15, 1812
13- 4-0-0-0	9 "	8 Ceh	Jan. 1, 1832
13- 5-0-0-0	7 "	8 Yaxkin	Sept. 18, 1851
13- 6-0-0-0	5 "	8 Uo	June 5, 1871
13- 7-0-0-0	3 "	13 Muan	Feb. 20, 1891
13- 8-0-0-0	1 "	13 Yax	Nov. 8, 1910
13- 9-0-0-0	12 "	13 Tzec	July 26, 1930
13-10-0-0-0	10 "	18 Cumhu	April 12, 1950
13-11-0-0-0	8 "	18 Mac	Dec. 28, 1969
13-12-0-0-0	6 "	18 Mol	Sept. 14, 1989
13-13-0-0-0	4 "	18 Zip	June 1, 2009

TABLE XIV. TABLE OF INTERVALS IN MAYAN YEAR FROM 0 POP

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pop	365	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Uo	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Zip	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
Zotz	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
Tzec	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
Xul	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
Yaxkin	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139
Mol	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
Chen	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179
Yax	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199
Zac	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219
Ceh	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
Mac	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259
Kankin	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279
Muan	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299
Pax	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319
Kayab	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339
Cumhu	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359
Uayeb	360	361	362	363	364															

First the correctness of the readings of the Mayan dates and distance numbers should be tested by the methods explained in the first part of this study and further illustrated in papers by Goodman, Bowditch, and Morley. The operation which we are most concerned in is to convert the Mayan year into the Gregorian year, this latter being greatly preferable for most purposes to the Julian year because its dates are constantly in correlation with the seasons. Dates concerned with the seasonal activities of man are sometimes self-revealing when expressed in terms of the natural year. The Mayan day number can be converted into the Julian day of the astronomers by adding the constant difference, 489,384 to the former. This simple equation makes it possible to use modern tables of eclipse data, such as Oppolzer's Canon and Shram's Tables, as well as tables dealing with the major planets. The equation of the Julian day hardly serves, however, for the ordinary purposes of history, which require statements of the Christian year and the day of the month if not that of the week.

TABLE XV. — POSITIONS OF 0 POP IN GREGORIAN YEARS

CENTURIES AFTER CHRIST

Years	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000
Read down 0				July 12				Oct. 17		
4	April 30	May 24	June 17	" 11	Aug. 5	Aug. 29	Sept. 22	" 16	Nov. 10	Dec. 4
8	" 29	" 23	" 16	" 10	" 4	" 28	" 21	" 15	" 9	" 3
12	" 28	" 22	" 15	" 9	" 3	" 27	" 20	" 14	" 8	" 2
16	" 27	" 21	" 14	" 8	" 2	" 26	" 19	" 13	" 7	" 1
20	" 26	" 20	" 13	" 7	" 1	" 25	" 18	" 12	" 6	Nov. 30
24	" 25	" 19	" 12	" 6	July 31	" 24	" 17	" 11	" 5	" 29
28	" 24	" 18	" 11	" 5	" 30	" 23	" 16	" 10	" 4	" 28
32	" 23	" 17	" 10	" 4	" 29	" 22	" 15	" 9	" 3	" 27
36	" 22	" 16	" 9	" 3	" 28	" 21	" 14	" 8	" 2	" 26
40	" 21	" 15	" 8	" 2	" 27	" 20	" 13	" 7	" 1	" 25
44	" 20	" 14	" 7	" 1	" 26	" 19	" 12	" 6	[illegible] 31	" 24
48	" 19	" 13	" 6	June 30	" 25	" 18	" 11	" 5	" 30	" 23
52	" 18	" 12	" 5	" 29	" 24	" 17	" 10	" 4	" 29	" 22
56	" 17	" 11	" 4	" 28	" 23	" 16	" 9	" 3	" 28	" 21
60	" 16	" 10	" 3	" 27	" 22	" 15	" 8	" 2	" 27	" 20
64	" 15	" 9	" 2	" 26	" 21	" 14	" 7	" 1	" 26	" 19
68	" 14	" 8	" 1	" 25	" 20	" 13	" 6	Sept. 30	" 25	" 18
72	" 13	" 7	May 31	" 24	" 19	" 12	" 5	" 29	" 24	" 17
76	" 12	" 6	" 30	" 23	" 18	" 11	" 4	" 28	" 23	" 16
80	" 11	" 5	" 29	" 22	" 17	" 10	" 3	" 27	" 22	" 15
84	" 10	" 4	" 28	" 21	" 16	" 9	" 2	" 26	" 21	" 14
88	" 9	" 3	" 27	" 20	" 15	" 8	" 1	" 25	" 20	" 13
92	" 8	" 2	" 26	" 19	" 14	" 7	Aug. 31	" 24	" 19	" 12
96	" 7	" 1	" 25	" 18	" 13	" 6	" 30	" 23	" 18	" 11

TABLE XV.—POSITIONS OF 0 POP IN GREGORIAN YEARS

CENTURIES AFTER CHRIST

900	800	700	600	500	400	300	200	100	0	*Years*
	Jan. 22				April 29				Aug. 4	Read down 0
Dec. 28	" 21	Feb. 15	Mar. 11	April 4	" 28	May 23	June 16	July 10	" 3	4
" 27	" 20	" 14	" 10	" 3	" 27	" 22	" 15	" 9	" 2	8
" 26	" 19	" 13	" 9	" 2	" 26	" 21	" 14	" 8	" 1	12
" 25	" 18	" 12	" 8	" 1	" 25	" 20	" 13	" 7	July 31	16
" 24	" 17	" 11	" 7	Mar. 31	" 24	" 19	" 12	" 6	" 30	20
" 23	" 16	" 10	" 6	" 30	" 23	" 18	" 11	" 5	" 29	24
" 22	" 15	" 9	" 5	" 29	" 22	" 17	" 10	" 4	" 28	28
" 21	" 14	" 8	" 4	" 28	" 21	" 16	" 9	" 3	" 27	32
" 20	" 13	" 7	" 3	" 27	" 20	" 15	" 8	" 2	" 26	36
" 19	" 12	" 6	" 2	" 26	" 19	" 14	" 7	" 1	" 25	40
" 18	" 11	" 5	" 1	" 25	" 18	" 13	" 6	June 30	" 24	44
" 17	" 10	" 4	Feb. 28	" 24	" 17	" 12	" 5	" 29	" 23	48
" 16	" 9	" 3	" 27	" 23	" 16	" 11	" 4	" 28	" 22	52
" 15	" 8	" 2	" 26	" 22	" 15	" 10	" 3	" 27	" 21	56
" 14	" 7	" 1	" 25	" 21	" 14	" 9	" 2	" 26	" 20	60
" 13	" 6	Jan. 31	" 24	" 20	" 13	" 8	" 1	" 25	" 19	64
" 12	" 5	" 30	" 23	" 19	" 12	" 7	May 31	" 24	" 18	68
" 11	" 4	" 29	" 22	" 18	" 11	" 6	" 30	" 23	" 17	72
" 10	" 3	" 28	" 21	" 17	" 10	" 5	" 29	" 22	" 16	76
" 9	" 2	" 27	" 20	" 16	" 9	" 4	" 28	" 21	" 15	80
" 8	" 1	" 26	" 19	" 15	" 8	" 3	" 27	" 20	" 14	84
" 7	Dec. 31	" 25	" 18	" 14	" 7	" 2	" 26	" 19	" 13	88
" 6	" 30	" 24	" 17	" 13	" 6	" 1	" 25	" 18	" 12	92
" 5	" 29	" 23	" 16	" 12	" 5	April 30	" 24	" 17	" 11	96

POSITIONS OF 0 POP IN GREGORIAN YEARS

CENTURIES BEFORE CHRIST

Years	0	100	200	300	400	500	600	700	800
Read up 96	Aug. 28	Sept. 21	Oct. 15	Nov. 8	Dec. 3	Dec. 27	Jan. 20	Feb. 13	Mar. 10
92	" 27	" 20	" 14	" 7	" 2	" 26	" 19	" 12	" 9
88	" 26	" 19	" 13	" 6	" 1	" 25	" 18	" 11	" 8
84	" 25	" 18	" 12	" 5	Nov. 30	" 24	" 17	" 10	" 7
80	" 24	" 17	" 11	" 4	" 29	" 23	" 16	" 9	" 6
76	" 23	" 16	" 10	" 3	" 28	" 22	" 15	" 8	" 5
72	" 22	" 15	" 9	" 2	" 27	" 21	" 14	" 7	" 4
68	" 21	" 14	" 8	" 1	" 26	" 20	" 13	" 6	" 3
64	" 20	" 13	" 7	Oct. 31	" 25	" 19	" 12	" 5	" 2
60	" 19	" 12	" 6	" 30	" 24	" 18	" 11	" 4	" 1
56	" 18	" 11	" 5	" 29	" 23	" 17	" 10	" 3	Feb. 28
52	" 17	" 10	" 4	" 28	" 22	" 16	" 9	" 2	" 27
48	" 16	" 9	" 3	" 27	" 21	" 15	" 8	" 1	" 26
44	" 15	" 8	" 2	" 26	" 20	" 14	" 7	Jan. 31	" 25
40	" 14	" 7	" 1	" 25	" 19	" 13	" 6	" 30	" 24
36	" 13	" 6	Sept. 30	" 24	" 18	" 12	" 5	" 29	" 23
32	" 12	" 5	" 29	" 23	" 17	" 11	" 4	" 28	" 22
28	" 11	" 4	" 28	" 22	" 16	" 10	" 3	" 27	" 21
24	" 10	" 3	" 27	" 21	" 15	" 9	" 2	" 26	" 20
20	" 9	" 2	" 26	" 20	" 14	" 8	" 1	" 25	" 19
16	" 8	" 1	" 25	" 19	" 13	" 7	Dec. 31	" 24	" 18
12	" 7	Aug. 31	" 24	" 18	" 12	" 6	" 30	" 23	" 17
8	" 6	" 30	" 23	" 17	" 11	" 5	" 29	" 22	" 16
4	" 5	" 29	" 22	" 16	" 10	" 4	" 28	" 21	" 15
0	" 4				" 9				" 14

POSITIONS OF 0 POP IN GREGORIAN YEARS

CENTURIES BEFORE CHRIST

900	1000	1100	1200	1300	1400	1500	1600	1700	*Years*
April 3	April 27	May 21	June 15	July 9	Aug. 2	Aug. 26	Sept. 20	Oct. 14	Read up 96
" 2	" 26	" 20	" 14	" 8	" 1	" 25	" 19	" 13	92
" 1	" 25	" 19	" 13	" 7	July 31	" 24	" 18	" 12	88
Mar. 31	" 24	" 18	" 12	" 6	" 30	" 23	" 17	" 11	84
" 30	" 23	" 17	" 11	" 5	" 29	" 22	" 16	" 10	80
" 29	" 22	" 16	" 10	" 4	" 28	" 21	" 15	" 9	76
" 28	" 21	" 15	" 9	" 3	" 27	" 20	" 14	" 8	72
" 27	" 20	" 14	" 8	" 2	" 26	" 19	" 13	" 7	68
" 26	" 19	" 13	" 7	" 1	" 25	" 18	" 12	" 6	64
" 25	" 18	" 12	" 6	June 30	" 24	" 17	" 11	" 5	60
" 24	" 17	" 11	" 5	" 29	" 23	" 16	" 10	" 4	56
" 23	" 16	" 10	" 4	" 28	" 22	" 15	" 9	" 3	52
" 22	" 15	" 9	" 3	" 27	" 21	" 14	" 8	" 2	48
" 21	" 14	" 8	" 2	" 26	" 20	" 13	" 7	" 1	44
" 20	" 13	" 7	" 1	" 25	" 19	" 12	" 6	Sept. 30	40
" 19	" 12	" 6	May 31	" 24	" 18	" 11	" 5	" 29	36
" 18	" 11	" 5	" 30	" 23	" 17	" 10	" 4	" 28	32
" 17	" 10	" 4	" 29	" 22	" 16	" 9	" 3	" 27	28
" 16	" 9	" 3	" 28	" 21	" 15	" 8	" 2	" 26	24
" 15	" 8	" 2	" 27	" 20	" 14	" 7	" 1	" 25	20
" 14	" 7	" 1	" 26	" 19	" 13	" 6	Aug. 31	" 24	16
" 13	" 6	April 30	" 25	" 18	" 12	" 5	" 30	" 23	12
" 12	" 5	" 29	" 24	" 17	" 11	" 4	" 29	" 22	8
" 11	" 4	" 28	" 23	" 16	" 10	" 3	" 28	" 21	4
			" 22				" 27		0

POSITIONS OF 0 POP IN GREGORIAN YEARS

CENTURIES BEFORE CHRIST

Years	1800	1900	2000	2100	2200	2300	2400	2500
Read up 96	Nov. 7	Dec. 1	Dec. 25	Jan. 18	Feb. 11	Mar. 7	April 1	April 25
92	" 6	Nov. 30	" 24	" 17	" 10	" 6	Mar. 31	" 24
88	" 5	" 29	" 23	" 16	" 9	" 5	" 30	" 23
84	" 4	" 28	" 22	" 15	" 8	" 4	" 29	" 22
80	" 3	" 27	" 21	" 14	" 7	" 3	" 28	" 21
76	" 2	" 26	" 20	" 13	" 6	" 2	" 27	" 20
72	" 1	" 25	" 19	" 12	" 5	" 1	" 26	" 19
68	Oct. 31	" 24	" 18	" 11	" 4	Feb. 28	" 25	" 18
64	" 30	" 23	" 17	" 10	" 3	" 27	" 24	" 17
60	" 29	" 22	" 16	" 9	" 2	" 26	" 23	" 16
56	" 28	" 21	" 15	" 8	" 1	" 25	" 22	" 15
52	" 27	" 20	" 14	" 7	Jan. 31	" 24	" 21	" 14
48	" 26	" 19	" 13	" 6	" 30	" 23	" 20	" 13
44	" 25	" 18	" 12	" 5	" 29	" 22	" 19	" 12
40	" 24	" 17	" 11	" 4	" 28	" 21	" 18	" 11
36	" 23	" 16	" 10	" 3	" 27	" 20	" 17	" 10
32	" 22	" 15	" 9	" 2	" 26	" 19	" 16	" 9
28	" 21	" 14	" 8	" 1	" 25	" 18	" 15	" 8
24	" 20	" 13	" 7	Dec. 31	" 24	" 17	" 14	" 7
20	" 19	" 12	" 6	" 30	" 23	" 16	" 13	" 6
16	" 18	" 11	" 5	" 29	" 22	" 15	" 12	" 5
12	" 17	" 10	" 4	" 28	" 21	" 14	" 11	" 4
8	" 16	" 9	" 3	" 27	" 20	" 13	" 10	" 3
4	" 15	" 8	" 2	" 26	" 19	" 12	" 9	" 2
0							" 8	

POSITIONS OF 0 POP IN GREGORIAN YEARS

CENTURIES BEFORE CHRIST

2600	2700	2800	2900	3000	3100	3200	3300	*Years* Read up
May 19	June 12	July 7	July 31	Aug. 24	Sept. 17	Oct. 12	Nov. 5	96
" 18	" 11	" 6	" 30	" 23	" 16	" 11	" 4	92
" 17	" 10	" 5	" 29	" 22	" 15	" 10	" 3	88
" 16	" 9	" 4	" 28	" 21	" 14	" 9	" 2	84
" 15	" 8	" 3	" 27	" 20	" 13	" 8	" 1	80
" 14	" 7	" 2	" 26	" 19	" 12	" 7	Oct. 31	76
" 13	" 6	" 1	" 25	" 18	" 11	" 6	" 30	72
" 12	" 5	June 30	" 24	" 17	" 10	" 5	" 29	68
" 11	" 4	" 29	" 23	" 16	" 9	" 4	" 28	64
" 10	" 3	" 28	" 22	" 15	" 8	" 3	" 27	60
" 9	" 2	" 27	" 21	" 14	" 7	" 2	" 26	56
" 8	" 1	" 26	" 20	" 13	" 6	" 1	" 25	52
" 7	May 31	" 25	" 19	" 12	" 5	Sept. 30	" 24	48
" 6	" 30	" 24	" 18	" 11	" 4	" 29	" 23	44
" 5	" 29	" 23	" 17	" 10	" 3	" 28	" 22	40
" 4	" 28	" 22	" 16	" 9	" 2	" 27	" 21	36
" 3	" 27	" 21	" 15	" 8	" 1	" 26	" 20	32
" 2	" 26	" 20	" 14	" 7	Aug. 31	" 25	" 19	28
" 1	" 25	" 19	" 13	" 6	" 30	" 24	" 18	24
April 30	" 24	" 18	" 12	" 5	" 29	" 23	" 17	20
" 29	" 23	" 17	" 11	" 4	" 28	" 22	" 16	16
" 28	" 22	" 16	" 10	" 3	" 27	" 21	" 15	12
" 27	" 21	" 15	" 9	" 2	" 26	" 20	" 14	8
" 26	" 20	" 14	" 8	" 1	" 25	" 19	" 13	4
		" 13				" 18		0

TABLE XVI. TABLE OF INTERVALS IN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
January	365	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
February	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
March	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
April	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
May	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
June	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166
July	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196
August	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227
September	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258
October	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288
November	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319
December	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349

Without tables the reduction of Mayan dates to the Gregorian calendar becomes a rather tedious process, but with the four tables especially compiled for this study any Mayan date can be transcribed readily into its Gregorian equivalent and vice versa. The first of these tables (Table XIII) gives the ending days of katuns in the European calendar for a range of several thousand years. The third one (Table XV) gives the position of 0 Pop, the Mayan New Years Day, in any Gregorian year over about the same period. Next follow two short tabulations (Table XIV and XVI) which furnish us with index numbers for any month position in the Mayan and Gregorian years. Lastly XVII supplies multiples of the various elements entering into the reduction of dates.

The katun-ending dates of Table XIII are compiled from the epoch of the Mundane Era, 13–0–0–0–0, Oct. 14, 3373 B.C. and give us fixed points in the Gregorian calendar at intervals of 7200 days. From this compilation it is generally possible to tell by mere inspection the Gregorian year of any Mayan date. Certain precautions should be taken. Since a katun is about 105 days shorter than 20 years the apparent interval between katun-ending days may occasionally be 19 instead of 20 years. But for ordinary purposes the tuns, added to the position indicated for the even katun will give the proper year unless the value of the uinals and days is sufficient to carry over into another year. Thus to find the Gregorian year of the Mayan date 9–15–12–11–13, 7 Ben 1 Pop: the table gives as a base 9–15–0–0–0, 4 Ahau 13 Yax, Oct. 22, 471 A.D. Adding 12 tuns to the year brings us into 483, obviously after the middle of this year since the 12 tuns are only a

GREGORIAN YEAR FROM JANUARY 1

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	January
47	48	49	50	51	52	53	54	55	56	57	58				February
75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	March
106	107	108	109	110	111	112	113	114	115	116	117	118	119		April
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	May
167	168	169	170	171	172	173	174	175	176	177	178	179	180		June
197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	July
228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	August
259	260	261	262	263	264	265	266	267	268	269	270	271	272		September
289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	October
320	321	322	323	324	325	326	327	328	329	330	331	332	333		November
350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	December

little less than 12 years. But the 11–13 for uinals and days is sufficient to reach 484. The year is tentative at this stage, but it furnishes the base for the next table.

Table XV records the positions in the Gregorian year of 0 Pop, the calendarial New Year of the Mayas. The presentation is quite formal and orderly, the years of the European century being arranged at intervals of four applying to all the century columns. Thus the row marked 44 under the century heading 1200 means 1244 and its date controls until the next space where 1248 is declared. For dates before Christ, the years read up and the centuries are indicated as before. The zero position is a point in time identical for B.C. and A.D. dates, but the first year before Christ is designated zero in conformity with astronomical usage. Without such a zero year we could not make direct subtractions and additions from the two sides of the turning point in chronology. Any person wishing to follow the clumsy historical usage can add one year to all B.C. dates.

This table of the positions of 0 Pop takes its real departure from the typical year of Landa when 12 Kan 2 Pop of the ancient usage, was July 16, 1553, Julian Calendar, or July 26, Gregorian Calendar and 0 Pop was two days earlier. By arrangement 0 Pop representing the vague year of 365 days makes a complete round of the seasons in 1508 years. The Sothic Cycle of Egypt is 1460, the sidereal year being aligned with the Julian year. The peregrinations of 0 Pop show how the Mayan year stands in the Gregorian calendar of the tropical year at any time within the historical period. It takes care of the obtrusive February 29.

For very accurate readings it may be necessary to have recourse now and then to the mean tropical year which is now calculated at 365.2421996 days as against a length for the Gregorian calendar of 365.2425 days. This means an error for the calendar of a day in something over 3000 years and it has been proposed to

TABLE XVII. — MULTIPLICATION TABLES FOR USE WITH THE MAYAN CALENDAR

	Baktuns	Katuns	Tuns	Uinals	Kins
1	144,000	7,200	360	20	1
2	288,000	14,400	720	40	2
3	432,000	21,600	1,080	60	3
4	576,000	28,800	1,440	80	4
5	720,000	36,000	1,800	100	5
6	864,000	43,200	2,160	120	6
7	1,008,000	50,400	2,520	140	7
8	1,152,000	57,600	2,880	160	8
9	1,296,000	64,800	3,240	180	9
10	1,440,000	72,000	3,600	200	10
11	1,584,000	79,200	3,960	220	11
12	1,728,000	86,400	4,320	240	12
13	1,872,000	93,600	4,680	260	13
14	2,016,000	100,800	5,040	280	14
15	2,160,000	108,000	5,400	300	15
16	2,304,000	115,200	5,760	320	16
17	2,448,000	122,400	6,120	340	17
18	2,592,000	129,600	6,480		18
19	2,736,000	136,800	6,840		19

	Vague Years	Gregorian Years	Tropical Years
1	365	365.2425	365.2421996
2	730	730.4850	730.4843992
3	1,095	1,095.7275	1,095.7265988
4	1,460	1,460.9700	1,460.9687984
5	1,825	1,826.2125	1,826.2109980
6	2,190	2,191.4550	2,191.4531976
7	2,555	2,556.6975	2,556.6953972
8	2,920	2,921.9400	2,921.9375968
9	3,285	3,287.1825	3,287.1797964

make the year 3600 or 4000 a leap year which would effect a very close correction from 325 A.D., the date of the Council of Nice. In the backward projection of the calendar the leap year day for 2000 B.C. has been inserted in this table for the same purpose. The principal difficulty in the Gregorian calendar comes at the

ends of centuries where there is, in three cases out of four, no leap-year intercalation for eight years. At such times, considerable warping of the Gregorian day out of its mean position must be allowed for. The extremes of such warping cause the fixed points of the tropical year to vary more than a day and a half either way from the mean positions.

Using the table of katun endings in conjunction with the positions of 0 Pop enables us to recover the beginning day of the Mayan year in relation to January 1 of the Gregorian year. The other two tables give immediate control over the other days in the two types of years.

Table XVI supplies the interval-index for all days in the Gregorian year (except the intercalary day February 29, which is taken care of in the table of the positions of 0 Pop) and Table XIV supplies the same interval-index for the Mayan year. These two tables will be found useful for purposes outside the actual transcription. By simple subtraction of the index numbers the number of days between any two days in either the Gregorian or the Mayan year can be obtained, as may be seen by these examples:

(*a*) To find how many days from January 7 to July 14: January 7=6; July 14=194; difference=188 days.

(*b*) To find how many days from July 14 to January 7: July 14=194, January 7=6. 365−194+6=177 days. The same operations apply to the Mayan year when the month pattern is much more regular. From a correlation of the two years at any point, cross statement can be effected for any other point:

(*c*) If 3 Uo=May 7, what is the equivalent of 6 Kayab? 3 Uo=23; May 7=126; 6 Kayab=326; 326−23=303 days; 126+303 =429−365=64=March 6 of the following year.

Let us now try the tables on actual inscriptions. On a stela at Los Higos, Honduras, the initial series is clearly 9–17–10–7–0, 9 Ahau 3 Tzec.

By Table XIII, 9–17–0–0–0, 12 Ahau 18 Cumhu equals Mar. 27, 511 and adding 10–7–0, puts us in 521.

By Table XV, in the year 521 0 Pop was March 31.

By Table XVI, March 31=89.

By Table XIV, 3 Tzec=83: 89+83=172.

By Table XVI, 173=June 22.

Therefore this initial series registers June 22, 511.

Next we take two dates joined by a distance number at the beginning of a calculation on Lintel 1 at El Cayo:

9–16– 0– 2–16, 6 Cib 9 Mol
11–17–10
9–16–12– 2– 6, 13 Cimi 19 Zotz

In Table XIII, of katun-ending dates, we find that 9–16–0–0–0 fell on July 491 A.D. and since there are only two uinals and sixteen kins more in this declaration we know we are still in the same year. In Table XV, of the positions of 0 Pop, we find that the Mayan calendrical New Year corresponded at this time to April 7 of the last previous intercalation on Feb. 29, 488. Now April 7 has the interval-index number 96 in the Gregorian year (Table XVI) and 9 Mol of our inscription has the interval-index number 149 (Table XIV). Adding these two numbers we get 245 and we find by turning back to our Table XVI of the Gregorian year that this is September 3. The first date may be transcribed, then, as 9–16–0–2–16, 6 Cib 9 Mol = Sept. 3, 491 A.D. It will be observed that we have not been called upon to consider in any way the day 6 Cib, only the month position which it occupies. Of course the correctness of all Mayan dates should be verified before transcription is attempted.

We now have an addition which carries us a little over twelve years forward and if we add twelve to the 491 previously determined we get the Gregorian year 503 and in this year we must obtain the Gregorian month position corresponding to 19 Zotz. Now we find 0 Pop as April 5 under the year 496 since 500 was not a leap year. This day has the index 94 and since 19 Zotz yields 79 we obtain by addition the number 173 which gives us June 23 in back references to the Gregorian year.

Astronomical Time

Both of these dates fall close to the end of a century and show rather harsh warping due to the system of Gregorian intercalations. In the twelve-year period there are only two leap-year days intercalated while ordinarily there would be three. Let us carry a more accurate intercalation backward from 1922, a year midway between two intercalations, although itself not exactly on the mean. The intervals from 1922 to 503 and 491 are 1419 and 1431 years

respectively and in the first case the required intercalation is 343.681905 days and the allowance by the Gregorian calendar is 343 days and in the second case the required intercalation is 346.5874845 days and the allowance by the Gregorian calendar is 345. In the normal Gregorian year these dates would correspond to September 2 and June 22, rather than September 3 and June 23.

Now it may have been noted by the reader that June 22 reached by both these inscriptions is the mean Gregorian date of the summer solstice. It may therefore be desirable to make an accurate determination on the basis of astronomical time. For this purpose the dates of the solstices and equinoxes for the year 1922 for Palenque, Copan and Chichen Itza have been computed as follows:

Table XVIII. — Astronomical Points of the Year 1922

		Palenque	Copan	Chichen Itza
Vernal Equinox	Mar. 21	3.41 A.M.	3.54 A.M.	3.58 A.M.
Summer Solstice	June 21	11.19 P.M.	11.32 P.M.	11.36 P.M.
Autumnal Equinox	Sept. 23	2.02 P.M.	2.15 P.M.	2.19 P.M.
Winter Solstice	Dec. 22	8.49 A.M.	9.02 A.M.	9.06 A.M.

The correlation between the Julian day and the Mayan day is accomplished by adding the number 489,384 to the long count from the epoch of the Mayan era. The data given above can be transcribed thus into the day counts of modern and ancient astronomers.

Table XIX. — Day Numbers for Astronomical Points of the Year 1922

	Julian Day	Mayan Day
Vernal Equinox	2,423,135.15	1,933,751.15
Summer Solstice	2,423,227.99	1,933,843.99
Autumnal Equinox	2,423,321.58	1,933,937.58
Winter Solstice	2,423,411.27	1,934,027.27

In this statement the Julian and Mayan days are separated by an equation in whole days. The Julian days, as used here, begin at midnight. The Mayan days probably began at either sunset or sunrise and observations of the solstices and equinoxes were almost certainly taken with the sun at the horizon. Therefore there is probably a plus or minus .25 for the Mayan day as compared with the Julian. For the time being judgment on this matter will be held in abeyance. Counting back from the summer

solstice of 1922 for the Copan base we obtain the following conditions in Julian days.

A.	Summer Solstice 1922 A.D. Jul. Day	2,423,227.99
	1401 Tropical years	511,704.32
	Summer Solstice 521 A.D. Jul. Day	1,911,523.67
	Day of the Monument	1,911,524.00
B.	Summer Solstice, 1922 A.D. Jul. Day	2,423,227.99
	1419 Tropical Years	517,278.68
	Summer Solstice 503 A.D.	1,904,949.31
	Day of the Monument	1,904,950.00

These readings are both very close but if we argue that the Mayan day began at sunset six hours before the Julian day then the statement in terms of the Julian day can be written as follows:

A.	Summer Solstice 521 A.D.	1,911,523,67
	Date of the Monument	1,911,527.75
B.	Summer Solstice 503 A.D.	1,904,949.31
	Date of the Monument	1,904,949.75

For purposes of more detailed examinations of the significance of such readings the points of sunset for Copan, Honduras, are given in intervals of 10 days in Table XX.

TABLE XX. — POINTS OF SUNSET AT COPAN, HONDURAS

Jan. 1	23.9° S. of W.	July 10	23.1° N. of W.
" 11	22.7	" 20	21.6
" 21	20.7	" 30	19.3
" 31	18.2	Aug. 9	16.6
Feb. 10	15.0	" 19	13.5
" 20	11.5	" 29	9.9
Mar. 2	7.7	Sept. 8	6.1
" 12	3.6	" 18	2.2
" 22	0.4 N. of W.	" 28	1.8 S. of W.
April 1	4.5	Oct. 8	5.9
" 11	8.4	" 18	9.7
" 21	12.1	" 28	13.5
May 1	15.5	Nov. 7	16.7
" 11	18.4	" 17	19.6
" 21	20.8	" 27	21.8
" 31	22.6	Dec. 7	23.4
June 10	23.6	" 17	24.2
" 20	24.3	" 27	24.3
" 30	24.1		

One thing brought out clearly in this table is the much greater difficulty of making a sharp reading on the days of the solstices than on the days of the equinoxes: in the first cases the sun is almost at a standstill for a considerable period and in the second one it is moving most rapidly. At the latitude of Copan (15° north) the extreme limits of the sunset and sunrise points do not

Table XXI. Four Kinds of Days

Astronomical	Civil	Mayan Elapsed	Mexican Current
		Sunset—	
	Midnight		
		0	—Sunrise
Noon—	1		
		Sunset—	1
1	—Midnight		
		1	—Sunrise
Noon—	2		
		Sunset—	2
2	—Midnight		
		2	—Sunrise
Noon—	3		
		Sunset—	3
3	—Midnight		
		3	—Sunrise
Noon—	4		
		Sunset—	4
4	—Midnight		
		4	—Sunrise
Noon—	5		
		Sunset—	

reach 25° north and south of the east and west line. The comparison for 20 days movement at the points of the year is instructive since it shows for the solstices a movement of about eight-tenths of a degree and for the equinoxes more than eight full degrees. We should therefore expect greater exactness in the determination of the equinoxes than in the determination of the solstices.

Types of Days in Central America and Mexico

There is a single day offset between the time counts of the tribes on the highlands of Mexico and Guatemala and the lowlands of

Maya. What is the explanation? When we learn that not only do the days of equivalent etymologies show this one day fault but that the beginnings of months are similarly displaced, we are justified in looking for a structural reason. Perhaps it is to be found in the custom of counting days from different points and from counting them according to the different systems of elapsed and current time. It may be remarked that the clash of elapsed and current counting systems is seen in British India in connection with Vikram, Saka and some other eras. The diagram in Table XXI illustrates four kinds of days, two being used by ourselves while the other two were the systems employed by the Mayas and Aztecs.

It will be seen that European recorders would probably give the Mayan day name positions one European day in advance of the Aztecs, while as a matter of fact they coincided for half of the twenty-four hours. This may not be the true explanation of the discrepancy but it is a possible explanation.

PART IV

WHAT THE INSCRIPTIONS REVEAL

The first supplementary proofs of the correlation just elaborated only came after tables were perfected which made possible a broadside attack on the record of dates. The dates connected with the lunar and Venus tables were at once converted in the hope that they would yield eclipses and conjunctions. This quest was unsuccessful although real significance for many of these dates has since come to light. But corroboration came from an unexpected quarter.

Etymologies and Symbols of Mayan Months

Students of art recognize in Mayan hieroglyphs conventional pictures and symbols of things and ideas. Indeed the beginnings of writing generally depend on such associations. In the Mayan calendar the day names are obviously drawn from animals, birds and aspects of nature. The probabilities are strong that the months of an original lunar calendar followed the descriptive pattern found among many primitive peoples. That is, the moons were designated by seasonal activities of man and nature. When the lunation was replaced in the Mayan calendar by an arbitrary period of twenty days, the association with the moon was clearly retained. But the etymologies of the new month names and the symbolism of the glyphs were drawn from the times of the year in which these twenty-day periods stood at the inauguration. The 365 day year made its revolution a little faster than the tropical year and the months were displaced so that the names and hieroglyphs no longer applied to the current setting in the natural year. So long, however, as the revealing names and signs remained unchanged the original placements could be reached by calculation.

Now it has long been recognized that the month Xul means end and that the next month, Yaxkin, means new, strong or green sun. Sometimes the prefix *dze* is added to this name and this prefix means beginning or foundation. The thought that im-

mediately suggests itself is that Xul was originally the end of one year and Yaxkin the beginning of the next and further inquiry indicates that this was a year commencing with the rainy season or with new agricultural activities that immediately preceded the rains. This thought is strengthened by other etymologies and examples of symbolism. Mol follows Yaxkin and means things piled up, like cumulus clouds, and the essential detail in the hieroglyph is probably a rain drop. The day Muluc has a similar meaning and hieroglyph.

The next four months are Chen, Yax, Zac and Ceh, and in connection with them it is perhaps sufficient to point out that the

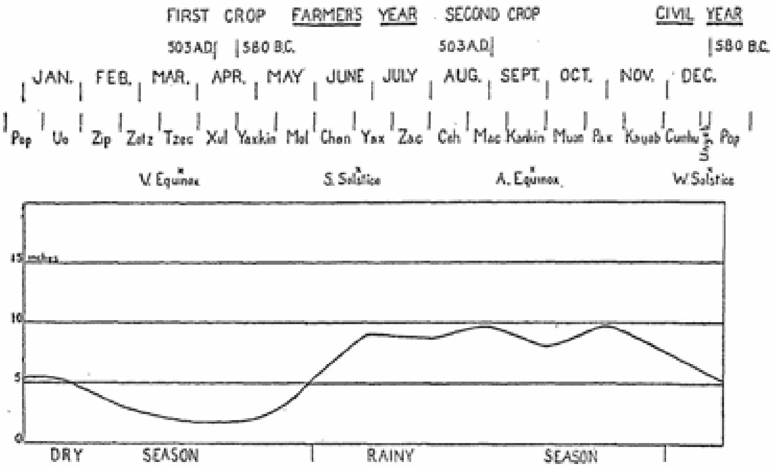


FIGURE 34. RAINFALL CHART OF THE MAYAN AREA SHOWING RELATION OF AGRICULTURAL AND ASTRONOMICAL YEARS

body of the hieroglyph in all four cases is the Cauac or rain glyph. The etymology of Cauac is uncertain but its Cakchiquel and Quiché cognate is Coak which means downpour or heavy rain. The Aztecan equivalent of the day Cauac is Quiahuitl which means rain. The sign Cauac also has the significance year in Mayan hieroglyphs, years being counted by rainy seasons.

Kankin means yellow sun but it may signify harvest sun since it would come at the time of the first harvest if Yaxkin were aligned with the beginning of the farmer's year. Several of the month names and hieroglyphs are noncommittal. Pop signifies mat

and hence rule since the throne of the ruler was covered with a mat. Uo and Zip in the dry season carry the diagonal cross of the galaxy and represent a time of clear skies.

When these months were arranged in order over a rainfall chart of the Mayan territory (fig. 34), it became apparent that if Yaxkin were placed in April the first of Pop would be close to the winter

TABLE XXII. — THE DOUBLE YEAR

Agricultural Year Begins:

April	21 to May 10	Yaxkin
May	11 to May 30	Mol
May	31 to June 19	Chen
June	20 to July 9	Yax
July	10 to July 29	Zac
July	30 to August 18	Ceh
August	19 to September 7	Mac
September	8 to September 27	Kankin
September	28 to October 17	Muan
October	18 to November 6	Pax
November	7 to November 26	Kayeb
November	27 to December 16	Cumhu
December	17 to December 21	Uayeb

Astronomical Year Begins:

December	22 to January 10	Pop
January	11 to January 30	Uo
January	31 to February 19	Zip
February	20 to March 11	Zotz
March	12 to April 1	Tzec
April	2 to April 20	Xul

solstice. Now the winter solstice is the natural starting point of the astronomical year. The sun has reached its most southern point and made the turn northward that will revive vegetation. Also this position explains more fully the glyph for Pop which contains a plaited detail for mat or rule and also a device which has been explained as south. The early Mayas may have had two years in one: an astronomical year beginning with Pop and a farmer's year beginning with Yaxkin. The former could be determined with scientific accuracy from year to year but the climatic evidences for the latter would fluctuate.

Carrying back 0 Pop from the position indicated in Landa's

year to a time when it coincided with the winter solstice before the inscriptions gave 580 B.C. as a tentative beginning for the Mayan calendar. It was noted at the time that this position is only about 33 years after the round number 7–0–0–0–0, 10 Ahau 18 Zac in the count of days from the Mundane Era, and that this round number may have served in some way as a natural base.[1]

The original layout of the Mayan year on these theoretical considerations was as follows for 580 B.C.

The Counting of Pop in Order

Famous passages in the Tizimin and Chumayel chronicles read "*Oxlahun Ahau; lai tzolci Pop*" and "*Oxlahun Ahau; tzolci Pop*" both being translated "Katun 13 Ahau; Pop was counted in order." Brinton supposed these entries to refer to the organization of the calendar. The Katun 13 Ahau according to the present correlation was the 7200-day period ending on 9–17–0–0–0, 13 Ahau 18 Cumhu, March 27, 511 A.D.

Inscriptions dealing with 0 Pop, or New Years day of the formal Mayan calendar, are not commonly met with but it happens that two of them one year apart are declared on a sculptured block at Copan known as Altar U. This altar is one of eight monuments emphasizing a date 6 Caban 10 Mol, the most prominent date at Copan, which Morley by careful analytical methods decided must be 9–16–12–5–17, 6 Caban 10 Mol. Actually this date is nowhere declared in an initial series, but there can be no doubt concerning its position. 6 Caban 10 Mol, then, lies in the Katun 13 Ahau when Pop was set in order, according to the chronicles, and it is associated with two declarations of 0 Pop.

The inscription on Altar U contains a number of dates and distance numbers. These have been taken out of the text (amended in a few details according to Morley's suggestions) and arranged in the order in which they were apparently intended to be read (fig. 35). The inscription opens with 3 Caban 0 Pop: next comes a distance number 2–13–0, written in an unusual fashion and reach-

[1] In latter sections of the study the date 7–0–0–0–0, 10 Ahau 18 Zac, is called the Epoch of the Historical Era and evidence is presented to show that the actual record of historical time began from this round number which corresponded to Aug. 6, 613 B.C. Or rather it would appear that the Epoch of the Mundane Era, 13–0–0–0–0, 4 Ahau 8 Cumhu was reached by counting back 7 baktuns from the first historical day.

ing no declared date. Actually it reaches a day just an even katun before the second important date on the monument. In the long count method the association is:

			A.D.
9–15– 9–10–17,	3 Caban 0 Pop,	April	9, 481
2–13– 0			
9–15–12– 5–17,	8 Caban 10 Mac,	Dec.	15, 483
1– 0– 0– 0			
9–16–12– 5–17,	6 Caban 10 Mol,	Sept.	2, 503

There are several other dates, which are discussed elsewhere, including a date 2 Eb 0 Pop just one year before the leading date and therefore 9–15–8–10–12, 2 Eb 0 Pop, April 9, 480, and a declaration of 9 Ik 10 Mol found as 9–15–9–0–2, 9 Ik 10 Mol, Sept. 6, 480, between these two statements of 0 Pop. But we will direct our attention at the controlling dates 3 Caban 0 Pop and 6 Caban 10 Mol, falling on April 9, 481 and September 2, 503. These indicate that Pop was recorded as having been "counted in order" when in its slow movement through the seasons it came to the point decided upon by the Mayas as the first day of their agricultural year. This day was not far distant from the earlier position of Yaxkin according to the internal evidence of month names and signs.

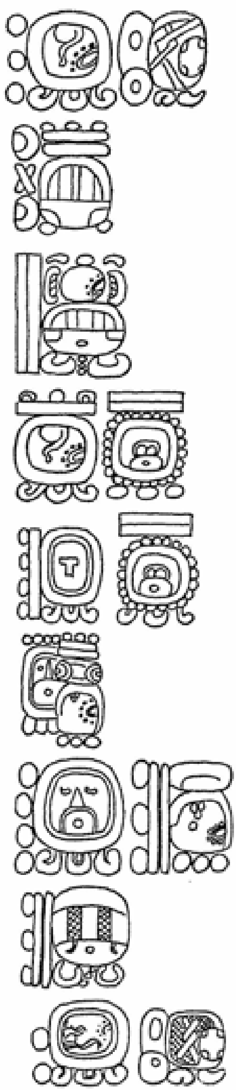


FIGURE 35. THE DATES ON ALTAR U AT COPAN

The Astronomical Base Line

These dates, April 9 and September 2, are extremely important and furnish, in the opinion of the writer, decisive proof of the correctness of the present correlation. For it has long been known that two monuments on hilltops on either side of the valley of Copan lie almost on an east and west line passing over the central

mound group of the ancient city. These markers are between four and five miles apart, and an observer standing at the eastern monument (Stela 12) and viewing the sun when it sets directly behind the western monument (Stela 10) has a line of sight so long as to make possible a practically perfect astronomical reading without the use of other instruments. The stone is now fallen, but once it stood out against the brilliant sky on a little platform and must have been unmistakably clear. And the sun sets today, as it did 1500 years ago, behind the western needle of this giant sundial on only two days of the year, namely, April 9 and September 2. The present appearance of these monuments is pictured in Plate 3.

In 1916 Morley, for the Carnegie Institution, had one of his assistants, named Carpenter, make very careful readings, following the instructions of the late Robert W. Willson, professor of astronomy at Harvard University, and from the data then secured, Willson determined the true bearing to be N. 81° 47′ W. He says:

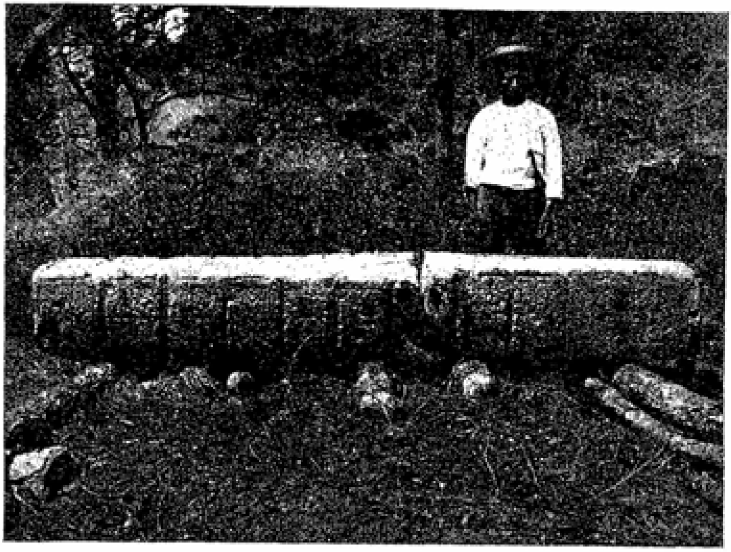
"Accepting this as the true bearing, the sun, as seen from Stela 12, would set behind Stela 10, 20.3 days after the vernal equinox and 20.6 days before the autumnal equinox, i.e. April 9 and September 2[1] of the present year, 1916 (Gregorian calendar).

"From Mr. Carpenter's observation of the magnetic bearing of Stela 10, W. 4° 25′ N., and the true bearing, N. 81° 47′, we find the present magnetic declination to be 3° 48′ east of north.

"Gordon gives the magnetic bearing of this line as N. 86° 46′ W. and the declination 6° E., which makes the true bearing N. 80° 46′ W., which would give for the date of sunset behind Stela 10, twenty-three days after the vernal and twenty-three days before the autumnal equinox."

The only probable element of inaccuracy in these determinations is that of elevation. Gordon's notes give an elevation of 228 meters for Stela 10 and 188.6 meters for Stela 12 above the level of the Great Plaza. An intermediate point of observation may have been established, in which case the matter of elevation would make a difference scarcely discernible. The straight line cuts the northern end of the Acropolis and also lies not far from the older center in the present village where Altars U and T were found in front of a pyramid.

[1] Morley has Sept. 10, apparently having misread the handwriting of Professor Willson, but 20.6 days before the autumnal equinox on Sept. 23 gives Sept. 2.



The Two Markers of the Astronomical Base Line at Copan. Above, the Western Marker, Stela 10; below, the Eastern Marker, Stela 12. Photographs by the Peabody Museum Expedition.

Figure 36 reproduces in diagrammatic form the condition of the astronomical base line, which will give sunset coincidences on April 9 and September 2. The same diagram also gives the other points of the year which might have been observed from Copan. The sketch of the ancient city shows the approximate location of Stela 12 on the eastern side and that of Stela 10 on the western side. It will be observed that the first coincidence takes place after the sun has passed the equinoctial line (due east and west) in the spring and is moving northward towards the solsticial point of summer,

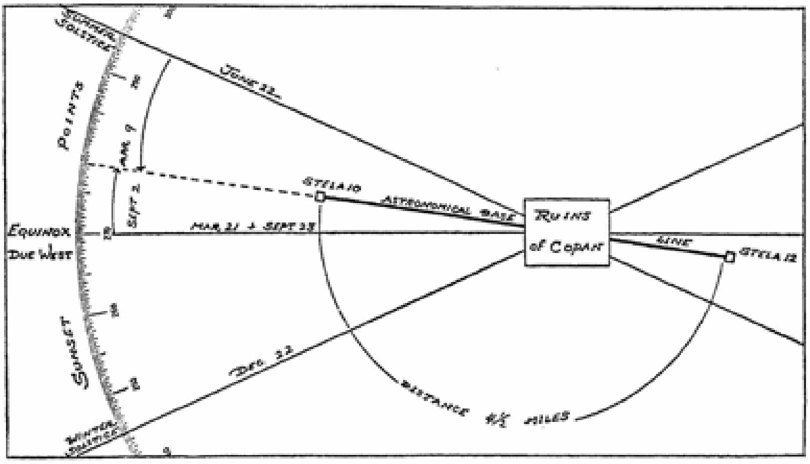


Figure 36. Diagram of Astronomical Base Line at Copan

which in the latitude of Copan is about 25° north of west. The second coincidence takes place after the sun has reached the summer solstice and turned back on its path. The second coincidence comes — on the average but not in any one year — at exactly the same time before the autumnal equinox that the first one comes after the vernal equinox. Of course, since the true year is not exactly 365 days, but instead 365.2421996 days, the moments of the equinoxes and solstices do not fall in consecutive years at the same longitudes on the earth's surface. In other words sunset observations can rarely be made at the exact moment when the sun crosses the equator or reaches one of the tropics. The difference would not be great although in extreme cases, as when the moment of the equinox occurs at sunrise, it would be impossible to decide between two days by sunset observation alone.

One or more intermediate points of observation might have been used in connection with this great sun dial of Copan but it seems more likely that for accurate measurement the observer stood before Stela 12 and waited for the day when the sun went down exactly behind Stela 10. The reversed sight line for sunrise could not be used easily because mountains rise behind Stela 12 and prevent a sky-line view except on a steep line of observation from the valley. Moreover the reciprocal days before the vernal equinox and after the autumnal equinox, approximately March 3 and October 13, which would be disclosed by sunrise observations along the same base line, do not seem to have been recorded at Copan although they do occur at other cities. A place of observation in the ceremonial center of Copan would have served well enough for the summer solstice and the winter solstice as well as for the equinoxes, both as regards sunset and sunrise points.

It will be shown presently that the two positions in the natural year, determined by the astronomical base line at Copan, were in common use throughout the Mayan area. The counting of Pop in order was not a matter that interested only one city, and it appears that the celebrated event involved a change or resetting of the astronomical base line susceptible to a very pretty explanation of scientific emulation between different cities.

Shifting the Base Line at Copan

The actual dates carved on the terminal stones of the astronomical base line at Copan will now engage our attention. These stones belong to a remarkable series of monuments with dates clustering around 9–11–0–0–0, 12 Ahau 8 Ceh. The date on Stela 10, the western marker, is fortunately readable although written in a style which long resisted decipherment (fig. 37). The initial series is 9–10–19–13–0, 3 Ahau 8 Yaxkin, just 100 days before 9–11–0–0–0, 12 Ahau 8 Ceh. The leading date on this stela therefore corresponds to Sept. 6, 392, A.D., a position four days removed from that found and recorded 110 years later in the much emphasized 6 Caban 10 Mol. The second date, the end of the katun, equals December 15 of the same year. Stela 12 in a ruined condition yields up two declarations which enclose the date on Stela 10, namely, an initial series of 9–10–15–0–0, 6 Ahau 13 Mac, Jan. 11,

388, and the same katun as before, namely, 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392. In the city proper, Stela 2 records the same pair of dates.

Now if the base line as originally set really gave the date Sept. 6 for the coincidence of sunset before the autumnal equinox it would give April 5 for the coincidence of sunset after the vernal equinox. Thus we would have April 5 and September 6 forming a mutual pair just as April 9 and September 2 form a mutual pair. The first set of these dates probably would mean that the base line was originally slightly nearer to the east and west line of the equinoxes, and that one or the other of the markers was shifted in a redetermination. This conclusion is reinforced by the fact that the resetting was consummated at a time when 0 Pop had passed April 9 and reached April 5.

Stela 12, Initial Series		Sept. 6, 392
" A, " "		April 5, 471
Altar U, 1st.	Principal Date	" 9, 480 (and 481)
" " 2d	"	" Sept. 2, 503
" " 3d	"	" " 6, 480

The bringing of Stela A into the complex depends upon the fact that its leading date recovers the missing date which pairs with September 6 on the western marker of the astronomical base line. The decipherable dates on Stela A declare the following simple relationships:

9–14–19– 8–0,	12 Ahau 18 Cumhu,	April 5, 471
3–0	subtract	
9–14–19– 5–0,	4 Ahau 18 Muan,	Feb. 4, 471
9–14–19– 8–0,	12 Ahau 18 Cumhu,	April 5, 471
10–0	add	
9–15– 0– 0–0,	4 Ahau 13 Yax,	Oct. 22, 471

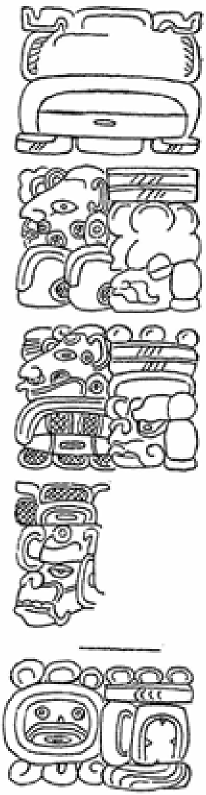


FIGURE 37. INITIAL SERIES ON THE WESTERN MARKER OF THE ASTRONOMICAL BASE LINE, COPAN

There is another partly destroyed date which follows the last one without a distance number. The day is clearly 12 Ahau and the month coefficient is 13. Possibly this is 9–15–0–3–0, 12 Ahau 13 Mac, Dec. 21, 471, intended for the winter solstice, but like-

wise repeating the month position 13 Mac declared on the Stela 12, the eastern marker, as well as on Stela 2. The repetition of the month position irrespective of the day and its coefficient means, of course, the exact anniversary of the 365-day year. The particular 4 Ahau 18 Muan reached by subtraction from the initial series is just three katuns later than a date on Stela I, occupying the position 9–11–19–5–0, 10 Ahau 13 Ceh. This latter month position is precisely that of the important round number 9–0–0–0–0, 8 Ahau 13 Ceh, which fell in a year when 0 Pop, the Mayan New Year day, stood at the summer solstice.

Morley offers reasons for believing that the calculations on Altar U are connected in some way with those on Stela A and the present writer is able to give additional proofs. On this altar there are clear declarations of 4 Ahau 13 Yax and 4 Ahau 13 Ceh. The latter repeats the month position commented upon above and probably refers specifically to 9–15–12–5–0, 4 Ahau 13 Ceh. In connection with these two dates there is a declaration of thirteen tuns and when this sum is subtracted from the latter one the date 9–14–19–5–0, 4 Ahau 18 Muan is reached and this date is likewise declared on Stela A. These correspondences seem sufficient to establish a community of interest in the calculations on Stela A and Altar U. Another important link is seen in the fact that 0 Pop in the year containing 6 Caban 10 Mol fell on April 5 which is the position in the tropical year reached by the initial series on Stela A. We will now re-examine four dates on the Altar U.

9–15– 8–10–12,	2 Eb 0 Pop,	April 9, 480 A.D.
9–15– 9– 0– 2,	9 Ik 10 Mol,	Sept. 6, 480
9–15– 9–10–17,	3 Caban 0 Pop,	April 9, 481
9–16–12– 5–17,	6 Caban 10 Mol,	Sept. 2, 503

The first and third dates record the beginning of the agricultural year and "the counting of Pop in order" as we have already seen. The second date is the position of the autumnal station recorded on Stela 10 and the fourth date is the position finally arrived at for the autumnal station. This evidence indicates an intentional readjustment made at the time when 0 Pop stood at April 5. From the record in other cities than Copan it seems that April 9 was long since considered the beginning day of the agricultural year and that the readjustment at Copan moved the autumnal station

to a position four days earlier in the year so that both the dates could be determined by observations along the same astronomical base line. April 9 may have been reached originally by counting 20 days, or 1 uinal, after the vernal equinox.

In the last section of this paper the dates of the principal Mayan inscriptions are taken up by cities and many records discussed

TABLE XXIII. INTERRELATION OF DATES ON COPAN MONUMENTS

9– 0– 0–0– 0,	8 Ahau	13 Ceh,	Feb. 10, 176 (Stela 3)
11– 0–0– 0			
9–11– 0–0– 0,	12 Ahau	8 Ceh,	Dec. 15, 392 (St. 12, 13, 2, 3, etc.)
19–5– 0			
9–11–19–5– 0,	10 Ahau	13 Ceh,	Dec. 16, 411 (Stela I)
3– 0–0– 0			
9–14–19–5– 0,	4 Ahau	18 Muan,	Feb. 4, 471 (Stela A, Altar U)
13–0– 0			
9–15–12–5– 0,	4 Ahau	13 Ceh,	Nov. 28, 483 (Altar U)
17			
9–15–12–5–17,	8 Caban	10 Mac,	Dec. 15, 481 (Altar U)
9–10–19–13– 0,	3 Ahau	8 Yaxkin,	Sept. 6, 392 (Stela 10)
5– 0			
9–11– 0– 0– 0,	12 Ahau	8 Ceh,	Dec. 15, 392 (St. 12, 13, 2, 3, etc.)
19– 5– 0			
9–11–19– 5– 0,	10 Ahau	13 Ceh,	Dec. 16, 411 (Stela I)
13– 0			
9–12– 0– 0– 0,	10 Ahau	8 Yaxkin,	Sept. 1, 412 (Altars 1 and 5)
2–19– 8– 0			
9–14–19– 8– 0,	12 Ahau	18 Cumhu,	April 5, 471 (Stela A)
9– 1–12			
9–15– 8–10–12,	2 Eb	0 Pop,	April 9, 480 (Altar U)
7–10			
9–15– 9– 0 2,	9 Ik	10 Mol,	Sept. 6, 480 (Altar U)
10–15			
9–15– 9–10–17,	3 Caban	0 Pop,	April 9, 481 (Altar U)
1– 2–13– 0			
9–16–12– 5–17,	6 Caban	10 Mol,	Sept. 2, 503 (Altar U, Q, T, etc.)

which do not fit into the present stage of our exposition. Before leaving Altar U, however, we will treat briefly another date and call attention to a remarkable series of statements on other monuments which demonstrate interrelations in subject matter with

Altar U. The other date lies exactly one katun before the important 6 Caban 10 Mol in a relation which we write as follows:

9–15–12–5–17,	8 Caban 10 Mac,	Dec. 15, 483
1– 0– 0– 0		
9–16–12–5–17,	6 Caban 10 Mol,	Sept. 2, 503

This earlier date strikes exactly the same position in the tropical year as does 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392, which is recorded on one and possibly both markers of the astronomical base line (Stelae 10 and 12) as well as on Stela 23 at Santa Rita, on Stela 13 located between Santa Rita and the main structure, Stelae 2 and 3 in the Great Plaza, and possibly on Stela 19 at Hacienda Grande, although not in this case by an initial series.

In the adjoined Table XXIII note anniversaries first in the natural year, second in the 365-day year (the latter indicated by the recurrence of the same month position in the Mayan calendar).

The two mutual dates of the earlier base line at Copan may also be referred to in the inscriptions on Altar G′ and Altar F′. The declarations on these monuments are as follows:

Altar G′	9–15–4–17– 1,	4 Imix 9 Mol,	Sept. 6, 476
" F′	9–17–4– 1–11,	2 Chuen 4 Pop,	April 6, 515

The first one gives September 6 in a year when 0 Pop is on April 10 and therefore comes very close to establishing the balance between the two dates which we have observed on Altar U. While the point reached in the second inscription appears to be one day out of place it may be noted that the Gregorian calendar makes a leap-year interpolation a few months later which would reduce this position to April 5 and therefore meet the conditions of our problem.

Some later monuments at Copan carry recurrences of these dates in terms of 260–, 360- and 365-day periods, that is, tzolkins, tuns and haabs. For instance, on Altar Q we have the month position 18 Cumhu as 9–17–0–0–0, 13 Ahau 18 Cumhu, March 27, 511. This month position is the same as that declared by the important initial series on Stela A and, although the Ahau coefficient is different, the haab repeats exactly. Now 9–17–0–0–0, 13 Ahau 18 Cumhu is also precisely the ending day of the katun 13 Ahau of the Books of Chilam Balam in which it is declared that Pop was

counted in order. On Altar T we find 9–17–12–4–17, 4 Caban 10 Zip, May 19, 523, which is the katun recurrence of 9–16–12–5–17, 6 Caban 10 Mol. To be sure, we have only the calendar-round declaration but the indications of position in the long count are very strong. Under this monument there was a stone called Fragment E′ which probably reached this day by an initial series. On Stela 8 we find also this recurrence as well as a date 9 Ik 15 Zip

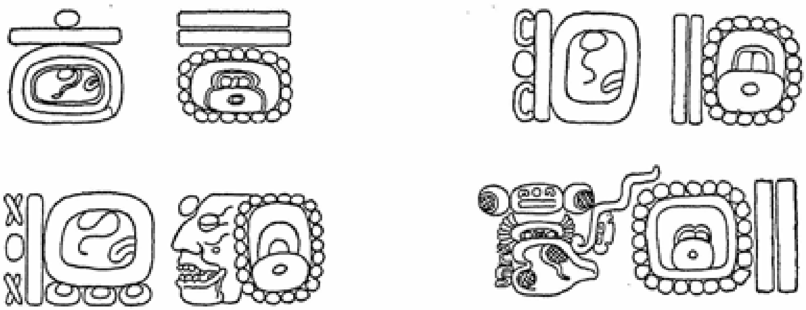


FIGURE 38. VARIOUS DECLARATIONS OF 6 CABAN 10 MOL AT COPAN

which is probably to be placed in the position 9–17–12–6–2, 9 Ik 15 Zip just five days later. The significance of this date can be seen from the following association of dates already discussed.

9–15– 9–0– 2,	9 Ik 10 Mol,	Sept. 6, 480 A.D.
9–16–12–5–17,	6 Caban 10 Mol,	Sept. 2, 503
5		
9–16–12–6– 2,	11 Ik 15 Mol,	Sept. 7, 503
9–17–12–5–17,	4 Caban 10 Zip,	May 20, 523
5		
9–17–12–6– 2,	9 Ik 15 Zip,	May 25, 523

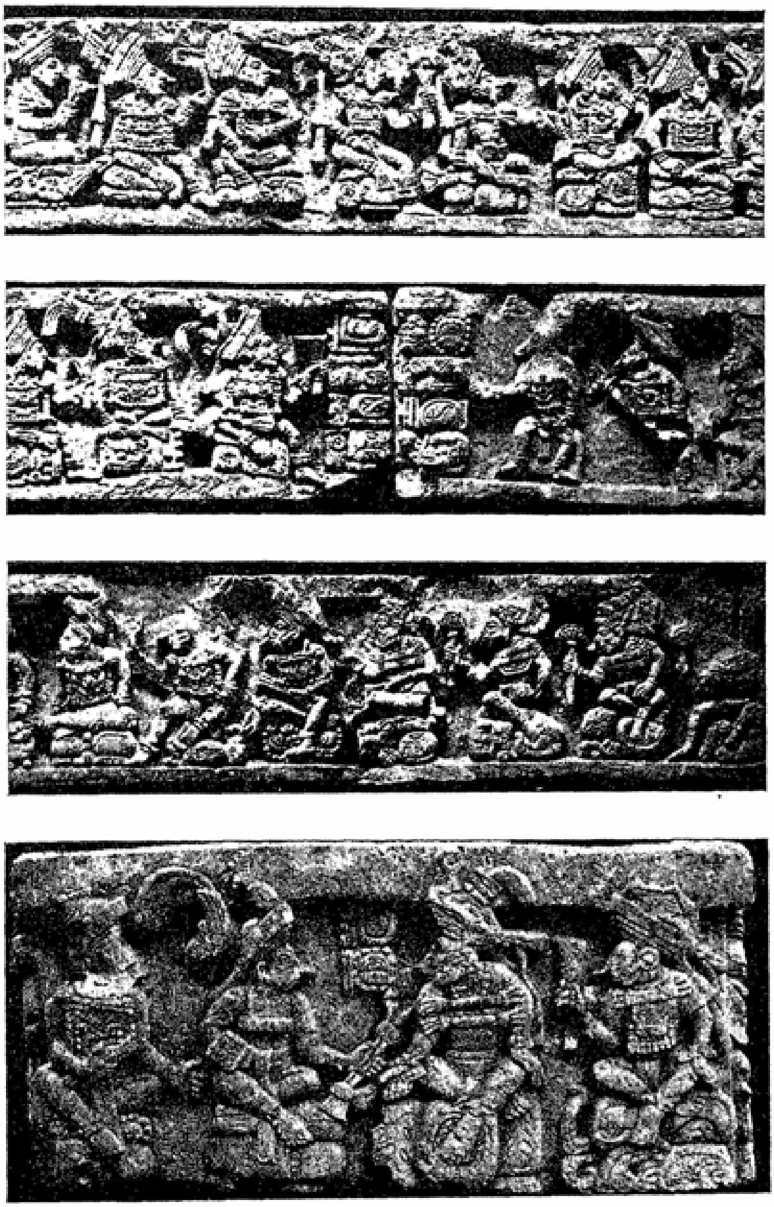
In terms of the Gregorian calendar we have obtained the dates September 6 and September 2 for the interval between the old and the new autumnal stations. Perhaps the apparent interval is close enough in terms of full days but the twenty-three years from 480 A.D. to 503 A.D. really call for five days of intercalation. At the time when 6 Caban 10 Mol was established, the original position might have well been calculated as 11 Ik 15 Mol, five days later. We have found the katun recurrence of 6 Caban 10 Mol recorded

as 4 Caban 10 Zip on Altar T. Now on Stela 8 the date 9 Ik 15 Zip is not only the katun recurrence of the 11 Ik 15 Mol referred to above, but likewise is the exact tzolkin recurrence of the day 9 Ik of 9 Ik 10 Mol on Altar U. In other words we have in this record ample proof that attention was paid to recurrences in the terms of different cycles. In the light of such evidence we are perhaps justified in transforming the initial series of Stela I — a monument already brought into our series — by considering it as marking the completion of a katun after some event. We then obtain:

9–12–3–14–0,	5 Ahau 8 Uo,	May 23, 416
1–0– 0–0		
9–11–3–14–0,	7 Ahau 8 Yaxkin,	Sept. 6, 395

The Astronomical Congress at Copan

The setting or counting of Pop in order becomes the first entry in the Mayan chronicles which can be corroborated. The archeological evidence indicates that this problem was settled at Copan by the resetting of the base line, but that the results were accepted if not anticipated in other cities. Palenque seems to have led Copan in the matter of brilliant achievements in astronomy. Now the important monuments at Copan which record the date 6 Caban 10 Mol, are decorated with rows of men seated upon hieroglyphs, and the question arises whether these are not more or less formalized pictures of an astronomical congress held in 503 A.D. The best sculptures of this kind are found on the sculptured step of Temple 11, upon the sides of Altar Q and upon the sides and top of Altar T and in less complete form on Altar U. In the first two cases we find 20 and 16 men respectively, seated upon hieroglyphs and facing inward towards a hieroglyphic statement of the date 6 Caban 10 Mol. On Altar Q there are 20 figures, some human and some partly human and partly animal. Two of the figures are anthropomorphic renderings of the day-sign Caban having the numbers 6 and 4 in the head-dress and holding the month statements, 10 Mol and 10 Zip, in their outstretched hand. These are the dates 6 Caban 10 Mol and 4 Caban 10 Zip, 7200 days apart, and the latter one commemorates the momentous congress after the lapse of one katun.



Representations of the Astronomical Congress at Copan. Above, three sections of sculptured step in Temple 11; below, one side of Altar Q. In both cases the figures of the astronomers are addressed towards the central date 6 Caban 10 Mol, Sept. 2, 503 A.D.

The figures of the astronomer-priests, if the hypothesis proves acceptable, are pleasingly attired. They wear head-dresses which are turbans or animal heads. Their breast plates are bars, jaguar heads, etc., of jade combined with beads. Feather capes are commonly worn as well as ear-plugs, wrist-bands, ankle-bands, and girdles with aprons attached. In their hands the astronomer-priests carry objects which may be ceremonial offerings or perhaps some simple instrument used in observation. We know from the pictures in ancient books from southern Mexico that the observations of stars were made through forked sticks sometimes set up in the door of the temple.

The hieroglyphs upon which these human beings are seated may give (*a*) the names of the individuals, (*b*) the cities or tribes they represent, (*c*) the religious society or craft or line of research which they represent. One difficulty is that only a few hieroglyphs are repeated in clearly recognizable form in the different monuments. In the case of Altar T there is also the difficulty that some of the figures are anthropomorphic birds and animals. But these might represent constituent tribes in the Mayan nation: one figure representing a bat may stand for the Tzotzil or Bat People. It is at least an interesting field for speculation whether or not the monuments dealing with the counting of Pop in order do not memorialize an astronomical congress (see Plate 4).

The Problem of Approximations

But before taking up the voluminous dates at other cities dealing with natural and arbitrary points in the year, let us briefly review the problem of approximations which has already thrust itself forward in some of the records just examined. In addition to the vernal and autumnal stations which were the ceremonial commencements of two maize crops upon which the life and prosperity of the Mayas depended, this people laid great stress upon the solstices and equinoxes and they also ventured to restate in current time the positions in the natural year occupied by the zero day or epoch of each of three eras, first the Mundane Era which departed from 13–0–0–0–0, 4 Ahau 8 Cumhu; second, the Historical Era which departed from 7–0–0–0–0, 10 Ahau 18 Zac; and third, the Era of the Chronicles which departed from 9–0–0–0–0, 8 Ahau

13 Ceh. These three zero days in the extension of the Gregorian calendar were October 14, 3373 B.C., August 6, 613 B.C., and February 10, 176 A.D., but in the recapitulations only the positions in the natural year, that is October 14, August 6 and February 10, appear.

We have, then, 10 positions out of the 365 positions in the year which were specially sought after in such inscriptions as deal with matters of astronomy. In their order in the year these are:

Feb. 10	Epoch of the Chronicles
Mar. 21	Vernal Equinox
April 9	First Station of Agricultural Year
June 22	Summer Solstice
Aug. 6	Epoch of the Historical Era
Sept. 2	Amended Second Station of the Agricultural Year
Sept. 6	Original Second Station of the Agricultural Year
Oct. 14	Epoch of the Mundane Era
Dec. 22	Winter Solstice

Ordinarily these positions in the natural year must be reached by numbers of days that are not those on which katuns, tuns or uinals end, but occasionally these round numbers will be found in exact coincidence with, or in close approximation to, the significant points in the year of seasons.

The rules of recurrence are mechanical, but we must be prepared to appreciate their convenience and the control which the accidental conditions sometimes exercised. The tzolkin shows no useful coördination with the tropical year in its lower revolutions. The first approach is between seven tzolkin and five years.

7×260	equals 1820 days
5 vague years	" 1825 "
5 tropical years	" 1826.21 days

This reasonably close approach was taken advantage of in making calculations shift from the base of the original autumnal station to the amended autumnal station, with a slight error. Here are two examples, one from Palenque and one from Quirigua:

PALENQUE. TEMPLE OF INSCRIPTIONS

9–11–14–17–0,	10 Ahau 13 Yaxkin,	Sept. 8, 407
5– 1–0		
9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412

QUIRIGUA. STELA D

9–16– 9– 5–0,	1 Ahau 8 Mol,	Aug. 31, 500
5– 1–0	subtract	
9–16– 4– 4–0,	1 Ahau 13 Mol,	Sept. 6, 495

It will be observed that the Mayan day is the same at both ends of the transaction while the month declaration shifts five positions.

Another rule of thumb of the Mayas involving the tzolkin recovers within a day over a somewhat longer period. It can be stated: one katun minus one tzolkin equals nineteen tropical years. As an example of this interval affording approximations the following calculation may be cited.

9–14– 0– 0–0,	6 Ahau 13 Muan,	Feb. 3, 452
1– 0– 0–0	add one katun	
9–15– 0– 0–0,	4 Ahau 13 Yax,	Oct. 22, 471
13–0	subtract one tzolkin	
9–14–19– 5–0,	4 Ahau 18 Muan,	Feb. 4, 471

Actually what happens is this:

7200 days minus 260 days equal 6940 days
19 tropical years " 6939.6 days

The month positions in an uncorrected year of 365 days diverge from fixed points in the tropical year at the rate of about one day in four years and there are various ways in which the divergence can be compensated in calculations. The Mayan tzolkin combines with the haab in a fifty-two year calendar round and during this term there are twelve or thirteen leap-year intercalations in the Gregorian unit. Thus if a calendar-round date falls twelve or thirteen days after a point in the tropical year at the present time it will coincide with the point 52 years hence and 104 years hence will precede it by the same interval (actually 12.59 days). The Mayan priests could see an approximation coming and reckon on it. Sometimes dates which are not fixed in the long count can be shifted into a somewhat more probable position by moving them up or down one or more calendar rounds. Care must be made not to bear much weight of argument upon readings achieved by this tentative method unless the coincidence in question is strongly reinforced. For instance on Stela 11 at Yaxchilan there are two

calendar-round dates, one being the same as an initial series date on Stela 12. Now if the dates are read in association with this fixed calculation on another monument they become:

9–15–10–17–14,	6 Ix 12 Yaxkin,	Aug. 19, 481
10– 0– 6		
9–16– 1– 0– 0,	11 Ahau 8 Tzec,	July 3, 492

This seems most acceptable at first glance because an even tun is reached, while a date much emphasized at Quirigua also equals July 3. But when we add one calendar round (2–12–13–0) to each of the above dates we get the following statement:

9–18– 3–12–14,	6 Ix 12 Yaxkin,	Aug. 7, 533
10– 0– 6		
9–18–13–13– 0,	11 Ahau 8 Tzec	June 22, 543

Now the first date is practically the restatement of the epoch of the Historical Era and the second one is exactly the summer solstice. When, on examination, we conclude that Stela 12 may also deal with the recapitulation of the Historical Era in somewhat different fashion while the date equalling July 3 may be anticipatory of the summer solstice one calendar round hence, we are inclined to accept the second reading.

Approximations in round numbers could also be foreseen and for the higher values assumed great importance when the approximations were close. Each tun of 360 days advanced in the tropical year an amount equal to five and a quarter days. If a tun-closing date was twenty-one days after a seasonal event the closing day of the fourth tun after would coincide with it. Hotuns approached and departed from a fixed point in the tropical year in twenty-five day strides and katuns in 105-day strides. These might, therefore, pass over an event without an approximation close enough to make a good association tag.

Previous positions in the natural year return with a small error in intervals of three and a half katuns or seventy tuns. This is because 70 times 360 days equals 25,200 days, and 69 tropical years (365.2421996 days) equal 25,201.71 days. Here the discrepancy is only 1.71 days over a very convenient interval in Mayan numeration. The most important family of round-number approximations to significant positions in the natural year runs

from a point beyond the original autumnal station of the agricultural year to a point before the amended station. All these katun and lahuntun declarations are memorialized by monuments, the first one being declared on Stela 4 at Uaxactun and the last on the Tablet of the Initial Series at Chichen Itza.

8–18– 0–0–0,	12	Ahau	8 Zotz,	Sept.	8, 136
9– 1–10–0–0,	5	"	3 Tzec,	"	7, 205
9– 5– 0–0–0,	11	"	18 "	"	5, 274
9– 8–10–0–0,	4	"	3 Xul,	"	3, 343
9–12– 0–0–0,	10	"	8 Yaxkin,	"	1, 412
9–15–10–0–0,	3	"	3 Mol,	Aug.	31, 481
9–19– 0–0–0,	9	"	18 Mol,	"	29, 550
10– 2–10–0–0,	2	"	13 Chen,	"	28, 619

It is highly probable that this remarkable series of approximations was largely responsible for the shifting of the opening day of the autumnal station from Sept. 6 to Sept. 2.

Another family of approximations was passing out when the first records begin. In 8–9–0–0–0, 4 Ahau 18 Ceh, April 9, 41 B.C., the first point of the agricultural year coincided with a round number of days from the era. The first notice of this series appears, however, in Stelae 18 and 19 at Uaxactun, 7 katuns later, when 8–16–0–0–0, 3 Ahau 8 Kankin was April 5 in the year 97 A.D. At the same city the recurrence 7 katuns later is noted on Stela 20 (9–3–0–0–0, 2 Ahau 18 Muan, April 3, 235). Next comes 9–6–10–0–0, 8 Ahau 13 Pax, April 1, 304, found on such interesting monuments as Stela 1 at Tuloom and Stela 9 at Copan. After this the recurrences approach the vernal equinox:

9–10– 0–0–0,	1	Ahau	8 Kayab,	Mar.	30, 373
9–13–10–0–0,	7	"	3 Cumhu,	"	28, 442
9–17– 0–0–0,	13	Ahau	18 Cumhu,	"	27, 511
10– 0–10–0–0,	6	"	8 Pop,	"	25, 580
10– 4– 0–0–0,	12	"	3 Uo,	"	23, 649

An approximation to the winter solstice took place at an early date and soon played out. It may be seen in this diminishing series mostly recorded as 7 katun intervals.

8–17–0–0–0,	1	Ahau	8 Chen,	Dec.	22, 116
9– 4–0–0–0,	13	"	18 Yax,	"	18, 254
9–11–0–0–0,	12	"	8 Ceh,	"	15, 392
9–18–0–0–0,	11	"	18 Mac,	"	12, 530

Exactly the reverse is true of an approximation to the autumnal equinox which culminates in one of the latest inscriptions of the Great Period. It falls on the first and third quarter of the katun.

9-11-15-0-0,	4 Ahau	13 Mol,	Sept.	28, 407
9-15- 5-0-0,	10 "	8 Chen,	"	25, 476
9-18-15-0-0,	3 "	3 Yax,	"	24, 545
10- 2- 5-0-0,	9 "	18 "	"	23, 613

For the epoch of the Historical Era an interesting coincidence takes place, which is fully discussed elsewhere, and the diminishing

Figure 39. Glyph for Observation of the Sun at the Horizon

series from 9-0-0-0-0, 8 Ahau 13 Ceh, Feb. 10 is quite obvious. There are a number of statements of coincidences on tuns other than hotuns but in such cases mere approximations were hardly worth taking note of.

Further Statements of the Farmer's Almanac

Today in Mayan territory the new fields are slashed as soon as the dry season begins and the dry bush is burned off about the first of April. The maize is planted at the time of the first rains which come about the first of May. Indeed the first rains are popularly associated with the Day of the Holy Cross, which is May 3. The crop ripens in August and a second one is then put in the ground so that it will get a good start with the last rains and ripen after the dry season has set in.

There is a distinct lull in the rains in August but the first crop is known as the crop of the folded-over ears because it is necessary to let the maize dry on the stalk with the ears inverted. The second crop is known as the crop of the standing ears, because it ripens during the dry season without tending. The vernal and autumnal stations were obviously devised as the leading dates in the farmer's almanac. We will now examine important records dealing with these dates in other cities than Copan.

At Tikal the outstanding date is 3 Ahau 3 Mol, safely established as 9–15–10–0–0, 3 Ahau 3 Mol, Aug. 30, 481. This date belongs

FIGURE 40. INSCRIPTION ON THE HIEROGLYPHIC STAIRWAY, NARANJO

in the series of approximations to the autumnal station already discussed. On Lintel 1 of Temple 2 the record reads:

9–15–10– 0– 0,	3 Ahau 3 Mol,	Aug. 30, 481
2–11–12		
9–15–12–11–13,	6 Eb 0 Pop,	April 8, 484
1		
9–15–12–11–14,	7 Ben 1 Pop,	April 9, 484

It will be noted that 6 Eb 0 Pop is exactly four years distant from the 2 Eb 0 Pop of Altar U at Copan and that in these four years one day of difference has accrued between the vague and tropical years. The original position is recovered by the addition of one day. A glyph having the numeral one pictures the sun caught in the angle between heaven and earth, in other words, at the horizon.

This might be called the caan-kin-caban or sky-sun-earth glyph for it pretty clearly means observation at sunset (see fig. 39).

On the Hieroglyphic Stairway at Naranjo one glyph block (fig. 40) gives a distance number 1–13–10, which, according to the method followed on this monument, proceeds from an undeclared date to a declared one, in this case, 8 Ik 5 Kankin. The actual position in the long count is not declared but the suppressed date is 2 Eb 0 Pop and the intention doubtless was to declare the beginning of the farmer's year. If the following arrangement is acceptable — and the artistic position of this monument indicates that it is — then we recover one of the dates on Altar U at Copan:

9–15– 8–10–12,	2 Eb 0 Pop,	April 9, 480
1–13–10		
9–15–10– 6– 2,	8 Ik 5 Kankin,	Dec. 30, 481

These two dates enclose the hotun ending which corresponded to Aug. 30, 481.

Aside from round number approximations, dates which are doubtless intended for this important position in the farmer's year are found in interesting situations. The most startling statement is found on the Temple of the Cross at Palenque which will be explained elsewhere. In the Temple of the Inscriptions the position is recorded as 9–8–1–8–0, 2 Oc 8 Kayab, April 10, 335. On Stela F at Quirigua it is probably intended by a day 13 Ahau lying in the following relation to the hotun declaration:

9–16–10– 0–0,	1 Ahau 3 Zip,	May 18, 501
2–0	subtract	
9–16– 9–16–0,	13 Ahau 3 Pop,	April 8, 501

Dates in the first part of September are strongly emphasized on some of the most notable monuments of the Mayas. For instance Stelae 1 and 3 at Piedras Negras begin with the same date in exquisitely carved hieroglyphs. It is 9–12–2–0–16, 5 Cib 14 Yaxkin, Sept. 7, 414: it emphasizes the earlier station although coming only two years after the round number, 9–12–0–0–0, 10 Ahau 8 Yaxkin, Sept. 1, 412, which popularized the amended station. However, the final dates of the monuments are considerably later than the initial series. The earliest monument at this city gives the approximation at Katun 5 of Baktun 9 (Sept. 5) which is also seen at Palenque.

At this last mentioned city the September dates are manipulated in an interesting fashion by the interval 5–1–0 (see page 142).

At Yaxchilan two dates are possibly intended for the second placing of the autumnal station:

9–12–18–4–18,	6 Ix 12 Yaxkin,	Sept. 1, 430
9–15–17–1–19,	1 Cauac 7 Mol,	Sept. 1, 489

The first of these is found on three different monuments but the placing is not certain. At Quirigua a variant of the transition described for Palenque is noted on Stela F: three dates in late August are reached as well as one on Sept. 6:

9–15–10– 0–0,	3 Ahau 3 Mol,	Aug. 30, 480
1– 0– 0–0	add	
9–16– 0– 0–0,	1 Ahau 3 Zip,	May 18, 501
13–0	subtract	
9–16– 9– 5–0,	1 Ahau 8 Mol,	Aug. 31, 500
5– 1–0	subtract	
9–16– 4– 4–0,	1 Ahau 13 Mol,	Sept. 6, 495
1–12– 9–0	subtract	
9–14–11–13–0,	1 Ahau 13 Yaxkin,	Aug. 25, 463

The lintel at El Cayo reaching September 3, which close reckoning reduces to September 2, has already received notice. Discussion of other aspects of September dates will be found in the formal analysis of inscriptions in the last section of this paper.

Other Points of the Year

The dates in April and September recoverable from the astronomical base line at Copan are not the only points in the natural year which Mayan astronomers deemed worthy of record. Also there are many statements which exactly correspond to the equinoxes and solstices and these are frequently made in significant combinations which relieve the self-revealing record from the objections of chance coincidence.

An initial series date that does not record a round number but reaches a significant point in the year can almost be taken at face value. Such a date is found on Stela 5 at Copan which declares 9–13–14–0–15, 6 Men 18 Kayab, Mar. 22, 447, almost coinciding with the vernal equinox. Here, however, we have the additional

circumstance that the month position 18 Kayab was intimately involved in the Tables of Venus, so the association was doubly important.

At Los Higos, a frontier site on the headwaters of the Chamelecon River, the stela described by Morley registers the fifth approximation of the position in the natural year of 9–0–0–0–0, 8 Ahau 13 Ceh, Feb. 10, 176 together with a declaration, in the initial series, of the summer solstice. Since 0 Pop, the formal New Year day of the calendar, coincided with the summer solstice at the time of Baktun 9, there is a double association implied in the record before us. The matter in parenthesis does not actually appear on the monument.

(8–19–19– 6–7,	9 Manik 0 Pop,	June 22, 175)
(13–3)		
(9– 0– 0– 0–0,	8 Ahau 13 Ceh,	Feb. 10, 176)
(17–10– 0–0)		
9–17–10– 0–0,	12 Ahau 8 Pax,	Feb. 2, 521
7–0		
9–17–10– 7–0,	9 Ahau 3 Tzec,	June 22, 521

An interesting record of the winter solstice is found on Stela N at Copan according to the reading of Goodman. The contemporary date is a lahuntun ending at the height of the Great Period but a distance number reaches back nineteen and a half katuns to a katun that ended on December 22. The record runs:

9–16–10–0–0,	1 Ahau 3 Zip,	May 18, 501
19–10–0–0		
8–17– 0–0–0,	1 Ahau 8 Chen,	Dec. 22, 116

At Naranjo several declarations strike the points of the tropical year. For instance the one decipherable date on Stela 11 is 9–17–18–0–0, 6 Ahau 8 Kankin, Dec. 22, 528. On Stela 6 is recorded another even tun, this time very close to the vernal equinox: 9–17–1–0–0, 9 Ahau 13 Cumhu, March 22, 512. Most important of all is the re-used part of a lintel which pieced out a broken block in the Hieroglyphic Stairway. It was probably put there as an historical relic:

9– 7–14–10– 8,	3 Lamat 16 Uo,	June 22, 328
2– 5– 7–12		
9–10– 0– 0– 0,	1 Ahau 8 Kayab,	Mar. 30, 373

At Yaxchilan the most likely placing of the calendar-round dates on Stela 12 link the original position of the historical epoch with the summer solstice:

9–18– 3–12–14,	6 Ix 12 Yaxkin,	Aug. 7, 533
10– 0– 6		
9–18–13–13– 0,	11 Ahau 8 Tzec,	June 22, 543

Lintel 7 probably records 9–15–8–5–3, 10 Akbal 16 Mac, Dec. 22, 479. Lintel 25 at the same city placed in the most likely position in accordance with advanced style of carving reaches the vernal equinox:

9–15–2– 3–1,	5 Imix 4 Mac,	Dec. 11, 472
2–2– 7–0		
9–17–4–10–0,	3 Imix 14 Chen,	Sept. 23, 515

Comment has already been made on the association of leading dates on Lintel 1 at the small ruin of El Cayo. The middle date reaches the summer solstice:

9–16– 0– 2–16,	6 Cib 9 Mol,	Sept. 3, 491
11–17–10		
9–16–12– 2– 6,	13 Cimi 19 Zotz,	June 23, 503
2– 4		
9–16–12– 4–10,	5 Oc 3 Yaxkin,	Aug. 6, 503

Numerous approximations to the points of the year as well as some calculations which exactly hit the mark are reached in unsupported readings. A hotun declaration exactly on the autumnal equinox is found on one of the latest monuments of the First Empire, namely Stela 1 at Saccaná which reads:

10–2–5–0–0, 9 Ahau 18 Yax, Sept. 23, 613

Of course such a round number coincidence as this was bound to happen once in a while, and it then received much attention.

This array of inscriptional evidence should convince the most wary of two things: first, that the correlation between the Gregorian and Mayan day must be correctly given, and second, that the ancient Mayas had developed great skill in determining the solstices and equinoxes. If any doubt remains it will be dispelled by the calculations on the tablets of Palenque which cluster around the date 9–12–18–5–16, 2 Cib 14 Mol, Sept. 23, 430. In these

inscriptions two hieroglyphs for the equinox are given, one the day-sign called kin which is drawn half dark and half light, and the other the face Ahau, lord of day, one half covered with stars. These glyphs are found in other situations where calculations from the equinoxes are under treatment (see fig. 41). Also the glyphs of the solstices have been revealed by association with solstitial dates. We now approach a problem of different type.

The Inauguration of the Mayan Calendar

0 Pop was followed in its mincing pace through the tropical year to the time when it coincided with the point of the winter solstice

FIGURE 41. HIEROGLYPHS FOR THE EQUINOX

at approximately 580 B.C. But since this position is only 33 years after the round number 7–0–0–0–0, according to the basic correlations, it seemed reasonable to assume that this round number marked the actual beginning of a count of days, while the four-year period during which 0 Pop coincided with the winter solstice marked the formal inauguration of the perfected calendar.

On the further assumption that the arbitrary elements in the Mayan calendar, such as the conversion of 30-day lunar months into 20-day mathematical months, demand an individual inventor (a first American scientist of high mentality and notable achievement), an attempt was made to reconstruct the conditions under which such a person might begin and complete his labors, using the traditional knowledge and methods usually found among tribes

on the agricultural horizon. One detail gives zest to this inquiry: the 33 years about embrace the working years of a full and fruitful life.

But the dates thus reached in the first place by speculative means were fully vindicated by later discoveries in inscriptions. Calculations at Copan and Palenque reach back to the year 580 B.C. when 0 Pop stood at the winter solstice. The seven baktuns of the legendary past, before history was recorded, ended on 7–0–0–0–0, 10 Ahau 18 Zac, Aug. 6, 613 B.C. They are clearly pictured in art and can be recovered in intricate calculations.

Morley solved the numerical portion of an interesting inscription on two altars at Copan which he designated Altars H′ and I′. The outstanding feature is a long distance number leading from Dec. 10, 580 B.C. to July 11, 422 A.D. in the following fashion:

7– 1–13–15–0,	9 Ahau 13 Cumhu,	Dec. 10, 580 B.C.
2–10–16– 3–0		
9–12–10– 0–0,	9 Ahau 18 Zotz,	July 11, 422 A.D.

Concerning this long distance number, covering 1001.58 tropical years, Morley writes:

"At first sight it would appear as though this long number, composed of 365,820 days, was meant to represent exactly 1,000 solar years, but such an explanation demands that the Maya had determined the solar year no more closely than one day every two years, which seems very unlikely in view of the accuracy of their other astronomical calculations. However, such a long stretch of time, probably purely an abstract conception as far as their actual history was concerned, since it goes back to Cycle 7, from which no other dates are known, bespeaks a high intellectual development, and indicates that the priesthood, or those who worked out the calculations presented upon the monuments, had reached a plane of mental achievement when they were dealing with periods of time far beyond the finite, so far as their own epoch was concerned."

But the date does not seem so incredibly ancient when we remember that the monumental records reach across more than half the interval and that the decadent Mayas at the Spanish Conquest still retained a grasp on more than 1350 years of their ancient history. The date 7–1–13–15–0, 9 Ahau 13 Cumhu, Dec. 10, 580 B.C. is the first Ahau preceding 0 Pop on Dec. 22. It implies exactly

what we dared to assume on purely theoretical grounds (see fig. 42).

At Palenque on the extensive tablets of the Temple of the Inscriptions is found another calculation reaching the same year as the calculation on Altar I′ at Copan and written about the same time since the terminal date of both monuments is 9–13–0–0–0, 8 Ahau 8 Uo, May 9, 432. At Palenque it is the preceding katun 9–12–0–0–0, 10 Ahau 8 Yaxkin, Sept. 1, 412 A.D. which is emphasized, however, since this round number makes a convenient point of departure at the autumnal station. The pair of altars at Copan involve the same relationship in declaring the date 9–9–14–17–5,

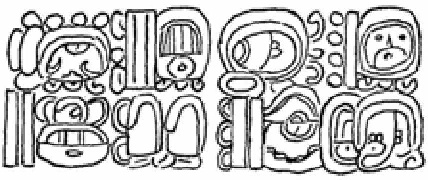


FIGURE 42. DISTANCE NUMBER REACHING BACK TO THE INAUGURATION OF THE CALENDAR

Copan, Altar I′.

6 Chicchan 18 Kayab, April 10, 368, for April 10 is the reciprocal of September 1 according to the rule that April 9 is the reciprocal of September 2 on the astronomical base line.

Morley has read the long inscription at Palenque in a manner which the author believes to be erroneous. The notation is recorded in 7 positions and may be construed into a record of 455,393,401 days, but the highest position with the coefficient 7 probably means Baktun 7 in the sense of the epoch of the Historical Era, while the next position with the coefficient 18 means 18 calendar rounds. The actual secondary series stands as 2–9–1–12–1. The matter of the calendar rounds can be interpreted as follows:

9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412 A.D.
5– 1–0		
9–11–14–17–0,	10 Ahau 13 Yaxkin,	Sept. 8, 407
2–12–13–0	1 calendar round	
9– 9– 2– 4–0,	10 Ahau 13 Yaxkin,	Sept. 21, 355
2– 7– 9– 0–0,	18 calendar rounds	
7– 1–13– 4–0,	10 Ahau 13 Yaxkin,	May 4, 580 B.C.

It will be observed that the departure is made first from approximately the revised autumnal station to approximately the earlier autumnal station (the relationship is closer than appears, as is explained elsewhere) and then passes back one calendar round to

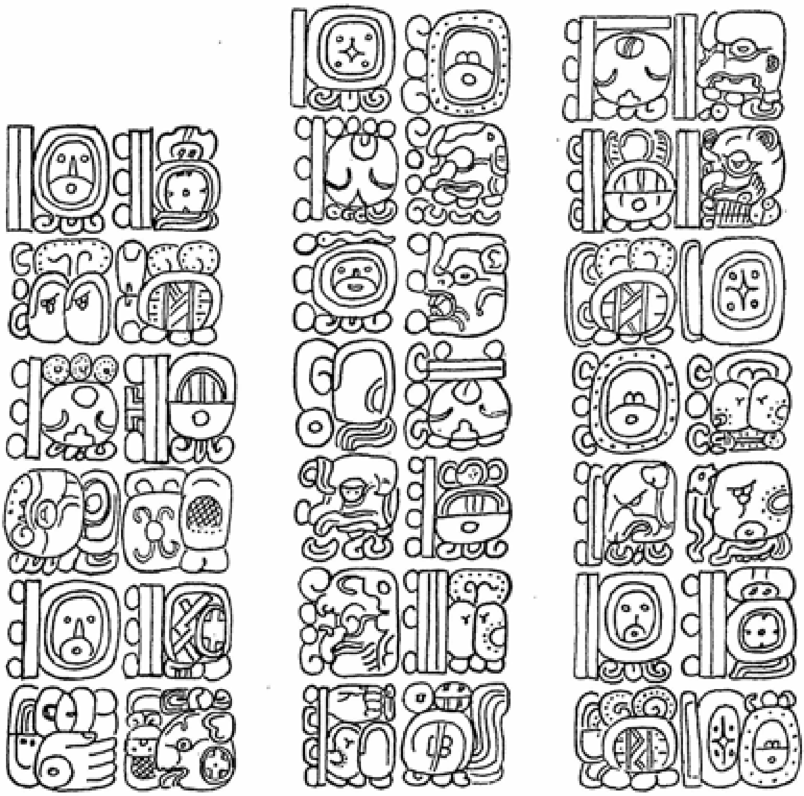


FIGURE 43. PASSAGES IN THE THIRD TABLET OF THE TEMPLE OF INSCRIPTIONS, PALENQUE

a date very close to the autumnal equinox. Then it leaps back to May 4, 580 B.C. just 11 uinals before the record at Copan, thus:

Palenque	7–1–13– 4–0,	10 Ahau 13 Yaxkin,	May	4, 580 B.C.
	11–0			
Copan	7–1–13–15–0,	9 Ahau 13 Cumhu,	Dec.	10, 580

The multiple problems which enter into the solution of the Palenque date are discussed somewhat more fully on pages 201–5. It

must be admitted that the secondary series which is preceded by the declaration of Baktun 7 and 18 calendar rounds does not reach any self-explanatory position. Subtracted from the designated position of 5 Lamat 1 Mol, the date around which the calculations revolve, it is in the first year of the historical period, thus:

9-9-2- 4-8,	5 Lamat 1 Mol,	Sept. 29, 355 A.D.
2-9-1-12-1		
7-0-0-10-7,	9 Manik 0 Zotz,	Feb. 28, 612 B.C.

But 9 Manik 0 Zotz is nowhere declared, nor are there any other declared dates which can be associated with the distance number: 1 Manik 10 Tzec is found but this comes 14–5–0 after the point.

This weakness is more than offset by the remarkable result achieved through a still longer distance number in the same general passage (see fig. 43). A date 8 Ahau 13 Pop is related to 5 Lamat 1 Mol in this fashion:

9-9- 0- 0-0,	3 Ahau 3 Zotz,	July 13, 353 A.D.
2- 4-8		
9-9- 2- 4-8,	5 Lamat 1 Mol,	Sept. 29, 355
12- 9-8	subtract	
9-8- 9-13-0,	8 Ahau 13 Pop,	May 27, 343

The second long distance number is 10–11–10–5–8 which can be analyzed into 12–9–8, the difference between 8 Ahau 13 Pop and 5 Lamat 1 Mol, plus 10–10–17–14–0 or 80 calendar rounds. Now this 5 Lamat 1 Mol is just 8 days in advance of 10 Ahau 13 Yaxkin, so we get:

9- 8- 9-13-0,	8 Ahau 13 Pop,	May 27, 343 A.D.
10-11-10- 5-8		
20- 0- 0- 0-8,	5 Lamat 1 Mol,	Dec. 25, 4512
8	subtract	
20- 0- 0- 0-0,	10 Lamat 13 Yaxkin,	Dec. 17, 4512

But baktuns are designated in groups of thirteen, so 20–0–0–0–0, 10 Ahau 13 Yaxkin, must be converted into 7–0–0–0–0, 10 Ahau 13 Yaxkin. In other words the Mayan mathematicians reached back to one Baktun 7 and forward to another and found the calendar-round date of this great culmination in the very year their calendar was inaugurated. One is tempted to speculate that the limit of future time was fixed in this inscription.

How the Calendar was Invented

The thirty-three years between Aug. 6, 613 B.C. and December 22, 580 B.C. witnessed, perhaps, the first admirably conceived and patiently completed piece of systematic science anywhere in the world. We read of the astronomical prowess of He and Ho in the legendary ages of China and we find a mystical glory wreathed around the head of Thales when Greece was young. But the unknown American scientist who solved the tangle of disharmonic lunations, planetary cycles and tropical years by inventing the Central American time machine did more than any of these. He carried out observations of an astronomical nature and created the very tools of thought with which to work. He developed a permutation, which gave fleeting units of time a personality and a name; he evolved a hieroglyphic method of recording essential facts in relation to each other; he devised place-value notation for numbers which made possible the first arithmetic. More than all this, he so impressed himself upon his fellowmen that the highly intellectual machine which his mind set in motion continued to function without a fault until it was wrecked upon the burning scaffolds of the Inquisition. The Mayan calendar which this man invented ran without the loss of a day for 2148 years and controlled the religious and civil life of several nations.

The hieroglyphs of Mayan months carry the tell-tale marks of the year when they were first drawn on paper.[1] The notational system for place-value numerals is linked with the moon: the conventional picture of that orb means 20, or completion, or zero, because the natural month of 29 or 30 days — measured from new moon to full—served as the imaginative basis of an arbitrary arithmetical month equal to the second degree in vigesimal numeration. This and the bar-and-dot numerals offer us a picture of the process of counting.

The great idea that presented itself to this calendar maker was to use the day as the unvarying measure of all time phenomena. This great idea came a second time to Scaliger, the father of the modern science of chronology, who published it with important results in 1582. The first American scientist conceived time as a

[1] Throughout the American tropics the fibrous bark of several trees was used for clothing and writing material.

sequence of days to be correlated with sequences of moons or months, with sequences of seasonal phenomena or years, with sequences in the slow journeyings of the planets across the starry waste. And this controlling sequence of the days he held in the leash of memory by a permutation of names and numbers.

He had, of course, some traditional matter to help him. The primitive year of primitive people is the sidereal year, determined by the heliacal setting and rising of certain stars and constellations, for this relationship once observed becomes fixed in story. We still speak of the rainy Hyades after the manner of Hesiod. Or else it is the year determined by the points of sunrise that the first observers see. In the 7th century before Christ, when our Mayan genius began his labors, the lunisolar year departing from the winter solstice seems to have been in use. Doubtless the 12 or 13 moons of this cycle had names which reflected the passing show of natural events. Doubtless also the shamans and magicians of that time were accustomed to try the fates on mechanistic layouts which were permutations of different kinds of things.

Let us say our calendar maker began a count of the days, a bead for each day and for each full moon a shell. Beads and sticks were grouped on the basis of the five-fingers-equal-one-hand method of counting, which enters into the vigesimal scheme where 20 is one man or one complete count of two hands and two feet. Remember our word calculate comes from calculus, a pebble. But a painted record is safer than strings of beads and bundles of sticks. So a dot became one and a bar became five. The bundle and the grasping hand were pictured for any completed unit: then, there were shells for moons (or pictures of the moon itself) and possibly green stones for years: these also connoted completion.

After several years' observation had yielded a record of celestial events which had been tied into a count of days, the necessity of simplification was felt. Perhaps shells for months and green stones for years were then counted on one side, as supplementary units, until the great scheme of place values came to mind. With this invention the month was reduced to twenty days and a sort of approximate year was made of 18×20 or 360 days. But the reduced month was still called u or uinal, moon, and pictured by a shell, and the conventional year was still tun, a stone. Afterwards a frog (uo for u) replaced the moon picture as a month

symbol because this had so many other uses. But lunar months of 29 or 30 days were written, to the end, by the moon for twenty days with nine or ten beside (fig. 8, *d*). The association between shells and the moon is a natural one; because shells are white and made into moon-shaped gorgets, because the moon draws back the sea tides and leaves the shells exposed, etc.

At any rate the physical basis of counting time units was simple enough and writing was merely pictures of the things used. The physical basis of the permutation with factors of 13 and 20 was also simple. The names of the days appear to have been twenty animals or powers in nature, drawn, perhaps, on bits of wood or bone and counted out to the thirteen points of a perfect universe with four directions on the three tiers of sky, earth and underworld, and the center for the last point. The month-signs were pictures of seasonal conditions or events.

At any rate these various concepts are obviously interlocked in their origin. The great idea was the never-ending count of days, in the modified vigesimal scale which rendered a 360-day unit close to a year. This base became a unit for a further count till the baktun or 400×360 days was obtained. But the year was really 365 days from the time the calendar was set in motion. Then — since a record of actual days had already existed for a space of thirty years or more — this count on hand was maintained as properly historical and seven baktuns were allowed for the past of the world. The same philosophy of a perfect cosmic number which suggested thirteen as the numerical factor in the permutation may also have suggested it as the proper designation of completion and zero in the higher cycles of time. Likewise seven may have been a sacred number here as in other parts of the world.

We will now consider further evidence as to the reality of the Historical Era as contrasted to the Mundane Era. This is of several sorts. First, there are examples of the recovery of the day of this historical era in current calculations; secondly, there are evidences of the ceremonial importance of a god of the number seven who may have been a deification of the great calendar maker; and, thirdly, there are evidences of the contrast between 7–0–0–0–0, 10 Ahau 18 Zac and 9–0–0–0–0, 8 Ahau 13 Ceh, the one standing for the control of the winter solstice or the dry season and the other for the control of the summer solstice or wet season.

Recovering the Epoch of History

Statements of Mayan dates which when transferred into the Gregorian calendar correspond to August 6 were in some instances clearly intended to fix in contemporaneous records the position in the natural year occupied by the point of departure, or epoch, of the Historical Era, 7-0-0-0-0, 10 Ahau 18 Zac, Aug. 6, 613 B.C. An interesting hotun approximation occurs three times at Piedras Negras on three different monuments:

Stela 25.	9- 8-15-0-0,	10 Ahau 8 Tzec,	Aug. 8, 348
	3-10-0-0		
" 39.	9-12- 5-0-0,	3 " 3 Xul,	" 6, 417
	3-10-0-0		
" 40.	9-15-15-0-0,	9 Ahau 18 Xul,	" 4, 486

While the second date furnishes the more accurate recapitulation, the first one would prove interesting to the Mayas because the interval exactly contains the tzolkin and therefore recovers the day 10 Ahau. The approximations depend upon the following coincidences:

Stela 25.	Interval 2-8-15-0-0.		
		961×365.242199	$=350,997.75$ days
		975×360	$=351,000.00$ "
		Difference	$=$plus 2.25 "
Stela 39.	Interval 2-12-5-0-0.		
		1030×365.242199	$=376,199.47$ days
		1045×360	$=376,200.00$ "
		Difference	$=$plus .53 "
Stela 40.	Interval 2-15-15-0-0.		
		1099×365.242199	$=401,401.78$ days
		1115×360	$=401,400.00$ "
		Difference	$=$minus 1.78 "

Until the recent discovery of a fragment of Stela 30 with a still earlier date, Stela 25 had the earliest known date at Piedras Negras, the next one coming a katun later. The last two monuments in the series are recent discoveries of Morley.

Now it may be claimed that the plain existence of these approximate dates does not make proof that their significance was perceived. Surely such a claim will hardly stand against the record on Stela 4 at Copan. This magnificent late monument has

for its initial series declaration the first of these dates recorded at Piedras Negras, recovering the position in the tropical year of the epoch of history within two and a quarter days and recovering as well the exact day 10 Ahau. Six katuns are then added and a position is reached which recovers the original 18 Zac. Thus:

7– 0– 0–0–0,	10 Ahau 18 Zac,	Aug. 6, 613 B.C.
2– 8–15–0–0		
9– 8–15–0–0,	10 Ahau 8 Tzec,	Aug. 8, 348 A.D.
6– 0–0–0		
9–14–15–0–0,	11 Ahau 18 Zac,	Nov. 17, 466

Doubtless the mathematicians of Copan knew that if another katun were added to the last date the third approximation would

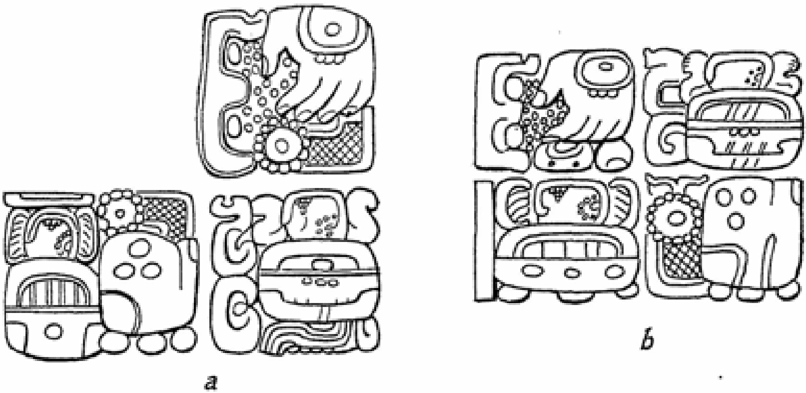


FIGURE 44. STATEMENTS OF AUG. 6, 417 A.D.
The exact recurrence of the epoch of the Historical Era after 1030 tropical years.
Stelae A and C, Quirigua.

be had with the true position of the original 10 Ahau 18 Zac almost exactly at the mean.

On Stelae A and C at Quirigua this mean enters into its own. These are sister monuments with the same final date, 9–17–5–0–0, 6 Ahau 13 Kayab, Feb. 28, 516. Both of these monuments deal with the epochs of eras. The zero of Mayan mundane chronology is recorded on one of them and while the epoch of the Era of the Chronicles is not completely written out it is clearly implied. Moreover, the heads in the introducing glyphs are pretty certainly those of the patron god of the number 7. The parallel passages reproduced in figure 44 are probably descriptive of the His-

torical Era since five katuns are recorded which subtracted from the contemporaneous date recovers the mean approximation of the original position of 10 Ahau 18 Zac. Thus:

9–17–5–0–0,	6 Ahau 13 Kayab,	Feb. 28, 516
5–0–0–0		
9–12–5–0–0,	3 Ahau 3 Xul,	Aug. 6, 417

Even more convincing is the combination of three dates at the beginning of the inscription on Lintel 1 at El Cayo. These three dates give with very close calculation (distorted somewhat by the Gregorian intercalation) 1st, the revised autumnal station, 2d, the summer solstice, 3d, the position of the epoch of the Historical Era.

9–16– 0– 2–16,	6 Cib 9 Mol,	Sept. 3, 491
11–17–10		
9–16–12– 2– 6,	13 Cimi 19 Zotz,	June 23, 503
2– 4		
9–16–12– 4–10,	5 Oc 3 Yaxkin,	Aug. 6, 503

A possible date on the very early Stela 5 at Uaxactun is an initial series which Morley reads as:

8–15–10–3–12, 11 Eb 5 Uo, Aug. 8, 87 A.D.

On the Temple of the Cross at Palenque we get a declaration of August 6 in another significant relation, tied to one of the approximations of the autumnal station.

9–1–10–0– 0,	5 Ahau 3 Tzec,	Sept. 7, 205 A.D.
1–16–7–17		
9–3– 6–7–17,	6 Caban 0 Zotz,	Aug. 6, 241

On the collar of Stela N at Copan the date is declared in this fashion:

9–16–10–16–15,	11 Men 13 Pop,	April 18, 502
2– 6 0		
9–16–13– 4–15,	6 Men 3 Yaxkin,	Aug. 6, 504

This is exactly one year later than the statement on Lintel 1 at El Cayo.

At Yaxchilan we find three records which may belong in this series.

Stela 11, front	9–15–15– 0– 0,	9 Ahau 18 Xul,	Aug. 4, 486
back	9–15–19– 1– 1,	1 Imix 19 Xul,	Aug. 4, 490
Stela 12.	9–18– 3–12–14,	6 Ix 12 Yaxkin,	Aug. 7, 533

The first of these is the approximation already considered; another example of the same is the unexpressed point of departure for the calculation on the Hieroglyphic Stairway at Seibal and other examples might be given (see page 273).

Seven Ages of the Past

Perhaps the great calendar maker was lifted to the skies. Mention was made of the patron deity of the number seven when the subject of face-variant numerals was being discussed. The god of seven also might be called the God of the Past because seven baktuns were counted back from the first historical date to reach the epoch of the Mundane Era — the first day of the world. It has already been pointed out that the face of this aged deity is distinguished by a twisted ornament over the bridge of his nose. This face is represented over a wider territory and a longer range of time than almost any other subject in Mayan art. It is especially prominent on shields and disks, and is also used on pottery vessels and figurines as well as in architectural decoration.[1]

On a wooden lintel from Tikal this god in youthful and human semblance stands behind the seated king and holds in his outstretched arms a ceremonial object no longer clear in the weathered sculpture. The number seven, a bar and two dots, is carved upon his cheek and while his face is human rather than grotesque, the twisted strap above the bridge of the nose is plainly discernible. The officiating priests on the famous circular altar at Tikal likewise wear the distinguishing feature of this divinity (see fig. 45 for various cases).

More remarkable still are representations at Palenque. In the center of the Tablet of the Sun is a sun shield which carries the front-view face of this god with the twisted nose ornament, only

[1] For the distribution of this type of face, see the author's *A Study of Maya Art*, p. 17. This face adorns the façade of the fine temple of Hochob.

here the face is of a strongly grotesque type suggesting a conventionalized owl. Possibly the Serpent Bird is partly involved in this drawing since a representation of the Serpent Bird at Tikal

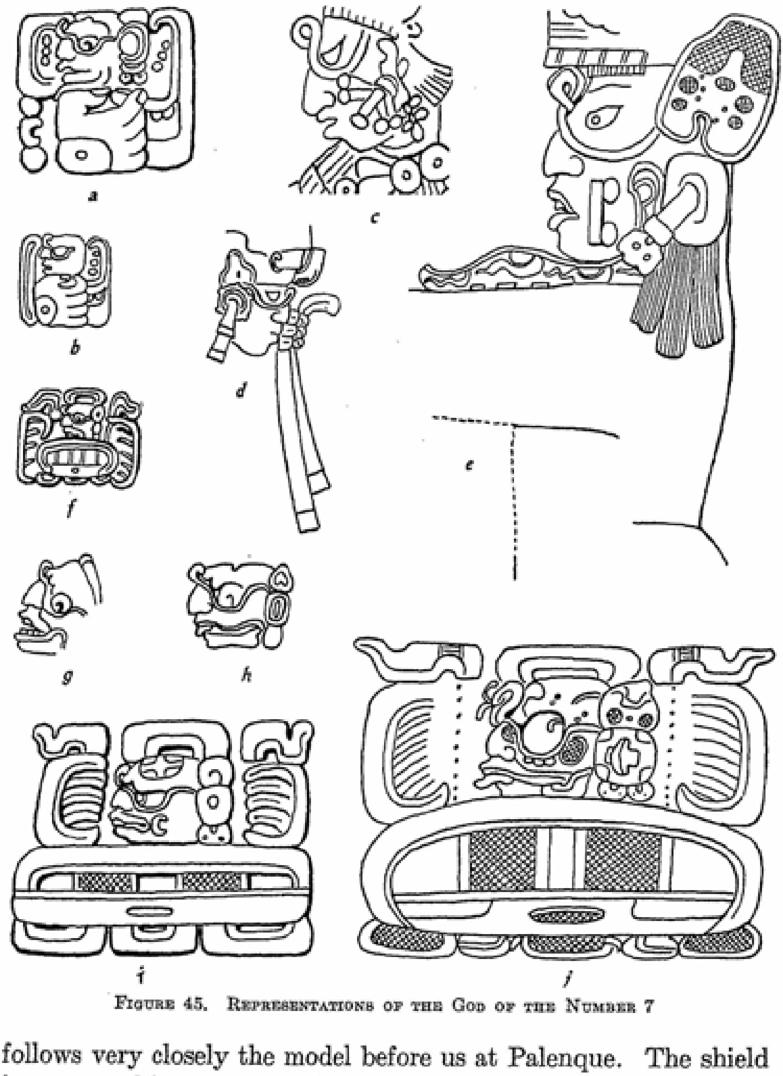


FIGURE 45. REPRESENTATIONS OF THE GOD OF THE NUMBER 7

follows very closely the model before us at Palenque. The shield is supported by two crossed spears, over an altar of serpent heads, and the altar is held aloft by two seated gods who wear birds on

their heads (frontispiece). The faces of these gods have the twisted detail over the nose exactly as it is shown on the profile faces of the hieroglyph for seven. On either side of the sun shield, and quite unsupported, is a large glyph-like head with appendages: on the left we see a face with a number seven and on the right a face with the number nine, both marked by carefully elaborated sym-

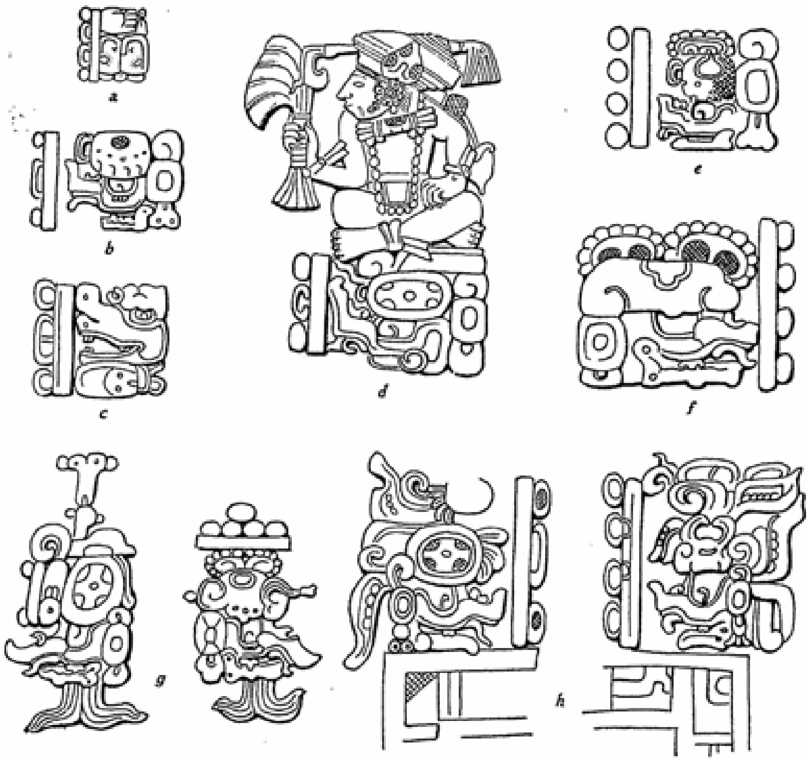


FIGURE 46. DECLARATIONS OF THE ERAS OF HISTORY AND OF THE CHRONICLES, OR BAKTUNS 7 AND 9 IN THE MUNDANE ERA

bolism. Perhaps the face with seven is intended to represent the seven ages of the past while the face with nine stands for the golden historical age of the great Mayan civilization, beginning with Baktun 9. Then, the central face on the shield in the guise of the owl is symbolical of the Mundane Era (see fig. 7, bottom row, for owl with 13).

Before proceeding with other matters at Palenque, let us now turn to Copan where on the sides of Stela D we find two other heads of exactly the same kinds also associated with seven and nine.

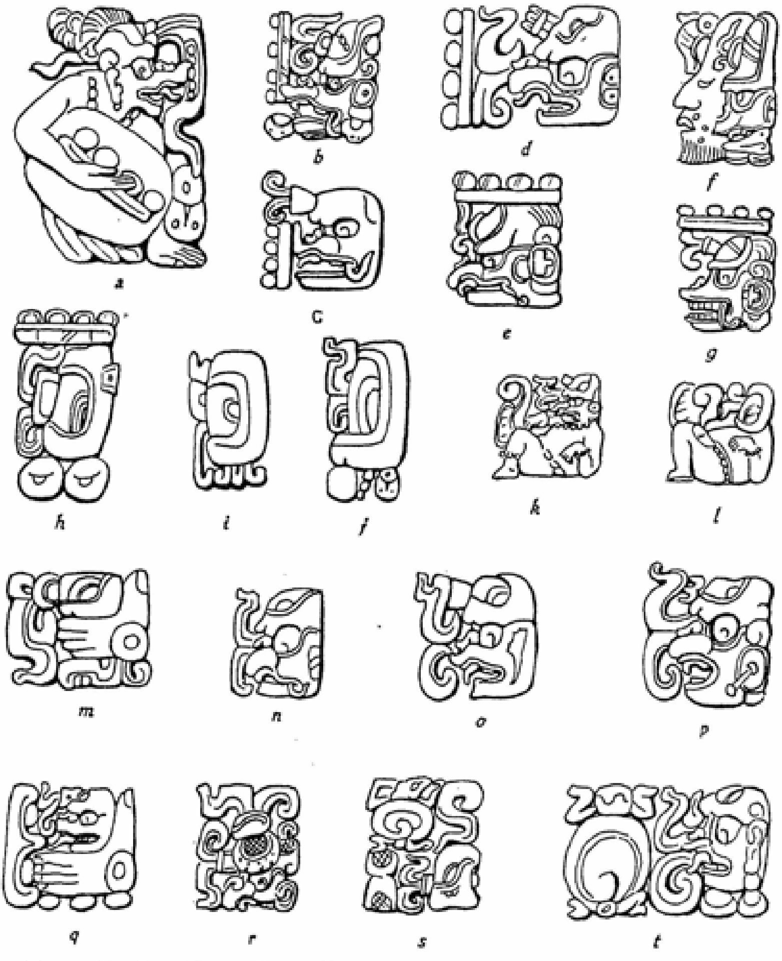


FIGURE 47. LONG-NOSED GOD OF RAIN AS PATRON OF THE ERA OF THE CHRONICLES, THE SUMMER SOLSTICE, AND THE RAINY SEASON

(fig. 46, *h*). It will be observed that the head for seven has on the forehead the four-part device which also appears at one side of the glyph Pop and in the eye of Kayab. This is differentiated from the kin device mostly by having the points in the diagonal corners

instead of the center of top, bottom, and sides. It has been recognized as one of the world-color glyphs and according to authorities on such matters it is the sign for yellow and for the south. It occurs in the celestial bands which are strips divided into rectangular spaces containing conventional figures for planets, stars, etc. Seler identifies it with the hieroglyph for Venus but it is surely as distinct from this as it is from the sign for the sun. The two heads on Stela D are placed over small sections of a celestial band.

Returning to Palenque, we find that on the Tablet of the Cross the priest at the observer's left stands upon the head for the number nine. No head for seven is pictured on this tablet but on the Tablet of the Foliated Cross, the so-called cross which is really a plant, rises out of a grotesque head with the four-part device at the top. All in all, then, it is not improbable that the Mayas recognized the seven predated baktuns of their calendar as an age or ages to be treated in cosmogonic chronology. In the cosmology of Mexico at a much later time the history of the world was divided into five ages, or suns, which were terminated by destructions and calamities. There is considerable confusion as to the length of these ages but they may reflect in a vague way some of the longer time periods of the Mayas.

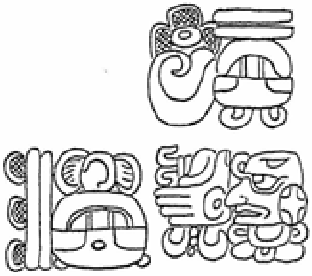


FIGURE 48. DISTANCE NUMBER ON STELA J, COPAN

It reaches Baktun 9, and implies relationship with Baktun 7 in the last glyph.

The representations of the patron god of seven do not end with the examples described above. Indeed one of the finest figures at Palenque, the old god blowing smoke through a tube, who is pictured on the lateral panel of the sanctuary of the Sun, is probably intended for this venerable personality. On Lintel 12 at Yaxchilan this god with cross-bones on his dress receives homage from kneeling captives. The face appears as the central element in introducing glyphs on several stelae (fig. 45, *i* and *j*).

Contrasted glyphs with coefficients of seven and nine have already received comment. A fine example of such a glyph with seven serves as a seat for a human figure on Altar T at Copan (fig. 46, *d*). The head is grotesque with the cosmic sign on the forehead. It seems highly probable that the god of seven was also

associated with the winter solstice and with the dry season which followed the winter solstice and that a god of nine stood for the opposite half of the year, the summer solstice and the rains. This is understandable because the first month of the Mayan year departed from the station of the winter solstice shortly after 7–0–0–0–0, 10 Ahau 18 Zac, and corresponded with the summer solstice at 9–0–0–0–0, 8 Ahau 13 Ceh. In the case of the god for nine we are dealing with the long-nosed Rain God and it is possible to show many glyphs of this god (either the entire figure, the head or the characteristic head-dress) combined with the numeral nine (fig. 47). The glyph sometimes has the value 9–0–0–0–0, as on Stela J at Copan (fig. 48). There the subtraction leads from 9–13–10–0–0 back to the Era of the Chronicles and we find the glyph of the Rain God with the number nine. Also the contrasting god of seven with the cosmic cross is pictured here.

Long Range Calculations

The inscriptions on various tablets at Palenque cover a surprising range of time with entire accuracy in the determination of tropical years. Also at Copan there are other evidences of calendrical manipulations embracing several thousand years and reaching results as accurate as those obtained from the use of the present Gregorian calendar.

In the last section of this paper the analysis of these records at Palenque is made step by step. The three inscriptions of the Temples of the Sun, the Cross and the Foliated Cross have interrelated calculations, the important historical date being 9–12–18–5–16, 2 Cib 14 Mol, Sept. 23, 430 A.D. This is exactly the autumnal equinox and ideographic hieroglyphs attesting this fact are plainly recorded. From this date the count goes back far into the legendary past. Important points of the natural year are restated in terms of the calendar at the epoch of the Mundane Era and other dates are given which concern planets, or possibly the sidereal year and the precession of the equinoxes.

Nowhere among the records of any early civilization anywhere in the world are there statements of scientific truth so crystal clear and gem-like as those on the Tablets of the Sun and of the Cross at Palenque where Mayan astronomers make projection of

contemporary fact backward for 3800 years with entire accuracy. Let the reader remember that concepts of time and space are the tap-roots of knowledge, that number is an imaginary construction, and perhaps he will be able to feel the intellectual power of the written dates that follow:

9–12–18– 5–16,	2 Cib 14 Mol	1,388,996	days,	Sept. 23, 430 A.D.
9–12–18– 5–16	subtract	1,388,996	"	
13– 0– 0– 0– 0,	4 Ahau 8 Cumhu	0	"	Oct. 14, 3373 B.C.
1– 9– 2,	add	542	"	
13– 0– 1– 9– 2,	13 Ik 0 Chen	542	"	April 8, 3371 B.C.
1–18– 3–12– 0,	add	274,920	"	
1–18– 5– 3– 2,	9 Ik 15 Ceh	275,460	"	Dec. 21, 2619 B.C.

Interpreting these figures into the terms of ancient knowledge we leave the point of the vernal equinox (fig. 49) and journey backward to the reputed birthday of the world, then we advance to the beginning day of the agricultural year, still determinable by the great sun dial of Copan, and finally come 754 years nearer to the present and stop on the winter solstice. The slight shift of a day for April 9 and December 22 is explained by the year and a half interval between 4 Ahau 8 Cumhu and 13 Ik 0 Chen. At the epoch 0 Chen is April 9 but in trying to secure a special day 13 Ik the Mayan astronomers overstepped the Gregorian intercalation of Feb. 29, 3372 B.C. And it must be remembered that we corrected our Gregorian tables by allowing a leap-year day at 2000 B.C. hardly justified by the arrangement of Pope Gregory. The number of 274,960 days is an accurate determination for the interval between April 9 and December 22 across a stretch of 752 years, or 754 years if counted from the epoch. This is half of 1508 years during which the 365-day year gains a revolution on the sun. The Mayan use of the 1508-year cycle will be discussed presently.

In the light of this proof of the long-range accuracy of the Mayas in dealing with the tropical year, let us see the entire layout of points and stations at the time of the epoch of the Mundane Era, and also the positions in the natural year occupied by the epoch of the Historical Era and the Era of the Chronicles. The correspondences emphasized at the left in Table XXIII are exact. However, 0 positions, or 3, 8, 13, 18 positions in the months have a special appeal when close approximations are to be had. These positions, occupied by Ahau, are bound to terminate an even

uinal, once every four years, while at wider intervals they terminate even tuns or katuns. The leap-year adjustment would not amount to a full day before Ahau could occupy these positions on a uinal at least.

Perhaps the most interesting coincidence is in regard to the months Mol and Chen, the 0 position of the former being within

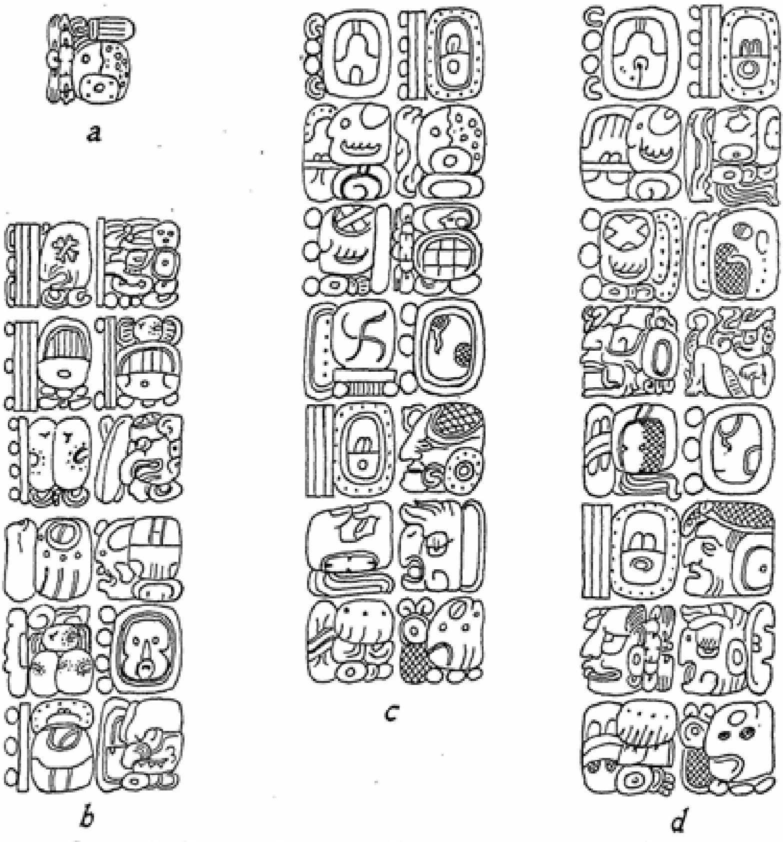


FIGURE 49. PARALLEL PASSAGES AT PALENQUE RELATING TO THE EQUINOX
a, *b*, and *c*, Tablet of the Sun; *d*, Tablet of the Foliated Cross.

a day of the vernal equinox, and that of the latter falling on the initial day of the agricultural year. The astronomical base line at Copan makes exactly this allowance in terms of full days. In regard to possible month positions of Ahau, and consequently

of round numbers, it might be noted that 13 Zip would be very close to the winter solstice, 13 Ceh to the summer solstice and 8 Kayab to the autumnal equinox. For the summer solstice the month position 13 Ceh would prove especially enticing since it was the month position of the Era of the Chronicles when 0 Pop equalled the summer solstice. We find 13 Ceh recorded in many interesting combinations on early and late monuments. We find evidence that other month positions in this list also were used as

TABLE XXIII. — POSITIONS OF MAYAN MONTHS IN THE TROPICAL YEAR AT THE EPOCH OF THE MAYAN ERA

Pop	Oct. 31–Nov. 19		
Uo	Nov. 20–Dec. 9		
Zip	Dec. 10–Dec. 29	12 Zip,	Winter Solstice
Zotz	Dec. 30–Jan. 18		
Tzec	Jan. 19–Feb. 7,		
Xul	Feb. 8–Feb. 27	12 Xul,	Epoch of the Chronicles
Yaxkin	Feb. 28–Mar. 19		
Mol	Mar. 20–April 8,	1 Mol,	Vernal Equinox
Chen	April 9–April 28,	0 Chen,	First Station
Yax	April 29–May 18		
Zac	May 19–June 7		
Ceh	June 8–June 27,	14 Ceh,	Summer Solstice
Mac	June 28–July 17		
Kankin	July 18–Aug. 6,	19 Kankin,	Epoch of History
Muan	Aug. 7–Aug. 26		
Pax	Aug. 27–Sept. 15,	6–10 Pax,	Second Station
Kayab	Sept. 16–Oct. 5,	9 Kayab,	Autumnal Equinox
Cumhu	Oct. 6–Oct. 25		
Uayab	Oct. 26–Oct. 30		

bases for calculations. Goodman, following the symbolism of numbers in ways which have not met with the full approval of modern students, arranged the Mayan months in a numerical sequence in which each month stood for a series for twenty days. He says: "The numerical order of the months begins with Chen so that there must have been an earlier form of the year in which the year commenced with that month." [1] Now sometimes the Chen glyph has a knotted superfix such as ordinarily means completion or zero. This detail might indicate that 0 Chen was the point from which a count was made.

[1] *Archaic Mayan Inscriptions*, p. 69.

In the Temple of the Cross the calculations proceed from the early dates near the Mundane Era to 5–8–17–15–17, 11 Caban 0 Pop, May 28, 1226 B.C., which is a New Years day lying more than 600 years before the commencement of history. After this comes 5 Cimi 14 Kayab and 1 Kan 2 Kayab separated by an interval which affords a transition from April 9 to March 21 across a term of years. These two calendar-round dates are not fixed in the long count but seem to belong in the following relationship to the recorded New Years day:

5– 8–17–15–17,	11 Caban 0 Pop,	May 28, 1226 B.C.
3– 4–14– 9		
5–12– 2–12– 6,	6 Cimi 14 Kayab,	April 11, 1162 B.C.
1–14– 7–18		
5–13–17– 2– 4,	1 Kan 2 Kayab,	Mar. 22, 1128 B.C.

Now if these dates are moved 29 calendar rounds forward they are found to occupy about the same places in the year, thus:

9– 5– 6–14–17,	11 Caban 0 Pop,	May 28, 281 A.D.
3– 4–14– 9		
9– 8–11–11– 6,	5 Cimi 14 Kayab,	April 12, 345
1–14– 7–18		
9–10– 6– 1– 4,	1 Kan 2 Kayab,	Mar. 23, 379

The last two dates are not exactly on the points of the year although April 12 is an important date in other calculations as we shall soon observe. But there is a distance number 1–2–5–14 recorded in the inscription. This added to the last two dates brings them exactly into line:

9– 8–11–11– 6,	5 Cimi 14 Kayab,	April 12, 345 A.D.
1– 2– 5–14		
9– 9–13–17– 0,	5 Ahau 18 Kayab,	April 9, 366
9–10– 6– 1– 4,	1 Kan 2 Kayab,	Mar. 23, 379
1– 2– 5–14		
9–11– 8– 6–18,	1 Eznab 6 Kayab,	Mar. 21, 400

The month position 18 Kayab thus reached is important in the Venus cycle and is strongly emphasized at Copan and in the Dresden Codex.

But the important fact of this calculation is that it seems to

indicate that the Mayas used the 29 calendar-round shift which is a marvelously accurate one:

29×18,960	days	=550,420 days
1507×365.2421996	"	=550,419.9948 days

Here the intercalation error is over a period of 1507 tropical years and 1508 vague years (29 × 52 × 365 days), and amounts to only .0052 of a day.

There is in the mind of the writer little doubt but that this shift was actually used. The Mayas seem, however, to have calculated the error for the period in an odd number of days slightly under 1508 of their years. This is indicated by some of the statements which follow in the same inscription. First we get:

9–1–10– 0– 0,	5 Ahau 3 Tzec,	Sept. 7, 205 A.D.
1–16– 7–17		
9–3– 6– 7–17,	5 Caban 0 Zotz,	Aug. 6, 241
1–19– 6–18		
9–5– 5–14–13,	11 Ben 1 Pop,	May 29, 280

This is a very interesting statement for it proceeds from a lahuntun on the autumnal station to a date corresponding to August 6, the position of the epoch of the Historical Era, then it goes to 11 Ben 1 Pop which can be connected with the New Years day 11 Caban 0 Pop as follows:

9– 5– 5–14–13,	11 Ben 1 Pop,	May 29, 280 A.D.
1– 0– 4	add one ritualistic year	
9– 5– 6–14–17,	11 Caban 0 Pop,	May 28, 280
3–16– 8–17– 0,	subtract 29 calendar rounds	
5– 8–17–15–17,	11 Caban 0 Pop,	May 28, 1226 B.C.

It is also important to note that the last date on the Temple of the Cross is 9–12–8–4–5, 11 Chicchan 13 Chen, Oct. 14, 420. It exactly repeats the astronomical position of the original 13–0–0–0–0, 4 Ahau 8 Cumhu, Oct. 14, 3373 B.C.

Comment has already been made on the long calculations into the future found in the Temple of the Inscriptions at Palenque. A number of other October dates which are probably declarations of the location of the original 4 Ahau 8 Cumhu might be given but we will pass on to a last inscription.

FIGURE 50.
INSCRIPTION ON
STELA C AT COPAN

On Stela C at Copan there is a calculation involved in the pattern of the Venus count. It reaches back 1,686,620 days from the end of Katun 14 of Baktun 9 to a day 6 Ahau in the significant month position 18 Kayab, as follows (fig. 50).

9–14– 0– 0–0,	6 Ahau 13 Muan,	Feb. 3, 452 A.D.
11–14– 5– 1–0	subtract	
10–19–14–17–0,	6 Ahau 18 Kayab,	April 12, 4165 B.C.

In the Dresden Codex on the famous page 24 that gives the multiplication table of the Venus calendar ($2920 = 8 \times 365 = 5 \times 584$) this month position is recorded at exactly the same place in the tropical cycle but 4528 years later:

9–9– 9–16–0,	1 Ahau 18 Kayab,	April 12, 363
6– 2–0		
9–9–16– 0–0,	4 Ahau 8 Cumhu,	April 21, 369

The coördination found in this impressive calculation does not stand unsupported. The interval of 4528 years is $3 \times 1508 + 4$ years. That is, it is one day by the intercalation test over the concordance between 29 calendar rounds and the complete lap gained by a 365-day year over one of 365.2421996 days. In the Dresden Codex the date April 12 is linked with April 21, six years later, which was 72 calendar rounds after the original 4 Ahau 8 Cumhu of the Mundane Era. On the Tablet of the Sun at Palenque we find 2–0–0–0–0, 2 Ahau 3 Uayeb, April 20, 2584 B.C. Also April 21 was the original position of 0 Yaxkin when the calendar was inaugurated in 580 B.C.

These Mayan dates are transcribed into the Gregorian calendar which did not come into use until after the eradication of Mayan learning by zealous churchmen. In the Julian calendar which all Europe used until 1582 and, which the Greek church has just agreed to abandon, the error over this long stretch of time would amount to a full month or more. After the mass of other proofs already presented that the

Mayas often recorded the date of the solstices, the equinoxes, and the conventional beginning day of a farmer's year, we are justified in assuming that the ancient priests of Central America had fixed the true length of the tropical year with extreme accuracy, and were able to project their knowledge backward with the same results as are reached by modern calculations.

Let us compare these results with the best which the Old World could offer at this time. The Julian year was about eleven minutes and eight seconds too long and it gained a full day in 128 years. In the 3800 years of the Palenque texts it would have suffered a displacement of about thirty days and in the 4528 years of the Copan texts about 36 days.

But a somewhat finer achievement than the Julian year is seen in the determination of Hipparchus of the Alexandrine school on the basis of the Metonic and Callipic cycles. The first of these, put in force in 432 B.C., expressed the double equation 19 tropical years = 235 lunations = 6940 days. Callipus about a hundred years later quadrupled the period and dropped one day, thereby obtaining 76 tropical years = 940 lunations = 27,759 days. Hipparchus discovered that the Metonic cycle was five days out and the Callipic one day out and suggested that the latter be quadrupled again and another day dropped. This gave 304 tropical years = 3760 lunations = 111,035 days. His correction for leap year is sometimes stated to have been the annual addition of 1/4 of a day minus 1/300 of a day. This result was not employed by the Greeks or Romans but it was probably taken over by the Jews and may have come to the notice of the astronomers of India. The coördination of Hipparchus gave the tropical year a value of 365 days 5 hours 55 minutes and 15 seconds against a true length of 365 days 5 hours 48 minutes 46.046 seconds. The error of about six and a half minutes is only half that of the Julian year, yet it would result in a fortnight's displacement over the space of the Mayan calculation.

Dates in the Dresden Codex

In the Dresden Codex twenty-seven initial series are written out in complete form by place-value notation without period glyphs and a considerable number of other dates in the long count can be reconstructed from the record. The subject matter of this

codex is now recognized to be largely astronomical and should be re-examined carefully in the light of our new correlation. This, however, is a matter of such vastness that it cannot be attempted in this paper. I only wish to touch some of the high spots and indicate ways in which new starts can be made in interpretation. The correspondences between the dates and calculations in this manuscript and those found in the inscriptions are often very close as we have just seen. Especial attention has been called to dates that repeat the month position 18 Kayab.

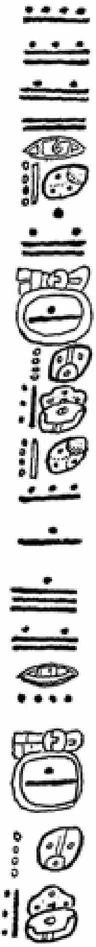


FIGURE 51. TWO RING NUMBERS IN THE DRESDEN CODEX

While the date 9–9–9–16–0, 1 Ahau 18 Kayab, April 12, 363 A.D. in the Dresden Codex may be concerned with the Venus count in some fashion yet to be disclosed, its prime significance here, as a point of departure, was on account of its strategic position near the beginning of the agricultural year in 363 A.D. This day is also involved in the lunar count of the Dresden Codex with its reëntering cycle of 11,960 days. This cycle was composed of three Mayan Saroids of 3987, 3986 and 3987 days each, equalling twenty-three eclipse seasons, and the whole counting 405 lunations with a minute remainder. The following dates in the Dresden Codex are recorded in connection with the interval 11,960, and other positions can be found by adding and subtracting the distance number 1–13–4–0:

1,352,400,	9– 7–16–12–0,	1 Ahau 18 Zip,	July 13, 330 A.D.
11,960,	1–13– 4–0		
1,364,360,	9– 9– 9–16–0,	1 Ahau 18 Kayab,	April 12, 363 A.D.
11,960,	1–13– 4–0		
1,376,320,	9–11– 3– 2–0,	1 Ahau 13 Mac,	Jan. 9, 395 A.D.

As calendar-round dates these can occur, of course, at intervals of fifty-two years and it is interesting to note that two of them do occur prominently in the inscriptions. The third date is the one reached by the initial series on the tablet of the Foliated Cross where it occupies the position 1–18–5–4–0, 1 Ahau 13 Mac, Jan. 8, 2618 B.C., almost exactly 3013 years before the indicated position in the Dresden Codex.

The so-called ring numbers in the Dresden Codex are supposed

to indicate subtraction but Willson argues with much force that they indicate the epochs of special counts before the 4 Ahau 8 Cumhu which is the epoch of the common count. The ring is a loop with a knot at the top which encloses the lower member of the number to be subtracted. In figure 51 we see two ring numbers from page 70 of the Dresden Codex. Both are in connection with a day 9 Ix which is shown immediately after the first long number and immediately before the second long number. The epoch date 4 Ahau 8 Cumhu follows the ring number in each instance.

First Statement		
9–13–12–10–0 =	1,394,120,	distance number
9 Ix		day of the special count
1–12–6 =	606,	ring number
4 Ahau 8 Cumhu		epoch of the Mundane Era
Second Statement		
9 Ix		day of the special count
8–6–16–12–0 =	1,201,200,	distance number
4–6	86,	ring number
4 Ahau 8 Cumhu		epoch of the Mundane Era

The numbers reduced are found to occupy the following positions.

First Statement			
Epoch of the Era	13– 0– 0– 0– 0,	4 Ahau 8 Cumhu,	Oct. 14, 3373 B.C.
Ring number	1–12– 6	subtract	
Epoch of Special Count,	12–19–18– 5–14,	9 Ix 7 Xul,	Feb. 15, 3374
Distance number	9–13–12–10– 0	add	
Historical date	9–13–10–15– 4,	9 Ix 12 Muan,	Feb. 5, 442 A.D.
Second Statement			
Epoch of the Era	13– 0– 0– 0– 0,	4 Ahau 8 Cumhu,	Oct. 14, 3373 B.C.
Ring number	4–6	subtract	
Epoch of Special Count,	12–19–19–13–14,	9 Ix 3 Kankin,	Aug. 10, 3373
Distance number	8– 6–16–12– 0	add	
Historical date	8– 6–16– 7–14,	9 Ix 7 Mac,	April 29, 84 B.C.

Now if these calculations deal with the revolutions of some planet it seems quite likely that an effort is being made to make the planetary calendar fit into the usual one. The dates are approximations to the epochs of all three eras and to the position of 0 Yaxkin at the epoch of the Historical Era. To be sure the correspondences are not exact but planetary periods are not easy matters to handle.

Förstemann makes much of the choice of numbers, which are common multiples of various numerical and astronomical cycles. The Mayas could not in every case gain exact precision as regards points of the year and at the same time find numbers which would be common multiples of many factors. They, therefore, as we have already seen in many examples, dealt in approximations. Let us examine the basic relationship of several suppressed or recorded long numbers in connection with page 70 of the Dresden Codex.

Mayan Number and Date		Arabic	Date Reached	Position 0 Pop
9–15–13–13– 0,	4 Ahau 3 Uo,	1,408,940,	May 1, 485 A.D.	April 8
8– 0		160		
9–15–14– 3– 0,	8 Ahau 3 Yax,	1,409,100,	Oct. 8, 484	April 8
15– 9–15–14		111,554		
10–11– 4– 0–14,	9 Ix 7 Zip,	1,520,654,	Mar. 15, 791	Jan. 25
9–19–11–13– 0,	4 Ahau 3 Uayeb,	1,437,020,	Mar. 19, 562	Mar. 21
8– 0		160		
9–19–12– 3– 0,	8 Ahau 18 Mol,	1,437,180,	Aug. 26, 562	Mar. 21
11–11–15–14		83,474		
10–11– 3–18–14,	9 Ix 7 Zip,	1,520,654,	Mar. 15, 791	Jan. 25
10– 3–10– 8– 0,	4 Ahau 13 Ceh,	1,465,360,	Oct. 22, 639	Mar. 3
8– 0		160		
10– 3–10–16– 0,	8 Ahau 8 Uo,	1,465,520,	Mar. 31, 640	Mar. 2
14– 2–14–12,		101,812		
10–17–13–12–12,	4 Eb 5 Pop,	1,567,332,	Dec. 30, 918	Dec. 25
10–12–16–14– 0,	4 Ahau 13 Mol,	1,532,440,	June 21, 820	Jan. 17
8– 0		160		
10–12–17– 4– 0,	8 Ahau 13 Pax,	1,532,600,	Nov. 28, 820	Jan. 17
4–16– 8–12		34,732		
10–17–13–12–12,	4 Eb 5 Pop,	1,567,332,	Dec. 30, 918	Dec. 25

It will be seen that several of these dates, as recorded, lie in the vicinity of the vernal equinox and the winter solstice and that another reaches the summer solstice. If we consider the position of 0 Pop in connection with these dates we find it occupied the important positions, April 8, March 21, and December 25. The writer is convinced that when the dates and calculations in the Dresden Codex have been fully transcribed and explained this manuscript will be acknowledged as one of the world's greatest books of early science.

The Original Toltecan Adaptation

In closing this section of our study let us turn again to Mexico and try to fix the date of introduction of the Mayan calendar among the highland peoples.

In the Mexican calendar of 1521, the intercalary period of five days, called nemontemi, fell before the month Atlacaualco but in earlier times it must have fallen before Toxcatl. The New Fire ceremony is basically one of the winter solstice and perhaps we are justified in reconstructing the original Toltecan adaptation of

Original Correlation of Mayan and Mexican Months in 600 A.D.

Dates in the Gregorian Calendar

Mayan Number	Mayan Initial Day	Mayan Date	Mexican Number	Mexican Initial Day	Mexican Date
1	0 Pop	Mar. 12	5	1 Tlaxochimaco	Mar. 12
2	0 Uo	April 1	6	1 Xocouetzi	April 1
3	0 Zip	April 21	7	1 Ochpaniztli	April 21
4	0 Zotz	May 11	8	1 Teotleco	May 11
5	0 Tzec	May 31	9	1 Tepeilhuitl	May 31
6	0 Xul	June 20	10	1 Quecholli	June 20
7	0 Yaxkin	July 10	11	1 Panquetzaliztli	July 10
8	0 Mol	July 30	12	1 Atemoztli	July 30
9	0 Chen	Aug. 19	13	1 Tititl	Aug. 19
10	0 Yax	Sept. 8	14	1 Izcalli	Sept. 8
11	0 Zac	Sept. 28	15	1 Atlacaualco	Sept. 28
12	0 Ceh	Oct. 18	16	1 Tlacaxipehueztli	Oct. 18
13	0 Mac	Nov. 7	17	1 Tozoztontli	Nov. 7
14	0 Kankin	Nov. 27	18	1 Uei Tozoztli	Nov. 27
....	....	....		1 Nemontemi	Dec. 17
15	0 Muan	Dec. 17	1	1 Toxcatl	Dec. 22
16	0 Pax	Jan. 6	2	1 Etzalqualiztli	Jan. 11
17	0 Kayab	Jan. 26	3	1 Tecuilhuitontli	Jan. 31
18	0 Cumhu	Feb. 15	4	1 Uei Tecuilhuitl	Feb. 20
	0 Uayeb	Mar. 7	....	....	....

the Mayan calendar according to a pattern possible for 600 A.D. The earliest historical statements in strict calendrical form referring to Toltecan history are subsequent to this date. There is no evidence that the Mexican year ever began with Tlaxochimaco, the equivalent of the Mayan month Pop, but in the suggested arrangement of the earliest Toltecan calendar, Toxcatl is made to begin at the winter solstice which was the original location of Pop

at the time the Mayan calendar was set in motion. The Toltec astronomers who took over the Mayan calendar in developed form may have chosen to make this slight readjustment so as to have their own point of departure. But it may have been in the Zapotecan region that the borrowing was consummated. In support of this hypothesis we find at Monte Alban glyphs of an owl associated with 13 which recall the Mayan owl, also joined with 13 in cryptic references to the Mundane Era.

PART V

A REVIEW OF MAYAN INSCRIPTIONS

In this section, extended series of inscriptions from the various cities will be analyzed and treated together so as to give a true picture of the relative importance of the days of astronomical or calendrical interest in the whole record. Breaks in the record make it impossible to give at this time a complete survey of all inscriptions. However, the most interesting texts are discussed in the following pages.

Three Inscriptions at Palenque

Palenque, a city of ceremonial importance during the First Empire, has extensive inscriptions which appear to have been carved during the Middle Period, judging by the terminal dates, but which were probably removed from their original temples to later structures during the Great Period. On architectural grounds we must place the temples of Palenque much later than the terminal dates of the tablets found in them and in this connection it may be noted that the stucco decorations of some of the temples also have the characters of late art. The principal inscriptions are in the sanctuaries of the Temples of the Sun, the Cross, and the Foliated Cross, and on the back wall of the inner chamber of the Temple of the Inscriptions. This last text covers three spaces with a total of 620 glyph blocks.

The tablets in the sanctuaries of the three temples usually named together are in the same style of low-relief carving, and the subject matter in all cases is enriched with celestial symbolism. The central object on the tablet of the Temple of the Sun is a shield placed over crossed spears, the whole supported on an altar which in turn, is held up by Atlantean gods. The shield carries the grotesque face, in front view, of a sun god characterized by a curled nose ornament. The face of this god in profile is seen in the head-variant glyphs for the numbers 7 and 17 and something has already been said about the importance of seven in relation to the Historical Era. On either

side of the shield and altar are officiating priests standing on the backs of gods. The platform of the tableau is a narrow panel with alternating hieroglyphs of the earth and the sky (see frontispiece).

In the case of the Temple of the Cross the arrangement of the ceremonial tableau is somewhat similar, only here we have a cross-like tree with a bird perched upon its top, rising out of a grotesque head. The general symbolism of this tablet refers to floods or perhaps the rainy season and is connected in some way with the front head of the so-called Two-headed Dragon, one of the most striking conceptions of Mayan art. Here the platform is a celestial band in which are seen the signs for Venus, the Moon and other luminaries. The Temple of the Foliated Cross has the same arrangement as that of the Cross. Here the tree is probably a highly conventionalized maize plant and the symbolism appears to refer to the rear head of the Two-headed Dragon and to drought or the dry season.

Bowditch showed the interrelation of the principal dates in these three temples at Palenque but his astronomical interpretation cannot stand in the light of our new correlation. The presentation of calculations on any particular tablet is often discontinuous and while a complete solution cannot be attempted at this time enough will be demonstrated to bring out the essential purposes of the calculations. It seems that we must learn to distinguish between the theoretical and the actual in the matter of Palenque dates. The initial series on all three monuments and the calculations most closely connected with them lie thousands of years in the past. These are:

	Temple of the Cross		
I. Ser.	12–19–13– 4–0,	8 Ahau 18 Tzec,	Feb. 7, 3379, B.C.
D 3–C 5	13– 0– 0– 0–0,	4 Ahau 8 Cumhu,	Oct. 14, 3373, B.C.
D 5–C 6	1– 9–2		
	(13– 0– 1– 9–2),	13 Ik (0 Chen),	Apr. 8, 3371, B.C.
D 13–C 15	1–18– 3–12–0		
E F 1	(1–18– 5– 3–2),	9 Ik 15 Ceh,	Dec. 21, 2619, B.C.
	Temple of the Sun		
I. Ser.	1–18– 5– 3–6,	13 Cimi 19 Ceh,	Dec. 25, 2619, B.C.
	Temple of the Foliated Cross		
I. Ser.	1–18– 5– 4–0,	1 Ahau 13 Mac,	Jan. 8, 2618, B.C.
C 3–D 4	1–14–14–0		
D 7–D 8	2– 0– 0– 0–0,	2 Ahau 3 Uayeb,	Apr. 20, 2584, B.C.

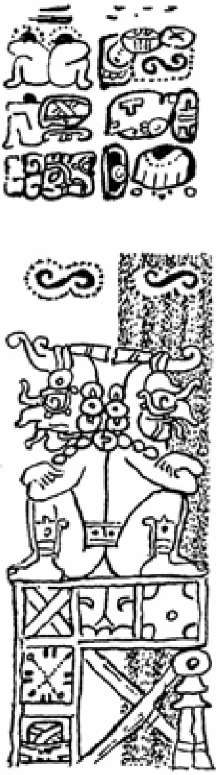


FIGURE 52. THE MAYAN JANUS

The reversal of the seasons Dresden Codex.

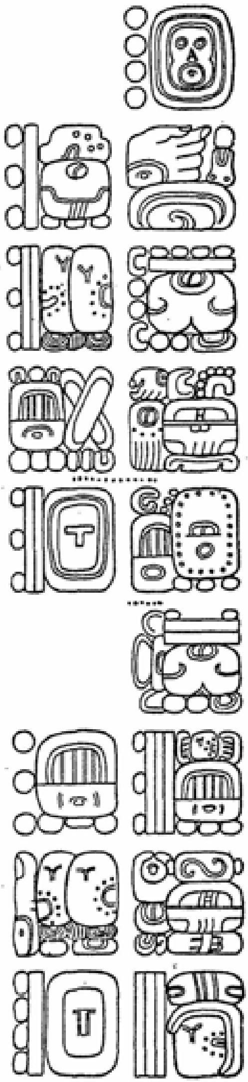


FIGURE 53. PASSAGE ON THE TABLET OF THE CROSS, PALENQUE

It covers the reversal of 15 Ceh from summer solstice to winter solstice.

It will be noted that leading dates within a few days of each other are recorded on all three tablets and that these dates cluster around the winter solstice. Not by the wildest flight of the imagination can these be regarded as anything but projecting backward in accordance with facts known in the fourth or fifth centuries A.D. The distance number 1–9–2 counted from the Mayan era leads to April 8 (or April 9, at the era, since we added a leap-year intercalation in 3372 B.C.). Nearly 4000 years later, this was the beginning of the agricultural year. If we can depend upon this date as secure evidence of the intention of the Mayan astronomers to record this station of the tropical year in their vague year, we must conclude that their system was more accurate than that of the Gregorian calendar, as has already been stated. While April 8 is reached by strict application of the Gregorian calendar rules (after a day's correction is made by the dropping of leap-year day in 2000 B.C.) we can say that it is April 9 as viewed from the era. And with one point of the natural year fixed at the era the others follow from rule of thumb. If April 9 corresponded to 0 Chen, then the summer solstice would correspond to 14 or 15 Ceh. When therefore we see 15 Ceh reached in 1–18–5–3–2, 9 Ik 15 Ceh, 275,460 days after the era and exactly on the winter solstice, we must grant that the calculation was deliberate and that the Mayas measured the time during which their 365-day year gained one-half lap on the year of the seasons. The reversal of the seasons is pictured in the Dresden Codex (fig. 52) by two long-nosed gods sitting back to back and looking opposite ways, Janus-like. The rain falls on one. An S-shaped device above these figures symbolizes the reversal of the seasons from dry to wet. In the passage at Palenque which covers the half-year shift from the summer to the winter solstice the same S-shaped device appears (in the glyph just before the final date in figure 53).

At the very beginning of these calculations there are dates and distance numbers which seem to present unsurmountable difficulties. On the Tablet of the Sun there is a secondary series 1–2–11 (A B 13), which comes between two statements of the same initial series and looks decidedly like an equation. There is a declaration of 10 Tzec, following this distance number but it cannot be reached by the distance number from the initial series. The element of doubt is great and the numerous possibilities will not be covered.

The situation as regards the first distance number on the Temple of the Foliated Cross (1–14–19) is somewhat better but not entirely satisfactory. After this number, we find the declaration of the month position 7 Yax, but the addition leads to 2 Yax. Here it is clear that the coefficient in the day position cannot be changed since it is already nineteen and therefore we must assume that a bar was added to the month-sign which does not properly belong with it.

I. Ser.	1–18–5– 4– 0, 1 Ahau 13 Mac,	Jan. 8, 2618 B.C.
B 12–B 13	1–14–19	
A 14	(1–18–7– 0–19, 10 Cauac) 2 Yax,	Nov. 1, 2617 B.C.

Again, on the Tablet of the Cross, we find a day 1 Ahau 18 Zotz (A B 16) after the initial series without a distance number. The nearest possible relation to the initial series of this date is just twenty days earlier than the initial series itself. Several long numbers are counted from this base as we shall see presently. Also a distance number, 8–5–0 in D 1 C 2, stands just before the declaration of 4 Ahau 8 Cumhu, the epoch of the Mayan era. If this is supposed to be counted backward from 4 Ahau 8 Cumhu, it will reach 12–19–11–13–0, 1 Ahau 8 Muan, Aug. 17, 3381 B.C., if counted forward it will reach 13–0–8–5–0, 7 Ahau 3 Zip, Dec. 11, 3365 B.C., if our figures are not in error.

After the perplexing early statements there come, on the Tablet of the Cross, some transitional dates which approach historical time by long distance numbers, but still stop in the pre-historic period before the actual formation of the calendar. This series is counted from the 1 Ahau 18 Zotz referred to above, and the first distance number stands after memorable ones reaching the beginning of the agricultural year and the winter solstice.

AB 16	(12–19–13– 3– 0),	1 Ahau 18 Zotz,	Jan. 19, 3379 B.C.
E 5–F 6	2– 1– 7–11– 2		
EF 9	(2– 1– 0–14– 2),	9 Ik 0 Yax,	Mar. 9, 2564 B.C.
E 10–F 11	3– 6–10–12– 2		
	(5– 7–11– 8– 4,	1 Kan 2 Cumhu),	May 11, 1252 B.C.
F 15–F 16	1– 6– 7–13		
Q 2 P 3	(5– 8–17–15–17),	11 Caban 0 Pop,	May 28, 1226 B.C.

This record is clouded. The date reached by the first addition is 9 Ik 0 Yax but 0 Zac is recorded: the base is one uinal before the

initial series, which might explain this error. Also 9 Ik is repeated after the next distance number and no sign of the 1 Kan 2 Cumhu actually reached. But the total of the addition arrives at a properly recorded 11 Caban 0 Pop. This is a New Years day.

The transition from mythical or projected dates to historical ones is accomplished still more rapidly on the Tablet of the Foliated Cross. The 1 Ahau 13 Mac of the initial series is repeated and immediately followed by a long distance number which carries us to a day 2 Cib 14 Yax.

I. Ser.	1–18– 5–4– 0,	1 Ahau 13 Mac,	Jan. 8, 2618 B.C.
D 14–C 15	(1–18– 5–4– 0),	1 Ahau 13 Mac	
	7– 7– 7–3–16		
	(9– 5–12–7–16,	2 Cib 14 Yax)	Dec. 7, 286 A.D.

In the case of the Temple of the Sun the transition is quickly achieved. At the bottom of the second double column on the left-hand side of the tablet we find a distance number: 9–12–18–5–16, which is in effect an initial series since it leads from the day 4 Ahau 8 Cumhu, declared near the top of the first double column on the right-hand block, to a day 2 Cib 14 Mol. This is far and away the most important date in all three of the temples under consideration but only in this one place is it definitely stated according to the long-count method. This date records exactly the autumnal equinox and its prominence goes far to justify the belief that some of the dates in the earlier passages are really intended for projections of the solstices, equinoxes, etc. We prefer to think of the statement before us as a distance number involving the following addition:

13– 0– 0–0– 0,	4 Ahau 8 Cumhu,	Oct. 14, 3373 B.C.
9–12–18–5–16		
9–12–18–5–16,	2 Cib 14 Mol,	Sept. 23, 430 A.D.

We have now cleared the ground for the examination of dates which can be regarded as actually historical. These are interrelated in a curious fashion in the three temples: sometimes the position of a date is fixed in one temple and assumed in others by simple declaration. The chronological frame-work consisting of historical dates in more than one temple is about as follows:

9–12–18– 5–16,	2 Cib 14 Mol,	Sept. 23, 430 A.D.
9–12–18– 5–17,	3 Caban 15 Mol,	Sept. 24, 430
9–13– 0– 0– 0,	8 Ahau 8 Uo,	May 19, 432

9–10– 2– 6– 6,	2 Cimi 19 Zotz,	July 24, 375
9–10– 8– 9– 3,	9 Akbal 6 Xul,	Aug. 18, 381
9–10–10– 0– 0,	13 Ahau 18 Kankin,	Feb. 6, 383
9–12–11–12–10,	8 Oc 3 Kayab,	Mar. 12, 424

We assume that the most important dates in the historical section are those in the large right-hand block, and that the dates in the small blocks are of lesser importance. A good beginning has already been made for the Tablet of the Sun with the demonstration of the long distance number leading to 2 Cib 14 Mol, exactly on the autumnal equinox. It will be observed that the equinox glyph, one half of the Ahau marked with starry dots, is juxtaposed to this date and that the hieroglyphic record on the two tablets shows a remarkable parallelism (fig. 49). We are not sure whether the declaration of 3 Caban 15 Mol, the day after 2 Cib 14 Mol, indicates a correction or not. The autumnal equinox usually falls on September 23 but sometimes reaches September 24 in the Gregorian calendar: actually at this time it took place on September 23. The heliacal setting of a star may be referred to in this place. Bowditch observed the possibility of interpreting the divided Ahau glyph as an ideograph of the equinox although his calculations which were based on the "frozen" month positions of Landa nowhere reached either of the equinoxes.

In the next position on the Tablet of the Sun a rather early date is reached by subtraction. The meaning does not disclose itself although the date is due to occur as 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392.

9–10– 8– 9– 3,	9 Akbal 6 Xul,	Aug. 18, 381
7– 6–12– 3	subtract	
9– 3– 1–15– 0,	12 Ahau 8 Ceh,	Jan. 22, 237

Next we find three dates, including one of those given above, joined by distance numbers:

9–10– 2– 6– 6,	2 Cimi 19 Zotz,	July 24, 375
6– 2–17		
9–10– 8– 9– 3,	9 Akbal 6 Xul,	Aug. 18, 381
1– 8–17		
9–10–10– 0– 0,	13 Ahau 18 Kankin,	Feb. 6, 383

Here it must be pointed out that both distance numbers are defective: the seventeen kins in the first instance are actually written

eighteen and in the second instance twelve. The last date in this statement practically strikes the same position in the natural year reached by the initial series of the Temple of the Cross, and it also lies close to the position of the terminal day of Baktun 9. Thus:

12–19– 3–4–0	8 Ahau 18 Tzec	Feb. 7, 3379 B.C.
9– 0– 0–0–0	8 Ahau 13 Ceh	Feb. 10, 176 A.D.
9–10–10–0–0	13 Ahau 18 Kankin	Feb. 6, 383

This ends the dates in the large block on the right-hand side of the tablet. There are several dates in two smaller blocks; 9 Akbal 6 Xul and 13 Ahau 18 Kankin are repeated and a new date, 8 Oc 3 Kayab, is given. This is repeated on another tablet in the position given below:

9–12–11–12–10, 8 Oc 3 Kayab, Mar. 12, 424

On the Tablet of the Foliated Cross the position 9–5–12–7–16, 2 Cib 14 Yax, Dec. 7, 286, had been reached at the bottom of the right-hand block of glyphs. At the top of the left-hand block we read:

9–12–10– 5–16, 2 Cib 14 Mol. Sept. 23, 430 A.D.

It will be observed that the day 2 Cib is repeated, while 14 Yax lies exactly 2 uinals later in the 365-day year than 14 Mol. Perhaps there is no significance to this correspondence. No distance number joins the two dates.

The parallelism between the passages beginning with 2 Cib 14 Mol in the Temple of the Sun and in the Temple of the Cross has received some comment. Nothing could be more satisfactory than the two signs for the equinox, the one in the passage before us presenting the kin, or day-sign, half dark and half light. In both cases a day is added but without the distance number or the sign of observation at the horizon which occurs in a somewhat similar case at Tikal. The statement is:

(9–12–18–5–16),	2 Cib 14 Mol,	Sept. 23, 430 A.D.
(1)		
(9–12–18–5–17),	3 Caban 15 Mol,	Sept. 24, 430 A.D.

Below this the following relation of dates is indicated:

	(9–10– 2– 6– 6,	2 Cimi 19 Zotz),	July 24, 375
M 17–NO 1	2– 9– 6– 4		
NO 5	(9–12–11–12–10),	8 Oc 3 Kayab,	Mar. 12, 424
NO 6	6–11– 6		
LM 1	9–12–18– 5–16,	2 Cib 14 Mol,	Sept. 23, 430
O 13–N 14	1–12– 4		
NO 15	9–13– 0– 0– 0,	8 Ahau 8 Uo,	May 19, 432

There only remains for passing notice a second record of 8 Oc 3 Kayab in a supplementary line of glyphs. But before leaving the tablet let us observe the last six glyphs of the second inscription on the Tablet of the Foliated Cross (fig. 54).

8 Ahau 8 Uo

2 Cib
(2 Cib 14 Mol
2 Cib 14 Yax)

1 tropical year

End of 13 katuns

A completion

1 solstitial round?

FIGURE 54. THE LAST GLYPHS ON THE TABLET OF THE FOLIATED CROSS, PALENQUE

They form an interesting study. 8 Ahau 8 Uo is declared to be the end of 13 katuns by a curious ending-sign placed over the 13. In glyph 3 is a reference to 2 Cib 14 Mol, while the next glyph may mean a completion. The fifth is, we believe, one tropical year measured from one station to the next although it may apply more especially to the agricultural year beginning with April 9. The last glyph may record the heliacal observation of a star, the hieroglyph of which is the grotesque head: then follows the device with a wavy division line, referring to the solstitial or equinoctial division points of the year. Evidence accumulates that Mayan hieroglyphs will prove to be largely ideographic.

The historical portion of the Temple of the Cross contains more dates than either of the companion pieces but the record in places is much clouded. We left off our previous consideration at a date

conclusively shown to be 5–8–17–15–17, 11 Caban 0 Pop, May 28, 1226 B.C. This is a declaration of the structural New Year day of the calendar, but it lies over 600 years before the commencement of the historical age and occupies a position without apparent interest. From this date the record passes without a distance number to 5 Cimi 14 Kayab, the position of which may, however, be fixed by a declarative glyph. As a matter of fact we find a single glyph between 11 Caban 0 Pop and 5 Cimi 14 Kayab and it is a glyph commonly found where divisions of the year are under treatment. When 5 Cimi 14 Kayab is placed in the long count in two positions next after 11 Caban 0 Pop, we get:

Q 2 P 3	5– 8–17–15–17,	11 Caban 0 Pop,	May 28, 1226 B.C.
	(12– 1– 9)		
PQ 4	5– 9– 9–17– 6,	5 Cimi 14 Kayab,	Apr. 24, 1214 B.C.
	(2–12–13– 0)	add one calendar round.	
	5–12– 2–12– 6,	5 Cimi 14 Kayab,	Apr. 11, 1162 B.C.

The last date is notably close to the ever-important April 9.

Next comes a clear declaration of 1 Kan 2 Kayab, which is not reached by the recorded distance number 1–2–5–14, but lies in the following interesting relation to the preceding date.

P Q 4	(5–12– 2–12– 6),	5 Cimi 14 Kayab,	Apr. 11, 1162 B.C.
	(1–14– 7–18)		
Q 8–P 9	(5–13–17– 2– 4),	1 Kan 2 Kayab,	Mar. 22, 1128 B.C.

It will be observed that these dates afford a very accurate shift from the first of the agricultural year to the vernal equinox. Now it does not seem likely that they were intended to refer only to a period 600 years before the opening of the historical age. If we add 3–16–8–17–0, or 29 calendar rounds, to these dates we will cover just 1,508 years of 365 days each, or 1,507 tropical years, with an extremely close adjustment. In other words, by the addition of 29 calendar rounds we can maintain our positions in both the Mayan calendar and the tropical year with most marvelous accuracy:

$$29 \times 18{,}960 \text{ days} = 550{,}420 \text{ days}$$
$$1507 \times 365.2421996 \text{ days} = 550{,}419.9948 \text{ days}$$

Now we found the Mayan priests in the earlier section of this very inscription calculate the position in their calendar correspond-

ing to April 9 at the epoch of their era (reaching also for a day Ik, for some unknown reason), and then we saw them determine a point 275,460 days from zero which was exactly the winter solstice. Effectively they reached a month position 15 Ceh for this winter solstice which seven hundred fifty-three and a half years before had stood at the summer solstice according to the tie-in which they had achieved. Also they reached the day Ik. If they could calculate so accurately in the distant past, surely they would show no less facility when nearing their own times.

Recasting the arrangement of the above dates for 29 calendar rounds later, we have:

Q 2–P 3	(9– 5– 6–14–17), (3– 4–14– 9)	11 Caban 0 Pop,	May 28, 281 A.D.
PQ 4	(9– 8–11–11– 6), (1–14– 7–18)	5 Cimi 14 Kayab,	Apr. 12, 345
Q 8–P 9	(9–10– 6– 1– 4),	1 Kan 2 Kayab,	Mar. 23, 379

Now these last two dates come about two days later than the points of the natural year which they may have been intended to strike. In PQ 6 we find a distance number 1–2–5–14, which stands between, yet does not connect, these dates. Added to each in turn this distance number reaches the points of the year which the declared dates just fail to reach. Thus:

PQ 4	(9– 8–11–11– 6),	5 Cimi 14 Kayab,	Apr. 12, 345 A.D.
PQ 6	1– 2– 5–14		
	(9– 9–13–17– 0,	5 Ahau 18 Kayab),	Apr. 9, 366 A.D.
Q 8–P 9	(9–10– 6– 1– 4),	1 Kan 2 Kayab,	Mar. 23, 379 A.D.
PQ 6	1– 2– 5–14		
	(9–11– 8– 6–18,	1 Eznab 6 Kayab),	Mar. 21, 400 A.D.

The first date not only becomes April 9 but it becomes a day Ahau in the important month position 18 Kayab, closely connected with the Venus cycle. It will be observed that the adjudication suggested here holds true of positions 29 calendar rounds or 1,507 tropical years apart.

We have passed uncharted shallows with the questing lead and are now safe in the mid channel of historical chronology. The next passage begins with 3 Eznab 11 Xul and proceeds with proper distance numbers and declarations to the most important round number in the actual history of the Mayas. The record runs:

PQ 10	(8–19– 6– 8– 8),	11 Lamat 6 Xul,	Oct. 10, 162 A.D.
PQ 12	13– 3– 9		
PQ 14	(8–19–19–11–17),	2 Caban 10 Xul,	Oct. 11, 175
P 15	6– 3		
Q 15–R 2	9– 0– 0– 0– 0,	8 Ahau 13 Ceh,	Feb. 10, 176

These October dates lie very close to the position in the tropical year of the original 4 Ahau 8 Cumhu, the epoch of the Mayan era. A fact which must have made 9–0–0–0–0, 8 Ahau 13 Ceh of supreme importance in calculations is that at this time 0 Pop fell exactly on the summer solstice.

We now find a distance number 1–8–1–18 and a clear declaration 3 Eznab 11 Xul. Now 3 Eznab 11 Xul is the next day after 2 Caban 10 Xul, the middle date in the preceding statement. It lies, therefore, in the following proximate relations to 8 Ahau 13 Ceh.

RS 7	(8–19–19–11–18),	3 Eznab 11 Xul,	Oct. 12, 175 A.D.
	(6– 2)		
Q 17–R 2	9– 0– 0– 0– 0,	8 Ahau 13 Ceh,	Feb. 10, 176
	(2–12– 6–18)		
RS 7	(9– 2–12– 6–18),	3 Eznab 11 Xul,	Sept. 30, 227

Neither of these seems important, but if we add two more calendar rounds to the last one we get:

9– 2–12– 6–18,	3 Eznab 11 Xul,	Sept. 30, 227 A.D.
5– 5– 8– 0		
9– 7–17–14–18,	3 Eznab 11 Xul,	Sept. 5, 331

It might seem pure gambling to find dates in this fashion and of course they have no value as proof, but in this case there is a rather surprising confirmation. The distance number 1–8–1–18 could not be made to reach 3 Eznab 11 Xul. Added to the baktun ending this number does reach a day Eznab. Thus:

Q 17	9–0–0–0– 0,	8 Ahau 13 Ceh,	Feb. 10, 176 A.D.
R 3 R 4	1–8–1–18		
	(9–1–8–1–18,	12 Eznab 11 Yaxkin),	Oct. 24, 203

This passage is followed by a statement of 5 Ahau 3 Tzec which is found at the next half katun, 9–1–10–0–0, 5 Ahau 3 Tzec, Sept. 7, 205. On the Temple of the Inscriptions we find a declaration of 9–5–0–0–0, 11 Ahau 18 Tzec, Sept. 5, 274. This day September 5 is so close to the September 6 which was reached by the astronomi-

cal base line at Copan (in its original setting) that we may assume it was here the object of definite calculation.

From the half-katun ending a distance number carries us safely forward to the significant August 6:

RS 10	(9–1–10–0– 0),	5 Ahau 3 Tzec,	Sept. 7, 205 A.D.
S 7 R 9	1–16–7–17		
S 12 R 13	9–3– 6–7–17,	5 Caban 0 Zotz,	Aug. 6, 241

Before the next declaration (5 Kan 12 Kayab), there is a distance number 1–19–6–16. The date cannot be reached by this number but if we add it to the foregoing date we get:

S 12 R 13	9–3– 6– 7–17,	5 Caban 0 Zotz,	Aug. 6, 241 A.D.
S 13–S 14	1–19– 6–18		
	9–5– 5–14–13,	11 Ben 1 Pop,	May 29, 280

This date is not declared but it is very close to the one arrived at when 11 Caban 0 Pop was moved forward 29 calendar rounds to a second recurrence at exactly the same place in the natural year. The relationship is as follows:

9–5–5–14–13,	11 Ben 1 Pop,	May 29, 280 A.D.
1– 0– 4	add one ritualistic year	
9–5–6–14–17,	11 Caban 0 Pop,	May 28, 281 A.D.

Other uses of the ritualistic year will be noted as we proceed. This conformity inspires faith that the Mayan astronomers really did intend to throw the date 11 Caban 0 Pop just 29 calendar rounds ahead of its designated position and treat it as of the recent past.

The date 5 Kan 12 Kayab, which is declared but not placed, reminds us of the 5 Cimi 14 Kayab and 1 Kan 2 Kayab of the earlier passage which were finally pulled into an exact statement of the vernal equinox and the beginning day of the farmer's year. Venturing to place 5 Kan 5 Kayab in proximate positions to these we get:

9– 7– 7– 5–4,	5 Kan 12 Kayab,	Apr. 15, 321 A.D.
2–12–13–0	add one calendar round	
9–10– 0– 0–4,	5 Kan 12 Kayab,	Apr. 3, 373
2–12–13–0	add one calendar round	
9–12–12–13–4,	5 Kan 12 Kayab,	Mar. 21, 425

Again we reach the day of the vernal equinox, at a date not distant from the 2 Cib 14 Mol that records the autumnal equinox in the other two temples of this group.

The reader will observe that the above passages in the text of the Temple of the Cross show a curious usage of distance numbers which lead to undeclared dates and declared dates for which no positions in the long count are indicated. Without a correlation disclosing significant possibilities no satisfactory readings could have been made and even with such a correlation not until methods of approach had been at least indicated in other inscriptions.

The date 5 Kan 12 Kayab which has just been given a habitation and a meaning is followed by a distance number at the top of the last pair of columns. If this is added to 11 Ben 2 Pop which was reached by the last long number we get a date which occupies an interesting month position:

	(9–5–5–14–13,	11 Ben 1 Pop),	May 29, 280 A.D.
TU 1	2–2– 4–17		
	(9–7–8– 1–10,	5 Oc 13 Mac),	Jan. 26, 322

This is the month position of the initial series of the Tablet of the Foliated Cross, but the day in that record was 1 Ahau instead of 5 Oc and it corresponded to January 8.

Next comes 1 Imix 4 Zip (U 5 –T 6) which may be found in any of the following positions at the usual fifty-two year intervals:

9–3–18–10–1,	1 Imix 4 Zip,	July 18, 253 A.D.
2–12–13–0	add one calendar round	
9–6–11– 5–1,	1 Imix 4 Zip,	July 8, 305
2–12–13–0	add one calendar round	
9–9– 4– 0–1,	1 Imix 4 Zip,	June 23, 357

The last reading is practically at the summer solstice.

After this is the number 1–1–1 with a declaration of 7 Kan 17 Mol below; then 2–8–4–7, followed by 11 Chicchan 13 Chen; then a last distance number which is probably 16–8–2. It would hardly be expected from the arrangement, but 1–1–1 is exactly the interval between 7 Kan 17 Mol and 11 Chicchan 13 Chen. The longer distance numbers must therefore have had some other use, so we add them to the connected calculation and obtain:

(9– 7– 8– 1–10,	5 Oc 13 Mac),	Jan. 26, 322
2– 8– 4– 7		
(9– 9–16– 5–17,	4 Caban 0 Xul),	Aug. 14, 369
16– 8– 2		
(9–10–12–13–19,	11 Cauac 2 Yax),	Nov. 1, 385

These stations are not self explanatory. The first number is near the date 9–9–16–0–0, 4 Ahau 8 Cumhu, exactly 72 calendar rounds from the epoch of the era. If the count added one uinal more the date would be highly satisfactory, for it would be the month position 0 Yaxkin, on September 3, and would mark the practical coincidence of the beginning month of the agricultural year, at the time the calendar was inaugurated with the autumnal station. In the Temple of Inscriptions 9–12–0–0–0, 10 Ahau 8 Yaxkin, Sept. 1, 412 is strongly emphasized. The last distance number stands in total darkness. The additions of distance numbers by dead reckoning are reviewed in the following statements. These positions must be regarded as doubtful but without our correlation would be entirely meaningless:

9– 1–10– 0– 0,	5 Ahau 3 Tzec,	Sept. 7, 205 A.D.
1–16– 7–17		
9– 3– 6– 7–17,	5 Caban 0 Zotz,	Aug. 6, 241
1–19– 6–18		
9– 5– 5–14–13,	11 Ben 1 Pop,	May 29, 280
2– 2– 4–17		
9– 7– 8– 1–10,	5 Oc 13 Mac,	Jan. 26, 322
2– 8– 4– 7		
9– 9–16– 5–17,	4 Caban 0 Xul,	Aug. 14, 369
16– 8– 2		
9–10–12–13–19,	10 Cauac 2 Yax,	Nov. 1, 385

The two joined dates can be satisfactorily placed near the end of the chronological record, thus:

(9–12–7–3–4),	7 Kan 17 Mol,	Sept. 29, 419
1–1–1		
(9–12–8–4–5),	11 Chicchan 13 Chen,	Oct. 14, 420

The last date would then strike exactly the position in the tropical year occupied by the original 4 Ahau 8 Cumhu. Since the calculations on the Tablets of the Cross, Sun, and Foliated Cross demonstrate beyond a doubt that the Mayan astronomers did reconstruct with amazing accuracy the points of the natural year at the epoch of their Mundane Era, it is not surprising that they would close the record by stating that the position of this all important point of departure is a current year? This explanation becomes all the more likely, we believe, when we take note that the date above this final date was itself Oct. 12 just one calendar round earlier. Who can

tell what meticulous pursuit of some special day or number controlled Mayan statements of identities and approximations? But will our boastful civilization of the present leave so legible a record a thousand years after it has passed away?

Elsewhere on the Tablet of the Cross there are two important distance numbers connecting dates which also appear in the inscriptions of the Temple of the Sun and the Temple of the Foliated Cross. We find:

L 1, 2	9–12–11–12–10,	3 Oc 3 Kayab,	Mar.	12, 424
O 2, 3	6–11– 6			
	(9–12–18– 5–16,	2 Cib 14 Mol),	Sept.	23, 430
GH 1	9–10– 8– 9– 3,	9 Akbal 6 Xul,	Aug.	18, 381
K 7, 8	1– 8–17			
K 9	9–10–10– 0– 0,	13 Ahau 18 Kankin,	Feb.	6, 383

This closes the first reading of a master work of ancient science. Doubtless many details of this remarkable record will be corrected and amplified by other students, for here the argument has mostly depended on self-revealing numbers. But there are the hieroglyphs some of which are clearly ideographic. These should smooth out passages which now seem obstruse and precarious.

The Record of the Temple of the Inscriptions

One of the longest Mayan inscriptions is that of the Temple of the Inscriptions at Palenque in three blocks with a total of 620 glyphs.[1] It starts with an initial series which reads 9–4–0–0–0, 13 Ahau 18 Yax, and proceeds to touch all the katun-ending days up to 9–13–0–0–0, 8 Ahau 8 Uo. But there are also intermediate dates, some clearly defined and some occupying doubtful positions, as well as several closely connected secondary series which record intervals between some of these dates. The beginning of the calculation occupies what might be called a strategic position because 9–4–0–0–0, 13 Ahau 18 Yax equals Dec. 18, 254 A.D. and is therefore only a few days out of place for the winter solstice from which the Mayan year once made its formal departure. This 176-year record appears to be mainly astronomical even though the immediate significance of most of the dates is beyond us.

[1] Maudslay's notation is used, I = pl. 60, II = pl. 61, III = pl. 62.

The first part of the inscription is badly eroded and it does not seem wise to go adventuring at this time in pursuit of possible interpretations. Near the bottom of the first pair of columns there is a distance number with three kins and ten uinals clear and probably thirteen tuns. This would lead to 9–4–13–10–3, 8 Akbal 16 Kayab, Apr. 7, 268, very close to the beginning of the agricultural year, and while no day and month are recorded, we do find a glyph that occurs at the point of the natural year. Next comes:

D 5–CD 6	9–5–0–0–0,	11 Ahau 18 Tzec,	Sept. 5, 274
F 4–E 5	9–6–0–0–0,	9 Ahau 3 Uayeb,	June 4, 294

The first of these is within a day of the earlier autumnal station of the agricultural year, an approximation which might have seemed remarkable to the ancient astronomers. The next undestroyed passage seems to involve a day 13 Akbal, but perhaps the glyph is not Akbal. Next comes a date which, from the coefficients, may be 9–6–10–0–0, 8 Ahau 13 Pax, Apr. 2, 304, and in the following set of columns there is a possible 9–6–13–0–0, 9 Ahau 18 Pop, June 11, 307. Between these is a face having the number nine and followed by a glyph which is found at stations of the tropical year.

In the center of the fifth double column there are two round number dates, namely:

J 5–I 6	9–7–0–0–0,	7 Ahau 3 Kankin,	Feb. 8, 314
IJ 10	9–7–5–0–0,	13 Ahau 18 Ceh,	Jan. 13, 319

At this place we may see the record of a round of hotuns. Our inscription began with 13 Ahau corresponding to 4–0–0–0–0. Now, the terminal days of hotuns follow in the order 13, 6, 12, 5, 11, 4, 10, 3, 9, 2, 8, 1, 7, so that the day corresponding to 7–5–0–0–0 is again 13 Ahau although falling in a different month. The record is written 13 Ahau 18 Ceh, end of hotun, end of cycle. The last device (J 11) has been explained as the symbol of the 52-year calendar round, but here it might mean 13 hotuns (65 tuns).

At the head of the sixth double column a distance number 9–14–12 is counted forward from this last date bringing us to a day which appears significant, namely 9–7–14–14–12, 9 Eb 0 Yaxkin. Here 0 Yaxkin the traditional beginning of the agricultural year falls on Sept. 14, 328 A.D. in the interval between the fall station of the agricultural year and the autumnal equinox. The day and

month-signs are suppressed, their places probably being taken by hieroglyphs equally intelligible to the priestly astronomers, if not to us in our present state of knowledge.

The calculation now jumps to the next katun ending and from that a number reaches out to the beginning of the farmer's year.

K–L 6	9–8–0–0– 0,	5 Ahau 3 Chen,	Oct. 26, 333
L 9–K 10	1–8–10		
	9–8–1–8–10,	2 Oc 8 Kayab,	Apr. 10, 335

While we do not find the resulting day and month-signs we do find a dog's head and are reminded that Oc means dog. Likewise we find glyphs (fig. 55) noted especially in connection with stations in the tropical year.

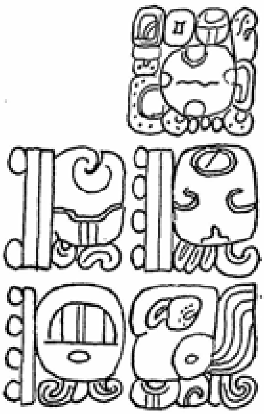


FIGURE 55. GLYPHS COMBINED WITH DISTANCE NUMBER

They concern significant points of the year.

Next, we find 5 Ahau 18 Tzec declared in connection with thirteen tuns (N 1–MN 2). This is undoubtedly 9–8–13–0–0, 5 Ahau 18 Tzec, exactly 73 tuns after the 9–5–0–0–0, 11 Ahau 18 Tzec in the first part of the inscription. This marks a round of all the possible month positions on which tuns can end. That date fell on Sept. 5, 274, while this one corresponds to Aug. 18, 346, eighteen days earlier in the tropical year. These eighteen days cover the accumulating error through lack of the leap-year correction. After this comes a passage, which leads roughly to the winter solstice, assuming that the calendar-round dates lie in order, and perhaps more exactly to the ending day of some undetermined cycle:

MN 7	9–8–17– 9– 0,	13 Ahau 18 Mac,	Jan. 23, 351 A.D.
MN 6	6–14		
MN 9	9–8–17–15–14,	4 Ix 7 Uo,	June 8, 351
N 11	10– 2		
	9–8–18– 7–16,	11 Cib 9 Ceh,	Dec. 27, 351

The last date is unrecorded. In OP 3 is 3 Ahau 3 Zotz, declared to be the end of nine katuns, and actually occurring in the long count

at 9–9–0–0–0, 3 Ahau 3 Zotz, July 13, 353. In OP 6 we find a repetition of nine cycles, nine katuns, followed by another glyph with nine for a coefficient, and before we reach another clear date there are two more occurrences of the numeral nine with untranslatable glyphs. The last of these is followed by a repetition of the day 3 Ahau, on which the katun ended, with a face representing the numeral 3 (Q 3).

Next comes a distance number 19–13–12 with the sign which is found in connection with stations of the tropical year. We assume this to be:

	9–9– 0– 0– 0,	3 Ahau 3 Zotz,	July 13, 353
R 9 Q 10	19–13–12		
	9–9–19–13–12,	4 Eb 0 Mac,	Jan. 1, 373

While this date is several days off the mark as far as the winter solstice is concerned, it lies at a convenient place for calculations, namely, the first position in the month, Mac.

At the top of the last double column on this first tablet of the Temple of the Inscriptions we read 1 Ahau 8 Kayab, end of ten katuns, and find a variant of the so-called lahuntun glyph which here must mean lahun katun. This is 9–10–0–0–0, 1 Ahau 8 Kayab, March 30, 373, a position as far beyond the vernal equinox as the preceding date was beyond the winter solstice. It might occur to the reader that some of these explanations are pretty obvious juggling: but the Mayan priests must have juggled time blocks in just such a fashion and the main proof of our thesis is quite above and apart from these minutiae. We know that the Mayas could read closer than these passages would indicate, and must conclude that other matters than the simple points of the natural year were under consideration.

The central tablet of the Temple of the Inscriptions is filled with the hieroglyphs of recurring cycles of planets and with heliacal settings or risings of stars. This much is reasonably certain although dates are few. Almost at the beginning, we read:

AB 2–B 3 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392

and 12 Ahau is repeated in the next set of columns, possibly denoting the end of the passage devoted to this Katun 12 Ahau which proved so important at Copan. The reader will note that the

system of the U Kahlay Katunob of later times is followed quite consistently.

The rest of this tablet and a part of the third one is given over to celestial correlations in connection with the end of the katun next in order. The reason for this prominence is not far to seek, for 9–12–0–0–0, 10 Ahau 8 Yaxkin corresponded to Sept. 1, 412, and therefore was very close to the autumnal station of their year of seasons. The priestly astronomers of Central America had at one end of this chronological section a date pretty close to the winter solstice and at the other end a date close to the autumnal station as finally decided upon in the astronomical base line at Copan. It will be noted that this position is only a few days out from that held exactly seven katuns before at 9–5–0–0–0, 11 Ahau 18 Tzec, Sept. 5, 274. Seven katuns are 3.46 days less than 138 tropical years.

On the middle tablet of the Temple of the Inscriptions the moon sign connected with the numeral one is repeated six times. It is quite within the range of possibility that the Mayan saroid of 3986 or 3987 days (135 synodical months = 23 eclipse seasons) is here considered although no numbers are available. The lunar problem is a fascinating one, now that a correlation has been obtained, and should be worked out with no great difficulty. A single certified eclipse record on an ancient monument would be a welcome proof since it would be exact to the very day. There is in G 7 an unmistakable Venus symbol over a spiral shell. This glyph also occurs at Tikal and Yaxchilan.

On A 6 is a possible reference to Jupiter, in combination with the number five. In this connection we may remember the cycles of Jovian years are much used in India and the Far East. Eleven synodical revolutions of this planet, and one sidereal revolution, are not far from twelve years, and this, taken five times, makes sixty years. In India there were constructed a twelve-year cycle of Jupiter, a sixty-year cycle, corrected every eighty-seventh year by dropping a year, or in some places counted without a correction, and a ninety-year cycle. The possible correlation between Jupiter and the Mayan tun offers interesting possibilities.

11 synodical revolutions of Jupiter	= 4387.5 days
1 sidereal revolution of Jupiter	= 4332.5 "
12 tuns	= 4320 "

Mars is possibly represented here by the hieroglyph of the rear head of the Two-headed Dragon. The front head of this monster usually carries the hieroglyph of Venus in the eye or elsewhere and the body is often modified into a line of celestial symbols. The so-called Mars Beast of the Dresden and Tro-Cortesianus codices may be an aspect of the rear head of this celestial monster. The hieroglyph, containing the characteristic head-dress of the rear head, appears twice on this tablet (D 5 and J 8). Calculations on Mars are made difficult because the synodical period of 779.936 days is readily convertible into three tzolkins: $3 \times 260 = 780$.

It is entirely possible that the heliacal settings and risings of important stars or constellations are recorded in glyphs which picture the name of the star in combination with a prefix containing an obvious kin or sun symbol. The movements of the Pleiades are said to have been noted by the Mayas as by nearly all tribes throughout the world and it is quite likely that dates in May are involved with this star group which Miss Clerke[1] describes as: "the immemorial group of the Pleiades, famous in legend and instructive above all others to exact inquirers — the meeting place in the skies of mythology and science."

On the third tablet of the Temple of the Inscriptions the calculations are in some places beyond our present knowledge, or at least they have escaped my efforts and those of other students whose works are available. Towards the bottom of the first double column we see the date 9–12–0–0–0, 10 Ahau 8 Yaxkin, Sept. 1, 412, repeated, possibly, to indicate the end of the section we have just considered. At the head of the second pair of columns is the record 9–13–0–0–0, 8 Ahau 8 Uo, May 19, 432, which appears to be the latest date in the inscription. The succeeding calculations are carried from back-dated bases.

In CD 7 the declaration 7 Ahau 18 Zip, may be 9–12–1–17–0, 7 Ahau 18 Zip, June 23, 414. In other words we find a uinal ending on a possible day of the summer solstice.

Next in CD 11 there is an unmistakable 10 Ahau 13 Yaxkin which has the following relation to the leading date:

9–11–14–17–0,	10 Ahau 13 Yaxkin,	Sept. 8, 407 A.D.
5– 1–0	add	
9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412

[1] *The System of the Stars.* London 1905, p. 215.

Not only is the interval exactly equal to seven tzolkin and five so-called ritualistic years of 364 days each, but the calculation runs in a convenient fashion from the earlier to the later determination of the autumnal station. The count is about a day out on this but the Gregorian intercalation distorts the relation with two leap days in five years. Furthermore the next earlier occurrence of 10 Ahau

FIGURE 56. *Glyphs of the Sacred Fires*

These were kindled after the ends of important time periods.

13 Yaxkin, which is involved in the subsequent calculation, fell on September 21, very close to the autumnal equinox.

The ritualistic year of 364 days was probably devised for its serviceable factors 4, 7, 13, 28, 91, and 182. In groups of five it satisfies the basic permutation ($5 \times 364 = 7 \times 260$) and the same days reënter in the same positions throughout. Also the period forms the lowest usable concordance between the tzolkin on the

one hand and the Mayan haab and the tropical year on the other, the discrepancies being five days and six and a quarter days, respectively.

In our text the declaration of 10 Ahau 13 Yaxkin is followed by a variant of the cycle glyph, characterized by a flaring superfix, and in the present instance associated with the numeral one. This means one calendar round or 52-year period. After it comes a hieroglyph picturing the sacred fire bundle which was kindled at the beginning of each calendar round (fig. 56). We will now see that this further statement implies the following subtraction:

9–11–14–17–0,	10 Ahau 13 Yaxkin,	Sept. 8, 407 A.D.
2–12–13–0	subtract one calendar round	
9– 9– 2 - 4–0,	10 Ahau 13 Yaxkin,	Sept. 21, 355

For the moment passing over a distance number and the declaration of 8 Ahau 13 Pop, we proceed to the key date of a difficult and perplexing passage which has hitherto resisted all attempts to give a satisfactory explanation. The date is 5 Lamat 1 Mol, coming just 8 days after 10 Ahau 13 Yaxkin. The location of this 5 Lamat 1 Mol in the long count is carefully defined:

EF 8	9–9–0–0–0,	3 Ahau 3 Zotz,	July 13, 353 A.D.
	2–4–8	add	
	9–9–2–4–8,	5 Lamat 1 Mol,	Sept. 29, 355

Let us now return to the declaration of 8 Ahau 13 Pop and the distance number which we had passed over. The distance number appears to be 12–3–8 but Goodman pointed out that the three dots over the uinal are three little wheels of the kind which ornament the face for 3, and that the numeral in this position is therefore $3 \times 3 = 9$. This is to some extent an explanation after the fact, because if the amendment is made the following adequate relationship is disclosed:

9–8– 9–13–0,	8 Ahau 13 Pop,	May 27, 343 A.D.
12– 9–8	add	
9–9– 2– 4–8,	5 Lamat 1 Mol,	Sept. 29, 355

The reason why 8 Ahau 13 Pop was chosen can only be surmised in part. Since Yaxkin and Pop were the initial months in two kinds of years, agricultural and astronomical, it might have seemed proper to balance the important position 13 Yaxkin by a corresponding position 13 Pop, both occupied by a day Ahau. But

there was doubtless a further reason for the choice, which may have arisen from relationships to some planetary cycle. The day Lamat is concerned in the ephemeris tables of both Venus and Jupiter in the Dresden Codex.

The most extraordinary feature of the calculation in connection with 5 Lamat 1 Mol now comes up for examination. This is a number, seemingly of seven positions, arranged in reverse order like a secondary series. According to Morley this passage reads: 7-18-2-9-1-12-1, and in Arabic notation is equivalent to 455,-393,401 — a vast number of days amounting to about 1,246,825 years. Needless to say it is not possible to manipulate any astronomical proofs over such a stretch of time.

However the inscription can be explained in a less dramatic but more serviceable fashion as Goodman attempted to do although he fell short of the significant proofs. The glyph of the supposedly highest value may indicate 7-0-0-0-0, 10 Ahau 18 Zac, the epoch of the Historical Era, and the next one may mean that 18 calendar rounds had passed since the formal inauguration of the Mayan calendar. Then the five lower members of the original notation may form a distance number to be counted back from 5 Lamat 1 Mol in its designated position.

First comes the matter of the 18 calendar rounds which are indicated to proceed from 10 Ahau 13 Yaxkin. The record before us enables us to make a complete reconstruction.

9-12- 0- 0-0,	10 Ahau 8 Yaxkin,	Sept. 1, 412 A.D.
5- 1-0	subtract 7 tzolkin	
9-11-14-17-0,	10 Ahau 13 Yaxkin,	Sept. 8, 407
2-12-13-0	subtract 1 calendar round	
9- 9- 2- 4-0,	10 Ahau 13 Yaxkin,	Sept. 21, 355
2- 7- 9- 0-0	subtract 18 calendar rounds	
7- 1-13- 4-0,	10 Ahau 13 Yaxkin,	May 4, 580 B.C.

From a constructive point of view this statement is almost perfect proof. By this record at Palenque we reach the year of the inauguration of the Mayan calendar and are now able to fix two significant positions in that year by inscriptions at two widely separated cities. These positions are:

Palenque	7-1-13- 4-0,	10 Ahau 13 Yaxkin,	May 4, 580 B.C.
	11-0		
Copan	7-1-13-15-0,	9 Ahau 13 Cumhu,	Dec. 10, 580

A second long number remains for consideration. This is 10–11–10–5–8, which can be analyzed into 12–9–8, the interval between 8 Ahau 13 Pop and 5 Lamat 1 Mol plus 10–10–17–14–0, or 80 calendar rounds, which would serve to maintain 5 Lamat 1 Mol. We will now make this addition and then withdraw the 8 days by which 5 Lamat 1 Mol is in excess of 10 Ahau 13 Yaxkin:

9– 8– 9–13–0,	8 Ahau 13 Pop	May 27, 342 A.D.
10–11–10– 5–8		
20– 0– 0– 0–8,	5 Lamat 1 Mol	Dec. 25, 4512
8,	subtract	
20– 0– 0– 0–0,	10 Ahau 13 Yaxkin	Dec. 17, 4512

On the theory that the baktuns in the long count were designated in groups of 13 according to the usage on the tablet of the Temple of the Cross this round number may be restated as:

20–0–0–0–0,	10 Ahau 13 Yaxkin
13–0–0–0–0	subtract
7–0–0–0–0,	10 Ahau 13 Yaxkin

In other words, we are carried far into the future when a recurrence of 10 Ahau 13 Yaxkin, a date closely connected with the inauguration of the calendar-round system shortly after the zero day, 7–0–0–0–0, 10 Ahau 18 Zac of the historical epoch, will terminate another 7–0–0–0–0. The point of departure is 8 Ahau 13 Pop, May 27, 342, a date only one day out from the 11 Caban 0 Pop, May 28, 1226 B.C., that was advanced 29 calendar rounds on the Tablet of the Cross to reach the identical place in the natural year.

This passage is followed by a blind record of 4 Manik 10 Zip, probably 9–11–0–9–7, 4 Manik 10 Zip, June 20, 393. After this the series is clear almost to the end reading as follows:

L 8	9–11– 0– 0– 0,	12 Ahau 8 Ceh,	Dec. 15, 392 A.D.
L 7–KL 8	6–16–17		
KL 11	9–11– 6–16–17,	13 Caban 10 Chen,	Oct. 17, 399
P 3–OP 4	9–11– 0– 0– 0,	12 Ahau 8 Ceh,	Dec. 15, 392
O 1	9–12– 0– 0– 0,	10 Ahau 8 Yaxkin,	Sept. 1, 412
OP 5	3– 6– 6		
O 7	9–12– 3– 6– 6,	7 Cimi 19 Ceh,	Dec. 21, 415
P 7–OP 8	9– 7–11– 3– 0	subtract	
OP 10	13– 4–12– 3– 6,	1 Cimi 19 Pax,	Aug. 24, 3282 B.C.
R 1	9–12– 3– 6– 6,	7 Cimi, 19 Ceh,	Dec. 21, 415 A.D.

R 3–Q 4	9– 9–13– 0– 0,	3 Ahau 3 Uayeb,	May 6, 366
Q 3	17		
QR 6	9– 9–13– 0–17,	7 Caban 15 Pop,	May 23, 366
QR 7–Q 8	2– 7– 6– 1		
Q 11	9–12– 0– 6–18,	5 Eznab 6 Kankin,	Jan. 15, 413
R 11–Q 12	9–11– 2		
S 1	9–12–10– 0– 0,	9 Ahau 18 Zotz,	July 11, 422
ST 4	1– 4– 8	(written 4–1–8)	
T 5	9–12–11– 4– 8	6 Eznab 11 Yax,	Oct. 22, 423

This last date is followed by a distance number 4–1–10–18 in T 6–S 7 but it is not clear how this number should be employed. The last date is apparently 9–12–11–12–10, 8 Oc 3 Kayab which occurs elsewhere at Palenque.

The piers of the Temple of the Inscriptions also carried blocks of hieroglyphs in stucco. These have been so completely destroyed that they cannot be reconstructed. We only know that there were two principal blocks of ninety-two glyphs each. The first one surely began with an initial series. There are, in addition to these, other glyphs in sunken circles. In one place we see the calendar-round date 1 Ik 10 Tzec. This is followed by a distance number 12–3–0. One occurrence of this date is 9–12–16–2–2, 1 Ik 10 Tzec, July 21, 428.

A number of other random records exist at Palenque. For instance, there is a slab with two columns of glyphs found by Maudslay southwest of the Temple of the Foliated Cross. It is a stela which once began with an initial series but the introducing glyph and the cycle and katun glyphs are missing. The inscription runs as follows:

9–12–6– 5–8,	3 Lamat 6 Zac,	Nov. 17, 418
1–10–1	subtract	
9–12–4–13–7,	1 Manik 10 Pop,	May 5, 417

On the Death's Head monument also near the Temple of the Foliated Cross there is a short inscription with two calendar-round dates which may be related in this way:

9–12–19–14–12,	5 Eb 5 Kayab,	Mar. 12, 431
3– 8		
9–13– 0– 0– 0,	8 Ahau 8 Uo,	May 19, 432

Although not close to the vernal equinox the first date possibly

refers to it since there is here the ideograph for the equinox already noted. There is also the sign of the kindling of ceremonial fire.

The hieroglyphic stairway of House C of the Palace has an initial series with beautiful face numerals. The first addition is:

9–8– 9–13–0,	8 Ahau 13 Pop,	May 27, 343
12– 9–8		
9–9– 2– 4–8,	5 Lamat 1 Mol,	Sept. 29, 355

It exactly equals a passage in the Temple of the Inscriptions — a very unusual circumstance. The first number is the one used in the Temple of Inscriptions as a basis for the long count into the future reaching 7–0–0–0–0, 10 Ahau 13 Yaxkin, Dec. 26, 4512, a great cycle ending near the winter solstice. If we count back 8 days from the 5 Lamat 1 Mol before us we obtain a position near the autumnal equinox, namely, 9–9–2–4–0, 10 Ahau 13 Yaxkin, Sept. 21, 355. Perhaps the hieroglyphic stairway of the Palace comes first as regards time of erection. There is, however, another distance number in this inscription which exceeds three katuns.

There were other hieroglyphic records at Palenque in stucco but unfortunately they are too far gone to be recovered. One initial series on pier *a* of House A of the Palace seems to have reached a month position 10 Tzec. In another place 19 Pop is recorded. Above the panel is a cartouche with 11 Katuns. Two massively sculptured human figures flanking the stairway to House A carry the dates 6 Eb 10 Uo and 7 Ben 11 Uo. Since the sculptures bearing these calendar-round dates are quite crude the dates may possibly equal:

9–8–16–15–12,	6 Eb 10 Uo,	June 11, 350
1		
9–8–16–15–13,	7 Ben 11 Uo,	June 12, 350

Or perhaps a calendar round before would not be too early:

9–6–4–2–12,	6 Eb 10 Uo,	June 23, 298
1		
9–6–4–2–13,	6 Eb 11 Uo,	June 24, 298

It is within the bounds of possibility that these dates were intended to record the summer solstice.

The base of House C in the Western Court has 13 Manik 0 Yaxkin which may be found in the position 9–9–18–7–7, 13 Manik

0 Yaxkin, Sept. 4, 371, the position nearest the initial series on the opposite side of House C. Here zero is indicated by a tun sign (fig. 57, *c*).

There is a small panel taken from Palenque by one of the early expeditions which registers 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392. Blom reports a date in a ruined temple which is probably 9–2–3–0–0, 9 Ahau 3 Zotz, Aug. 15, 218. The writer believes that some of the tablets at Palenque are reset in later buildings. The principal evidence of this is derived from the development of the sanctuary illustrated in the temples of Yaxchilan with dated lintels. Palenque was an early center of learning for the Mayas.

Correlations at Tikal

The calendrical correlations already demonstrated for Copan and Palenque also interested the ancient astronomers at Tikal several hundred miles distant. These correlations do not take exactly the same form because they apply to different years, but they reach the same astronomical results and in some respects are even more definite than the inscriptions of Copan. In the following inscription on Lintel 1 of Temple 2,[1] we find an unmistakable intercalation for New Years day and a tying-in with the autumnal equinox. The location of the glyphs in Maudslay, III, pl. 74, is described by letters for columns and numbers for positions in the column.

AB 1	3 Ahau 3 Mol,	9–15–10– 0– 0,	Aug. 30, 481 A.D.
A 2	Half-katun		
B 2–A 3	2–11–12	2–11–12	
B 3–A 4	6 Eb 0 Pop,	9–15–12–11–12,	Apr. 8, 484
A 7	1 Sunset Observation	1	
B 7–A 8	7 Ben 1 Pop	9–15–12–11–13,	Apr. 9, 484
A 9	6 Caban (10 Chen	9–15–12– 0–17,	Sept. 25, 483)
AB 16	3–2–7	3– 2– 7	
AB 17	3 Ahau 13 Uo,	9–15–15–14– 0,	May 11, 487

It will be observed that the half-katun ending, 3 Ahau 3 Mol, was probably chosen as a September approximation. Since, how-

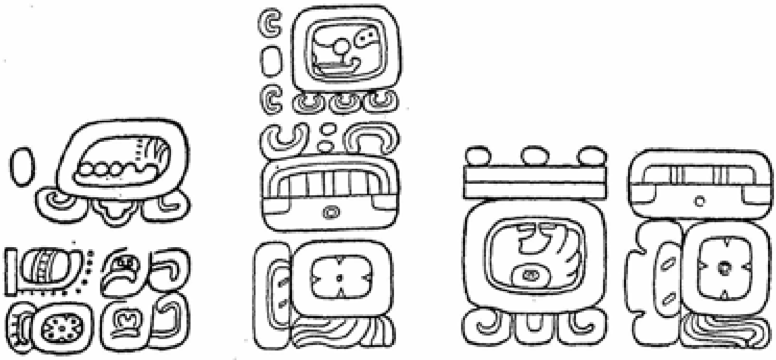
[1] Maudslay is probably in error in ascribing these beams to Temple 1.

ever, the latest date on this monument is considerably earlier than the final date on Altar U at Copan, it is possible that September 6 was still in vogue as the initial day of the autumnal agricultural season.

The great interest of the inscription lies in the fact that the leap-year correction is very clearly indicated. On Altar U at Copan, we have the New Year days 2 Eb 0 Pop and 3 Caban 0 Pop corresponding to April 9, 480 A.D. and April 9, 481 A.D. On this inscription at Tikal we find the New Year day 6 Eb 0 Pop, just four years later than 2 Eb 0 Pop, given above, in the position corresponding to April 8, 484 A.D., in the Gregorian calendar, the difference of one day being explained by our intercalated day on Feb. 29 of the last named year. The Mayan astronomers also noted the discrepancy of one day in comparison with the sunset observation, and writing the numeral one in connection with the hieroglyph for sunset observation, they reached the next day, 7 Ben 1 Pop, which actually corresponded to April 9 and restored the balance between the vague 365-day year and the tropical year of 365.2421995 days. Moreover, it should be noted that there is in this inscription the record of a day 6 Caban which is not reached by any numerical calculation. If we count back from the New Year day by the distance number to the first previous occurrence of this day we find that it corresponded to 9–15–12–0–17, 6 Caban 10 Chen, two days off the autumnal equinox. The last date, by adding 3–2–7 to the corrected New Year day, equals May 11, 487. Its exact significance is not apparent.

Before dismissing this inscription we should take note of the sculptured tableau with which it is connected. The ruler is seated on a throne and behind him stands a much larger figure with curiously curled ornament over the nose and the number seven carved upon his cheek. This is pretty clearly a humanization of the god with the twisted nose ornament who is represented in all parts of the Mayan area. His face replaces the numeral seven in the more complicated glyphs and in this instance he may be regarded as a God of the Past because seven baktuns were allowed for the past when the Mayan calendar was put in motion. The king on his throne wears a shield on one arm with the front-view face of the same god in its usual grotesque form. This face also occurs on the shield of the Tablet of the Sun at Palenque.

Another lintel similar to the one just examined probably belongs to the second doorway of Temple 1. The fragmentary sculpture represents a great jaguar standing behind a king seated upon a throne. The inscription begins with the day 9 Ahau 13 Pop and the natural assumption is that this should be placed in the position 9–13–3–0–0, 9 Ahau 13 Pop where it will be a tun ending. There is, however, no declaration to help us in this matter and the artistic classification puts the sculpture in the same period as the lintel just



a b c

FIGURE 57. EXAMPLES OF THE USE OF THE TUN SIGN FOR ZERO OR COMPLETION

described. Let us proceed from the base 9–13–3–0–0 which can always be shifted fifty-two years without distrubing the relationship between the calendar-round dates.

In B 2 the interval is clearly 7–18 and counting this number forward we reach 2 Eznab 11 Chen not the 11 Eznab 11 Chen in the text. Here it will be observed that the only difficulty is in the coefficient of the day. At the top of the second column we find declared 12 Eznab 11 Zac but we find upon examination of Goodman's tables that counting two uinals forward from 2 Eznab 11 Chen will bring us to 3 Eznab 11 Zac. There is, however, no recognizable record of two uinals as a distance number. Before deciding the matter of the correctness of the day-sign coefficient, let us proceed to the end of the inscription. In the fragment now in the British Museum we find a distance number clearly ten uinals and two kins and with the numeral before the tun sign erased. Immediately after this distance number we find 5 Cib and a month-sign Zotz

with the numeral erased. In the case of both the tun coefficient and the Zotz coefficient there is enough space for two or three bars and one or more dots. Running the changes we decide that the distance number is 11–10–2, which added to 3 Eznab 11 Zac carries us to 5 Cib 14 Zotz. This success of finding a distance number which will make a continuous count justifies the assumption that an error was made in the coefficient of the day-signs.

The full presentation proceeding from the base mentioned above gave us:

AB 1	9–13– 3– 0– 0,	9 Ahau 13 Pop,	May 4, 435
B 2	7–18		
AB 3	9–13– 3– 7–18,	2 Eznab [1] 11 Chen,	Oct. 9, 435
	2– 0	not recorded	
CD 1	9–13– 3– 9–18,	3 Eznab [2] 11 Zac,	Nov. 18, 435
F 7–E 8	11–10– 2,	subtract	
F 8–E 9	9–12– 9–17–16,	5 Cib 14 Zotz,	July 7, 422

Inspection shows that none of the dates in this series occupies a position of astronomical significance. We now shift the table one calendar-round cycle forward into a position better justified by artistic considerations and obtain a second table.

9–15–15–13– 0,	9 Ahau 13 Pop,	Apr. 21, 487
7–18		
9–15–16– 2–18,	3 Eznab 11 Chen,	Sept. 26, 487
2– 0		
9–15–16– 4–18,	3 Eznab 11 Zac,	Nov. 5, 487
11–10– 2		
9–15– 4–12–16,	5 Cib 14 Zotz,	June 24, 475

In the new correlation the second date in the table comes within three days of the autumnal equinox and the last date within one day of the summer solstice. This is doubtless the true position of the sculpture.

On the fine lintel of Temple 3, Tikal, the original of which is now in the Museum at Basle, Switzerland, the following calculations are very clearly written:

AB 1	3 Ahau 3 Mol,	9–15–10–0–0,	Aug. 30, 481
A 2	Half-katun		
B 2–A 3	2–2–2	2–2–2	
B 3–A 4	11 Ik 15 Chen,	9–15–12–2–2,	Oct. 1, 483

[1] Written 11 Eznab by error. [2] Written 12 Eznab by error.

C 4	1 Sunset Observation	1	
D 4–C 5	12 Akbal 16 Chen,	9–15–12–2–3,	Oct. 2, 483
F 1		3–0–0	
E 2–F 2	13 Akbal 1 Chen,	9–15–15–2–3,	Sept. 16, 485

It will be observed that the inscription starts with the same 3 Ahau 3 Mol as the first one we examined from Tikal and that this date is likewise declared to end a half-katun or lahuntun to use Morley's term. We then find an addition of 762 days which carries us from Aug. 30, 481 to Oct. 1, 483. Again we see the hieroglyph for observation of the sun at the horizon combined with the numeral one. This is taken as meaning a single day and we find in effect that this addition carries us to Oct. 2, 483 B.C. In the latter part of the inscription there is the addition of three tuns carrying us to a day corresponding to Sept. 16, 485. These two dates are on either side of the autumnal equinox but so far from it that probably neither was intended to mark its exact location. These inscriptions show that the Mayas were fully aware that their 365-day year did not exactly keep pace with the sun but they maintained it, nevertheless, for the greater advantages of an orderly time count in terms of days which would enable them to measure the periods of revolutions for the moon and the leading planets as well as the recurrent seasons. We find constant evidence of supplementary cycles and may confidently expect that some of them will be worked out in time.

At Tikal the number of sculptured stelae is not great but there are many plain ones which probably had designs and calculations painted upon them. Such stelae as are sculptured and do bear dates cover a very long range of history. The ones with simple dates [1] are:

Stela 8,	9– 0–10–0–0,	7 Ahau 3 Yax,	Dec. 12, 185
" 9,	9– 2– 0–0–0,	4 Ahau 13 Uo,	July 17, 215
" 7,	9– 3– 0–0–0,	2 Ahau 18 Muan,	Apr. 3, 235
" 15,	9– 3– 0–0–0,	2 Ahau 18 Muan,	Apr. 3, 235
" 6,	9– 4– 0–0–0,	13 Ahau 18 Yax,	Dec. 18, 254
" 16,	9–14– 0–0–0,	6 Ahau 13 Muan,	Feb. 3, 452
" 5,	9–15–13–0–0,	4 Ahau 8 Yaxkin,	Aug. 14, 484
" 11,	10– 2– 0–0–0,	3 Ahau 3 Ceh,	Oct. 19, 609

1 Some of the early stelae at Tikal have proved very difficult: the readings are mostly those of Morley.

Some of these monuments seem to mark time stations of more than usual interest. The year of the first monument began with 0 Pop on June 20, within a day or two of the summer solstice while the half-katun which it dedicated was pretty close to the winter solstice. Two monuments, Stela 7 and Stela 15, were set up when a katun ended near the spring station of the farmer's year. Stela 4 reiterates the date close to the winter solstice which begins the count on the Temple of the Inscriptions at Palenque. The beautiful Stela 5 was erected in a year when 0 Pop coincided with April 9.

Two or three monuments at Tikal remain for special consideration. Stela 10 carries on its western side what some persons regard as the longest Mayan inscription reading 1–1–11–19–9–3–6–2–0 equalling 1,841,639,800 days or about five million years. The lowest member of the notation is omitted, probably because it had a zero coefficient. The period glyphs register unmistakably the proper positions of the other members, and after restoring the kin place it is found that the five lowest places constitute an ordinary initial series from the Mayan era. This chronological statement is therefore 9–3–6–2–0, 9 Ahau 9 Pax, corresponding to April 7, 241 A.D. This long number may be intended to lead to the New Year day, later established astronomically as April 9. The higher orders in this number cannot be accepted without further corroboration.

At Tikal there is also an irregular stone carrying the same initial series on two sides, which is called Stela 17. This initial series is 9–6–3–9–15, 10 Men 18 Chen, which corresponds to Nov. 18, 297. While this has no recognizable significance, it may be noted that there is some evidence of a lunar count in connection with it. At the top of the third column, we see a glyph in which the crescent of the new moon is associated with the numeral one.

Because Stela 16 has the famous round Altar 5 before it Morley placed the dates on the altar in the calendar round providing the closest approximation to the date on the stela. This monument declares a katun ending. He, therefore, found the following order:

Altar 5.	9–12–19–12– 9,	1 Muluc 2 Muan,	Jan. 27, 432
	11–11–18		
	9–13–11– 6– 7,	13 Manik 0 Xul,	July 28, 443
	8– 9–19		
	9–13–19–16– 6,	11 Cimi 19 Mac,	Jan. 1, 452

	3	undeclared	
	9–13–19–16– 9,	1 Muluc 2 Kankin,	Jan. 3, 452
Stela 16.	9–14– 0– 0– 0,	6 Ahau 13 Muan,	Feb. 3, 452

The artistic evidence is noncommittal: at least it cannot be urged that the two pieces are in exactly the same style. Let us see, then, what happens when the dates on the altar are moved up one calendar round and made to fall after that of the stela instead of before it.

Stela 16.	9–14– 0– 0– 0,	6 Ahau 13 Muan,	Feb. 3, 452
Altar 5.	9–15–12– 7– 9,	1 Muluc 2 Muan,	Jan. 15, 484
	11–11–18		
	9–16– 4– 1– 7,	13 Manik 0 Xul,	July 15, 495
	8– 9–19		
	9–16–12–11– 6,	11 Cimi 19 Mac,	Dec. 20, 503
	3		
	9–16–12–11– 9,	1 Muluc 2 Kankin,	Dec. 23, 503

The last entry is clearly the winter solstice and by nice calculation can be made to equal December 22. Since the year 500 was not a leap year in the Gregorian calendar there was no interpolation from 496 to 504 and this date lies at the end of the eight-year stretch. The reader will also note that the calculation began in a year when 0 Pop fell on April 9, and although the importance of that fact is not stated here, we have already seen it given proper consideration on the carved lintels of the temples at Tikal.

A Summary of Copan Dates

The dates at Copan have already been treated in considerable detail and it now remains to give them as a continuous and orderly record. The city of Copan offers indirect evidence of very early habitation. The crudest monuments are not dated and the earliest and latest contemporary dates embrace a period extending from 225 A.D. to about 530 A.D. One or two doubtful pieces may be slightly later than this. There are two declarations of Baktun 10 (570 A.D.) which are believed to refer to the future.

Perhaps the earliest monuments at Copan are the shattered, archaic figures under Stelae 4 and 5. After these Morley arranges Altars J′, K′, L′, M′, P′ and Q′, and Stelae 20, 22, 24, and 25, of

which only Stela 24 has been dated with certainty. Even the earliest of these altars probably does not belong in Baktun 8. Altars J′ and K′, sister monuments, were once associated in some way with Stela 10, the western marker, and it would be interesting to discover whether they served as markers for this position before the present one was set up. Altar L′ has a glyph which may register 9 baktuns but no day or month-sign is in evidence. Altar M′, with a fragmentary inscription, resembles the preceding one in style. Altar Q′ has a half-katun glyph which Morley tentatively places as 9–4–10–0–0, 12 Ahau 8 Mol, Oct. 27, 264 A.D. This, however, is not the earliest date at Copan: Stela 22 probably records 9–2–10–0–0, 3 Ahau 8 Cumhu, May 15, 225, interesting as a half-katun recovering the month position of the epoch. Stela 24 surely records this same date, while Stela 20 has been doubtfully referred to a position one katun earlier, where it would equal 9–1–10–0–0, 5 Ahau 3 Tzec,[1] Sept. 7, 205. This position might have had significance by reason of its close proximation to the autumnal station in the farmer's year.

Altars X, Y, and A′ were probably buried in a ceremonial manner as early relics. The first two are extremely interesting but unfortunately carry only calendar-round dates which disclose no special significance.

The date on Altar X is 11 Eznab 1 Kankin and that on Altar Y is 6 Cimi 19 Uo, just 1–1–12–8 distant. Three locations of these dates are:

Altar X.	9–3– 6–17–18,	11 Eznab 1 Kankin,	Feb. 23, 242
	9–5–19–12–18,	11 Eznab 1 Kankin,	Feb. 10, 294
	9–8–12– 7–18,	11 Eznab 1 Kankin,	Jan. 28, 346
Altar Y.	9–4– 8–12– 6,	6 Cimi 19 Uo,	July 11, 263
	9–7– 1– 7– 6,	6 Cimi 19 Uo,	June 28, 315
	9– 9–14– 2–6,	6 Cimi 19 Uo,	June 16, 367

Morley suggests that Altar X was possibly associated with Stela 16 and Altar Y with Stela 17, making the most probable dates the second one given above for the first monument in the following relation:

Altar X.	9–5–19–12–18,	11 Eznab 1 Kankin,	Feb. 10, 294
Stela 17.	9–6– 0– 0– 0,	9 Ahau 3 Uayeb,	June 4, 294

[1] This date is recorded in Temple of the Cross at Palenque and is followed by two other dates at the same position in the natural year.

Unfortunately the date is not disclosed by the small fragment of Stela 17, but the katun coefficient is pretty clearly 6, and so far the dates at Copan have nearly all reached round numbers. Altar X in this association exactly records the position in the natural year of the Era of the Chronicles.

In the case of Altar Y, it is likely, if this association holds, that the date for Stela 16 should be given one calendar round later. The two monuments would then fit together as follows:

Altar Y.	9–7–1– 7–6,	6 Cimi 19 Uo,	June 28, 315
Stela 16.	9–7–2–12–0,	5 Ahau 8 Yaxkin,	Sept. 25, 316

This last arrangement would establish proximations with the summer solstice and the vernal equinox, not very accurately to be sure. Stela 16 registers a date which is pretty clearly 5 Ahau 8 Yaxkin, although these glyphs are given in reverse order which is most unusual.

Stela 15 reaches 9–4–10–0–0, 12 Ahau 8 Mol, Oct. 27, 264, by an interesting initial series with highly ornamented glyphs. There is another date almost certainly 9 Ahau 13 Ceh in the strategic position 9–0–0–0–0, 9 Ahau 13 Ceh, Feb. 10, 176, as well as the month position 13 Kayab which at the time of the initial series would correspond to April 30. Stelae 15 and 24 are the leading texts in early glyphic history at Copan.

We now come to Stela 9, which carried an admirably preserved inscription on three sides. This monument must now be studied from photographs and casts since it was destroyed in 1912 to make a foundation for a mud wall. The initial series was very clearly 9–6–10–0–0, 8 Ahau 13 Pax, April 1, 304. There were no secondary dates.

Stela 18 may have marked 9–7–0–0–0, 7 Ahau 3 Kankin, Feb. 8, 314. This date would doubtless have had a significance to Mayan mathematicians owing to the fact that after 7 katuns any calendar-round date returns to within two or three days of its earlier position in the tropical year. They thus would have:

9–0–0–0–0,	8 Ahau 13 Ceh,	Feb. 10, 176
7–0–0–0		
9–7–0–0–0,	7 Ahau 3 Kankin,	Feb, 8, 314

It is not unlikely that this circumstance is indicated on the monu-

ment by a glyph to which Morley[1] calls attention. He links the two dates given above without indicating the fact that they record a return to almost the same time in the natural year.

The first monument at Copan on which a human figure is carved in connection with inscriptions was Stela 18 but Stela 7 furnishes us with the earliest useful example. The relief in the sculpture of this figure is extremely low, but the details are drawn with a nice precision. The beautiful fragment of Stela 24 giving the earliest certain date at the city was used as a foundation offering at the time this monument was erected. Morley says, "It has been noted that the mound of Stela 7 was the richest repository of archaic monuments in the entire valley. For example, of the 22 monuments now referable to the Early Period at Copan, 8 were either found on this mound or were traceable to it as already described:

Stela 20	Stela 18
Stela 24	Stela 7
Stela 25	Altar P′
Stela 15	Altar Q′

And of the fourteen fragments V′ now in the cabildo, 12 were found in the excavation of this mound or built into the walls of houses or pavements in the immediate vicinity[2] . . . ." A probable explanation of this circumstance is that Copan village rather than the present site of the acropolis was the earliest ceremonial center of the ancient city.

Stela 7 has an initial series date expressed with face numerals which is quite clearly 9–9–0–0–0, 3 Ahau 3 Zotz, July 13, 353. No other calculations are apparent.

The next monument in order at Copan was Stela E, carrying out the idea of the sculptured human figure which is here given in somewhat higher relief. With this monolith is associated a drum-shaped altar and the calculations on the stela pass over to the supplementary altar. There is much uncertainty as to the date with which the inscription on Stela E begins, but it may be tentatively deciphered as 9–9–2–17–0, 10 Ahau 8 Uo, June 8, 356. A second date is 13 Ahau 18 Tzec, possibly 9–9–1–2–0, 13 Ahau 18 Tzec, Aug. 17, 354. On the altar a quarter-katun or hotun ending is reached

[1] *Inscriptions at Copan*, pp. 98–101.
[2] *Ibid*, p. 106.

at 9–9–5–0–0, 9 Ahau 18 Uo, June 18, 358. There is a possibility that this round number, interesting because of its proximation to the summer solstice, is recorded on the stela as well as on the altar.

Stela P gives a record for the next hotun ending namely 9–9–10–0–0, 2 Ahau 13 Pop, May 22, 363. It does not supply other dates but the hieroglyphs seem to treat of astronomical matters; for instance, there is one glyph of the Long-Nosed God with the numeral 9 which may refer to the time when the formal beginning of the Mayan year fell on the summer solstice and in the rainy season (see fig. 47).

Under the title Fragments V′, Morley considers several pieces containing important hieroglyphs. No dates are recoverable, but there is evidence that they existed. One hieroglyph is suggestive of the equinox. It consists of an Ahau face, half dark and half light, standing above a baktun symbol. Also there is a form of Kankin half dark and half light (see fig. 41). Fragment S offers evidence of a secondary series.

The early monuments at Copan hitherto considered show only the simplest kind of calculations and in the majority of cases record but one date. An examination of the hieroglyphs, however, impresses the student with the fact that important matters were already being considered beyond the scope of the recorded dates. One passage showing this quite clearly is on the altar of Stela E, where a glyph meaning observation at the horizon is recorded. Stelae 16 and 17 seem to be a pair treating of the sun and moon as indicated by the devices set in the introducing glyph. The device representing the sun is connected with a day in the month Yaxkin and we have already seen that this month was the original beginning of the agricultural year at the beginning of the Historical Era. On Stela 9 the same device appears preceded by an element (apparently the lip of a shell) which may mean Yax and followed by a Cauac year-sign.

The Middle Period extends from 9–10–0–0–0 to 9–15–0–0–0, practically a century. At the beginning of this period the astronomical base line was first established. Following this the tremendous labor of building the acropolis with all its temples was probably undertaken. There are no monuments at Copan which record the date 9–10–0–0–0, and in contrast there are no less than seven which reach 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392. These are:

Stelae 10 and 12, the markers of the astronomical base line; Stela 19 at Hacienda Grande; Stela 23, now at Santa Rita; Stela 13, located between the main structure and Santa Rita; and Stelae 2 and 3 in the Great Plaza.

Stela 10 starts off with the initial series declaration 9–10–19–13–0, 3 Ahau 8 Yaxkin, Sept. 6, 392. Several passages on this monument furnish an excellent field for further research. Stela 12 has two dates which enclose the date on Stela 10, namely an initial series of 9–10–15–0–0, 6 Ahau 13 Mac, Jan. 11, 388, and period-ending date of 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392.

Stela 19 has the initial series date 9–10–19–15–0, 4 Ahau 8 Chen, Oct. 16, 392. This date has no apparent significance unless it is intended for a recapitulation of 4 Ahau 8 Cumhu, Oct. 14, 3373 B.C. This is certainly an interesting possibility. The day reached is 4 Ahau, the same as that at the era. The month position 8 Chen has the same coefficient. Moreover, at the era, as we have already seen, 0 Chen corresponded to April 9. At Palenque a few years after this monument at Copan was erected, we have indisputable evidence that the results here indicated were actually reached by calculation. The date of Stela 19 is clearly repeated on the fragments of its altar.

Stela 13 declares by an initial series the date 9–11–0–0–0, 12 Ahau 8 Ceh, Dec. 15, 392. There is also a record of a day 1 Ahau which placed before the terminal day corresponds to June 18: it may have been intended for an approximation of the summer solstice.

Stela 23 began with an initial series which had the numeral 10 in the katun position. Morley considers the calculations on this monument, which are determined from two or three calendar-round declarations and one distance number, to involve the following addition, the middle date being that of the initial series.

9–10–18–12– 8,	8 Lamat	1 Yaxkin,	Aug. 31, 390
(1– 0– 0)			
9–10–19–12– 8,	4 Lamat	16 Xul,	Aug. 26, 391
5–12			
9–11– 0– 0– 0,	12 Ahau	8 Ceh,	Dec. 15, 392

Also there is a clear declaration of 4 Ahau 8 Cumhu, the epoch of the Mayan era. This calculation probably deals with some aspect of the autumnal station, but Lamat is a day intimately associated

with the Venus calendar, and it is here designated by a variation of the Venus symbol.

The two monuments of this series in the Great Plaza, namely Stela 2 and Stela 3, from the artistic considerations do not appear to be strictly contemporaneous. As a matter of fact Stela 2, like Stela 12, records the last quarter of Katun 10 as well as Katun 11; while Stela 3 resembles Stela 19 in registering a point in the distant past. This latter is the earliest of the Copan stelae with a full-length figure carved on two opposite sides. The writer is inclined to believe that this monument belongs to a slightly later date than 9–11–0–0–0 in view of its superiority over Stela 2 in the matter of sculpture. It may have been set up as a general memorial of the calculations having to do with the establishing of the astronomical base line. The dates on the two monuments are:

Stela 2.	9–10–15–0–0,	6 Ahau 13 Mac,	Jan. 11, 388
	9–11– 0–0–0,	12 Ahau 8 Ceh,	Dec. 15, 392
Stela 3.	9– 0– 0–0–0,	8 Ahau 13 Ceh,	Feb. 10, 176
	9–11– 0–0–0,	12 Ahau 8 Ceh,	Dec. 15, 392

Also on Stela 3 there is a record of 13 uinals and of 13 Kayab. This is probably one tzolkin before the final date or 9–10–19–5–0, 12 Ahau 13 Kayab, Mar. 30, 392.

It has already been pointed out that 0 Pop fell on June 22, the summer solstice, in 176 A.D., a coincidence which made the round number 9–0–0–0–0, 8 Ahau 13 Ceh exceedingly valuable for calculations. The round number 9–11–0–0–0,12 Ahau 8 Ceh, can be used in conjunction with the former number. It reaches Dec. 15, a rough approximation to the winter solstice. This approximation can be made much closer than appears at first glance. The month position in the first statement is 13 Ceh, and that in the second statement is 8 Ceh five days earlier in the 365-day year.

If we imagine the Mayas could accomplish the mental arithmetic of carrying the 5 days forward they would get to Dec. 20 and say: "When Baktun 9 in the numerical count was completed, 0 Pop fell on summer solstice day (June 22) and the baktun itself was completed on 13 Ceh. Now, after 11 katuns have been counted and we have just finished setting up our markers to determine the agricultural year, the number 9–11–0–0–0 calls for 8 Ceh only five days earlier in our haab than the 13 Ceh of 9–0–0–0–0. But

this 8 Ceh is only five or six days before winter solstice day and if we count to 13 Ceh we are practically on that day. Then if we count back one permutation round from our 9–11–0–0–0, 12 Ahau 8 Ceh, we reach 12 Ahau 13 Kayab (Mar. 30) and this is near enough to vernal equinox day to be worthy of taking note."

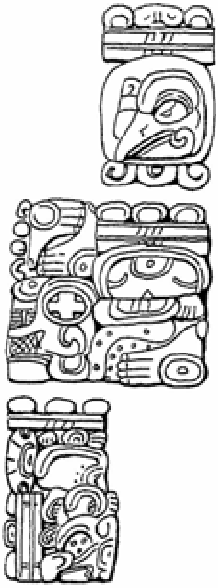


Figure 58. The Reversal of the Seasons on Stela 3 Copan

In justification of this explanation the reader is referred to the passage reproduced in figure 58. In the upper hieroglyph we see 12 Ahau and in the lower one 8 Ceh, end of 11 katuns. In the middle glyph block we see 13 uinals, that is one tzolkin round. Also in this block are two hands in a reversed order above a sign which pretty clearly means the winter solstice. This essential element in this sign is recorded in connection with the epoch of the historical era when 0 Pop was at the winter solstice. At the right under the 13 uinals is a hand throwing out water, probably a substitute for the head of the Rain God carrying the number 9 which would be an admirable ideograph for the summer solstice.

A hotun ending only five days off the autumnal equinox is declared on two monuments. This is 9–11–15–0–0, 4 Ahau 13 Mol, Sept. 28, 407, and the two monuments are Stela 1 and the East Altar of Stela 5. The initial series of Stela 1 registers a position 14 uinals later, according to the arrangement that follows:

9–11–15–14–0,	11 Ahau 8 Zotz,	July 4, 408
14–0	subtract	
9–11–15– 0–0,	4 Ahau 3 Mol,	Sept. 28, 407

The significance of the initial series date is not apparent.

The date 9–12–0–0–0, 10 Ahau 8 Yaxkin, Sept. 1, 412 which is so emphatically treated on the tablets of the Temple of the Inscriptions at Palenque, is reached on the Altar of Stela 1 and the West Altar of Stela 5. Both of these drum-shaped altars are in bad preservation but it has been possible to decipher the hieroglyphs with reasonable assurance. The initial series on the Altar of Stela 1 is

pretty clear as regards the first four positions except that the tun coefficient shows only a bare bone in the lower part of the face and may be any numeral from 13 to 19 instead of the most likely 10. There is a secondary series which fits into four positions but without a single coefficient being legible. The last date in the record is a clear declaration of 12 katuns. Morley reconstructs the text on the basis of 0 in the kin position, as follows:

9– 9–10–10–0,	7 Ahau 13 Zac,	Dec. 8, 363
2– 9– 8–0		
9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412

If the coefficient of the kin glyph were 14 instead of zero, the number would reach December 22, but we are not justified in assuming that it was.

The West Altar of Stela 5 is almost as bad. The initial series has been very cleverly deciphered by Morley as 9–7–19–17–11, 9 Chuen 14 Mol, Oct. 17, 333. Nearly a hundred years later this month position fell exactly on the autumnal equinox and 2 Cib 14 Mol was used as the point of departure for extremely interesting calculations at Palenque. The final date on this monument at Copan is apparently 9–12–0–0–0, 10 Ahau 8 Yaxkin, Sept. 1, 412, some 17 or 18 years before the chronological position of the Palenque calculations.

We now come in the natural order of leading dates to Stela I and its altar which have interlocking inscriptions. The stela is an extremely important monument with a human figure wearing the mask of a Sun God and carrying a ceremonial bar representing a dead serpent. The snouts of dead serpents, it may be said in parenthesis, protrude from the four corners of the greater sun-disks represented on the celestial canopies of Yaxchilan, etc. There is evidence that Stela I memorialized some important results of an astronomical nature. The initial series is 9–12–3–14–0, 5 Ahau 8 Uo, May 23, 416, which does not seem promising. Two other dates on the stela come before the initial series and the first of them is 10 Ahau 13 Ceh, almost on the winter solstice, which recovers the month position of 9–0–0–0–0, 8 Ahau 13 Ceh, Feb. 10, 176, and also nearly recovers the summer solstice at the epoch of the Mundane Era. This layout was also used on Stela 3, it will be remembered. The additions on the Altar of Stela I reach two hotun endings and

also declare an intermediate date which is probably exactly five katuns later than the initial series on the West Altar of Stela 5, namely:

9– 7–19–17–11,	9 Chuen 14 Mol,	Oct. 17, 333
5– 0– 0– 0		
9–12–19–17–11,	12 Chuen 19 Pop,	May 10, 432

Also the initial series of Stela I is just 8 tuns later than that of Stela 1: and just 16 haabs earlier than the terminal date on the altar, thus:

9–11–15–14–0,	11 Ahau 8 Zotz,	July 4, 408
8– 0–0,	(8 × 360 days)	
9–12– 3–14–0,	5 Ahau 8 Uo,	May 23, 416
16– 4–0	(16 × 365 days)	
9–13– 0– 0–0,	5 Ahau 8 Uo,	May 19, 432

Still another significant interval is seen in the following:

9–11–19– 5–0,	10 Ahau 13 Ceh,	Dec. 16, 411
13–0,	(one tzolkin)	
9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412

On a much later monument (Stela A) we shall see the first date in this addition carried forward 3 katuns:

9–11–19–5–0,	10 Ahau 13 Ceh,	Dec. 16, 411
3– 0–0–0		
9–14–19–5–0,	4 Ahau 18 Muan,	Feb. 4, 471

Still another kind of reiteration occurs at intervals of 7 katuns. The following series is found to fetch up at almost the same positions in the natural year:

Stela 3.	9– 0– 0–0–0,	8 Ahau 13 Ceh,	Feb. 10, 176
	7– 0–0–0		
Stela 18.	9– 7– 0–0–0,	7 Ahau 3 Kankin,	Feb. 8, 314
	7– 0–0–0		
Stela 5.	9–14– 0–0–0,	6 Ahau 13 Muan,	Feb. 5, 452
	19–5–0		
Stela A.	9–14–19–5–0,	4 Ahau 18 Muan,	Feb. 4, 471

We are also reminded that at Palenque, 10 Ahau 13 Yaxkin, the day of the new fire ceremony of the calendar round, was tied to

one of the pivotal dates in the present complex by the device of five ritualistic years:

9–11–14–17–0,	10 Ahau 13 Yaxkin,	Sept. 8, 407
5– 1–0	(5 × 364 days)	
9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412

This practically effected the transition from the earlier to the later autumnal stations of the agricultural year, since the warping from the Gregorian intercalation makes the difference appear as seven days when it is only six and a quarter days. In view of these manifold correspondences, we may reasonably expect to find in the initial series of Stela I the completion of some important interval from some important date. By subtracting one katun we recover the point in the natural year reached by the earlier setting of the astronomical base line at Copan and the very position in the natural year recorded on Stela 10. Thus:

9–12–3–14–0,	5 Ahau 8 Uo,	May 23, 416
1– 0–0–0	subtract	
9–11–3–14–0,	7 Ahau 8 Yaxkin,	Sept. 6, 395

Exactly the same sort of thing is on record in connection with the day 6 Caban 10 Mol: the katun interval, reaching 4 Caban 10 Zip, is memorialized on Altar T and Stela 8. From these considerations it appears that the choice of September 2 as the important day of the autumn for agriculturalists was forecast as early as 9–12–0–0–0, 10 Ahau 8 Yaxkin. This final day by close calculation is very nearly in the proper position. Also we find here gratifying proofs of the unity of intellectual research among the early Mayas.

After this extraordinary lot of interlocking coincidences we should not be surprised if the hotun ending 9–12–5–0–0, 3 Ahau 3 Xul, Aug. 6, 417 might have been chosen for emphasis because it recovers the position in the natural year of the epoch of the Historical Era, 7–0–0–0–0, 10 Ahau 18 Zac, Aug. 6, 613 B.C. Perhaps this is only an accident. Also if we treat the recalcitrant initial series of Stela I in the same fashion we find it yields a possible statement of the position in the natural year of the original 4 Ahau 8 Cumhu (October 14). Thus:

9–11–15–14–0,	11 Ahau 8 Zotz,	July 4, 408
1– 0– 0–0	subtract	
9–10–15–14–0,	13 Ahau 8 Chen,	Oct. 9, 388

While there is not space to enter at this time into an examination of the hieroglyphs, we should take note that the God of the Twisted Nose Ornament, who rules the number 7 and beginning of the Historical Era, is clearly represented in the introducing glyph and also in the heads adorning the belt of the priestly figure. Thirteen cycles, that is 13–0–0–0–0, are perhaps intended in the glyph following 10 Ahau in the top-most block on the south side: this glyph can hardly be Ceh, which is recoverable by the distance number. The last era, that of 9–0–0–0–0, is perhaps intended in the head-dress of the Long-Nosed God with the number 9 as superfix. Many examples of this glyph have already passed under observation.

Stela 6 registers, by the initial series method, the half-katun 9–12–10–0–0, 9 Ahau 18 Zotz, July 11, 422, exactly the position occupied by the only unexplained date on Stela I. We have, then:

Stela I.	9–11–19–15– 8,	10 Lamat 16 Zotz,	July 11, 412
	10– 2–12	(10 × 365 days + 2 days)	
Stela 6.	9–12–10– 0– 0,	9 Ahau 18 Zotz,	July 11, 422

There is also on Stela 6 a declaration of 8 Ahau immediately after the lahuntun glyph. Morley suggests that this may be 9–13–0–0–0, 8 Ahau 8 Uo, May 19, 432. If this is so then the declaration of three katuns in glyph 16 (Maudslay's numbering) might imply the use of the three-and-a-half katun interval to recover practically the same place in the natural year:

9– 9–10–0–0,	2 Ahau 13 Pop,	May 22, 363
3– 0–0–0		
9–12–10–0–0,	9 Ahau 18 Zotz,	July 11, 422
10–0–0		
9–13– 0–0–0,	8 Ahau 8 Uo,	May 19, 432

The dates in May possibly have some significance in connection with the transformation indicated for Stela I, leading from May 23 to September 6. The first of these dates is, in fact, the initial series of the important Stela 9. Now glyph 17 on the south side of Stela 9 is a katun sign surmounted with smoke symbols possibly indicating a celebration of one complete katun from 9–8–10–0–0, 4 Ahau 13 Xul, Sept. 3, which stood almost at the autumnal station. The use of the three-and-a-half-katun interval to strike approximately the same positions in the natural year (70 × 360 = 25,200 days.

69 tropical years = 25,201.7 days) is pretty clearly indicated at Copan, Palenque, Tikal, etc.

9– 1–10–0–0,	5 Ahau 3 Tzec,	Sept. 7, 205
9– 5– 0–0–0,	11 Ahau 18 Tzec,	Sept. 5, 274
9– 8–10–0–0,	4 Ahau 13 Xul,	Sept. 3, 343
9–12– 0–0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412
9–15–10–0–0,	3 Ahau 3 Mol,	Aug. 31, 481
9–19– 0–0–0,	11 Ahau 18 Mol,	Aug. 29, 550

The series begins with the earliest Copan date, that on Stela 24, which also appears on the Tablet of the Cross at Palenque. The next date is recorded in the Temple of the Inscriptions; the third one does not appear to be recorded unless above; but the fourth is very strongly emphasized at Copan and Palenque; while the fifth serves as a basis for the most interesting calculations at Tikal, and also appears at Quirigua. The last date is played up at Naranjo and Quirigua.

Altar K has a safe initial series reading 9–12–16–7–8, 3 Lamat 16 Yax, Nov. 5, 428. The day reached is Lamat, closely connected with Venus, and the Venus symbol appears in the introducing glyph. In this year Venus had inferior conjunction with the sun on Feb. 6 (Julian day, 1877420.2). Possibly the date on this monument was intended for the last day of visibility of the planet before superior conjunction. The problem of the Venus calendar is most interesting, but there is not space to enlarge upon it in this preliminary study. The hieroglyphs on this monument are unusual but we see a sacred fire symbol and a record of four katuns given twice.

Considerable space has already been devoted to the unusually important inscriptions on Altars H′ and I′ which Morley brought to light. The first altar contains the following steps, the first date being that of the initial series:

9–12– 8– 3– 9,	8 Muluc 17 Mol,	Sept. 28, 420
2–13– 4– 4	subtract	
9– 9–14–17– 5,	6 Chicchan 18 Kayab,	Apr. 10, 368
1–14–11,	add to first date	
9–12–10– 0– 0,	6 Ahau 18 Zotz,	July 11, 422

It will be observed that a position five days from the autumnal equinox is recorded and then the count is sent back fifty-two years,

and a very little more, to the first of the agricultural year. The last date is a round number, useful for purposes of ready association, and already recorded on Stela 6. The position of this terminal date in the year is exactly stated on Stela I where 9–11–19–15–8, 10 Lamat 16 Zotz reaches July 11, 412. Also the initial series date corresponds in the natural year to the hotun ending 9–11–15–0–0, 4 Ahau 13 Mol, Sept. 28, 407, on Stela 1 and the East Altar of Stela 5. Perhaps the declaration of the month position 18 Kayab which corresponds to April 10 rather than April 9 was determined by the importance of this month position in the Venus calculations.

Altar I′ commences with a distance number which connects the initial series immediately following with that on Altar H′. The initial series records a round number, 9–13–0–0–0, 8 Ahau 8 Uo, May 19, 432, then comes the sensational long distance number giving the interval between the date of the inauguration of the completed calendar and the half-katun ending 9–12–10–0–0, 9 Ahau 18 Zotz, July 11, 422. Thus:

(Altar H′.	9–12– 8– 3– 9,	8 Muluc 17 Mol,	Sept. 28, 420)
Altar I′.	11–14–11		
	9–13– 0– 0– 0,	8 Ahau 8 Uo,	May 19, 432
	7– 1–13–15– 0,	9 Ahau 13 Cumhu,	Dec. 10, 580 B.C.
	2–10–16– 3– 0		
	9–12–10– 0– 0,	9 Ahau 18 Zotz,	July 11, 422

Stela J, with its strangely braided inscription containing the initial series 9–13–10–0–0, 7 Ahau 3 Cumhu, Mar. 28, 442, and with eighteen tuns counted in sequence upon its two sides, stirs the imagination as a puzzle to be solved. These tuns are numbered and each one is accompanied by an explanatory glyph, but no ending days are given. There is in this inscription a distance number 6–10–0–0, which is doubtless intended to be counted forward from the day in the initial series to the important round number in the future designated as 10–0–0–0–0, reaching 7 Ahau 18 Zip. The actual record gives 13 Zip instead of 18 Zip. Another distance number states the interval from a day 7 Lamat to the day of the initial series as follows:

9–13–10– 0– 0,	7 Ahau 3 Cumhu,	Mar. 27, 442 A.D.
6–11–12	subtract	
9–13– 3– 6– 8,	7 Lamat 1 Mol,	Sept. 9, 435 A.D.

There are other dates and chronological implications. On the front of the monuments the hieroglyphs partly overlie a highly formalized face of the Sun God. The emphatic date here is 9–12–12–0–0, 1 Ahau 8 Zotz, June 30, 424. The tun count begins with the next tun after the one recorded in this date. Also we find two different declarations of 13 baktuns which probably mean 13–0–0–0–0, 4 Ahau 8 Cumhu. Then there is the date 7 Ahau 3 Cumhu, reached by the initial series on the back. There is also a distance number 13–10–0–0 which subtracted from the initial series gives 9–0–0–0–0, 8 Ahau 13 Ceh, Feb. 10, 176, that position being declared by the glyph of the Long-Nosed God (fig. 48).

A curious detail is the day 1 Ahau combined with a hand and shell with the numeral 8 for superfix. This probably means 8 days,[1] leading from Ahau to Lamat in the following setting (and followed by a reference to 13 baktuns):

9–12–12–0–0,	1 Ahau 8 Zotz,	June 30, 424
8		
9–12–12–0–8,	9 Lamat 16 Zotz,	July 8, 424

The days Ahau and Lamat are bonded in similar fashion in the Temple of the Inscriptions at Palenque and in the Dresden Codex. Possibly the date 7 Lamat 1 Mol in the braided cryptogram on the back of Stela J is related to the day Ahau falling eight days before. Let us now compare the various statements:

PALENQUE — TEMPLE OF THE INSCRIPTIONS

A.	9– 9– 2– 4–0,	10 Ahau 13 Yaxkin,	Sept. 21, 355
	8		
	9– 9– 2– 4–8,	5 Lamat 1 Mol,	Sept. 29, 355
B.	9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412
	5– 1–0	subtract	
	9–11–14–17–0,	10 Ahau 13 Yaxkin,	Sept. 8, 407
	8		
	9–11–14–17–8,	5 Lamat 1 Mol,	Sept. 16, 407

COPAN — STELA J

A.	9–12–12–0–0,	1 Ahau 8 Zotz,	June 30, 424
	8		
	9–12–12–0–8,	9 Lamat 16 Zotz,	July 8, 424

[1] The kin glyph in several instances takes the form of a spiral shell.

B.	9–13– 3–6–0,	12 Ahau 13 Yaxkin,	Sept. 1, 435
	8		
	9–13– 3–6–8,	9 Lamat 1 Mol,	Sept. 9, 435

It will be observed that the Palenque record is quite similar to statement B reconstructed from Stela J at Copan. The positions in Yaxkin are at strategic stations in both records. Now in the Dresden Codex, the calculations involving Ahau and Lamat are carried back to the epoch of the Mundane Era. We find:

A.	13–0–0–0–0,	4 Ahau 8 Cumhu,	Oct. 14, 3373 B.C.
	8		
	13–0–0–0–8,	12 Lamat 16 Cumhu,	Oct. 22, 3373
B.	13–0–0–0–0,	4 Ahau 8 Cumhu,	Oct. 14, 3373
	5–1–0		
	13–0–5–1–0,	4 Ahau 3 Cumhu,	Oct. 8, 3368
	8		
	13–0–5–1–8,	4 Ahau 11 Cumhu,	Oct. 16, 3368

Statement A from Stela J at Copan, given above, can perhaps be considered to memorialize the completion of a katun after the establishment of an important calendrical fact. If we reduce the statement by one katun we obtain a relationship of dates very similar to the one in the Dresden Codex:

9–12–12–0–0,	1 Ahau 8 Zotz,	June 30, 424
1– 0–0–0	subtract	
9–11–12–0–0,	3 Ahau 3 Chen,	Oct. 13, 404
8		
9–11–12–0–8,	11 Lamat 16 Chen,	Oct. 21, 404

This is within a day of restoring conditions at the epoch, and we found in connection with the first date given above two records of 13 baktuns, that is 13–0–0–0–0, 4 Ahau 8 Cumhu.

In view of this satisfactory working out of an involved matter let us examine again the record on Stela I. We have seen that the initial series becomes highly important when carried back one katun to reach no less a base than September 6. The date containing Lamat submits to the same treatment:

9–11–19–15–8,	10 Lamat 16 Zotz,	July 11, 412
1– 0– 0–0	subtract	
9–10–19–15–8,	12 Lamat 16 Chen,	Oct. 24, 392
8	subtract	
9–10–19–15–0,	4 Ahau 8 Chen,	Oct. 16, 392

If the series of eighteen tuns on Stela J ends with the initial series, as Morley assumes, they must begin with 9–12–13–0–0, 10 Ahau 3 Zotz, June 25, 425 A.D. There is in this complex of time periods an obvious attempt to express relationships with the summer solstice of June 22, the vernal equinox of March 21, the formal beginning of the haab on the day 0 Pop and the stations of the agricultural year in April and September. The relativity of uneven time cycles, namely, the 260-day tzolkin, the 360-day tun, and the 365-day haab, is achieved with surprising accuracy. Shots are taken at the determinable astronomical points in the tropical year. In the record before us, the last days of tuns move forward in the true year a distance equal to that between the summer solstice and the vernal equinox in the space of 18 × 360, or 6480 days.

Correlation in the Tun Sequence, Stela J, Copan

Tun Endings			Haab Beginnings	Astronomical Points
9–12–13–0–0,	10 Ahau 3 Zotz,	June 25, 425	Apr. 23	Summer
9–12–14–0–0,	6 Ahau 18 Zip,	June 20, 426	" 23	Solstice
9–12–15–0–0,	2 Ahau 13 Zip	" 15, 427	" 23	
9–12–16–0–0,	11 Ahau 8 Zip	" 9, 428	" 22	
9–12–17–0–0,	7 Ahau 3 Zip	" 4, 429	" 22	
9–12–18–0–0,	3 Ahau 18 Uo	May 30, 430	" 22	
9–12–19–0–0,	12 Ahau 13 Uo	" 25, 431	" 22	
9–13– 0–0–0,	8 Ahau 8 Uo	" 19, 432	" 21	
9–13– 1–0–0,	4 Ahau 3 Uo	" 14, 433	" 21	
9–13– 2–0–0,	13 Ahau 18 Pop	" 9, 434	" 21	
9–13– 3–0–0,	9 Ahau 13 Pop	" 4, 435	" 21	
9–13– 4–0–0,	5 Ahau 8 Pop	Apr. 28, 436	" 20	
9–13– 5–0–0,	1 Ahau 3 Pop	" 23, 437	" 20	
9–13– 6–0–0,	10 Ahau 3 Uayeb	" 18, 438	" 20	
9–13– 7–0–0,	6 Ahau 18 Cumhu	" 13, 439	" 20	
9–13– 8–0–0,	2 Ahau 13 Cumhu	" 7, 440	" 19	
9–13– 9–0–0,	11 Ahau 8 Cumhu	" 2, 441	" 19	
9–13–10–0–0,	7 Ahau 3 Cumhu	Mar. 28, 442	" 19	Vernal Equinox

The two disk-shaped altars of Stela 5 have already been considered: they are of somewhat earlier workmanship than the stela. The initial series on Stela 5 arrives at a very interesting date. It is 9–13–14–0–15, 6 Men 18 Kayab, Mar. 22, 446. Now the month position 18 Kayab is prominent in the Dresden Codex in connection with the Venus calendar. In its declared position on this monument

it stands very close to the vernal equinox. There is at least one other date on Stela 5, namely 10 Ahau 3 Pax, 35 days earlier than the date already commented upon, or February 15, 447.

The dates of the Middle Period are closed with this stela and the reader will note the evidence of vast progress disclosed by the calculations on monuments of the Middle Period (9–10–0–0–0 to 9–15–0–0–0) over those of the Early Period. This intellectual advance comes out more clearly at Copan than at any other Mayan city.

The monuments of the Great Period begin with Stela A which has as its initial series the statement of the reciprocal date of September 6, along the original setting of the astronomical base line. It then reaches forward three uinals to a date which is three katuns after one of the dates on Stela I. There is also on Stela A a distance number leading from the initial series date to the end of the current katun. The gist of the calculation follows:

Stela A.	9–14–19– 8–0,	12 Ahau 18 Cumhu,	Apr. 5, 471
	3–0	subtract	
	9–14–19– 5–0,	4 Ahau 18 Muan,	Feb. 4, 471
	(3– 0– 0–0)		
Stela I.	(9–11–19– 5–0,	10 Ahau 13 Ceh,	Dec. 16, 411)
	(13–0)		
	(9–12– 0– 0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412)
Stela A.	9–14–19– 8–0,	12 Ahau 18 Cumhu,	Apr. 5, 471
	10–0		
	9–15– 0– 0–0,	4 Ahau 13 Yax,	Oct. 22, 471

Stela B gives us only the round-number date 9–15–0–0–0, 4 Ahau 13 Yax, Oct. 22, 471, and Altar S declares this date in conjunction with another five katuns in advance:

9–15–0–0–0,	4 Ahau 13 Yax, Oct. 22, 471
5–0–0–0	
10– 0–0–0–0,	7 Ahau 18 Zip, May 17, 570

Goodman argues that the date of Stela B was of tremendous importance to the Mayas because it lies in a significant position in a grand era of 341,640 years. This date is at the height of Mayan civilization, but it does not appear on as many monuments as several other katun ending dates. The inscription on Altar S contains several very suggestive glyphs of the ideographic type.

Stela D presents a simple initial series in complicated full-figure glyphs. This is 9–15–5–0–0, 10 Ahau 8 Chen, Sept. 25, 476. Also

on the sides are the glyphs of the 7th and 9th baktuns. Only five initial series in full-figure glyphs are known, two at Copan and three at Quirigua. Back of Stela D there are two hieroglyphic steps on Mound 2 which give two somewhat doubtful dates possibly connected with the date on the stela. They are, according to Morley,

9–14–16–11–8,	1 Lamat 16 Zotz,	June 28, 466
9–15–17– 0–0,	1 Ahau 8 Xul,	July 24, 488

Temple 26, approached by the Hieroglyphic Stairway, at the base of which was erected Stela M, must have made a most imposing sight when the Mayan civilization was in full flower. The temple itself carried an inscription in full-figure glyphs. The stairway had about 90 steps, of which only the lower 15 are in place, while another section of about the same number was found in a form which permitted restoration. Too great praise cannot be given to the painstaking efforts of Morley to restore the text of this great inscription which may well have covered the history of the city.

Morley recovered an imposing array of twenty-eight dates. Some of these are not quite complete, however, and can offer us no help in our present inquiry. The following dates are usable although a few of them are doubtful.

Steps in Place

Date	1	Step D	9– 5–19– 3– 0, 1– 5–15–18	8 Ahau 3 Zotz,	July 27, 294
"	2		9– 7– 5– 0– 8,	8 Lamat 6 Mac,	Jan. 21, 319
"	3	" E	9– 7– 5– 0– 8, 2– 9–16–17	8 Lamat 6 Mac,	Jan. 21, 319
"	4		9– 9–14–17– 5,	6 Chicchan 18 Kayab,	Apr. 10, 368
"	5	" F	9– 9–14–17– 5,	6 Chicchan 18 Kayab,	Apr. 10, 368
"	7	" H	9– 6– 4– 7–19,	9 Cauac 17 Yaxkin,	Oct. 8, 298
"	9	" K	9– 6– 4– 7–19, 7–14– 9–10	9 Cauac 17 Yaxkin,	Oct. 8, 298
"	8		9–13–18–17– 9,	12 Muluc 7 Muan,	Jan. 27, 451
"	10	" K+L	9–13–18–17– 9,	12 Muluc 7 Muan,	Jan. 27, 451

Steps in Sequence but not in Place

"	11	" P	9–15–12–10–10,	10 Oc 3 Cumhu,	Mar. 17, 483
"	12	" Q	9–15– 5–10–10, 6– 5–10	12 Oc 3 Pop,	Apr. 17, 476
"	13	" R	9–15–11–16– 0,	7 Ahau 13 Tzec,	July 11, 483
"	14	" S	9–15–11–16– 0,	7 Ahau 13 Tzec,	July 11, 483

DISCONNECTED FRAGMENTS

Date 15	Step (*a*)	9– 5–17–13– 7,	2 Manik 0 Muan,	Mar. 1, 292
" 21	" (*b*)	9–13–10– 0– 0,	7 Ahau 3 Cumhu,	Mar. 28, 442
" 22	" (*a*)	9–14–15– 0– 0, 11–14– 6	11 Ahau 18 Zac,	Nov. 17, 466
" 23	" (*b*)	9–15– 6–14– 6,	6 Cimi 4 Tzec,	July 3, 477
" 24	" (*b*)	9–13– 3– 7– 8,	1 Lamat 6 Chen,	Oct. 4, 435
" 25	" (*b*)	9–14–10–10–12,	9 Eb 10 Tzec,	July 13, 462
" 26	" (*b*)	9–15– 6–16– 5,	6 Chicchan 3 Yaxkin,	Aug. 10, 481

Of the four dates which are given twice by initial series the second pair repeats a date on Altar H′. It corresponds to April 10, 368, and therefore comes within a day of the beginning of the agricultural year. It is possible that some of the other dates given on this monument may also have an astronomical significance but the reader is warned against assuming that all Mayan dates are astronomical. It would be strange, indeed, if important historical events were not also recorded in their time sequence. The dates on the Hieroglyphic Stairway probably covered the outstanding events in 200 years of Copan history.

The most interesting date in the Hieroglyphic Stairway is one which occurs several times at Quirigua. This is 9–15–6–14–6, 6 Cimi 4 Tzec, July 3, 477. "The occurrence," says Morley,[1] "of such a date at two adjacent cities suggests that it marks an event common in the history of both; in a word, it is the first indication from the chronological side that more than one city participated in the same historical event."

Stela M, set like a sentinel at the base of the monumental stairway, was found in a badly shattered condition. The initial series is 9–16–5–0–0, 8 Ahau 8 Zotz, June 12, 496. No other dates are decipherable, if indeed they are recorded.

In reading the secondary series on Stela N at Copan, where the initial series is pretty clearly 9–16–10–0–0, 1 Ahau 3 Zip, May 18, 501, Morley differs widely from Goodman and Bowditch. He takes his lead from Stela 10 at Tikal, and makes the initial series on the Copan monument represent the last five positions of a number with nine degrees of value. Then he proceeds to subtract an apparent distance number of six degrees of value which forms the secondary series. Thus:

[1] *Inscriptions at Copan*, p. 258.

(1-1-11-19)-9-16-10-0-0,	1 Ahau 3 Zip
14-17-19-10-0-0	subtract
(1-1-11- 4)11-17- 0-0-0,	12 Ahau 13 Pax

The day reached by this subtraction is not declared so there is no direct proof of the spectacular recapitulation of higher values found on a single monument in a distant city. To be sure, Morley uses the same method on Stela C but the cases are not similar enough to support each other.

Goodman reads the date in a very different fashion. He holds that the terminal declaration 1 Ahau 8 Chen, is a period-ending date for 17 katuns. Now the fifth position in the secondary series is 17 and if the first four positions, 19-10-0-0 are considered to be a distance number we might have:

9-16-10-0-0,	1 Ahau 3 Zip,	May 18, 501
19-10-0-0	subtract	
8-17- 0-0-0,	1 Ahau 8 Chen,	Dec. 22, 116

The fact that the resulting date coincides with the winter solstice is a strong point in favor of this second solution.

On the pedestal or collar of Stela N there are two dates which have been deciphered in the following relation:

9-16-10-16-15,	11 Men 13 Pop,	Apr. 18, 502
2 -6- 0		
9-16-13- 4-15,	6 Men 3 Yaxkin,	Aug. 6, 504

The second of these dates recovers exactly the position in the natural year of the epoch of the Historical Era, namely 7-0-0-0-0, 10 Ahau 18 Zac, Aug. 6, 613 B.C.

Altar L, an unfinished monument, has two human figures of the type shown on the sculptures which deal with the astronomical congress of 503 and one of them is seated upon the hieroglyph of observation at the horizon. The date is pretty clearly:

9-16-11-0-5, 2 Chicchan 3 Zip, May 18, 502

Now this date has no special significance to us as it stands, but if we imagine the monument was set up to celebrate the completion of one katun after an important event then we would have as the date of this original subject:

9-15-11-0-5, 4 Chicchan 3 Mol, Aug. 30, 486

Altar L may have been intended, therefore, to memorialize the arrangement at Tikal on the basis of 9–15–10–0–0, 3 Ahau 3 Mol, Aug. 30, 481.

Two minor monuments which seem to register 8 Zac are Altars B′ and D′, the latter possibly giving 9–16–13–9–0, 13 Ahau 8 Zac, Oct. 29, 504, which would be very close to the restatement of the position of 0 Pop at the epoch of the Mundane Era. However, there are no indications that it was the intention to make such a restatement.

The monuments which record the date 6 Caban 10 Mol were clearly not sculptured at one time. Some of them mark the completion of an entire katun after the event which was probably the most important in the history of Copan. We have seen that the fame of this happening was conserved in the Mayan chronicles, written down in Spanish script more than a thousand years later.

Although not so highly embellished as many other monuments at Copan, Altar U has proved to be the most useful for the purposes of chronological reconstruction. It brings together a considerable number of significant dates and indicates something of the processes used in calculation. We are fortunate to have the careful readings of Morley made without our present end in view and therefore free from any suspicion of warping the evidence. The following is a transcription of Morley's statement:

	(9–14–19– 5– 0,	4 Ahau 18 Muan,	Feb. 4, 471)
	(13– 0),		
O–P 1	9–15– 0– 0– 0,	4 Ahau 13 Yax,	Oct. 22, 471
O–P 3	9–15– 8–10–12,	2 Eb 0 Pop,	Apr. 9, 480
L 5 M 1	9–15– 9– 0– 2,	9 Ik 10 Mol,	Sept. 6, 480
AB 1	9–15– 9–10–17,	3 Caban 0 Pop,	Apr. 9, 481
A 2	2–13– 0		
	(9–15–12– 5–17,	8 Caban 10 Mac,	Dec. 15, 483)
O 2	13– 0– 0	to be added to first date	
N 4	9–15–12– 5– 0,	4 Ahau 13 Ceh,	Nov. 28, 483
	9–15–12– 5– 7,	11 Manik 0 Mac,	Dec. 5, 483
I 1	1 –0– 0–10		
KL 1	9–16–12– 5–17,	6 Caban 10 Mol,	Sept. 2, 503

The first date is tied in with the record on Stela I and Stela A. The strategic value of the month position 13 Ceh has already received some comment. Here we have:

Stela I.	9–11–19–5–0, 3– 0–0–0	10 Ahau 13 Ceh,	Dec. 16, 411
Stela A.	9–14–19–5–0, 13–0–0	4 Ahau 18 Muan,	Feb. 4, 471
Altar U.	9–15–12–5–0,	4 Ahau 13 Ceh,	Nov. 28, 483
Stela 3.	9– 0– 0–0–0, 11– 0–0–0	8 Ahau 13 Ceh,	Feb. 10, 176
	9–11– 0–0–0, (5)	12 Ahau 8 Ceh,	Dec. 15, 392
	(9–11– 0–0–5,	4 Chicchan 13 Ceh,	Dec. 20, 392)

The beautiful Altar Q at Copan has sixteen human beings seated upon hieroglyphs arranged around its four sides, and its top surface is covered with six columns of glyphs, six glyphs in a column. The key date, 6 Caban 10 Mol, is shown on the center of one side between the only two human figures which face each other. We must omit consideration of the hieroglyphs upon which the figures are seated for they are probably the names of persons or towns.

Calculations on Altar Q

AB 1	5 Caban 15 Yaxkin,	9–15– 6–16–17, (3)	Aug. 23, 478
B 3–A 4	8 Ahau 18 Yaxkin,	9–15– 6–17– 0,	Aug. 26, 478
A 6		7–13 [1]	
CD 1	5 Ben 11 Muan,	9–15– 7– 6–13,	Jan. 24, 479
Front	6 Caban 10 Mol,	9–16–12– 5–17,	Sept. 2, 503
C 6		9–17– 0– 0– 0,	Mar. 27, 511
D 6–E 1	6 Ahau 13 Kayab,	9–17– 5– 0– 0,	Feb. 28, 516
E 5		3– 4	
E 6	5 Kan 12 [2] Uo,	9–17– 6– 3– 4,	May 3, 516

Except for 6 Caban 10 Mol no days in this series fall at positions of recognizable astronomical significance. One calendar round earlier the first two dates would be close to the autumnal stations. It is entirely within the field of probability that the heliacal risings and settings of important stars or constellations were noted as well as eclipses. On this altar there are three hieroglyphs containing a parrot's head in a form which suggests that this might be the sign

[1] Written 12.

[2] Written 13. Morley makes a plausible suggestion that the sculptor got his instructions mixed and reversed the order of 12 and 13 in these two places. The additions demand the numbers as given here.

of some important star. This glyph also appears at Tikal in calculations dealing with the calendrical correlation.

Altar T in satisfactory fashion memorializes the completion of one katun after the event which took place on 6 Caban 10 Mol. Thus:

9–16–12–5–17,	6 Caban 10 Mol,	Sept. 2, 503
1– 0– 0–0,		
9–17–12–5–17,	4 Caban 10 Zip,	May 20, 523

We see two humanized Cabans with 6 and 4 in their head-dresses, holding out their relative month positions.

Stela 8 carries on the record from 6 Caban 10 Mol for another katun, and then skips with some prophetic or anticipatory reference to the end of Baktun 10. The following dates are clear:

9–16–12–5–17,	5 Caban 10 Mol,	Sept. 2, 503
1– 0–0– 0	not declared	
9–17–12–5–17,	4 Caban 10 Zip,	May 20, 523
5	not declared	
9–17–12– 6–2,	9 Ik 15 Zip,	May 25, 523
10– 0– 0– 0–0,	7 Ahau 18 Zip,	May 17, 570

But if 4 Caban 10 Zip is the katun round from 6 Caban 10 Mol, September 2, then 9 Ik 15 Zip is the katun round from 11 Ik 15 Mol, September 7. It repeats the day Ik found on Altar U as 9 Ik 10 Mol, which was September 6. Thus:

9–15– 9–0–2,	9 Ik 10 Mol,	Sept. 6, 480
1– 3–6–0		
9–16–12–6–2,	11 Ik 15 Mol,	Sept. 7, 503
1– 0–0–0		
9–17–12–6–2,	9 Ik 15 Zip,	May 25, 523

The resetting of the autumnal station is treated on the small Altar V. Here there are two calendar-round dates, one being 6 Caban 10 Mol and the other 9 Cimi 14 Yaxkin. The former corresponded as we have seen to September 2, and 9 Cimi 14 Yaxkin was 9–16–5–3–6, corresponding to Aug. 17, 496. If we go back one calendar round before this position we find 9 Cimi 14 Yaxkin falling on August 29, and two calendar rounds before it comes within six days of the date on Stela 10, the western marker.

9-10-19-13-0,	3 Ahau 8 Yaxkin,	Sept. 6, 392
6		
9-10-19-13-6,	9 Cimi 14 Yaxkin,	Sept. 12, 392

Other minor objects at Copan with calendar-round dates appear to have been memorials of the significant astronomical discoveries. Thus:

Altar F′	9-17-4- 1-11,	2 Chuen 4 Pop,	Apr. 6, 515
" G′	9-15-4-17- 1,	4 Imix 9 Mol,	Sept. 6, 476

In the last case 0 Pop occupied the position April 10, so the association was a double one.

Altar Z has two calendar-round dates in the following possible relation:

9-16-18-9-19,	12 Cauac 2 Zac,	Nov. 11, 509 A.D.
1-8- 1	not recorded	
9-17- 0-0- 0,	13 Ahau 18 Cumhu,	Mar. 28, 511 A.D.

Altar G 3 has two calendar-round dates which fall on adjacent hotuns:

9-16-15-0-0,	7 Ahau 18 Pop,	Apr. 22, 506 A.D.
5-0-0	not recorded	
9-17- 0-0-0,	13 Ahau 18 Cumhu,	Mar. 28, 511 A.D.

They are probably correctly placed, but the first one, moved one calendar round later, becomes 9-19-7-13-0, 7 Ahau 18 Pop, April 9, 558 A.D. At this time 0 Pop would be March 22, practically coinciding with the vernal equinox, and 18 Pop would be April 9. This inscription pictures an interesting possibility but does not advance us along the road of proof.

Altar W probably records the arrangement expressed below, although the month glyph in the final date is either omitted or wrongly written.

9-17-5-0-0,	6 Ahau 13 Kayab,	Feb. 28, 516
9-4		
9-17-5-9-4,	8 Kan 12 Mol,	Aug. 31, 516

Altar R gives us the date of the astronomical conference and then counts back to a day 7 Ahau 3 Zip, placed in the year when 3 Caban 0 Pop fell on April 9. If we subtract one katun from this date the basic intention is disclosed. We have:

9–15–9–13–0,	7 Ahau 3 Zip,	May 22, 481
1–0– 0–0		
9–14–9–13–0,	9 Ahau 3 Mol,	Sept. 4, 462

Temple 11 was probably dedicated in connection with the astronomical activities of 503 A.D. at Copan. The step leading into the inner chamber has the date 16–15–12–5–17, 6 Caban 10 Mol, Sept. 2, 503, and the jamb of the north door declares 9–14–15–0–0, 11 Ahau 18 Zac, Nov. 17, 466. On the north side of Temple 11 we find Stela N which declares 9–16–10–0–0, 1 Ahau 3 Zip, May 18, 501. We find this month position treated on Altar R.

The hieroglyphic step on the south side of the pyramid of Temple 11, which Morley[1] calls the Reviewing Stand in the Western Court, probably belongs with the series of monuments now passing under discussion. Two calendar-round dates, each occurring in two places, are reasonably clear and the following arrangement is suggested although the required distance number is wanting.

9–17–0–0–0,	13 Ahau 18 Cumhu,	Mar. 27, 511
3–0		
9–17–0–3–0,	8 Ahau 13 Zip,	May 27, 511

Perhaps this inscription is intended to convey the relationship of vernal equinox and summer solstice in the nearest round numbers. There are other numerals connected with glyphs in the inscription, and it may have been the intention to give relationships with a number of other cycles or perhaps with astronomical points depending on heliacal risings. We see an ending-sign connected with Imix following a distance number which is two tuns, that is 720 days:

9–17–0–0–0,	13 Ahau 18 Cumhu,	Mar. 27, 511
2–0–0		
9–17–2–0–0,	5 Ahau 8 Cumhu,	Mar. 16, 513

Now it may have been the intention of the Mayan recorders to refer here to the repetition of 8 Cumhu the month position of their era at the end of a tun. Imix was the first day of the tzolkin and when used it might have referred to a longer cycle. Goodman suggests that the same superfix over the normal form of the cycle or baktun glyph was the calendar round of fifty-two years. In the

[1] 1920, pp. 321–323 and plate 30.

inscription before us the scroll detail occurs over a grotesque head in combination with the sky-earth-sun glyphs which we have seen on the monuments which record sunset observations.

There remain for consideration at Copan a number of important sculptures which represent the latest work at the city. The calculations are cryptic as might be expected from a people who had passed through the heyday of first discovery and acquired subtleties in mathematical technique. These monuments are Stelae C, 4, F and H.

As regards Stela C, the first glyph following the introducing glyph on both sides of the monument is probably thirteen cycles although Morley reads it eleven cycles. The thirteen might indicate infinity. On the south side of the stela this high period glyph is followed by the declaration 6 Ahau 18 Kayab, then, after three half-glyph blocks of other matter, comes the secondary series 11–14–5–1–0, which leads to 6 Ahau 13 Muan. This declaration is followed by a second record of 6 Ahau 18 Kayab.

This distance number 11–14–5–1–0 equals 1,686,620 days or 4,617 years and 297 days. Placing 6 Ahau 13 Muan at 9–14–0–0–0, 6 Ahau 13 Muan, Feb. 3, 452, and counting back this distance number we reach a position in the tropical year equal to April 12, or within three days of the beginning of the agricultural year. We have already seen that the Mayas were able to recover positions in the tropical year with a very slight error over long reaches of time.

Now on page 24 of the Dresden Codex, the famous introducing page to the perpetual ephemeris of Venus, is a statement of 9–9–9–16–0, 1 Ahau 18 Kayab, Apr. 12, 363, in obvious connection with 9–9–16–0–0, 4 Ahau 8 Cumhu, Apr. 22, 369, the end of 72 calendar rounds from the epoch of the era. The month position 18 Kayab in the passage on Stela C is recovered in the same place in the natural year, many centuries in the past.

Stela C.	9–14– 0– 0–0,	6 Ahau 13 Muan,	Feb. 3,	452 A.D.
	11–14– 5– 1–0			
	10–19–14–17–0,	6 Ahau 18 Kayab,	Apr. 12,	4,165 B.C.
Dresden Codex.	9– 9– 9–16–0,	1 Ahau 18 Kayab,	Apr. 12,	363 A.D.
	6– 2–0			
	9– 9–16– 0–0,	4 Ahau 8 Cumhu,	Apr. 21,	369

Perhaps the explanation of this date is concealed in the third

glyph below the introducing glyph (fig. 50). Here we see first an Imix symbol, then underneath it the face for eight (i. e., the face of the Maize God pictured twice on this monument in place of the numeral eight in declaration of 4 Ahau 8 Uo and 5 Ahau 8 Uo) and then, at the bottom of the left half of the glyph block, the sign for the planet Venus. The right half of the glyph block contains the sign for Imix over a bird face closely resembling forms which appear as the tun symbol. It is just possible this glyph refers to the eight-

TABLE XXVI. — TYPICAL VENUS CYCLES

Year in Venus Cycle			First Series		Second Series	
	Ahau	Kayab	A	B	A	B
1	1	18	9- 9- 9-16-0	9-14-15- 6-0	9-12- 2-11-0	9-17- 8- 1-0
9	9	18	9- 9-18- 0-0	9-15- 3- 8-0	9-12-10-13-0	9-17-16- 3-0
17	4	18	9-10- 6- 2-0	9-15-11-10-0	9-12-18-15-0	9-18- 4- 5-0
25	12	18	9-10-14- 4-0	9-15-19-12-0	9-13- 6-17-0	9-18-12- 7-0
33	7	18	9-11- 2- 6-0	9-16- 7-14-0	9-13-15- 1-0	9-19- 0- 9-0
41	2	18	9-11-10- 8-0	9-16-15-16-0	9-14- 3- 3-0	9-19- 8-11-0
49	10	18	9-11-18-10-0	9-17- 4- 0-0	9-14-11- 5-0	9-19- 6-13-0
57	5	18	9-12- 6-12-0	9-17-12- 2-0	9-14-19- 7-0	10- 0- 4-15-0
65	13	18	9-12-14-14-0	9-18- 0- 4-0	9-15- 7- 9-0	10- 0-12-17-0
73	8	18	9-13- 2-16-0	9-18- 8- 6-0	9-15-15-11-0	10- 1- 1- 1-0
81	3	18	9-13-11- 0-0	9-18-16- 8-0	9-16- 3-13-0	10- 1- 9- 3-0
89	11	18	9-13-19- 2-0	9-19- 4-10-0	9-16-11-15-0	10- 1- 7- 5-0
97	6	18	9-14- 7- 4-0	9-19-12-12-0	9-16-19-17-0	10- 2- 5- 7-0

year Venus cycle, the Imix carrying the idea of cycle by reason of its being the formal beginning day of the tzolkin.

It is obvious that the Mayan planetary tables are generalized. They give a pattern of relationships rather than concrete statements. But these tables must have been based on concrete observations and for 18 Kayab we are able to see about how the associations were built up. Conventional Venus years of 584 days were considered in groups of five, in correlation with groups of eight conventional solar years. A series of such $5 \times 584 = 8 \times 365$ day periods can be associated with two sets of dates in two calendar rounds with basic offsets of 4 years. One typical set in Table XXI begins with 9-9-9-16-0, 1 Ahau 18 Kayab, Apr. 12, 363, and terminates with 9-14-7-4-0, 6 Ahau 18 Kayab; the other set begins with 9-12-2-11-0, 1 Ahau 18 Kayab and terminates with

9–16–19–17–0, 6 Ahau 18 Kayab. In the adjoining table are two cycles of each type.

Not to go too deeply into the matter at this time, a series of days for inferior conjunction of Venus at 8-year intervals is next given. The equation of the Julian day and the Mayan day is accomplished by adding 489,384 to the latter.

TABLE XXVII. — INFERIOR CONJUNCTIONS OF VENUS IN EIGHT-YEAR INTERVALS

Julian Day	Gregorian Date	18 Kayab	0 Pop
1,878,586.6	431 Apr. 17	Mar. 26	Apr. 22
1,881,506.25	439 " 15	" 24	" 20
1,884,426.2	447 " 13	" 22	" 18
1,887,345.8	455 " 10	" 20	" 16
1,890,265.5	463 " 8	" 18	" 14
1,893,185.2	471 " 6	" 16	" 12
1,896,104.9	479 " 3	" 14	" 10
1,899,024.6	487 " 1	" 12	" 8
1,901,944.2	495 Mar. 29	" 10	" 6
1,904,863.9	503 " 26	" 8	" 5
1,907,783.6	511 " 24	" 7	" 3
1,910,703.3	519 " 22	" 5	" 1
1,913,623.0	527 " 19	" 3	Mar. 30
1,916,542.7	535 " 17	" 1	" 28
1,919,462.3	543 " 15	Feb. 27	" 26
1,922,381.9	551 " 12	" 25	" 24
1,925,301.6	559 " 10	" 23	" 22

The difficult inscription of Stela C at Copan probably concerns the planet Venus and may be a calculation to correct the error in the simple correlation of $5 \times 584 = 8 \times 365$. The mean synodical revolution of Venus is 583.92 days which gives a divergence from the true year of about 30 days in 104 years. We find the Venus glyph in association with Imix which might mean cycle, with the face of the Maize God used as 8 in two other places in the same inscription, and a modified tun face which may mean the true year.

Other dates on Stela C are:

9–16–19–2–0,	5 Ahau 18 Uo,	May 11, 510
9–17– 2–0–0,	5 Ahau 8 Cumhu,	Mar. 16, 513
9–17–11–5–0,	4 Ahau 18 Uo,	May 8, 522
9–17–12–0–0,	4 Ahau 18 Muan,	Jan. 23, 524

The first three dates are in the nature of an equation or shift from the statement of the Mundane Era, 4 Ahau 8 Cumhu, to 5 Ahau 18 Uo. First a shift to 8 Cumhu is made, the day not changing, then a shift to 4 Ahau is made, the month not changing. The last date is here placed one calendar round after its position on Stela A.

Stela H has only one date namely 4 Ahau 18 Muan. On the theory that this date is necessarily the date of dedication, Morley decides it must be 9–17–12–0–0, 4 Ahau 18 Muan.

Now it happens that the next previous occurrence of 4 Ahau 18 Muan is recorded on Stela A by an unmistakable initial series. While it is perfectly obvious that Stela H was carved at a later time than Stela A, it is not perfectly obvious that a sole date on a late Mayan sculpture is necessarily the date of dedication for this contemporary date may have been implied in some circumstance or statement, not apparent to modern students. There are indications that some of the later monuments of Copan celebrate accomplishments in mathematical and astronomical science, or perhaps calendar-round anniversaries of such matters.

Stela F raises the same questions. The declaration is very clearly 9–14–10–0–0, 5 Ahau 3 Mac, Dec. 13, 461, by the device of combining the date with a lahuntun symbol. There is also a declaration of the end of Katun 15, but nothing to give a hint of the subject considered in connection with these dates. Here again Morley assumes a calendar-round addition to reach a time late enough to explain the style of sculpture. He adds a calendar round to the katun ending declaration and obtains:

9–15– 0– 0–0,	4 Ahau 13 Yax,	Oct. 22, 471
2–12–13–0		
9–17–12–13–0,	4 Ahau 13 Yax,	Oct. 10, 523

The only circumstance in favor of the placing is the fact that October 10 is near the October 14 of the Mundane Era.

Stela 4 is obviously a fine late example of Copan art. But here too Morley's belief that dates are necessarily contemporaneous led to the suggestion that the last date should be advanced one calendar round from its most comfortable position, this last date being the same as the last date on Stela H. Perhaps there is good reason for the suggestion. This monument restates in two of its dates the epoch of the Historical Era, 7–0–0–0–0, 10 Ahau

18 Zac, Aug. 6, 613 B.C. First it records 9–8–15–0–0, 10 Ahau 8 Tzec, Aug. 8, 348 A.D., recovering the Mayan day and the approximate position in the year. Then 6 katuns are added and the month position 18 Zac is recovered in 9–14–15–0–0, 11 Ahau 18 Zac Nov. 17, 466. Meanwhile the exact statement of August 6 had taken place in 9–12–5–0–0, 3 Ahau 3 Xul, Aug. 6, 417, and the next recurrence was only one katun away in 9–15–15–0–0, 9 Ahau 18 Xul, Aug. 4, 486. The advancing of 4 Ahau 13 Yax gives a closer restatement of the epoch of the Mundane Era.

Some Inscriptions of Naranjo

The ruined city of Naranjo in eastern Peten boasts a large number of stelae and furnishes a considerable number of dates. The following record is nearly but not quite complete. For comparison, the reader is referred to Morley's Inscriptions of Naranjo.

The earliest date is on Stela 25 and closes with a date 445 years later. This early date is 8–5–18–4–0, 7 Ahau 3 Kankin, May 18, 102 B.C., which may, however, have some undisclosed relation to 9–7–0–0–0, 7 Ahau 3 Kankin, Feb. 8, 314, a date which very nearly reproduces the conditions of 9–0–0–0–0, 8 Ahau 13 Ceh, Feb. 10, 176 A.D. The final date on Stela 25 is 9–9–0–0–0, 3 Ahau 3 Zotz, July 13, 353.

Stelae 20, 21, 22, 23, 24, 28, 29, 30, and 31 form an earlier group in the Middle Period. The record for the first two runs:

Stela 20.	9–13–2–8–16,	7 Cib 14 Yax,	Nov. 1, 434
Stela 21.	9–13–9–3– 2,	8 Ik 5 Zip,	June 3, 441

The initial series on Stela 22 at Naranjo records 9–12–15–13–7, 9 Manik 0 Kayab, and at once attracts the attention because it does not give a round number of days. There is a hiatus of three days and then comes a long accurately presented calculation extending over a term of fifteen years. The first date is March 11, 428. The three days' hiatus brings this up to March 14, still far short of the vernal equinox. At no place in the calculation is there evidence of astronomical adjustment. These dates may refer, of course, to heliacal usings but the chances are that they record events in civil history. While astronomical dates are emphasized in this paper, ordinary historical events must also have been recorded.

9–12–15–13– 7,	9 Manik 0 Kayab,	Mar. 11, 428
3		
9–12–15–13–10,	12 Oc 3 Kayab,	Mar. 14, 428
5– 8– 9		
9–13– 1– 3–19,	5 Cauac 2 Xul,	Aug. 1, 433
1– 0		
9–13– 1– 4–19,	12 Cauac 2 Yaxkin,	Aug. 21, 433
4– 6		
9–13– 1– 9– 5,	7 Chicchan 8 Zac,	Nov. 15, 433
4– 9		
9–13– 1–13–14,	5 Ix 17 Muan,	Feb. 12, 434
1– 2–16		
9–13– 2–16–10,	5 Oc 8 Cumhu,	Apr. 4, 435
1– 3– 3		
9–13– 4– 1–13,	12 Ben 1 Zip,	May 30, 436
1– 3– 0		
9–13– 5– 4–13,	3 Ben 16 Tzec,	July 25, 437
1– 0– 4		
9–13– 6– 4–17,	3 Caban 15 Tzec,	July 24, 438
5– 7		
9–13– 6–10– 4,	6 Kan 2 Zac,	Nov. 8, 438
3– 0– 0		
9–13– 9–10– 4,	7 Kan 7 Yax,	Oct. 23, 441
1		
9–13– 9–10– 4,	8 Chicchan 8 Yax,	Oct. 24, 441
7–16		
9–13–10– 0– 0,	7 Ahau 3 Cumhu,	Mar. 28, 442

Stela 23 is only decipherable in part. A katun before May 23 we find September 6.

West side.	9–13–18– 4–18,	8 Eznab 16 Uo,	May 23, 450
	4–17		
	(9–13–18– 9–15),	1 Men 13 Yaxkin,	Aug. 28, 450
East side.	9–13–18– 4–18,	8 Eznab 16 Uo,	May 23, 450
	1– 1– 5		
	(9–13–19– 6– 3),	3 Akbal 16 Zip,	June 12, 451
	11–17		
	(9–14– 0– 0– 0),	6 Ahau 13 Muan,	Feb. 3, 452

Stela 24 may declare the summer solstice twice with tolerable accuracy.

Front.	(9–13– 7– 3– 8),	9 Lamat 1 Zotz,	June 20, 439

East side.	9-12-10- 5-12,	4 Eb 10 Yax,	Oct. 31, 422
	5- 7-15		
	(9-12-15-13- 7),	9 Manik 0 Kayab,	Mar. 9, 428
	11- 8- 1		
West side.	(9-13- 7- 3- 8),	9 Lamat 1 Zotz,	June 20, 439
	2-14-12		
	(9-13-10- 0- 0),	7 Ahau 3 Cumhu,	Mar. 28, 442

Stela 28 has a calendar-round date.

(9-12-19- 0- 0),	12 Ahau 13 Uo,	May 24, 432

Stela 29 is partly defaced. The repetition of the first date from Stela 24 is interesting. This date recovers the position 0 Pop at the epoch of the Mundane Era.

9-12-10- 5-12,	4 Eb	10 Yax,	Oct. 31, 422
3			
(9-12-10- 5-15),	7 Men	13 Yax,	Nov. 3, 422
5- 7-12			
(9-12-15-13- 7),	9 Manik	0 Kayab,	Mar. 9, 428
7- 4-13			
9-13- 3- 0- 0,	9 Ahau	13 Pop,	May 4, 435
1- 0- 0- 0			
(9-14- 3- 0- 0),	7 Ahau	18 Kankin,	Jan. 17, 455

Stela 30 begins with the same date that closes the record of Stela 29 and emphasizes it by repetition.

Front.	(9-14- 3- 0- 0),	7 Ahau 18 Kankin,	Jan. 17, 455
	(9-14- 2- 4- 0),	13 Ahau 3 Uayeb,	Apr. 14, 454
	(14- 0)		
	(9-14- 3- 0- 0),	7 Ahau 18 Kankin,	Jan. 17, 455
	9-14- 3- 0- 0,	7 Ahau 18 Kankin,	Jan. 17, 455
	3- 0- 0	subtract	
	(9-14- 0- 0- 0),	6 Ahau 13 Muan,	Feb. 3, 452
	1- 3-19		
	(9-14- 1- 3-19),	3 Cauac 2 Pop,	Apr. 18, 453
	(8-10)		
	(9-14- 1-12- 9),	4 Kan 12 Chen,	Oct. 5, 453

There are other dates too weathered to read. Stela 31 declares on the front:

(9-14-10- 0- 0),	5 Ahau 3 Mac,	Dec. 13, 462

A second series of dates at Naranjo fall during the Great Period and belong mostly to a newly built part of the city, except for Stela 32 which was placed in the commanding position in the old plaza. These monuments will be given in the order of their numerical designations.

Stela 5 at Naranjo carries a single calendar-round date. Morley placed this according to a scheme of association which in this particular instance was quite inconclusive. Here are two possibilities a calendar round apart.

9–17–13– 2–8,	9 Lamat 1 Cumhu,	Mar. 6, 523
2–12–13–0	(one calendar round)	
9–15– 0– 7–8,	9 Lamat 1 Cumhu,	Mar. 19, 472

In this case, other things being equal, a position within two days of the vernal equinox probably gives the true date of the monument.

Stelae 6, 7, and 8 stand before a single temple and the middle one, in the commanding position, carries the latest date. Note that 10 Ahau 18 Zac of the Historical Era is here stated in a two-part equation by 4 Ahau 18 Zac and 10 Ahau 8 Zac in accordance with examples at Copan.

Stela 6.		9–17– 1–0–0,	9 Ahau 13 Cumhu,	Mar. 22, 512
Stela 7.		9–19– 0–0–0,	9 Ahau 18 Mol,	Aug. 29, 550
		3–0		
		(9–19– 0–3–0),	4 Ahau 18 Zac,	Oct. 28, 550
Stela 8.	Front.	(9–18–13–0–0),	11 Ahau 13 Yax,	Oct. 5, 543
	Back.	9–18–10–0–0,	10 Ahau 8 Zac,	Oct. 20, 540

Stela 10, except for its initial date, is the same as Stela 7.

9–17– 0– 2–12,	13 Eb 5 Zip,	May 18, 511
1–19–15– 8,		
9–19– 0– 0– 0,	9 Ahau 18 Mol,	Aug. 29, 550
3– 0		
9–19– 0– 3– 0,	4 Ahau 18 Zac,	Oct. 28, 55.

Stela 11 has one decipherable date according to available information. It is the winter solstice:

9–17–18– 0– 0, 6 Ahau 8 Kankin, Dec. 22, 528

The dates in the long inscription on the back of Stela 12 at Naranjo are transferred into the Gregorian calendar as follows:

A 1 B 1	9–17– 0– 0–12,	12 Eb	5 Pop,	Apr. 8, 511
A 5 A 6	1– 8– 8– 0			
A 7	9–18– 8– 8–12,	8 Eb	5 Uo,	Apr. 21, 539
B 8	4			
A 9	9–18– 8– 8–16,	12 Cib	9 Uo,	Apr. 25, 539
B 14	2			
B 14 B 15	9–18– 8– 8–18,	1 Eznab	11 Uo,	Apr. 27, 539
D 4	2–13			
C 5	9–18– 8–11–11,	2 Chuen	4 Tzec,	June 20, 539
D 7	4–11			
C 8	9–18– 8–16– 2,	2 Ik	15 Chen,	Sept. 18, 539
C 11	2–11			
D 11	9–18– 9– 0–13,	1 Ben	6 Ceh,	Nov. 8, 539
D 14 C 15	8–15			
C 15 D 16	9–18– 9– 9– 8,	7 Lamat	16 Uo,	May 1, 540
E 3 F 3	4– 7			
F 3 E 4	9–18– 9–13–15,	3 Men	3 Yaxkin,	July 27, 540
F 11	4– 5			
E 12	9–18–10– 0– 0,	10 Ahau	8 Zac,	Oct. 20, 540

The initial date is within a day of the April 9 which perhaps may be considered the normal beginning of the ancient agricultural year, and June 20 may be intended for the solstice. The majority of the dates remain to be explained.

Stela 13 does not offer anything of outstanding significance:

Front	(9–17–10– 0– 0),	12 Ahau	8 Pax,	Feb. 2, 521
Back	(9–17–10– 0– 0),	12 Ahau	8 Pax,	Feb. 2, 521
	10–13–10			
	(9–18– 0–13–10,	3 Oc	8 Zip	May 16, 531

Stela 14. The date on the back is probably intended for the farmer's New Year day, while the two katun-ending dates are interesting approximations.

Front	9–17– 0– 0– 0,	13 Ahau	18 Cumhu,	Mar. 27, 511
Back	9–17–13– 4– 3,	5 Akbal	11 Pop,	Apr. 10, 524
	10–13– 3			
	(9–18– 3–17– 6,	7 Cimi	4 Ceh,	Nov. 7, 533)
	9–18– 0– 0– 0,	11 Ahau	18 Mac,	Dec. 12, 530

Stela 19 repeats 9–17–10–0–0, 12 Ahau 8 Pax, Feb. 2, 521.

Stela 32, the latest and perhaps the finest of the monuments at

Naranjo carries the following series of dates, the last set being incised on the bottom of the throne.

First date illegible. Second date illegible.

9–19– 3– 4– 1,	13 Imix 4 Ceh,	Nov. 2, 553
14–19		
9–19– 4– 1– 0,	13 Ahau 18 Mol,	Aug. 28, 554
1		
9–19– 4– 1– 1,	1 Imix 19 Mol,	Aug. 29, 555
5–13–19		
9–19– 9–15– 0,	13 Ahau 8 Zip,	May 9, 559
3– 0,		
9–19–10– 0– 0,	8 Ahau 8 Xul,	July 8, 559
9–19– 4–15– 1,	8 Imix 14 Zotz,	June 4, 556
12–11		
9–19– 5– 9–12,	12 Eb 5 Kayab,	Feb. 10, 557

Here the leading dates are illegible in the published photograph. If the first one were 9–19–0–0–0, 9 Ahau 18 Mol, it would correspond to August 29. Four years later it has slipped down to August 28 and one day is added to pull it back. But this date 9–19–0–0–0, 9 Ahau 18 Mol belongs to a memorable series giving approximations to the autumnal station, which began with 9–1–10–0–0, 5 Ahau 3 Tzec, Sept. 7, 205, and proceeded with a cycle of three and a half katuns. The final date is the Era of the Chronicles after 381 years.

The blocks on the Hieroglyphic Stairway at Naranjo yield a number of dates. This ornamented stairway has twelve groups of glyphs, which Maler numbers Inscription 1, 2, etc. They begin at the left-hand side of the second step with number 1. In the middle of this step are three jaguar heads, on either side of which are Inscriptions 5 and 6 of somewhat larger size than the others. Inscriptions 11 and 12 are on the ends of the fourth step. Block 8 was broken in ancient times and repaired by a portion of a lintel with an inscription which curiously enough has one date the same as the stairway inscriptions proper. The calculations in several places proceed from suppressed dates, only a distance number being given which leads to the next date stated in full. There are at least three or four inscriptions which are unrelated so far as connective distance numbers are concerned and it is a problem to decide whether

or not these should be placed in the nearest arrangement to the dates which are exactly designated in the long count. Such foot-loose dates would recur at intervals of fifty-two years.

The first distance number leads up to the initial series from a suppressed date. The second one leads up to a katun-ending day, which is ten tuns earlier than the initial series and is counted from another suppressed beginning day. Morley suggests that this position might really come three calendar rounds later, but in its present place it stands at March 30, pretty close to the vernal equinox for a katun ending, and in the preceding Inscription 5 we see a fine glyph with the half-dark, half-light kin sign of the equinox. The third statement begins slightly before the second one, in the nearest location, and covers one day more than a tzolkin round. Here the distance number is counted from a suppressed base to a date with the day and month-signs far from clear. The fourth date, if placed in its nearest location to the others, has no special seasonal significance, although it is counted from 0 Pop. But if this is put two calendar rounds later, it coincides exactly with the day when 0 Pop is counted in order at the beginning of the agricultural year according to Altar U at Copan. This New Year date is suppressed, although the essential fact may have been contained in a descriptive hieroglyph. The coincidence is too strong to be dismissed as accidental and might very well mean that the people of Naranjo had made a local record of the result reached at Copan. Two other dates are tied into this calculation and tend to corroborate it. One comes within a few days of the winter solstice while the last one strikes a position in the Gregorian year within two days of a position recorded in another part of the stairway for a date 110 years earlier. The complete statement follows:

Insc.	1	Nothing decipherable			
"	2	Nothing decipherable			
"	3	Nothing decipherable			
"	4	(9–10– 0– 9–10,	9 Oc	13 Mol),	Oct. 6, 374
		9– 8–10			
"	5	9–10–10– 0– 0,	13 Ahau	18 Kankin	Feb. 6, 383
"	6	(9– 9–17–11–14,	9 Ix	7 Zac),	Nov. 30, 370
		1– 4 9			
		9– 9–18–16– 3,	7 Akbal	16 Muan,	Feb. 26, 372
		1– 1–17			
		9–10– 0– 0– 0,	1 Ahau	8 Kayab,	Mar. 30, 373

Insc. 7	(9– 9–14– 8– 9, 13– 1	12 Muluc	2 Mol),	Sept. 27, 367
	9– 9–15– 3–10,	13 Oc	18 Zip,	July 4, 368
" 10	(9–15– 8–10–12, 1–13–10	2 Eb	0 Pop),	Apr. 9, 480
	9–15–10– 6– 2, 14– 2	8 Ik	5 Kankin,	Dec. 30, 481
	9–15–11– 2– 4,	4 Kan	2 Yax,	Oct. 8, 482

The reused part of a lintel, which pieced out the broken block of Inscription 8, reads as follows:

9– 7–14–10– 8, 2– 5– 7–12	3 Lamat 16 Uo,	June 22, 328
9–10– 0– 0– 0,	1 Ahau 8 Kayab,	Mar. 30, 373

This first date coincides with the summer solstice to the day, and the katun ending reached by the distance number is an approximation of the vernal equinox, remarkably close for such an important round number. We have seen this same date in the Inscription 6 of the Hieroglyphic Stairway. Perhaps this early piece was intentionally introduced in the stairway as a relic of antiquarian interest.

Some Dates at Yaxchilan

The great ruin of Yaxchilan [1] has a considerable number of dated monuments and buildings but no long texts. The earliest date at Yaxchilan is recorded on Lintel 21, but it moves forward more than fifteen katuns:

9– 0–19– 2–4, 15– 1–16–5	2 Kan 2 Yax,	Dec. 17, 194
9–16– 1– 0–9,	7 Muluc 17 Tzec,	July 12, 492

These dates are 315 years apart and at almost opposite sides in the Gregorian year. The last one is just 9 days after a date reached on other monuments about to be considered.

Stela 1 at Yaxchilan records 9–16–10–0–0, 9 Ahau 3 Zip, May 18, 501. Stela 6 has an initial series reading 9–11–3–10–13, 5 Ben 1 Zotz, June 30, 395. The so-called altar near Structure 44 has:

[1] For a correlation of the monuments published by Maudslay with the designations of Maler which are used here, see the author's *Maya Art*, pp. 259–260.

9–12–8–14–1,	12 Imix 4 Pop,	Apr. 28, 420
12–0	subtract	
9–12–9– 8–1,	5 Imix 4 Mac,	Dec. 24, 421

A round altar near Structure 19 has a date 9–15–15–0–0, 9 Ahau 18 Xul, Aug. 4, 486, as well as others which cannot be read on the available photograph.

The so-called altar near Structure 44 has a clear initial series and a secondary series, namely:

9–12–8–14–1,	12 Imix 4 Pop,	Apr. 28, 420
12–0		
9–12–9– 8–1,	5 Imix 4 Mac,	Dec. 24, 420

Although slightly out of position, the last date was probably intended for the winter solstice.

The beautiful Stela 11 at Yaxchilan furnishes four dates. The event in nature this inscription is intended to refer to was probably one related to the tropical year, because we find in the second and third entries exactly the same location four years apart. One day is added to the previous month position to overcome the absence of leap-year correction:

Front	9–15– 9–17–16,	12 Cib 19 Yaxkin,	Aug. 26, 480
Front	9–15–15– 0– 0,	9 Ahau 18 Xul,	Aug. 4, 486
Back	9–15–19– 1– 1,	1 Imix 19 Xul,	Aug. 4, 490
I. Ser.	9–16– 1– 0– 0,	11 Ahau 8 Tzec,	July 3, 492

The last date marks a point in the tropical year strongly emphasized at Quirigua.

Stela 12 has two calendar-round dates one of which is the final day reached by the initial series on Stela 11. Bowditch places this date one calendar round later than the position indicated on Stela 11 and while his arguments do not appear conclusive, the possible significance is enhanced. The first date almost recovers the epoch of the Historical Era and the second one is exactly the summer solstice. The calculation is as follows:

9–15–10–17–14,	6 Ix 12 Yaxkin,	Aug. 19, 481
10– 0– 6		
9–16– 1– 0– 0,	11 Ahau 8 Tzec,	July 3, 492

9–18– 3–12–14,	6 Ix 12 Yaxkin,	Aug. 7, 533
10– 0– 6		
9–18–13–13– 0,	11 Ahau 8 Tzec,	June 22, 543

On Lintels 27 and 28 the same date, 6 Ix 12 Yaxkin, is treated possibly in the position one calendar round earlier than the first one given above. This would give:

9–12–18– 4–14,	6 Ix 12 Yaxkin,	Sept. 1, 430
10– 0– 6		
9–13– 8 –5– 0,	11 Ahau 8 Tzec,	July 16, 440

It must be apparent that an interval nicely adjusted to various interested approximations is under treatment here.

Stela 18 has a calendar-round date which is in all probability 9–16–5–4–6, 3 Cimi 14 Mol, Sept. 6, 496. This date shows clearly enough that all Mayan cities had a community of interest in scientific matters. Stela 19 has a calendar-round statement which must be one of the two given below:

9–17–14– 4–0,	11 Ahau 3 Pop,	Apr. 2, 525
2–12–13–0		
9–15– 1– 8–0,	11 Ahau 3 Pop,	Apr. 14, 472

Stela 20 has a calendar-round date which contains an obvious error. The day-sign is clearly 6 Ix and the month-sign is 16 Zotz or 16 Kankin, which must be changed to 17 in order to go with the day Ix. It seems hardly worth while to consider the multiple possibilities.

Yaxchilan has many carved lintels which are often dated by calendar-round declarations.

Structure 16 at Yaxchilan has Lintels 38, 39, and 40 which Bowditch places as follows:

Lintel 40.	9–15–17– 1–19,	1 Cauac	7 Mol,	Sept. 1, 489
" 38.	9–16– 1–15–13,	12 Ben	16 Uo,	May 12, 492
" 39.	9–16– 3– 3– 6,	4 Cimi	4 Mol,	Aug. 28, 494

The first of these dates is evidently the second location of the autumnal station with which the last one may also have been related in some way or other. There is a possibility that the first date should be read 3 Ix 7 Mol which would be found at 9–16–12–5–14 just 3 days before the famous 6 Caban 10 Mol of Copan. Was this a rival scheme for the calendar? We have before us a date 4 Cimi 4 Mol and on Lintel 14 in Structure 20 is a date in a corresponding position, namely 4 Imix 4 Mol, just one day after the 3 Ahau 3 Mol

at Tikal. This date therefore equals 9–15–10–0–1, 4 Imix 4 Mol, Aug. 31, 481.

Lintels 1, 2, and 3 are in Structure 33. Lintel 1 gives a clear declaration of 11 Ahau 8 Tzec already found at 9–16–1–0–0, July 3, 492. Lintel 2 may be 9–16–6–0–0, 4 Ahau 3 Zotz, June 7, 497. There is also on this monument a record of 3 katuns. Lintel 3 gives 8 Ahau 8 Zotz, occurring at 9–16–5–0–0, and equalling June 12, 496. There are two statements of three katuns which may be added or subtracted.

Lintels 5, 6, and 7 are in Structure 1. Lintel 5 may be 9–16–1–2–0, 12 Ahau 8 Yaxkin, Aug. 12, 492. Two calendar rounds earlier this date was Sept. 7, 488. Lintel 6 may be 9–16–1–8–6, 8 Cimi 14 Mac, Dec. 16, 492. For Lintel 7 Bowditch suggests either

9–15–19–15–3,	10 Akbal 16 Uo,	May 12, 491

or

9–15– 8– 5–3,	10 Akbal 16 Mac,	Dec. 22, 479

The last date is more likely, because it exactly reaches the winter solstice.

Passing by a number of lintels that offer nothing that can be relied upon we come to Lintels 12, 13, and 14 in Structure 20. On the last of these is the 9–15–10–0–1, 4 Imix 4 Mol, Aug. 31, 481, already referred to. This comes in a year when 0 Pop falls on April 9, and the recorded date is very close to the reciprocal station, September 2.

On the front, Lintel 26 in Structure 23 had an initial series which has not been read safely. The month position seems to be 8 Yaxkin which might easily occupy a significant position but the katun is probably 14 which would be too late. In connection with the same Structure 23 there were two beautiful lintels now in the British Museum (Maudslay, plates 86–89). The date on the first of these is pretty clearly 9–16–10–10–12, 5 Eb 15 Mac, Dec. 16, 501. Now on Lintel 6, it will be remembered, we found a possible 9–16–1–8–6, 8 Cimi 14 Mac, Dec. 16, 492, and on another lintel in the same building Dec. 22, 479 was reached. In Structure 23, Lintel 25 has 5 Imix 4 Mac, a date appearing on the Altar near Structure 44 as 9–12–9–8–1, 5 Imix 4 Mac, Dec. 24, 420. If we add to this date the distance number which opens the inscription on the outer face of Lintel 25 we obtain:

9–12– 9– 8–1,	5 Imix 4 Mac,	Dec. 24, 420
2– 2– 7–0		
9–14–11–15–0,	3 Imix 14 Chen,	Oct. 5, 463

Bowditch read the date on the outer face of this lintel as 3 Imix 14 Zac but the knotted superfix over the Cauac element is a sure indication of Chen (possibly because 0 Chen at the epoch of the era corresponded to April 9). Now we have no certain evidence that the count was made in the exact calendar round given above. The style of carving would demand a somewhat later contemporary date. We may have, therefore:

9–15–2– 3–1,	5 Imix 4 Mac,	Dec. 11, 472
2–2– 7–0		
9–17–4–10–0,	3 Imix 14 Chen,	Sept. 23, 515

The count proceeds directly to the autumnal equinox.

Lintel 23, now in Berlin, has an obvious mistake. According to the number the date should be 1 Imix 19 Zotz whereas it is clearly 7 Imix 19 Zip, one uinal earlier. The last date is preferable since it involves only one error and we have:

9–15– 6–13– 1,	7 Imix 19 Zip,	June 8, 477

If this number were correct, the position reached would be June 28, 477.

In Structure 24 are Lintels 27 and 28. Bowditch transcribes the calculation in the first of these as:

9– 8– 8– 4– 5,	6 Chicchan 8 Zac,	Dec. 8, 341
1–17– 5– 9		
9–10– 5– 9–14,	6 Ix 12 Yaxkin,	Sept. 14, 378
6–13–10		
9–10–12– 5– 4,	5 Kan 7 Pop,	May 10, 385

This is made on the supposition that 8 katuns is indicated. The second lintel may be calculated from the middle date above:

9–10– 5– 9–14,	6 Ix 12 Yaxkin,	Sept. 14, 378
8–15– 9		
9–10–14– 7– 3,	10 Akbal 16 Uo,	June 8, 387
4– 9–14		
9–10–18–16–17,	6 Caban 10 Zac,	Nov. 28, 391

On Stela 12 the date 6 Ix 12 Yaxkin is two or three calendar rounds later than the position given here which rests upon weak evidence. One calendar round later brings the pivotal date 6 Ix 12 Yaxkin directly on the second setting of the autumnal station which seems to have come into usage as a result of the approximation of 9–12–0–0–0, 10 Ahau 8 Yaxkin, Sept. 1, 412.

9–10– 5– 9–14,	6 Ix 12 Yaxkin,	Sept. 14, 378
2–12–13– 0		
9–12–18– 4–14,	6 Ix 12 Yaxkin,	Sept. 1, 430

The other dates in the arrangement suggested by Bowditch should be advanced one calendar round and reduced by 12 or 13 days as regards their positions in the natural year.

Lintel 29 has an initial series with the Venus sign in the introducing glyph. It records 9–13–17–12–10, 8 Oc 13 Yax, Oct. 27, 449. This lintel occurs in Structure 10 along with Lintels 30, 31, and 32. The date on Lintel 30 is one month earlier than that on Lintel 29, namely 9–13–17–11–10, 1 Oc 13 Chen, Oct. 7, 449. This second date taken one calendar round later becomes:

9–13–17–11–10,	1 Oc 13 Chen,	Oct. 7, 449
2–12–13– 0		
9–16–10– 6–10,	1 Oc 13 Chen,	Sept. 25, 501

Lintels 30 and 31 have inter-related calculations which put a different complexion on this matter. The addition runs:

Lintel 30.	9–13–16–10–13,	1 Ben 1 Chen,	Sept. 25, 448
	1– 0–17		
	9–13–17–11–10,	1 Oc 13 Chen,	Oct. 7, 449
	2– 3– 6–10	(written 2–3–5–10)	
	9–16– 1– 0– 0,	11 Ahau 8 Tzec,	July 3, 492
Lintel 31.	12– 0– 0		
	9–16–13– 0– 0,	2 Ahau 8 Uo,	May 2, 504
	7– 0– 0		
	9–17– 0– 0– 0,	13 Ahau 18 Cumhu,	Mar. 27, 511

While it is pretty clear that the 1 Oc 13 Chen is to be placed on October 7, its position one calendar round earlier is indicated by 1 Ben 1 Chen. In other words 12 days are here allowed for the neglected intercalation in a calendar round.

Lintel 32 as well as Lintel 33 is in the same building as the ones just considered. The former seems to declare the end of Katun 18 by a calendar-round date:

9–18–0–0–0, 11 Ahau 18 Mac, Dec. 12, 530

The latter has 5 Cimi 14 Yaxkin, which is probably intended for 9–16–1–2–6, 5 Cimi 14 Yaxkin.

Lintels 34, 35, 36, and 37 in Structure 12 are in a peculiar style which offers small hope of decipherment. The first is broken and partly missing and has never been photographed. Lintel 35 is in the British Museum (Maudslay, Plate 79*b*). Lintel 36 is badly weathered and 37 is pictured by both Maler and Maudslay. Lintel 37 may contain a date 1 Cauac 7 Yaxkin. Lintel 36 has a pretty clear 1 Cimi 14 Muan. There are some interesting signs involving elements used in calculating from the epochs.

We have already considered Lintels 38 to 40 in Structure 16.

Lintels 41, 42, and 43 belong to Structure 42. The first has a day 13 Ahau 8 Yaxkin. The second has a day Cimi (the coefficient being destroyed) on 14 Mac, and the third is 7 Imix 14 Tzec connected, apparently, with the end of a Venus count. From the style of sculpture these lintels must be among the latest at Yaxchilan.

Structure 44 contains Lintels 44, 45, and 46 from which no exact dates can be gleaned. This survey of Yaxchilan dates leaves much to be desired. Nevertheless it shows some interesting astronomical calculations. One thing noticeable is the prevalence of dates with Imix instead of Ahau, or with the first of the series of day-signs rather than the last.

Dates at Quirigua

The terminal dates on the monuments of Quirigua fall in a neat series with a five-tun interval unbroken from 9–15–15–0–0, 9 Ahau 18 Xul, Aug. 4, 486 to 9–19–0–0–0, 9 Ahau 18 Mol, Aug. 29, 550. Except in rare cases of approximation it would be too much to expect such dates to lie at the astronomical points of the year. The range of these terminal dates probably does not give us a correct idea of the range of occupation of Quirigua as a city. As a matter of fact there is an earlier date which occurs on several inscriptions and is the most prominent date at Quirigua. This is 9–14–13–4–17,

12 Caban 5 Kayab corresponding to Mar. 4, 465. It has been suggested that this date refers to the founding of Quirigua as a colony of Copan. This theory no longer seems likely in view of the recent discovery of two weather-worn stelae on the crest of the hill north of the principal ruins at Quirigua. A second prominent date at this city is 9–15–16–14–6, 6 Cimi 4 Tzec, July 3, 478. This date also occurs on the Hieroglyphic Stairway at Copan and seems to be a strong link between the two cities.

Calculations reaching important points of the astronomical year are less prominent at Quirigua than at any other great Mayan cities. One date, which may be an attempt to reach the summer solstice, falls five days short of it. This is 9–15–9–14–6, 8 Cimi 9 Zotz and it may be significant that it falls in a year when 0 Pop is April 9. Two approximations which appear to be put into the record on certain monuments because of their seasonal bearing are 9–15–10–0–0, 3 Ahau 3 Mol, Aug. 30, 481, which figures prominently at Tikal and is pretty close to the second station of the farmer's year; and 9–15–5–0–0, 10 Ahau 8 Chen, Sept. 25, 476, which is within two days of the autumnal equinox. Still more important is 9–18–15–0–0, 3 Ahau 3 Yax, Sept. 24, 545. The calculations on the more important monuments of Quirigua have been subjected to critical examination by Goodman, Bowditch, and Morley.

The terminal dates on the monuments of Quirigua are distributed in this fashion:

Stela S.	9–15–15–0–0,	9 Ahau	18 Xul,	Aug.	4, 486
" H.	9–16– 0–0–0,	2 "	13 Tzec,	July	9, 491
" J.	9–16– 5–0–0,	8 "	8 Zotz,	June	12, 496
" F.	9–16–10–0–0,	1 "	3 Zip,	May	18, 501
" D.	9–16–15–0–0,	7 "	18 Pop,	Apr.	22, 506
" E.	9–17– 0–0–0,	13 "	18 Cumhu,	Mar.	28, 511
" A.	9–17– 5–0–0,	6 "	13 Kayab,	Feb.	28, 516
" C.	9–17– 5–0–0,	6 "	13 Kayab,	Feb.	28, 516
Altar B.	9–17–10–0–0,	12 "	8 Pax,	Feb.	2, 521
" G.	9–17–15–0–0,	5 "	3 Muan,	Jan.	7, 526
" O.	9–18– 0–0–0,	11 "	18 Mac,	Dec.	12, 530
" P.	9–18– 5–0–0,	4 "	13 Ceh,	Nov.	16, 535
Stela I.	9–18–10–0–0,	10 "	8 Zac,	Oct.	20, 540
" K.	9–18–15–0–0,	3 "	3 Yax,	Sept.	24, 545
Temple 1.	9–19– 0–0–0,	9 "	18 Mol,	Aug.	29, 550

We will take up the monuments of Quirigua in the order of their terminal dates. We are not able to give the date for the two weather-worn stelae before the little temple on the crest of the hill, but believe that they go back as far as 9–12–0–0–0. Stela S is also badly weather worn and nothing can be deciphered on it except the initial series.

Stela H has an inscription with strips of glyphs arranged in plaited form similar in general to that of Stela J at Copan but not so complicated. Nothing except the initial series can be deciphered with certainty although there seems to be statement near the bottom of two tuns reaching a day with a coefficient four.

Stela J at Quirigua has an inscription of much technical interest. The calculation written out or left to be inferred takes the form given below. The last date in this arrangement is the one presented in the initial series where face-variant numerals replace the ordinary bars and dots. 8 Ahau is repeated but no other recognizable calendrical signs are in evidence. The Venus symbol is found, and many cyclic signs.

	9–14–13– 4–17,	12 Caban	5 Kayab,	Mar. 4, 465
	0–11–13– 3			
	9–15– 5– 0– 0,	10 Ahau	8 Chen,	Sept. 25, 476
	1–14– 6			
	9–15– 6–14– 6,	6 Cimi	4 Tzec,	July 3, 478
	18– 3–14			
I. Ser.	9–16– 5– 0– 0,	8 Ahau	8 Zotz,	June 12, 496

The reference to two hotun endings one katun apart is especially interesting in view of the fact that the first of these is within two days of the autumnal equinox. In this period the 360-day tun advances more than a quarter of a year and reaches a point in front of the summer solstice. This layout suggests the more accurate one registered on Stela J at Copan.

The dates on Stela F at Quirigua [1] begin on the west side with an initial series found on other monuments. With the exception of the day 3 Ahau 3 Mol which occurs in the same position as on the Tikal monuments and comes within two or three days of the September astronomical station, none of the dates seems at first glance to have solar significance. But after the declaration of the 9–16–

[1] In the numbering of the glyphs, Maudslay's notation is not followed. Instead, the designation is in columns A and B with the introducing glyphs counted as 1 and 2 in each column.

10–0–0 on the bottom of the west side there is a 13 Ahau preceded by the so-called lahuntun glyph. The nearest 13 Ahau to this half-katun ending falls on April 8, the farmer's New Year day. This tying-in of a round number in the long count to an astronomically ascertained point in the tropical year by an hitherto unexplained date in the simple permutation is decidedly suggestive.

I. Ser.	9–14–13– 4–17,	12 Caban 5 Kayab,	Mar. 4, 466
B 10	13– 9– 9		
B 11 A 12	(9–15– 6–14– 6),	6 Cimi 4 Tzec,	July 3, 478
	(3– 3–14)		
A 15	(9–15–10– 0– 0),	3 Ahau 3 Mol,	Aug. 30, 481
	(10– 0– 0),	subtract	
A 17	(9–15– 0– 0– 0),	4 Ahau 13 Yax,	Oct. 22, 471
B 17 A18	1–16–13– 3		
A 18 B 18	(9–14–13– 4–17),	12 Caban 5 Kayab,	Mar. 4, 466
AB 19	(9–16–10– 0– 0),	1 Ahau 3 Zip,	May 18, 501
	(2– 0),	subtract	
B 19	(9–16– 9–16– 0),	13 Ahau (3 Pop),	Apr. 8, 501

The inscription on the east side of the monument begins by the declaration in an initial series of the half-katun ending found at the bottom of the west side. The day reached is 1 Ahau 3 Zip and in the remaining part of the inscription other dates with 1 Ahau are given. We have here an attempt to attain approximations in a permutation cycle. An interesting feature to be noted is that in all these cases the coefficient one of 1 Ahau is indicated by a thumb. The first date after the initial series is the day 1 Ahau without an accompanying month glyph. If we count back one tzolkin from the final date of the initial series we reach a day corresponding to August 31 and therefore very close to the autumnal station of the agricultural year. Following this there are two other declarations in somewhat unusual form and associated with cyclic glyphs of unknown significance. The first occurrence of these calendar-round dates before the terminal date of the monument is given in the table which follows:

I. Ser.	9–16–10– 0–0,	1 Ahau 3 Zip,	May 18, 501
	(13–0),	1 tzolkin 260 days	
B 10	(9–16– 9– 5–0),	1 Ahau (8 Mol),	Aug. 31, 500
	(5– 1–0),	7 tzolkins 1820 days	
B 14	(9–16– 4– 4–0),	1 Ahau 13 Mol,	Sept. 6, 495
	(1–12– 9–0),	45 tzolkins 11,700 days	
B 16 A 17	(9–14–11–13–0),	1 Ahau 13 Yaxkin,	Aug. 25, 463

On Stela D we find two initial series in the complicated style with full-figure glyphs. That on the west side is 9–16–13–4–17, 8 Caban 5 Yaxkin, Aug. 7, 504, exactly two katuns later than 9–14–13–4–17, 12 Caban 5 Kayab, Mar. 4, 465, which has appeared on other monuments. The initial series on the east side is 9–16–15–0–0, 7 Ahau 18 Pop, Apr. 22, 506. The distance number to connect these two dates is probably recorded on the west side. It would be 1–13–3 and we see in glyph 20 on Maudslay's plate three kins and thirteen uinals and there is room for a tun with 1 at the left. The tun with 5 in the lower section may have some special significance.

Again there is a harping on the recurrence of the day. In the third glyph after the month declaration of the initial series we see a day 7 Ahau with ending-signs and a winged Cauac. Three glyphs still farther on is what looks like thirteen cycles, or perhaps thirteen great cycles, and a declaration of 7 Ahau 3 Pop. Then at the bottom we find again 7 Ahau 18 Pop of the initial series. 7 Ahau 3 Pop in its nearest position before and after the initial series approximates the spring station. Of these the position before the terminal date seems the more likely.

9–14–17– 8–0,	7 Ahau 3 Pop,	Apr. 15, 469
2–12–13–0		
9–17–10– 3–0,	7 Ahau 3 Pop,	Apr. 3, 521

The calculations on Stela E are given in their chronological order in the table below. Actually the initial series on the west side records 9–16–13–4–17, 8 Caban 5 Kayab and that on the east side 9–16–15–0–0, 7 Ahau 18 Pop. Distance numbers are omitted in two places but the record is sufficiently clear.

9–14–13– 4–17,	12 Caban 5 Kayab,	Mar. 4, 465
6–13– 3		
9–15– 0– 0– 0,	4 Ahau 13 Yax,	Oct. 22, 471
5– 0– 0,	not recorded	
9–15– 5– 0– 0,	10 Ahau 8 Chen,	Sept. 25, 476
1–14– 6		
9–15– 6–14– 6,	6 Cimi 4 Tzec,	July 3, 478
3– 0– 0,	not recorded	
9–15– 9–14– 6,	7 Cimi 9 Zotz,	June 17, 481
1– 1–16–15		
9–16–11–13– 1,	11 Imix 19 Muan,	Jan. 29, 503
8– 4–19		
9–17– 0– 0– 0,	13 Ahau 18 Cumhu,	Mar. 28, 511

There is nothing here which leads us exactly to an astronomical point but there are three approximations. The record is mostly presented on the west side of the monument. On the east side the final date is repeated in an initial series and changes are rung on 13 Ahau. In other words there is probably an attempt to use tzolkin approximations to significant stations. The inscription closes with a second repetition of the date of the initial series.

Stelae A and C form a pair, having the same date, being executed in the same style, and standing side by side. We will begin our consideration with the latter monument. In the initial series on the east side of Stela C we find the declaration of the zero day of the Mayan era, 13–0–0–0–0, 4 Ahau 8 Cumhu, and on the west side, 9–1–0–0–0, 6 Ahau 13 Yaxkin, still very early, and below it, 9–17–5–0–0, 6 Ahau 13 Kayab, the contemporary date of the monument. The distance number, 17–5–0–0, indicates that 9–0–0–0–0, 8 Ahau 13 Ceh was involved in the calculation (fig. 59). Also the subtraction of 5 katuns from the final date to reach the significant position August 6 on this monument and on Stela A effects a tie-in with the Historical Era (see page 161). All three eras are under consideration here.

Under the standing figure on the south side of the monument we have 1 Eb 5 Yax followed by two glyphs, the last one of which reads 6 Ahau, tun ending, and on the north side there is a declaration of 9 Ahau after a glyph bearing the coefficient eight and having an inverted Ahau over a tun. This latter may imply 9–0–0–0–0, 8 Ahau 13 Ceh, Feb. 10, 176 A.D. A possibly significant relation comes to light when these dates are written out in the proper correlation to the tropical year.

9– 1–0– 0– 0,	6 Ahau 13 Yaxkin,	Oct. 29, 195
9–17–5– 0– 0,	6 Ahau 13 Kayab,	Feb. 28, 516
9– 0,	not recorded	
9–17–4–11– 0,	9 Ahau 13 Yax,	Oct. 12, 515
8	not recorded	
9–17–4–10–12,	1 Eb 5 Yax,	Oct. 4, 515

Perhaps the October 12 reached here is intended for the original location of the epoch of the Mundane Era in the tropical year.

On Stela A there is a calculation of the same type from the same contemporary date. We find as before a second declaration of the day 6 Ahau, end of a hotun, and after this the calendar-round date

6 Ahau 13 Chen coming just after a strange glyph with number 19. Bowditch identifies the month with Zac but the forms at Tikal show that it is Chen. In other words, here is an emphasis on 6 Ahau which in two cases occupies the thirteenth day of a month although the two month positions are 160 days apart in the year. 6 Ahau 13 Chen recurs, of course, at intervals of 2–12–13–0, or fifty-two years, and, as a hotun ending, is found in 9–4–5–0–0 when it corresponded to Nov. 23, 259 A.D. It may have been intended to express on this monument some relationship between 9–17–5–0–0,

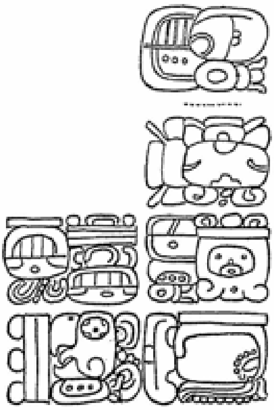


FIGURE 59. PASSAGE INDICATING A COUNT FROM THE ERA OF THE CHRONICLES

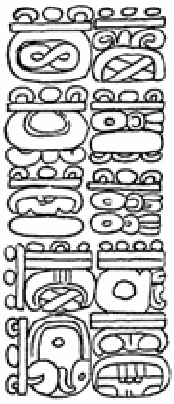


FIGURE 60. VARIOUS CYCLIC ENDINGS

6 Ahau 13 Kayab and 9–4–5–0–0, 6 Ahau 13 Chen, exactly thirteen katuns earlier. We are unable to find strong indications that this might be the case except the parallelism on Stela C, the sister monument to Stela A, and the attempt on several other monuments at Quirigua to use the return of positions in the tzolkin.

Perhaps the calculation was concerned with the nearest occurrence of 6 Ahau 13 Chen to the day reached by the initial series. The adjoining table shows this relationship and we see that 6 Ahau 13 Chen would lie very close to the autumnal equinox, three years later than the date of the initial series. If we imagine that the Mayan calendar expert calculated the position of 13 Chen in the immediate future from the initial series itself, he might well identify this month position with September 22. The next pre-

vious occurrence of 6 Ahau 13 Chen is forty-eight years before the initial series and much less satisfactory from our present point of view.

9–17– 5– 0–0,	6 Ahau 13 Kayab,	Feb. 28, 516
3–11–0		
9–17– 8–11–0,	6 Ahau 13 Chen,	Sept. 21, 519
2–12–13–0	subtract	
9–14–15–16–0,	6 Ahau 13 Chen,	Oct. 3, 467

We now leave for a time the upright stones called stelae with their impressive priestly figures, and take up a series of grotesque monsters carved on large boulders. These monuments will be called altars even though it cannot be proven that offerings were once piled upon them. Some authors have used instead the affected term zoömorph. But surely it is false science to sacrifice easy understanding to caliginous terminology and no sincere work of art deserves the opprobrium of being called a zoömorph when it is merely a ceremonial visitant from the land of imagined creatures.

Altar B has nothing but an initial series and a supplementary series presented in glyphs of the full-figure type which are marvels of grotesque elaboration only to be compared to the great glyph blocks of the two initial series on Stela D. This initial series is, as we have seen, 9–17–10–0–0, 12 Ahau 8 Pax, Feb. 2, 521.

Altar G records the initial series 9–17–15–0–0, 5 Ahau 3 Muan, Jan. 5, 526, and has as its latest declaration 10–0–0–0–0, 7 Ahau 18 Zip which is May 17, 570. The inscription on this monument is extensive but some parts are so badly eroded that a complete statement of the dates and distance numbers is well nigh impossible. The commonest dates at Quirigua, that is, 12 Caban 5 Kayab and 6 Cimi 4 Tzec, are both recorded and serve as the basis for further calculation.

The initial series is found in a strip of thirty-two glyphs along the east side of the monster and on the opposite side is a similar strip. Then there are two heavy blocks of forty glyphs each, higher up on the sides between the doubled-up legs. Thus we have 224 glyphs to consider. The initial series is expressed with faces replacing the bars and dots and appears to be the only date on that side of the monument.

The first of the upper blocks on the opposite side from the initial series has the long-distance number 3–1–8–6 and below this is

12 Caban 5 Kayab which we assume to be in the usual position, namely, 9–14–13–4–17, 12 Caban 5 Kayab, Mar. 4, 465. Next we come to the distance number 2–13–7–18, to accept Maudslay's drawing, and after it we see the easily recognized date 9–15–6–14–6, 6 Cimi 4 Tzec, July 3, 478. The two long numbers are probably to be added to these principal dates. The record begins in the right-hand upper block and, in the arrangement adopted here, passes, after the addition of the long number, to the bottom strip. The dates and distance numbers which do not appear in the record are in parentheses.

1st block	9–14–13– 4–17,	12 Caban	5 Kayab,	Mar. 4, 465
	3– 1– 8– 6			
	9–17–14–13– 6,	(12 Akbal	6 Yax)	Oct. 2, 525
Lower strip	9–17–14–13– 0,	9 Ahau	3 Yax,	Sept. 29, 525
	(2)			
	9–17–14–13– 2,	11 Ik	5 Yax,	Oct. 1, 525
	(10)			
	9–17–14–13–12,	8 Eb	15 Yax,	Oct. 11, 525
2d block	9–18– 2–15– 2,	6 Ik	5 Yax,	Sept. 29, 533

Before going further it might be wise to examine this record a little more closely. It will be observed that the end of the first addition overlaps the beginning of the second statement by three days, or by one day if 11 Ik 5 Yax is considered the leading date.

The statement of 6 Ik 5 Yax in the second block is very clear. It is interpolated in a record where a distance number sweeps over to the end of the baktun, that is, 10–0–0–0–0, 7 Ahau 18 Zip. It strikes the Gregorian day of 9 Ahau 3 Yax, providing a correction for two leap-year days which have accumulated in the interval, and it is located six days off the autumnal equinox. This may not be very significant but deserves to be noted.

We now revert to the day 8 Eb 15 Yax at the end of the lower strip and pass up to the left-hand block.

Lower strip	9–17–14–13–12,	8 Eb	15 Yax,	Oct. 11, 525
2d block	4– 8			
	9–17–15– 0– 0,	5 Ahau	3 Muan,	Jan. 7, 526
	2– 5– 0– 0			
	10– 0– 0– 0– 0,	7 Ahau	18 Zip,	May 17, 570

The first distance number according to Maudslay's drawing is 4–7 instead of 4–8, the middle dot being given as hollow: but the stone is badly weathered. The only unusual feature is the interpolation of 6 Ik 5 Yax already referred to and here the intention might have been to collect in one statement everything referring to the future: 9–17–15–0–0, 5 Ahau 3 Muan is the contemporary date.

We now go to the reasonably sure 5 Ahau in the ultimate corner of the last block, assuming that it is nothing else than the initial series date, and counting backwards we get:

9–17–15– 0– 0,	5 Ahau 3 Muan,	Jan. 7, 526
1– 2	subtract	
9–17–14–16–18,	9 Eznab 1 Kankin,	Dec. 16, 525
3–16	subtract	
9–17–14–13– 2,	11 Ik 5 Yax,	Oct. 1, 525

The recovery of the leading date 11 Ik 5 Yax is practical proof that this calculation is correct. The day and month-signs in Maudslay's drawing resemble 7 Akbal 1 Kayab and may indeed represent 9 Eznab 1 Kankin in the original, since the weathering is bad and glyphs small. The day 11 Ik reached by this backward count from the hotun ending is recorded but the month is not visible.

We now have only one matter left, namely, the long-distance numbers added to 9–15–6–14–6, 6 Cimi 4 Tzec, July 3, 478. If Maudslay's drawing is again accepted we get the following statement with the day and month-signs suppressed.

9–15– 6–14– 6,	6 Cimi 4 Tzec,	July 3, 478
2–13– 7–18		
9–18– 0– 4– 4,	4 Kan 2 Cumhu,	Mar. 6, 530
3–18		
9–18– 0– 8– 2,	4 Ik 15 Zip,	May 23, 530

The second date is only two days away from the original position in the tropical year of 12 Caban 5 Kayab. To make these distance numbers connect 6 Cimi 4 Tzec with 11 Ik 5 Yax would involve a number of changes in the record, as we now have it. This long inscription yields us very little in the way of astronomical correlation as we now understand the matter, but it may prove significant in future developments. There are several similarities to the record on Stela C.

On the badly weathered Altar O we are only able to recover the initial series which is 9–18–0–0–0, 11 Ahau 13 Mac, Dec. 12, 530.

The inscription on Altar P, the so-called Great Turtle, may once have presented a correlation of many cycles of greater or lesser import. Unfortunately the controlling dates are no longer legible. We call attention in figure 60 to a record of ten cyclic characters mostly carrying the numeral six but in one case with twelve on top and eight in front which might mean 128.

The initial series date is clear enough as 9–18–5–0–0, 4 Ahau 13 Ceh, Nov. 16, 535. The importance of the Mayan month position, 13 Ceh, has already been discussed. The calendar-round date 9 Ahau 3 Zotz occurs in two places: before and after the initial series it is found at:

9–15–17–16–0,	9 Ahau 3 Zotz,	June 9, 488
2–12–13–0		
9–18–10–11–0,	9 Ahau 3 Zotz,	May 28, 540

Neither of these seems important, and on closer examination we find one occurrence of this date further apparently specified as "end of seven tuns." This can hardly be anything else than 9–5–7–0–0, 9 Ahau 3 Zotz, July 30, 281. This date may belong to one of the many cycles recorded in figure 60. There is also a calendar-round declaration which may be 9–17–19–12–0, 8 Ahau 18 Yaxkin, Aug. 14, 530.

The dates on Stela I are probably correctly stated below:

9–18–0– 0–0,	11 Ahau 18 Mac,	Dec. 12, 530
9–15–5– 0–0,	10 Ahau 8 Chen,	Sept. 25, 476
1–14–0		
9–15–6–14–0,	13 Ahau 18 Zotz,	June 27, 478

The first one is fixed by initial series. The second one occurs also on Stela J and forms an interesting approximation with the autumnal equinox. The third date overruns the summer solstice but is an even uinal. It is six days in advance of the much repeated 6 Cimi 4 Tzec. Finally it may be noted that this brace of dates falls at a time when 0 Pop was standing at April 9. All these conditions favor the placing of the calendar-round dates at the stated position in the long count.

The Hotun Series of Piedras Negras

That the hotun, literally five tun, was used as a formal interval in the erection of monuments has been argued by Morley. It is indeed true that many monuments are dated at round numbers in the

HOTUN SEQUENCE AT PIEDRAS NEGRAS

Stela	Hotun	Date	Gregorian day
30	9– 5– 0–0–0,	11 Ahau 18 Tzec,	Sept. 5, 274
	.....		
25	9– 8–15–0–0,	10 " 8 Tzec,	Aug. 8, 348
	.....		
26	9– 9–15–0–0,	8 " 13 Cumhu,	Apr. 25, 368
	.....		
31	9–10– 5–0–0,	7 " 3 Pax,	Mar. 4, 378
	.....		
32	9–10–15–0–0,	6 " 13 Mac,	Jan. 11, 388
	.....		
35	9–11–10–0–0,	11 " 18 Chen,	Oct. 24, 402
36	9–11–15–0–0,	4 " 13 Mol,	Sept. 28, 407
37	9–12– 0–0–0,	10 " 8 Yaxkin,	Sept. 1, 412
39	9–12– 5–0–0,	3 " 3 Xul,	Aug. 6, 417
38	9–12–10–0–0,	9 " 18 Zotz,	July 11, 422
6	9–12–15–0–0,	2 " 13 Zip,	June 15, 427
8	9–13– 0–0–0,	8 " 8 Uo,	May 19, 432
2	9–13– 5–0–0,	1 " 3 Pop,	Apr. 23, 437
4	9–13–10–0–0,	7 " 3 Cumhu,	Mar. 28, 442
1	9–13–15–0–0,	13 " 18 Pax,	Mar. 2, 447
3	9–14– 0–0–0,	6 " 13 Muan,	Feb. 3, 452
5	9–14– 5–0–0,	12 " 8 Kankin,	Jan. 6, 457
7	9–14–10–0–0,	5 " 3 Mac,	Dec. 13, 461
1[1]	9–14–15–0–0,	11 " 18 Zac,	Nov. 17, 466
11	9–15– 0–0–0,	4 " 13 Yax,	Oct. 22, 471
9	9–15– 5–0–0,	10 " 8 Chen,	Sept. 25, 476
10	9–15–10–0–0,	3 " 3 Mol,	Aug. 30, 481
40	9–15–15–0–0,	9 " 18 Xul,	Aug. 4, 486
2[1]	9–16– 0–0–0,	2 " 13 Tzec,	July 9, 491
22	9–16– 5–0–0,	8 " 8 Zotz,	June 12, 496
23	9–16–10–0–0,	1 " 3 Zip,	May 18, 501
16	9–16–15–0–0,	7 " 18 Pop,	Apr. 22, 506
13	9–17– 0–0–0,	13 " 8 Cumhu,	Mar. 27, 511
	.....		
14	9–18– 0–0–0,	11 " 18 Mac,	Dec. 12, 530
12	9–18– 5–0–0,	4 " 13 Ceh,	Nov. 16, 535

[1] Altars.

count of days from the era and especially at even, half, and quarter katuns. The artistic sequence justifies the arrangement by hotuns in the majority of cases, and yet it is perfectly clear that important events either mundane or celestial could not be expected to happen very often at round numbers of days. Mayan stelae were more than mere mile-posts along the time course of history. They were memorials of events, such as conquests, and the accession of rulers, and of intellectual progress as well. How else can we explain the pictures of kings upon thrones, of captives degraded and bound with ropes, and of calculations extending over terms of years and giving astronomical and mathematical results which must astonish intelligent persons to-day? In this paper our emphasis is placed upon astronomical corroboration in the matter of transcribed dates. We cannot isolate the record of political events, but we may be assured that it is there. While Mayan monuments seem, therefore, to have been dedicated at round numbers of days, this fact need not militate against their interpretation as essentially historical. It would be an excellent thought for modern American cities to erect memorials to progress at stated intervals.

The sequence of hotun markers is more impressively demonstrated at Piedras Negras and Quirigua than at other Mayan cities. It is not especially noticeable at Yaxchilan and Copan. The sequence at Piedras Negras is given on the opposite page.

In a considerable number of instances, dates which do not end on hotuns are recorded on stelae at Piedras Negras and hotuns are reached by means of additions. In a few instances the unconventional dates do not tie in with round numbers so far as the legible record goes. The earliest date that does not declare a round number is the initial series of Stela 25, and while it reaches one by addition, one or two stops are apparently made.

9–8–10– 6–16,	10 Cib 9 Mac,	Jan. 16, 343
4–11–4		
9–8–15– 0–0,	10 Ahau 8 Tzec,	Aug. 8, 348

As the transcription stands, no astronomical meaning is disclosed. Yet the hieroglyph in F 2 is almost surely a half-obscured Ahau of the equinox and this is repeated in I 10. An intermediate date and a short distance number do not aid us.

Stela 36 reads:

9–10– 6– 5– 9,	8 Muluc 2 Zip,	June 16, 379
(9– 9–13– 4– 1),	6 Imix 19 Zotz,	July 26, 366
2– 1–13–19		
(9–11–15– 0– 0),	4 Ahau 13 Mol,	Sept. 28, 407

This offers no more evidence than the preceding stela and yet there is in C 7 an undoubted reference to the nearness of the final date to a point of solar observation. The same thing recurs where this date is repeated at the end of the inscription on Lintel 2.

Stela 34, according to Morley's reading, makes a possible declaration of 9–10–19–5–9, 7 Lamat 7 Chen, Oct. 15, 392, which is also barren unless it is a restatement of the Mundane Era.

We now come to two stelae with perhaps the most interesting inscriptions at Piedras Negras. They have been explained as possibly referring to the lives of individuals, one a man (Stela 3) and one a woman (Stela 1). Doubtless personalities are represented but personalities do not die on round numbers of days. The initial series are identical and equal September 7, 414. Probably this date gives the autumnal station of the year as adopted at this city. This may be only a fraction of a day off from the September 6 that is recorded on the western marker at Copan. None of the other dates on either monument have any outward astronomical meaning. The records follow:

Stela 1.	9–12– 2– 0–16,	5 Cib 14 Yaxkin,	Sept. 7, 414
	12– 9–15		
	9–12–14–10–11,	9 Chuen 9 Kankin,	Jan. 15, 427
	5		
	9–12–14–10–16,	1 Cib 14 Kankin,	Jan. 20, 427
	1– 0– 2– 5		
	9–13–14–13– 1,	5 Imix 19 Zac,	Nov. 23, 446
	4–19		
	9–13–15– 0– 0,	13 Ahau 18 Pax,	Mar. 2, 447
Stela 3.	9–12– 2– 0–16,	5 Cib 14 Yaxkin,	Sept. 7, 414
	12–10– 0		
	9–12–14–10–16,	1 Cib 14 Kankin,	Jan. 20, 427
	1– 1–11–10		
	9–13–16– 4– 6,	4 Cimi 14 Uo,	May 21, 448
	3– 8– 5		
	9–13–19–13– 1,	11 Imix 14 Yax,	Oct. 27, 449
	4–19		
	9–14– 0– 0– 0,	6 Ahau 13 Muan,	Feb. 3, 452

Stela 8 has a series of dates but the only ones recoverable from available records are the following:

9–11–12– 7– 2,	2 Ix 10 Pax,	Mar. 4, 404
9–13– 0– 0– 0,	8 Ahau 8 Uo,	May 19, 432
14–13– 1		
9–13–14–13– 1,	5 Imix 19 Zac,	Nov. 23, 446

It will be noted that the last date is in advance of the hotun which this monument is supposed to mark and that it is also recorded on Stela 1. Which was the contemporary date of the erection?

Stela 40 is said to give 9–15–14–9–13, 11 Ben 16 Pax, Feb. 18, 485. Perhaps the most interesting dates at Piedras Negras will be those on lintels and altars which cannot be given now.

Miscellaneous Dates at First Empire Sites

To clear the record as far as possible, reference will now be made to dates at smaller sites mostly along the Usumacinta or in the plains of Peten. One interesting inscription comes from northern Honduras and several from the highlands of Guatemala and northern Yucatan.

At El Cayo on the Usumacinta, Lintel 1 has the initial series 9–16–0–2–16, 6 Cib 9 Mol, Sept. 3, 491. Actually it becomes September 2 with close calculation. This Lintel 1 is badly weathered but those parts of the calculation which can be deciphered with a fair degree of certainty read as follows:

Init. Ser.	9–16– 0– 2–16,	6 Cib 9 Mol,	Sept. 3, 491
CD 1	11–17–10		
CD 3	9–16–12– 2– 6,	13 Cimi 19 Zotz,	June 23, 503
	(2– 4)		
EF 3	9–16–12– 4–10,	5 Oc 3 Yaxkin,	Aug. 6, 503
G 4 H 3	8–16– 2		
IJ 1	9–17– 1– 2–12,	9 Eb 0 Zip,	May 12, 512
K 13	2–16		
KL 14	9–17– 1– 5– 8,	1 Muluc 17 Tzec,	July 8, 512

The second day reached, some twelve years later, corresponds exactly to the summer solstice by exact calculations. The necessary distance number of 2–4 to lead from this date to the next one is

wanting but the eight tuns of the following distance is clear as is the month, sign 0 Zip and the coefficient for Eb. Then comes the proper distance number to carry us to 1 Muluc 17 Tzec. There are some other glyphs with numeral coefficients but it is not certain that they are month glyphs. Finally there is a declaration of two katuns but without an ending-sign and an Ahau without a numeral. It is apparent that here as in other inscriptions the ancient astronomers were proceeding from important astronomical points to others of less general importance, but, probably, greater special interest. The first three dates give us: 1, the revised autumnal station; 2, the summer solstice; 3, the position in the natural year of the epoch of the Historical Era, 7–0–0–0–0, 10 Ahau 18 Zac, Aug. 6, 613 B.C.

Also at El Cayo there is a possible hotun-ending date on Stela 1, namely 9–17–5–0–0, 6 Ahau 13 Kayab, Feb. 28, 516.

At the neighboring ruin of La Mar, Stela 1 has two calendar-round dates connected by a distance number. It reads:

AB 1	2 Muluc 2 Uo,	9–17–12– 4– 9,	Apr. 22, 523
B 5 A 6		2–13–11	
B 7 A 8	5 Ahau 3 Muan,	9–17–15– 0– 0,	Jan. 6, 526

The first of these catches the position of 9–16–15–0–0, 7 Ahau 18 Pop, Apr. 22, 506. The sign for the planet Venus seems to be present. Stela 2 may be a katun later.

Altar de Sacrificios and El Pabellon on opposite sides of the Rio Salinas at its confluence with the Rio de Pasion have several monuments with the following dates, all but one being round numbers.

Stela 1.	El Pabellon,	9–10– 0–0–0,	1 Ahau 8 Kayab,	Mar. 30, 372
" 4.	Altar de Sac,	9–10–10–0–0,	13 Ahau 13 Kankin,	Feb. 6, 383
" 7.	Altar de Sac,	9–14– 0–0–0,	6 Ahau 13 Muan,	Feb. 3, 452

The initial series on Stela 4 at Altar de Sacrificios is 9–10–3–17–0, 4 Ahau 8 Muan, Feb. 17, 376.

At the ruins of Tzendales, near the Rio Tzendales, is an inscription on a stela giving:

9–12–19– 1– 1,	7 Imix 14 Zip,	June 5, 431
16–19		
9–13– 0– 0– 0,	8 Ahau 8 Uo	May 19, 432

An interesting stela at Aguas Calientes on the Rio de Pasion contains the following statement:

9–18–0– 0– 0,	11 Ahau 18 Mac,	Dec. 12, 530
13–18		
9–18–0–13–18,	3 Eznab 11 Chen,	Sept. 16, 530

The fine city of Seibal near the Rio de Pasion contains several very late dates on some extremely beautiful monuments. The longest inscription is in connection with a hieroglyphic stairway containing five panels of glyphs.

Fragments of these panels have been published in Maler's report wrongly labeled as parts of stelae. For information concerning this monument and a transcription of the dates, the author is indebted to Mr. S. G. Morley of the Carnegie Institution.

Panel A.	No dates	Not published	
Panel B.		Not published, but cast made	
	(9–15–15– 0– 0,	9 Ahau 18 Xul,	Aug. 4, 486)
	1– 7–17		
	9–15–16– 7–17,	6 Caban 10 Kankin,	Jan. 1, 488
Panel C.		Maler, Pl. 6, Nos. 2 and 3	
	3–10– 3		
	9–16– 0– 0– 0,	2 Ahau 13 Tzec,	July 9, 491
Panel D.		Maler, Pl. 6, No. 8	
	9–15–16– 7–17,	6 Caban 10 Kankin,	Jan. 1, 488
	16–16– 7–17	subtract	
	8–19– 0– 0– 0,	10 Ahau 13 Kayab,	May 26, 156
Panel E.		Maler, Pl. 6, Nos. 4 and 5	

The other dates at Seibal record round numbers:

Stela 6.	9–17– 0– 0– 0,	13 Ahau 18 Cumhu,	Mar. 27, 511
Stela 12.	9–18– 0– 0– 0,	11 Ahau 18 Mac,	Dec. 12, 530
Stela 7.	9–18–10– 0– 0,	10 Ahau 8 Zac,	Oct. 20, 540
Stelae 8 to 11.	10– 1– 0– 0– 0,	5 Ahau 3 Kayab,	Jan. 31, 590
Stela 1.	10– 2– 0– 0– 0,	3 Ahau 3 Ceh,	Oct. 19, 609

Still farther up the Rio de Pasion is Cancuen which boasts a few exquisite pieces of sculpture. Two round number dates are found:

Stela 2.	9–18–0–0–0,	11 Ahau 18 Mac,	Dec. 12, 530
Altar 2.	9–18–5–0–0,	4 Ahau 13 Ceh,	Sept. 24, 545

The ruins of Itsimté Sakluk near the little town of Libertad have two certain round number dates on stelae and two doubtful ones on altars. Thus:

Altar 1.	9–14– 0–0–0,	6 Ahau 13 Muan,	Feb. 3, 452
Altar 2.	9–14–10–0–0,	5 Ahau, 3 Mac,	Dec. 13, 461
Stela 5.	9–15– 0–0–0,	4 Ahau 13 Yax,	Oct. 22, 471
Stela 2.	9–15–10–0–0,	3 Ahau 3 Mol,	Aug. 30, 481

Ixkun, near Dolores, was a city of some importance with five or more stelae. Stela 1 has an error in the statement of the initial series, but the intention is clear enough. Stela 2 probably has supplementary dates, but no record of these is at hand:

Stela 2.	9–17– 9–0–13,	3 Ben 6 Kayab,	Feb. 20, 520
Stela 1.	9–18– 0–0– 0,	11 Ahau 13 Mac,	Dec. 12, 530
Stela 5.	9–18–10–0– 0,	10 Ahau 8 Zac,	Oct. 20, 540

Passing north from Ixkun we find late dates at Ucanal, Benque Viejo, Nakum, La Honradez and a fairly early one at Yaxha. These dates give us round numbers in practically all instances.

Ucanal.	Stela 3.	10– 1– 0–0–0,	5 Ahau 3 Kayab,	Jan. 31, 590
Benque Viejo.	Stela 1.	10– 1– 0–0–0,	5 Ahau 3 Kayab,	Jan. 31, 590
Nakum.	Stela U.	9–17– 0–0–0,	13 Ahau 18 Cumhu,	Mar. 27, 511
	Stela C.	9–19–10–0–0,	8 Ahau 8 Xul,	July 8, 559
		1–0,		
		9–19–10–1–0,	2 Ahau 8 Yaxkin,	July 28, 559
La Honradez.	Stela 7.	9–17– 0–0–0,	13 Ahau 18 Cumhu,	Mar. 27, 511
	" 6.	9–17–10–0–0,	12 Ahau 8 Pax,	Feb. 2, 521
	" 5.	9–18– 0–0–0,	11 Ahau 18 Mac,	Dec. 12, 530
	" 4.	9–18–10–0–0,	10 Ahau 8 Zac,	Oct. 20, 540

Of this last lot only Stela 7 can be regarded as certain.

During several recent explorations Morley has been successful in finding archeological sites in Peten with monuments containing hieroglyphs. He has published four dates from Xultun as follows:

Stela 6.	9– 3– 7–0–0,	13 Ahau 3 Kankin,	Feb. 25, 242
" 11.	9– 5– 7–0–0,	9 Ahau 3 Zotz,	July 30, 281
" 5.	9–12– 0–0–0,	10 Ahau 8 Yaxkin,	Sept. 1, 412
" 21.	9–14–10–0–0,	5 Ahau 3 Mac,	Dec. 13, 461

With the exception of the third one which is an important approximation of the autumnal station, none of these dates seems of astronomical significance, but no statement of a secondary series is available.

At Uaxactun, an extensive ruin not far from Tikal which is now being explored by the Carnegie Institution, there are thirty-nine stelae, twenty of which are sculptured. The dates on thirteen of these twenty sculptured monuments have been deciphered. Stela 9 is the earliest Mayan monument *in situ* and Stela 12 the latest one at any city of the First Empire. The list follows:

Stela	9.	8–14–10–13–15,	8 Men	8 Kayab,	June 10,	68 A.D.
"	5.	8–15–10– 3–12,	5 Eb	11 Uo,	Aug. 14,	87
"	18.	8–16– 0– 0– 0,	3 Ahau	8 Kankin,	April 5,	97
"	19.	8–16– 0– 0– 0,	3 "	8 Kankin,	April 5,	97
"	4.	8–18– 0– 0– 0,	12 "	8 Zotz,	Sept 8,	136
"	17.	8–19– 0– 0– 0,	10 "	13 Kayab,	May 26,	157
"	20.	9– 3– 0– 0– 0,	2 "	18 Muan,	April 3,	235
"	3.	9– 3–13– 0– 0,	2 "	13 Ceh,	Jan. 22,	248
"	1.	9–14– 0– 0– 0,	6 "	13 Muan,	Feb. 3,	452
"	10.	9–16– 0– 0– 0,	2 "	13 Tzec,	July 9,	491
"	7.	9–19– 0– 0– 0,	9 "	18 Mol,	Aug. 29,	550
"	13.	10– 0– 0– 0– 0,	7 "	18 Zip,	May 17,	570
"	12.	10– 3– 0– 0– 0,	1 "	3 Yaxkin,	July 6,	629

This array of dated monuments gives the otherwise unprepossessing ruin of Uaxactun the peculiar distinction of the longest occupation of any Mayan city of the First Empire, namely from June 10, 68 A.D. to July 6, 629, or almost exactly 561 years. Some of the dates are not without interest in possible astronomical bearing. Stela 4 gives the first member of the series of round number declarations, separated by intervals of three and a half katuns, which afford approximations, first to the earlier and then to the later setting of the autumnal station (September 6 and September 2 at Copan). Stela 7, ten days removed in the natural year carries a date exactly 21 katuns after that on Stela 4. Approximations to the vernal station are also emphasized by three stelae situated in the same court. Stelae 18 and 19 stand side by side and both record a date which corresponds to April 5, 97 A.D., while Stela 20 strikes almost the same position 7 katuns later (April 3, 235). Perhaps April 9 was chosen at a time when it coincided with the round number 8–9–0–0–0, 4 Ahau 18 Ceh, April 9, 41 B.C., 7 katuns before this early pair of monuments.

Although no explanation presents itself, there are two other cases of reiteration of approximately the same points in the natural year at Uaxactun across a wide range of time. Stelae 17 and 13

are 21 katuns apart, the one corresponding to May 26, 156, and the other to May 17, 570. Stelae 2 and 12 are 7 katuns apart corresponding to July 9, 491 and July 6, 629.

At Naachtun, a new site found by Morley[1] in the northwest corner of Peten, the available datings are all on round numbers.

Stela 3.	9- 5- 0-0-0,	11	Ahau	18 Tzec,	Sept. 5, 274
" 5.	9- 6-10-0-0,	8	"	13 Pax,	April 1, 304
" 1.	9- 9-10-0-0,	2	"	13 Pop,	May 22, 363
" 2.	9-10-10-0-0,	13	"	13 Kankin,	Feb. 6, 383
" 9.	9-15- 0-0-0,	4	"	13 Yax,	Oct. 22, 471
" 8.	9-16- 0-0-0,	2	"	13 Tzec,	July 9, 491
" 10.	9-16-10-0-0,	1	"	3 Zip,	May 18, 501
" 7.	9-17- 0-0-0,	13	"	8 Cumhu,	Mar. 27, 511

Several of these readings are doubtful, especially those of Stelae 5 and 7. It will be noted that the first two dates are approximations to the two leading dates in the farmer's almanac.

A stela of Uolontun has the date:

8-18-13-5-11, 6 Chuen 14 Xul, Oct. 21, 149

Ixlu, a new site near the eastern end of Lake Peten, has two late dates:

Stela 1.	10-1-10-0-0,	4 Ahau 13 Kankin,	Dec. 10, 599
" 2.	10-2-10-0-0,	2 Ahau 13 Chen,	Aug. 28, 619

At Flores, the last capital of the Itzas, there are two dates from the end of the First Empire:

Stela 1.	10-1-0-0-0,	5 Ahau 3 Kayab,	Jan. 31, 590
" 2.	10-2-0-0-0,	3 Ahau 3 Ceh,	Oct. 19, 609

A stone tablet found by Maler at Chinikiha has two calendar-round dates one month apart which may possibly be arranged thus:

9-17-6-15-0, 7 Ahau 3 Kankin, Dec. 20, 517
1-0
9-17-6-16-0, 1 Ahau 3 Muan, Jan. 9, 518

This placing would agree with the advance style in the carving of the glyphs. There is also a distance number which shows 1 katun, 5 tuns and 14 uinals but the kin coefficient is lacking. It appears

[1] Reported with other sites in the *Year Books* of the Carnegie Institution of Washington.

to lead to a day-sign with a numeral 2, but this day-sign is probably not Ahau. Some other glyphs of the incised type are reproduced in Maler's text.

At the new site of Tortuguero on the western fringe of the Mayan area there is one clear date where 1 Ahau 3 Kankin is at the end of a tun 13 which has been reported by Blom. This can only be:

9–10–13–0–0, 1 Ahau 3 Kankin, Jan. 21, 386

At Los Higos, on the head-waters of the Chamelecon River and on the opposite side of the Mayan field, there is a fine stela of Copan type which has two dates, one an initial series and the second a period-ending date in the following association:

9–17–10–7–0,	9 Ahau 3 Tzec,	June 22, 521
7–0	subtract	
9–17–10–0–0,	12 Ahau 8 Pax,	Feb. 2, 521

Undoubtedly in this case the main purpose of the monument was to mark the summer solstice, and the carrying of the date backward to a half-tun ending was for convenient association.

At Saccaná, or Quen Santo, two fragments of late crude stelae were described by Seler. One has the Venus symbol in the introducing glyph. They are:

Stela 1.	10–2– 5–0–0,	9 Ahau 18 Yax,	Sept. 23, 613
" 2.	10–2–10–0–0,	2 Ahau 13 Chen,	Aug. 28, 619

The first one exactly reaches the autumnal equinox.

From Toniná near Comitan came the top portion of a stela now in a private collection in Mexico City. It has an initial series in which the katun coefficient is from 16 to 19. It also has a long number seemingly in eight positions but with the tun omitted. The three higher values all have the coefficient 13 and are heads of the baktun type. Perhaps the numeral 13 is here used in the sense of completion or infinity. There are one or two calendar-round dates but no conclusions can be drawn from the documents under observation as to the positions in the time-count.

Dates in Northern Yucatan

North of the Peten district in Yucatan, dates, especially of the initial series type, are few and far between. The earliest one is on Stela 1 at Tuloom which reads:

9–6–10–0–0, 8 Ahau 13 Pax, April 1, 304

This date, from about the time when "Bacalar was discovered" according to the Mayan chronicles, is not the contemporaneous date of the monument. On stylistic grounds the stela belongs to the Middle Period with close analogies to works at Naranjo and Palenque. The contemporary date is a hotun ending on 7 Ahau. Morley places this one baktun after the initial series declaration, thus:

9–6–10–0–0,	8 Ahau 13 Pax,	April 1, 304
1–0– 0–0–0		
10–6–10–0–0,	7 Ahau 18 Yaxkin,	July 4, 698

But all the conditions can be met in a more satisfactory way by placing it 7 katuns after the first date:

9– 6–10–0–0,	8 Ahau 13 Pax,	April 1, 304
7– 0–0–0		
9–13–10–0–0,	7 Ahau 3 Cumhu,	Mar. 28, 442

We have already observed that almost the same position in the natural year returns after 7 katuns. Both these dates concern the farmer's year and are approximate recurrences of the position of 8–9–0–0–0, 4 Ahau 18 Ceh, Apr. 9, 41 B.C., or of 8–16–0–0–0, 3 Ahau 8 Kankin, Apr. 5, 97 A.D. which is memorialized in two stelae at Uaxactun.

It is not unlikely that Tuloom was abandoned at the close of the First Empire and then repopulated. It was probably an inhabited site when the Spaniards visited Yucatan and the buildings are of a late and decadent style. Three other stelae, late in style, were found at Tuloom by the expedition of the Carnegie Institution, one being painted and two carved after the fashion of the Mayapan monuments. On one of these is a day 2 Ahau which may mean a Katun 2 Ahau. In this case it would either be

11–15–0–0–0, 2 Ahau 8 Zac, April 28, 1260

the position preferred by Lothrop, or

12– 8–0–0–0, 2 Ahau 3 Pop, Aug. 5, 1516

the position preferred by Morley. We read in documents of the 16th century that the last katun stone to be erected was that of Katun 2 Ahau, corresponding to the latter date. Curiously enough it practically recovers the position in the natural year of 7–0–0–0–0, 10 Ahau 18 Zac, Aug. 6, 613 B.C. In other words, the first legitimate date in Mayan history and the last one to be put on record by the natives in their gentility may cover 2,129 tropical years.

The famous initial series inscription on the lintel at Chichen Itza advances to the end of the following hotun:

10–2– 9– 1– 9, 9 Muluc 7 Zac, Oct. 1, 618
(16–11)
10–2–10– 0– 0, 2 Ahau (13 Chen), Aug. 28, 619

Both of these dates fall within the last katun of the first occupation of this northern capital according to the chronicles. The last one is the tailings of a most important approximation.

The only other initial series known to exist in northern Yucatan is the difficult one at Holactun, or Xcalumkin. The most likely reading is as follows:

11–2– 8– 4– 9, 7 Muluc (17 Tzec), Mar. 9, 1011
(4–13–11)
11–2–13– 0– 0, 2 Ahau (8 Cumhu), Nov. 14, 1016

The points upon which this reading is based are:

1st. The uinal and tun are clearly 4 and 9,
2d. The day is 7 Muluc,
3d. The day 2 Ahau is stated to end a tun 13.

As regards the other coefficients in the initial series, the tun face appears to have a death symbol on the cheek which would make it 10 or above. But this may be part of the maize foliage that adorns the face for the required 8. The other coefficients, 11 for the baktun and 2 for the katun, are rarely represented by faces. Alternative readings are found at intervals of 13 katuns, before and after. They are:

10- 9- 8- 4- 9,	7 Muluc (2 Pax),	Dec. 2, 755
(4-13-11)		
10- 9-13- 0- 0,	2 Ahau (8 Yax),	Aug. 8, 760
11-15- 8- 4- 9,	7 Muluc (17 Mac),	June 14, 1268
(4-13-11)		
11-15-13- 0- 0,	2 Ahau (3 Mol),	Feb. 19, 1273

The latest Mayan dates in inscriptions are abbreviated statements in northern Yucatan made long after the custom of complete initial series had been discontinued. There Morley has done pioneer work, recovering chronology in Chichen Itza during the second occupation and also at Uxmal and Mayapan, the other two members of the famous league that controlled the destinies of the Second Empire. For Chichen Itza he suggests the following readings:

Temple of the Two Lintels		
11- 7-12-16-18,	9 Eznab 11 Yax,	May 19, 1109
Temple of the High Priest's Grave		
11-19-11- 0- 0,	2 Ahau 18 Xul,	Dec. 31, 1339
Temple of the Owl		
12- 2-13- 0- 0,	1 Ahau 13 Ceh,	April 17, 1411
Lintel found by Thompson		
11-12- 8-13- 4,	6 Kan 2 Pop,	Oct. 16, 1209

The first of these dates is not entirely satisfactory. The text, reproduced in figure 61, shows quite clearly 9 Eznab 11 Yax, with an interpolated bird's head. Below, the declaration of 13 tuns is unmistakable and this is followed by a day 1 Ahau. If we imagine that was intended for 5 Ahau then Morley's reading is acceptable. 1 Ahau ends 14 tuns instead of 13 according to the following arrangement:

11-7-12-16-18,	9 Eznab 11 Yax,	May 19, 1109
1- 2		
11-7-13- 0- 0,	5 Ahau 13 Zac,	June 10, 1109
1- 0- 0		
11-7-14- 0- 0,	1 Ahau 8 Zac,	June 5, 1109

The Temple of the Two Lintels is one of two ruined temples with three hieroglyphic lintels between them, situated several miles from the center of Chichen Itza. In style the hieroglyphs are

quite similar to those on the Lintel of the Initial Series. This may, however, be explained by the circumstance that the Mayas on their return to this city after an absence of 260 years found Old Empire models in writing. While Morley's reading hardly meets the basic assumption that the calendar-round date should be placed in a tun ending on 1 Ahau, no better rendering can be suggested. It does fall, as it should, in a tun 13.

No serious objection can be made to the interesting date in the Temple of the High Priest's Grave, which is a monument showing the florescence of the Mexican school in Chichen Itza. This date records 2 Ahau 18 Xul, ending tun 11. The 2 Ahau and 18 Xul are both very clear and the coefficient 11 is before an indistinct glyph which is followed by a second declaration of 2 Ahau (fig. 62, *a*). This presentation leaves little doubt that a period-ending date for a stated tun of a katun is recorded and since the repetition of such a date is at intervals of over 18,700 years there is one possible historical position. The date 11–19–11–0–0, 2 Ahau 18 Xul, Dec. 31, 1339, falls in the latter part of the epoch of Mexican overlords already assigned limits on artistic and other grounds.

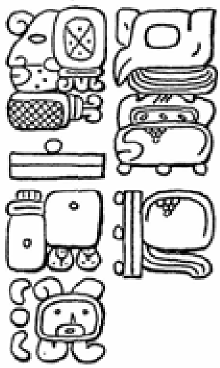


FIGURE 61. A DATE AT CHICHEN ITZA

In the case of the Temple of the Owl, the artistic position disclosed by the style of building and by the subject matter and design of the painted lintel are entirely in keeping with the date. Nevertheless the reading is somewhat doubtful because the glyphs are not at all clear. The date as deciphered strikes the month position 13 Ceh which has already received emphasis as the month position of the Era of the Chronicles and since the U Kahlay Katunob system was in vogue at this time this circumstance is worthy of note. Also this declaration lies near the beginning of the farmer's year, giving us a double association.

A painted lintel found by Thompson in a small ruined building east of the main structure of the estate records a day 6 Kan in a tun 9 (fig. 22), which has been interpreted to mean 6 Kan 2 Pop in a tun 9, the 6 Kan being a year-bearer. Morley offers strong arguments for the position 11–12–8–13–4, 6 Kan 2 Pop, Oct. 16,

1209. This is probably a restatement of the position in the natural year occupied by the epoch of the Mundane Era which was Oct. 14, 3373 B.C. This rather sensational conclusion rests upon the fact that one of the two dates at Uxmal registers the same position in the natural year some 67 years later. Moreover, we have just examined a date at Chichen Itza giving the eral month position 13 Ceh very close to the beginning of the agricultural year, and we shall find in the second known date at Uxmal this vernal station

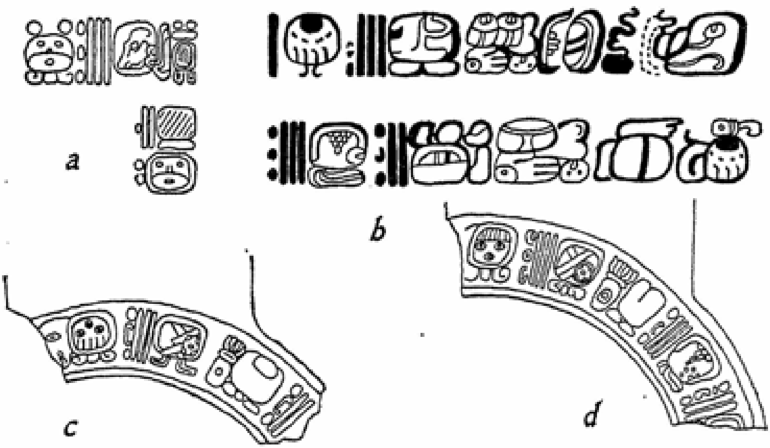


FIGURE 62. EXAMPLES OF THE LATEST MAYAN DATES
a, in Temple of the High Priest's Grave, Chichen Itza; *b*, in the Nunnery of Uxmal; *c*, in the Ball Court, Uxmal.

defined with sharp accuracy. Surely such a complex in view of the demonstrated efficiency of the Mayas can not be dismissed as idle chance.

We will now consider two important dates at Uxmal. The painted text reproduced in figure 62, *b*, from a capstone in the Eastern Range of the Nunnery Quadrangle at Uxmal records in the first two glyphs of the first line 5 Imix 19 Kankin and in the corresponding glyphs of the second line 18 tuns 13 katuns. This is to be read "a day 5 Imix 19 Kankin in a tun 18 of a katun 13." In other words the tun will be 18 when it ends and the katun will be 13. The long count presentation for this date is 11–12–17–11–1, 5 Imix 19 Kankin, Apr. 10, 1218. The date records the farmer's New Year. It will be noted that the completed katun is 12 rather than 13 and the completed tun is 17 rather than 18. The time-

honored custom of counting elapsed time was breaking down, probably under Mexican influence since this date falls in the 13th century A.D., when Mexican conquerors had already raised their standards in Yucatan.

The peculiar character of the Mayan time-counts that cannot be overemphasized is that the day-count was continuous and inviolate. The association of the day-count with positions in the month although of great importance in the formation of the calendar round was nevertheless capable of certain readjustment. An examination of Mexican calendars will show that a confusion was natural between the concepts of passed and passing units. The shifting of the days one position forward in the months, which marks the late Mayan dates, was occasioned, we have reason to believe, by a reflection of Mexican usage during an epoch of strong Mexican influence.

Morley explains in detail a remarkable inscription on the rings of the Ball Court at Uxmal where a day Ix is given on one ring as 17 Pop, one of its classical positions, and on the other ring as 16 Pop. The ball court is a type of structure which Mexican conquerors introduced into Yucatan and the date of this particular structure is accurately recorded as in a tun 17 ending on a day 12 Ahau, the specific date being 11–15–16–12–14, 10 Ix 17 Pop, Oct. 15, 1276. The double entry on these two rings of stone would seem to memorialize a change in point of usage regarding the position of the day in the month (fig. 62, *c* and *d*).

Now Morley reached his results in this case at Uxmal and in the last case treated at Chichen Itza, without any intimation that the two inscriptions find October 15 and October 16 in the natural year which is almost a perfect redeclaration of the zero day of Mayan chronology. In both these cases it seems that the Mexican concept of current time is at clash with the Mayan concept of elapsed time. We converted the year-bearer 6 Kan into the calendar-round date 6 Kan 2 Pop of the ancient calendar, although it is highly probable that 6 Kan 1 Pop of the New Empire usage was really intended. If so, these two inscriptions declare:

Chichen Itza

$$6 \text{ Kan} \begin{Bmatrix} 2 \text{ Pop} \\ 1 \text{ Pop} \end{Bmatrix} \quad 11\text{–}12\text{–}\ 8\text{–}13\text{–}\ 4, \quad \text{Oct. } 16, 1209$$

Uxmal

$$10 \text{ Ix} \left\{ \begin{matrix} \text{17 Pop} \\ \text{16 Pop} \end{matrix} \right\} \quad \text{11–15–16–12–14, Oct. 15, 1276}$$

While the calculation in neither of these statements is quite so accurate as that reached by the Gregorian calendar, which happens to be rather favorably situated, the error is very much less than that obtained by using the contemporaneous Julian calendar over the same interval. Thus:

Chichen Itza — 4,582 tropical years

Modern calculation	........1,673,539.76....	error	.00	days
Gregorian "	.........1,673,541.14....	"	1.38	"
Mayan "	.........1,673,544.00....	"	4.24	"
Julian "	.........1,673,575.50....	"	35.74	"

Uxmal — 4,649 tropical years

Modern calculation	........1,698,010.99....	error	.00	days
Gregorian "	.........1,698,012.38....	"	1.39	"
Mayan "	.........1,698,014.00	"	3.01	"
Julian "	.........1,698,047.25....	"	36.26	"

The reduction of the month position between the ancient and the modern usage partly corrects the errors in this statement but there is no evidence that this was the purpose of the change.

A few extremely doubtful dates might be added and others will doubtless be secured on painted capstones in temples of northern Yucatan. On Stela 9 at Mayapan there are indications of 10 Ahau as a katun-ending day. This may be 12–4–0–0–0, 10 Ahau 18 Uo, Sept. 28, 1437 in which case it would register a date just before the abandonment of this city. In the Cave of Loltun there may be a declaration of 12–1–0–0–0, 3 Ahau 18 Kayab, Aug. 8, 1378.

In Mound 1 at Santa Rita, Gann recovered frescoes of the period of Mexican influence. On the northern façade of this structure a succession of tuns may be pictured. On the eastern half of the façade is painted a series of gods with their hands bound by a continuous rope. The second figure from the last carries the day-sign 1 Ahau, and the others in order carry the same day but with a continuous difference of four in the number, except for the second figure. But 5 Ahau probably was written on the destroyed lower part of this figure, with which emendation the numbers com-

bined with Ahau read 1, 5, 9, 13, 4, 8, 12, which is precisely the order of the numerical coefficients for the day Ahau terminating a series of tuns. Unfortunately no more is legible except a succession of 2 Ahau and 11 Ahau on the western half, which are apparently in reverse order. There are some slight reasons for believing that the pictures referred to the twenty tuns of a Katun 8 Ahau, the first katun in the order of the U Kahlay Katunob. If so, it might refer to the katun ending in the position 12–5–0–0–0, 8 Ahau 3 Pax, June 16, 1457. Unfortunately a table of hieroglyphs was destroyed by superstitious Indians before it could be copied.

Miscellaneous Dated Objects

The Tuxtla Statuette and the Leyden Plate have been referred to; they record, respectively,

8– 6–2–4–17,	8 Caban 0 Kankin,	May 16, 98 B.C.
8–14–3–1–12,	1 Eb 0 Yaxkin,	Nov. 17, 60 A.D.

As for dates in the codices, those in the Dresden have been considered. The only date in the Tro-Cortesianus Codex is 13 Ahau 13 Cumhu which is very likely 11–6–5–0–0, 13 Ahau 13 Cumhu, Nov. 2, 1087.

Among other small objects with dates is an engraved peccary skull from Copan which registers 9–7–8–0–0, 1 Ahau 3 Ceh, Dec. 28, 321. Several jade ornaments with dates found in the Sacred Cenote at Chichen Itza obviously belong to the First Empire. The most notable one, a great bar bead, carries the leading date 13 Ahau 18 Kankin which ends a lahuntun in this position 9–10–10–0–0, 13 Ahau 18 Kankin. After this date come two others; namely, 2 Cib 14 Mol and 9 Manik 0 Pop. Then there is a day 1 Imix without a month position. These dates can be arranged as follows:

9–10–10– 0– 0,	13 Ahau 18 Kankin,	Feb.	6, 383
4– 7			
9–10–10– 4– 7,	9 Manik 0 Pop,	May	3, 383
9–10–10– 0– 0,	13 Ahau 18 Kankin	Feb.	6, 383
1			
9–10–10– 0– 1,	1 Imix 19 Kankin	Feb.	7, 383

9–10– 5–10–16,	2 Cib	14 Mol	Oct. 6, 378
2–12–13– 0			
9–12–18– 5–16,	2 Cib	14 Mol	Sept. 23, 430

The first date is an approximation to the Era of the Chronicles, next comes a declaration of the calendrical New Year on a calendar-round date which at the epoch of the Era of the Chronicles had exactly equalled the summer solstice, thus:

8–19–19– 6– 7,	9 Manik 0 Pop,	June 22, 175 A.D.
11–13		
9– 0– 0– 0– 0,	8 Ahau 13 Ceh,	Feb. 10, 176

Then comes a single day added to the approximation at the head of the inscription to get 1 Imix 19 Kankin. Now the day 1 Imix begins the tzolkin and the month position 19 Kankin at the epoch of the Mundane Era, exactly equalled August 6, the position in the natural year of the epoch of the Historical Era, thus:

12–19–19–14–11,	13 Chuen	19 Kankin,	Aug. 6, 3373 B.C.
3– 9			
13– 0– 0– 0– 0,	4 Ahau	8 Cumhu,	Oct. 14, 3373
7– 0– 0– 0– 0			
7– 0– 0– 0– 0,	10 Ahau	18 Zac,	Aug. 6, 613

Finally the date 2 Cib 14 Mol, the famous date on the tablets of Palenque stands close to the position of the epoch of the Mundane Era or exactly on the autumnal equinox if advanced one calendar round. Surely no clearer statement of scientific facts could be asked, or one better summing up the remarkable achievements of the Mayas.

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