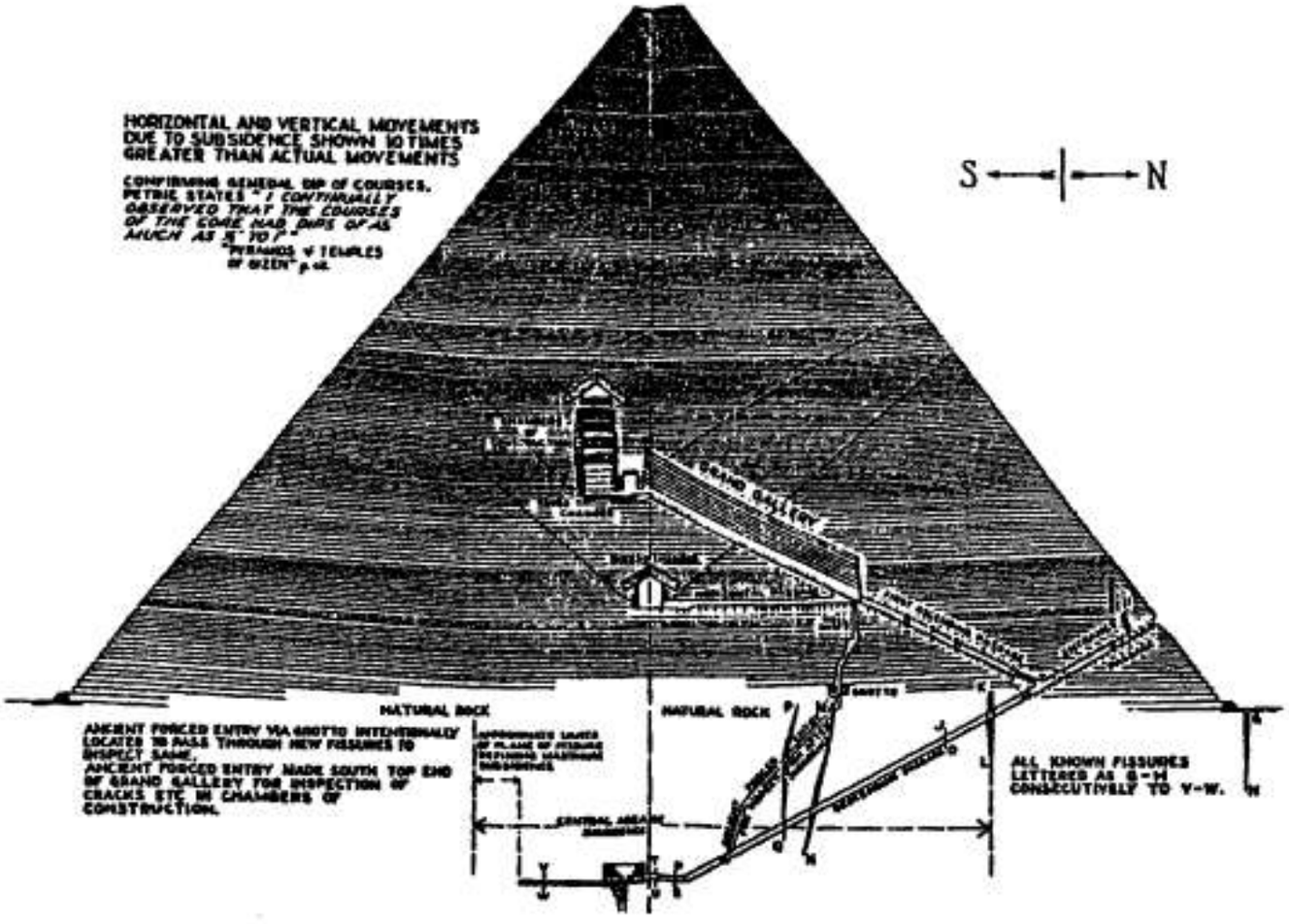
The Great Pyramid
its Divine Message

AN ORIGINAL CO-ORDINATION OF HISTORICAL
DOCUMENTS AND ARCHAEOLOGICAL EVIDENCES



D. Davidson and H. Aldersmith

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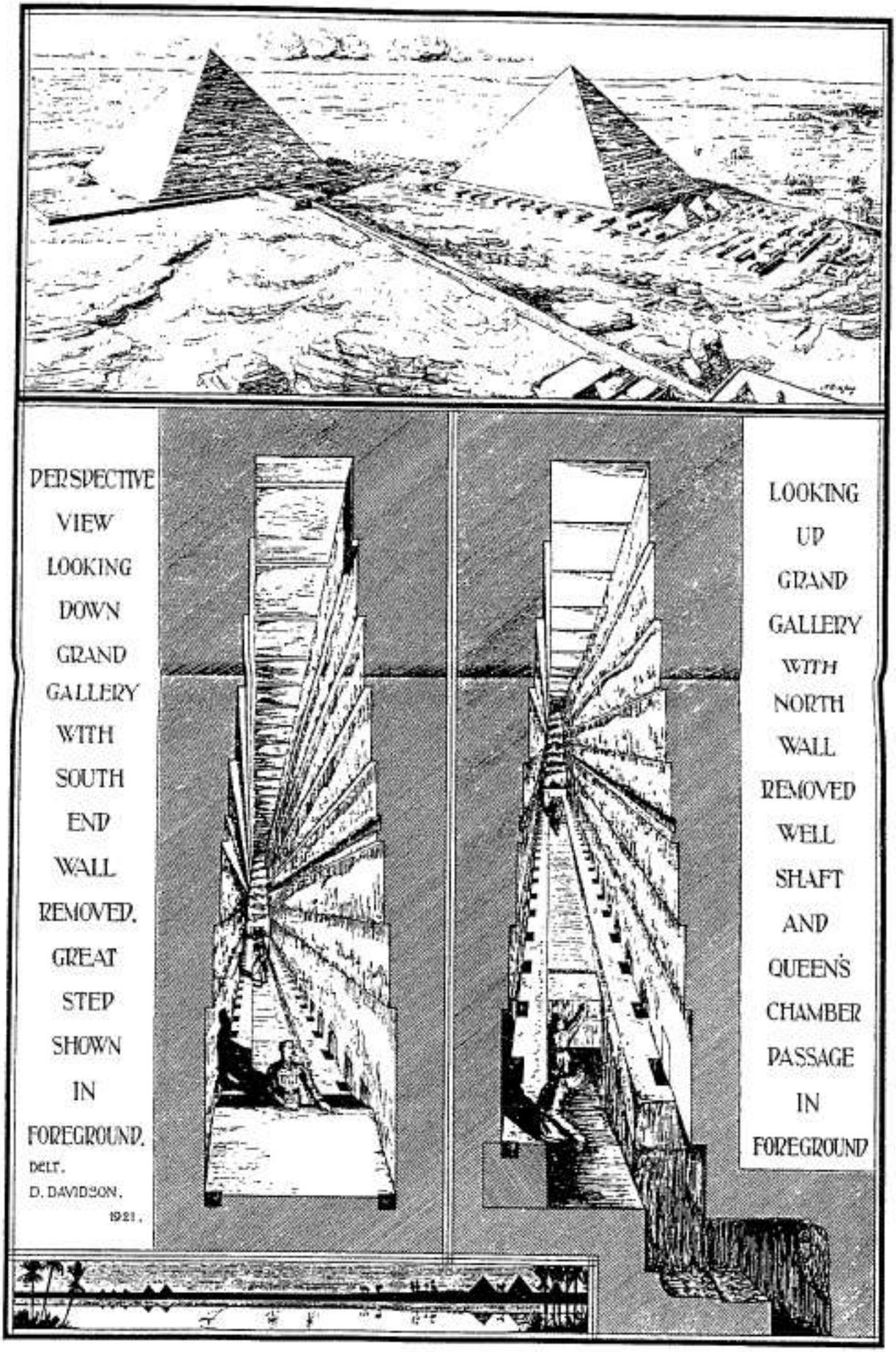


The Edge of the Great Step—now badly broken and grooved, opposite the standing figure in the left-hand panel above—is here shown restored.

My elucidation of the various phases of the Great Pyramid's design has led me to perceive that it is an expression of the Truth in structural form.

I proclaim, with humility and yet with confidence, that the Pyramid's Message establishes the Bible as the Inspired Word of God, and testifies that Jesus Christ, by HIS DISPLACEMENT, paid the purchase price of mankind's Redemption, and effected the Salvation of all who truly believe in Him.

This Message concerns all mankind, to whom, in a humble spirit, this work is dedicated, in the hope that it may bring enlightenment and comfort to many.

D. D.

INTRODUCTION

It is very probable that the reader has already perused many other books dealing with the Great Pyramid, and professing to elucidate its mystery, and to demonstrate its connection with ancient astronomy and its supposed confirmation of Biblical prophecy. The history of modern Pyramid theory is not a long one, commencing only in the second half of the 18th century. During the latter half of this century, and at the beginning of the 19th century, several works were published containing the theory that the Pyramid's base measurements were an intentional representation of the number of days in the year. A considerable advance in Pyramid theory was made in the year 1859, when Mr. John Taylor, a London publisher of some repute as a literary man and mathematician, published a book advancing the hypothesis that the proportion of the Pyramid's height to its base circuit was that of the diameter of a circle to its circumference, that the Great Pyramid was built to convey a Divine Revelation, and that its unit of measure was the Polar Diameter inch.

Strong confirmation of Taylor's theories was furnished by the survey undertaken by Professor Piazzi Smyth in 1864-65. The interior of the Pyramid was carefully measured, and angular measurements were taken of the casing stones *in situ*, and of the slope of the passages. These measurements indicated the probability that the Polar Diameter inch was the unit of measure employed; that the base circuit was a representation of the solar year; and confirmed Taylor's theory relating to the proportion of height to base. This survey and the accurate survey made by Sir William M. F. Petrie are very fully discussed in the present work, and furnish the materials for the authors' reconstruction of the Great Pyramid.

In 1865 Mr. Robert Menzies advanced the theory that the Passage System was a chronological representation of prophecy; that the scale of the chronology was one Polar Diameter inch to a solar year, and that the Great Gallery symbolised the Christian Dispensation. Subsequent development of this theory indicated that the entrance doorway to the Antechamber symbolised the beginning of the final period of Great Wars and Tribulations prophesied in the Bible. It should be noted that these identifications were made long before any evidence had been obtained from Egyptian texts to show that this interpretation was correct, and before anything was known about the ancient Egyptian Messianic prophecy.

Menzies' theory was adopted by Piazzi Smyth, but, unfortunately, he also adopted Menzies' idea that the Christian Dispensation began at the Birth of Christ, and accepted the date of the Nativity as 1 A.D. The Christian Dispensation, of course, did not begin until the Resurrection, or until Pentecost of the Crucifixion year, and had this been realised by Smyth and his followers, and had they adopted a perpendicular co-ordinate instead of a vertical co-ordinate for the end of the Grand Gallery, they would have defined, fifty-nine years ago, the precise date of the beginning of the Great War.

Many Christian thinkers realised that it was incorrect to date the beginning of the Christian Dispensation from the Birth of Christ, and protest was first made in 1881–82 by the Rev. Commander L. G. A. Roberts, who took up the matter with Smyth's followers, but was unable to persuade them to accept his views. About the same time, Dr. H. Aldersmith and the Rev. Dr. Denis Hanan both agreed that if the Grand Gallery symbolised the Christian Dispensation, then the commencement of the Gallery must necessarily symbolise the date of the Crucifixion or that of the Pentecost of the Crucifixion year.

But it was not until 1905 that Col. J. Garnier, R.E., published a work entitled "The Great Pyramid, Its Builder and Prophecy," in which he identified the beginning of the Grand Gallery with the date of the Crucifixion. His system of chronology was invalidated, however, by his adoption of 31 A.D. as the date of the Crucifixion and by his use of a vertical instead of a perpendicular co-ordinate at the end of the Grand Gallery. Nevertheless, he obtained the date of 1913 A.D. for the beginning of the War Chaos.

Following this short history of the development of Pyramid theory, the writer desires to submit a brief epitome of the subjects discussed and the conclusions reached in the present work. It is demonstrated that—

(1) The Great Pyramid is a geometrical representation of the mathematical basis of the science of a former civilisation.

(2) This former civilisation had condensed its knowledge of natural law into a single general formula, and the application of this formula was analogous to the modern application of Einstein's Theory of Relativity.

(3) The universal application of this formula in the world of this former civilisation left its impress on every form of constructional expression, whether ethical, literary, or artistic.

(4) This civilisation was anterior to all other known civilisations of the ancient East. These civilisations were established by the former civilisation, firstly, by intercourse, and finally, by migration, and their various phases of ethical, literary, and artistic expression all bear the stamp of the original scientific principles of the former civilisation.

(5) The Egyptian Records define the geometrical dimensions and the unit of measure of a Standard Pyramid that constitutes the geometrical expression of the ancient Law of Relativity.

(6) The survey of Sir William M. F. Petrie shows that the Great Pyramid of Gizeh is the Standard Pyramid defined by the Egyptian Records.

(7) The Passage System forms the graphical representation of an elaborate system of prophetical chronology, intimately related to the Biblical prophecy, giving various essential datings for the Christian Dispensation and accurately predicting the precise dates of the beginning and ending of the Great War.

(8) The Pyramid symbolism, when considered in conjunction with Biblical prophecy, indicates that its message is addressed to the present era, and that the final Time of Tribulation, so often prophesied in the Bible, is now upon us.

The reader will realise that many new and startling interpretations are presented that will give ample scope for criticism to students of many and various branches of science. The authors do not claim to be experts in any particular science, but believe they have succeeded in co-ordinating the finished work of the best authorities in each particular branch of knowledge that is alluded to in this work.

It will be found that the work naturally divides itself into the following subjects :—

I. The History of Geometry and Metrology.
II. Gravitational Astronomy.
III. Astronomical Chronology.
IV. Archæology and History.
V. Theology.

This range of deep and apparently unrelated subjects is necessary because it is found that the literary records of the ancient civilisations of the East—but particularly those of the Egyptians and Hebrews—indicate that the mathematical application of the ancient Law of Relativity governs the ancient form of presentation of each of the subjects enumerated.

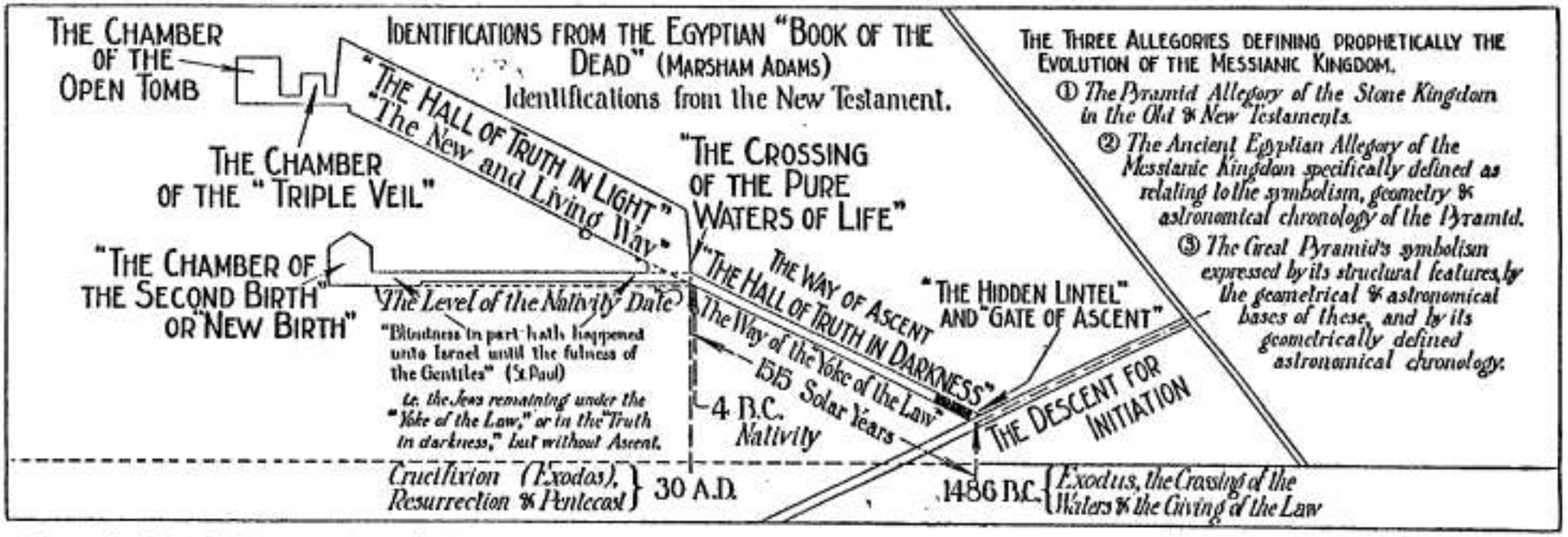
A brief discussion of the scope of the present work under each of these headings will not be out of place.

I. THE HISTORY OF GEOMETRY AND METROLOGY.

It is shown that the system of ancient metrology was founded upon two functions of the earth and its orbit, the standard time unit being the solar year, and the standard distance unit a decimal sub-division of the earth's Polar Diameter. This standard distance unit is established independently from innumerable ancient metrological sources, from the Egyptian texts, and from the Great Pyramid itself, as the primitive or Pyramid inch, of the value of 1·0011 British inches. Twenty-five of such inches are one ten-millionth part of the earth's Polar Radius, and are also equal to the ancient Hebrew Sacred Cubit.

THE SURVIVING FRAGMENTS OF ANCIENT EGYPTIAN MESSIANISM IN THE EGYPTIAN "BOOK OF THE DEAD" COMPARED WITH THE MESSIANIC ALLEGORIES OF THE OLD AND NEW TESTAMENTS; AND THE RELATION OF THE IMAGERY OF BOTH TO THE STRUCTURAL SYMBOLISM OF THE GREAT PYRAMID.

"The Pyramids and the 'Book of the Dead' reproduce the same original, the one in words, the other in stone" *(the late Sir Gaston Maspero, Director-General of Antiquities in Egypt.)*



Commencing from the Entrance or Descending Passage, the successive structural features are as follows:—

(1) The 1st Ascending Passage = "The Hall of Truth in Darkness";

(2) The Horizontal Passage and Queen's Chamber ("The Chamber of Second—or New—Birth");

(3) The 2nd Ascending Passage or Grand Gallery = "The Hall of Truth in Light"; its roof line being raised—"uplifted"—by the extent of the Pyramid's Displacement Factor, above the line of the roof of the 1st Ascending Passage. This is the symbolic equivalent of St. Paul's statement that Jesus Christ "will raise us up by His own Power" (1 Cor. vi, 14).

Then, following the horizontal floor from the Great Step at the upper end of the Grand Gallery (refer to Plate LXVc, as derived from Plates XLIII, LXVa, and LXVb in "The Great Pyramid: Its Divine Message").

(4) The 1st Low Passage; 4-5 August, 1914, to 11 November, 1918.

(5) The Antechamber = The Chamber of the "Triple Veil"; 11 November, 1918 —29 May, 1928.

(6) The 2nd Low Passage; 29 May, 1928 to 16 Sept., 1936

(7) The King's Chamber = The Chamber of the Open Tomb, also called "The Hall of the Grand Orient."

The central Axial Plane of the Passages is displaced eastwards from the central North to South Vertical Central Plane of the Pyramid by the extent of the Pyramid's Displacement Factor. The Pyramid's Central North to South Vertical Plane cannot be reached within the structure until the King's Chamber is entered

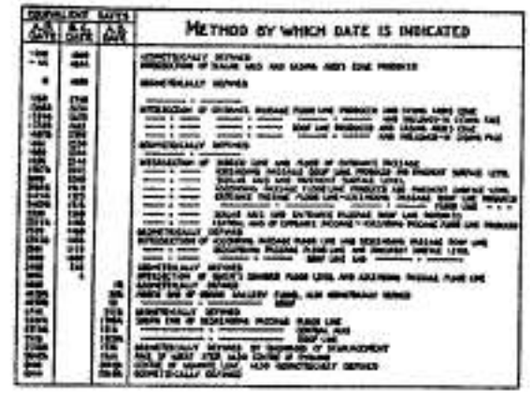
THE GREAT PYRAMID

RIGHT VERTICAL NORTH – SOUTH SECTION

DATE OF BUILDING UNCERTAIN BUT CIRC. 3000–2500 B.C.

S ← → N

POLE STAR AND ALCYONÊ ALIGNMENTS DEFINE PYRAMID'S YEAR BEGINNING AS AUTUMNAL EQUINOX AND DAY BEGINNING AS MIDNIGHT (PYRAMID TIME)



DATES DEFINED BY THE PYRAMID'S GEOMETRICAL REPRESENTATION OF THE FORMULAE OF GRAVITATIONAL ASTRONOMY

NOTE –

— 4000 B.C. (NEARLY)

— 3909 B.C. (ASTRONOMICAL)

— DEATH OF 1 B.C. (NEARLY)

— —"— 0 B.C. (ASTRONOMICAL)

— —"— 1 A.D.

— —"— 1844 A.D.

6000 A.E. — —— 6000 ASTRONOMICAL (TROPICAL YEARS (WHEN SUM 2170 A.D. = 2170 B.C.)

IF 2nd 1823 A.D. = 10173 A.D.

FIG. B.

FIG. A.

In Fig. A., the hollowing-in is magnified ten times, and is such that $DD_1 = HH_1 = \frac{1}{10}$th Pyramid's Displacement Factor (366.1022) in Pyramid inches.

To the Scale of 100 Pyramid inches to the day :—

(1) The structural circuit of 4 bases sides such as AD_1H_1B gives the mean value of the Sidereal year.

(2) The square circuit ABYX gives the mean values of the Solar or Tropical year.

(3) The circuit of 4 base sides such as AmB gives the mean value of the Anomalistic or Orbital year.

For the Effects of Subsidence, and for the engineering features devised to counteract such effects, the technical reader is referred to Chap. III. "The Great Pyramid: Its Divine Message."

In Fig. A, K_1 and K_2 produced meet at a point K such that KO gives, to the scale of $\frac{1}{10}$ millionth, the length of the Major Axis of the Earth's Orbit. To the same scale NOP = UOV, gives the minimum value, and WOC = LOM gives the maximum value of the Eccentricity of the Earth's Orbit. The value NOP (= UOV = DCH) is defined by the Aroura parallelograms, AFDE and BGEH, in Fig. B.

This representation of the Earth's Orbit is based on the Aroura rectangle, the length of which is 1,652·42 P.", defining the Solar year to the scale of 10 P." to a day.

Now the $\frac{1}{10}$ millionth part of the Earth's Polar radius is 10 P." The Earth and its Orbit are thus completely defined to the same scale.

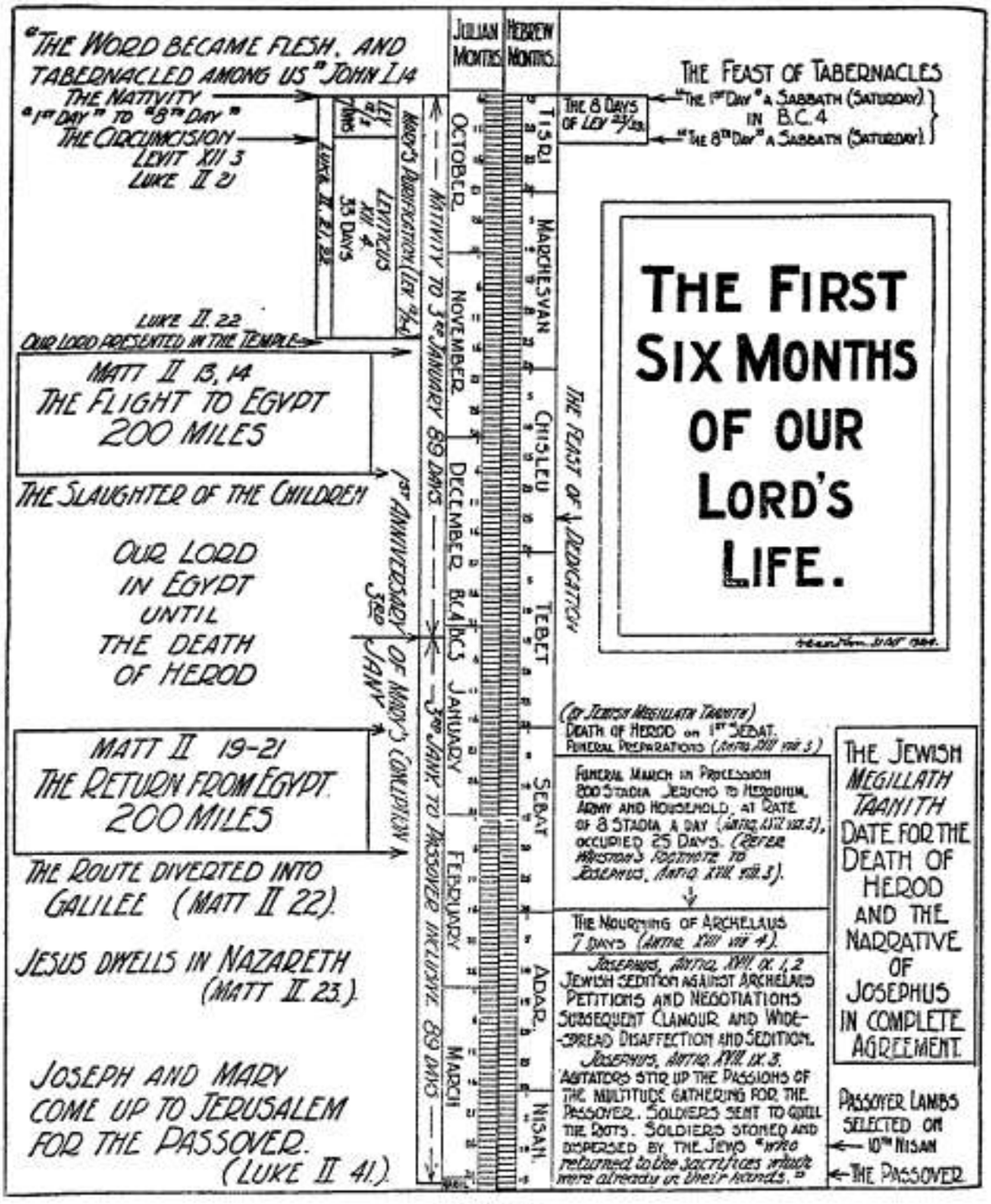


PLATE I.

• BORN "THE LORD OF THE SABBATH":—Our Lord's "1st day" and His "8th day" of Circumcision (Levit. xii, 3; Luke ii, 21) coincided with "the 1st day" and "8th day" of Tabernacles respectively, which were both "holy Sabbaths" (Levit. xxiii, 39), regardless of the day of the week upon which they fell. In this particular year, these days fell upon the actual weekly Sabbath. Now the revision in 1446 B.C. at the time of Joshua's "long day" (Note ** to p. 3), had altered the weekly Sabbath from the original 7th day to the original 1st day of the week (*i.e.*, to the 8th day) when reckoned by clock time. The circumstances of the Resurrection indicate what this prefigured (Note to p. 1)

THE FEAST OF TABERNACLES PREFIGURES THE NATIVITY.

The Feast of Tabernacles began on the 15th Tisri and continued for 7 days. FOURTEEN LAMBS were sacrificed on each of the 7 days. With the Nativity on the Feast of Tabernacles, these 7 days would be the initial 7 days of purification of Levit. xii, 2, prior to our Lord being circumcised on the 8th day (Levit. xii, 3 and Luke ii, 22). With this realised, the symbolical significance of the fourteen lambs of the Feast of Tabernacles becomes apparent as soon as we read Matt. i, 17. This deals with the generations prior to the Birth of our Lord. These are :—

Abraham to David	14 generations.
David to Jewish Exile	14 generations.
The Jewish Exile to Christ	14 generations.

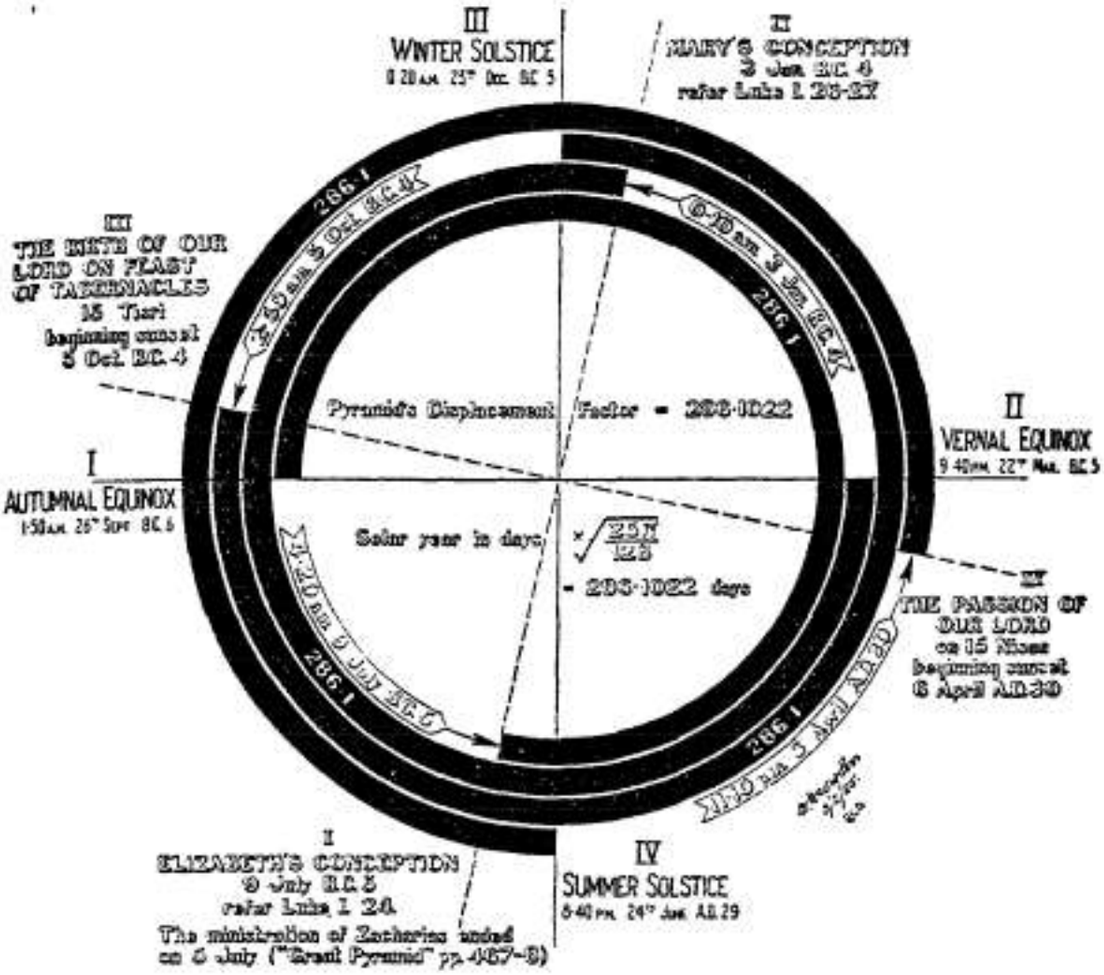
Moreover, at the Feast of Tabernacles beginning on the 15th of Tisri, the Divine Command in Levit. xxiii, 39, states " ye shall keep a feast unto the Lord 7 days : on the *first day* shall be a *Sabbath* and on the *eighth day* shall be a *Sabbath*."* Why ? Because our Lord was to be born at the Feast of Tabernacles, in a year divinely appointed in which the decreed 1st day should fall, in the natural course of events, upon a Sabbath. This occurred in B.C. 4, in the year that saw the Birth of our Lord. In that year the first day of the Feast—the 15th of Tisri—fell on the Sabbath, Saturday, 6th October (Julian) and the decreed 8th day fell on the Sabbath, Saturday, 13th October (Julian) when our Lord was circumcised.

Everything points to our Lord having been born at the Feast of Tabernacles, the Romans having arranged that the enrolling or census should be taken at the great gathering of the people for this Feast. In B.C. 4, the actual day of the Feast of Tabernacles fell on 6th October (Julian), a Sabbath (*i.e.*, Saturday). If we take this as the day of the Nativity, our Lord was taken up to the Temple on 15th November, and shortly afterwards taken to Egypt. He would arrive in Egypt at latest early in December, where He remained until after the death of Herod on the following 18th January. He returned to Nazareth some time in February, and His parents went up to Jerusalem to be present at the Passover on the following 31st March (refer to Plate I.)

THE COURSE OF ABIA CONFIRMS THE DATE.

The date of the Nativity at 6th October does not, therefore, depend upon our interpretation of the statement concerning the course of Abia. The two, however, are mutually confirmatory, it being admitted that the course of Abia (Luke i, 5) began fifteen months before our Lord's birth. Now there were 24 orders for " the governors of the sanctuary " (I Chron., xxiv), and Abia was the eighth. In the parallel cases of the twelve captains that served the king, and the twelve officers of the royal household, the courses began with the year (at 1st Nisan), and completed the year, a course for a month (I Chron., xxvii, 1-15 and I Kings, iv, 7). By the same sequence, the 24 orders of the priests above began on 1st Nisan and completed the year, two courses a month. This is not necessarily so, but if it gives the 6th October Nativity date, the two lines of evidence are in agreement. In such case, the 1st course would begin at 1st Nisan in B.C. 5, and the 8th course, that of Abia, on 15th Tammuz of the same year. The Nativity was fifteen months later. This gives the 15th Tisri in B.C. 4. Now, 15th Tisri is the date of the Feast of Tabernacles, and in B.C. 4, 15th Tisri coincided with the 6th October. The two items of evidence are therefore in agreement. Our Lord was born on 6th October, B.C. 4. This is all fully discussed in " The Great Pyramid : Its Divine Message," pages 463 and 471.

* RESURRECTED " THE LORD OF THE SABBATH."—In the year of the Crucifixion there were again a " 1st day " and an " 8th day." These fell not on the 7th day of the week but on the 1st day of the week. Our Lord was selected as God's Passover " Lamb " on the 10th Nisan (John xii, 23-33 ; John i, 29 ; Rev. xiii, 8 ; I Cor. v, 7), when the Passover lambs were selected (Exod. xii, 13). This was on " Palm Sunday," the " 1st day " of the week. After His Crucifixion and burial, He rose again from the dead on the 1st day of the week, 17th Nisan, on " the 8th day." He rose as " The Sun of Righteousness." Born " the Lord of the Sabbath " (Mark ii, 28) under the Law, He was resurrected " the Lord of the Sabbath " bringing in the New Birth and the New Covenant, and consecrating His day of Resurrection as the Sabbath (Rest-day) of the New Covenant. What happened to the week in the time of Joshua again occurred at the Resurrection. Sunday is therefore the Christian's Sabbath (Rest) by the New Spiritual " Circumcision of Christ " (Col. ii 11-14), who is both " the minister of circumcision " (Rom. xv, 8) and " the Lord of the Sabbath " (Mark ii, 28). That is why circumcision was on " the 8th day."



A recently discovered geometrical representation of the Pyramid formulæ for the Equinoxes and Solstices from 4429 B.C. to 2001 A.D. gives essentially the same results—within less than an hour of variation—as are to be derived from Hansen's solar tables. The Pyramid representation is given in terms of the Displacement Factor and other simple functions of the geometry of the solar year circle. Hansen's solar tables are confirmed by Newcomb's discussion of all recorded eclipses from 721 B.C. to 1750 A.D.

NOTE.—The Dates given above for the Solstices and Equinoxes are the exact Julian dates for the particular years stated The usual Julian dates given by Christian chronologers are for the 2nd Century A.D. This confirms the date of origin of the traditional Christian Calendar. For explanation of Gregorian Calendar dates refer page 8.

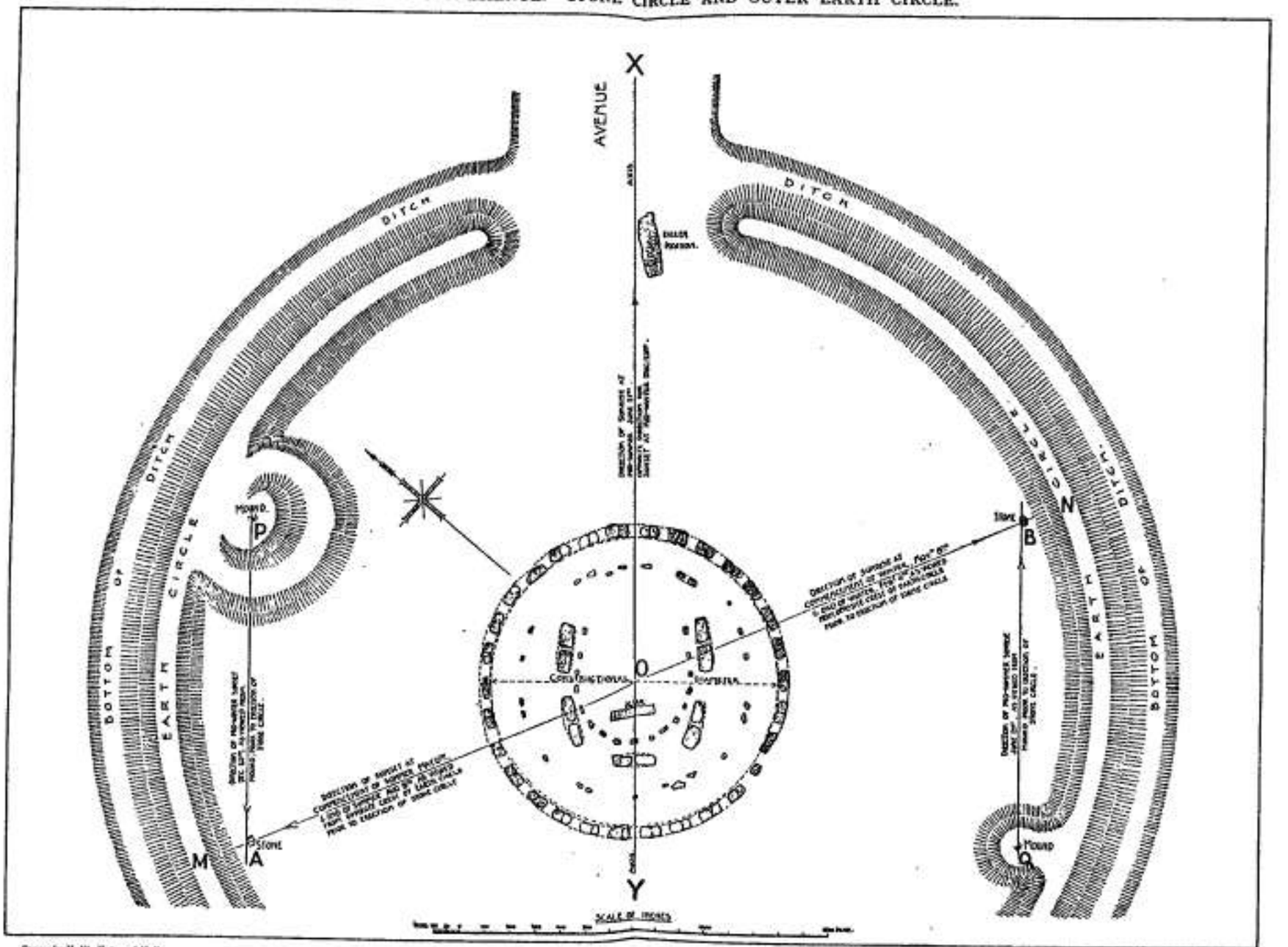
PLATE II.

The above diagram shows the Displacement Factor defining the 15th Nisan beginning Sunset 6th April, A.D. 30, as the day of the Passion of our Lord. This is confirmed by the Great Pyramid dating which is 4028·531789 A.P., i.e., 15th Nisan, 7th April, A.D. 30, 1-20 p.m. at Jerusalem, the time when our Lord was on the Cross.

The governing physical properties of the earth and its orbit (as given in Booklet No. 1 page 12), the Crucifixion date and the expression of SPIRITUAL UPLIFT accorded to man on that date are all defined by the same Displacement Factor. This constitutes a clear declaration—given in terms of God's Creative Law—proclaiming THE DIVINITY OF OUR LORD JESUS CHRIST, and confirming the words of the Apostle concerning "The mystery, which from the beginning of the world hath been hid in God, WHO CREATED ALL THINGS BY JESUS CHRIST," "in whom are hid all the treasures of wisdom and knowledge."

PLATE I.

PLAN OF STONEHENGE. STONE CIRCLE AND OUTER EARTH CIRCLE.



Drawn by H. W. Hayward Hall.

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PLATE II.

PERSPECTIVE VIEW OF STONEHENGE AT TIME OF SUNRISE OF SUMMER SOLSTICE. 1680 B.C.

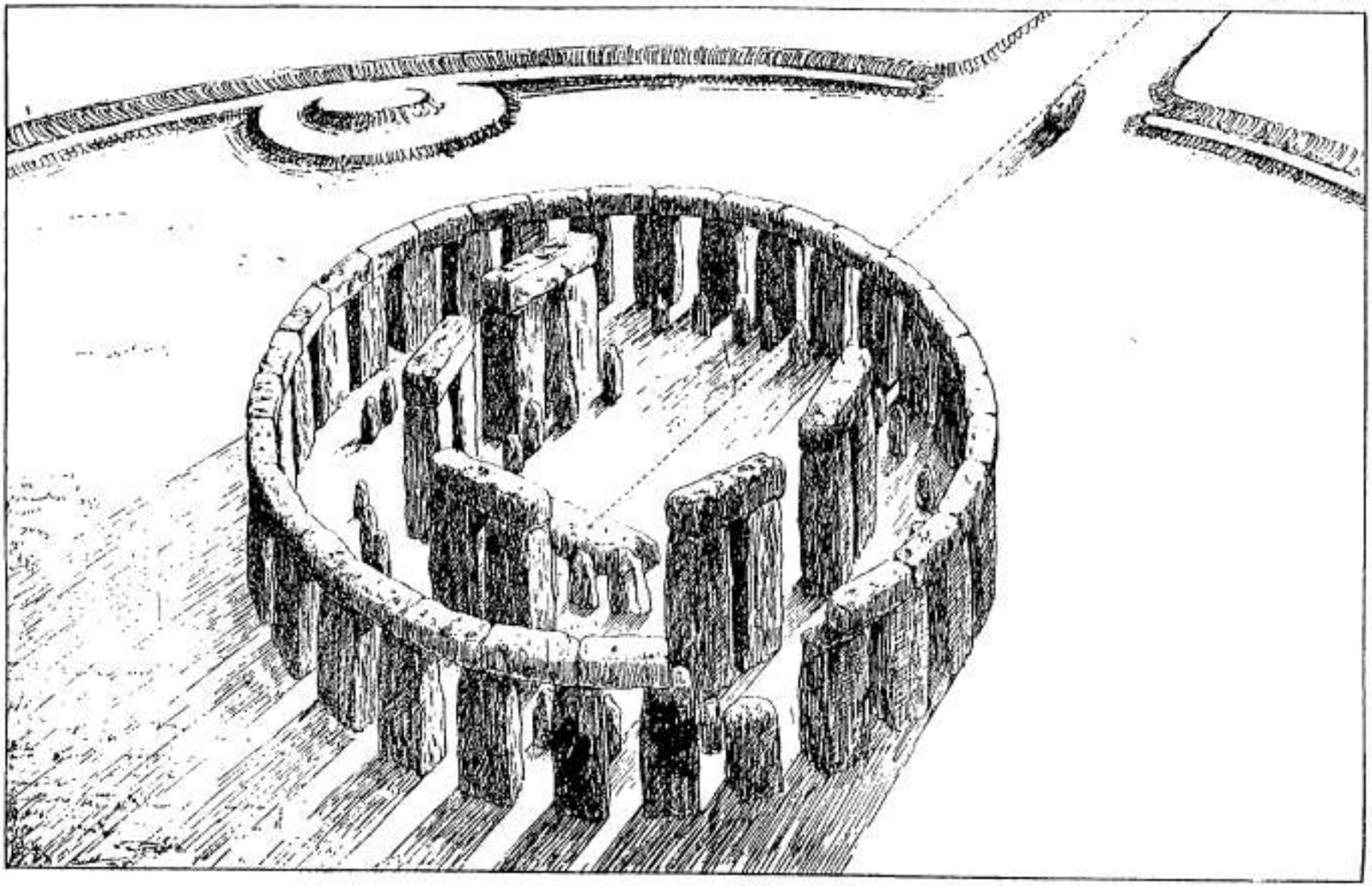

TABLE I.

THE TWO RECOGNISED FORMS OF SOLAR YEAR IN ANCIENT TIMES.

(STATED WITH REFERENCE TO MODERN CALENDAR YEAR FOR 1901 A.D.)

The Solar Astronomical Year.			*The Solar Vegetation Year.*
Early Semitic Astronomical Year began at AUTUMNAL EQUINOX	23 SEPT.		
WINTER BEGINS ..	MID-WAY ..	8 NOV.	Ancient November Agricultural Year began.
WINTER SOLSTICE ..	23 DEC.		
SPRING BEGINS ..	MID-WAY ..	4 FEB.	Chinese Agricultural Year began, (B.C. 2448).[1]
Later Semitic Astronomical Year began at VERNAL EQUINOX	21 MAR.		
SUMMER BEGINS ..	MID-WAY[2] ..	6 MAY	Ancient May Agricultural Year began.
SUMMER SOLSTICE ..	21 JUNE.		
AUTUMN BEGINS ..	MID-WAY[2] ..	8 AUG.	
AUTUMNAL EQUINOX	23 SEPT.		

¶ 2. STONEHENGE TEMPLE OBSERVATORY AND ALMANAC CIRCLE. (Plates I and II).

In our own country there exist hundreds of ancient structural devices for indicating the principal points of the two recognised forms of the Solar year. The best-known monument of this nature is that of the Stonehenge circle. This consists of the arrangement of upright stones and lintels contained within the earthwork circle, as figured restored, on Plates I and II. The Avenue Approach to the Circle cuts the Earthwork circle as shown on the Plates.

Stonehenge Alignments define the points of the Solar Astronomical and Solar Vegetation Years.

[1] "The Chinese *Shu-King*." W. G. Old, pp. 301-2, and note. Translation of Book I, Sect. I, pp. 1-2, and Translator's notes to same.
Encycl. Brit. (11th Edit.), Vol. VI, p. 317.

[2] By "Mid-Way" is intended 45° of *Right Ascension* from an Equinox or Solstice; not mid-way as defined by the interval in days.

PLATE III.

MAP OF THE NILE DELTA.

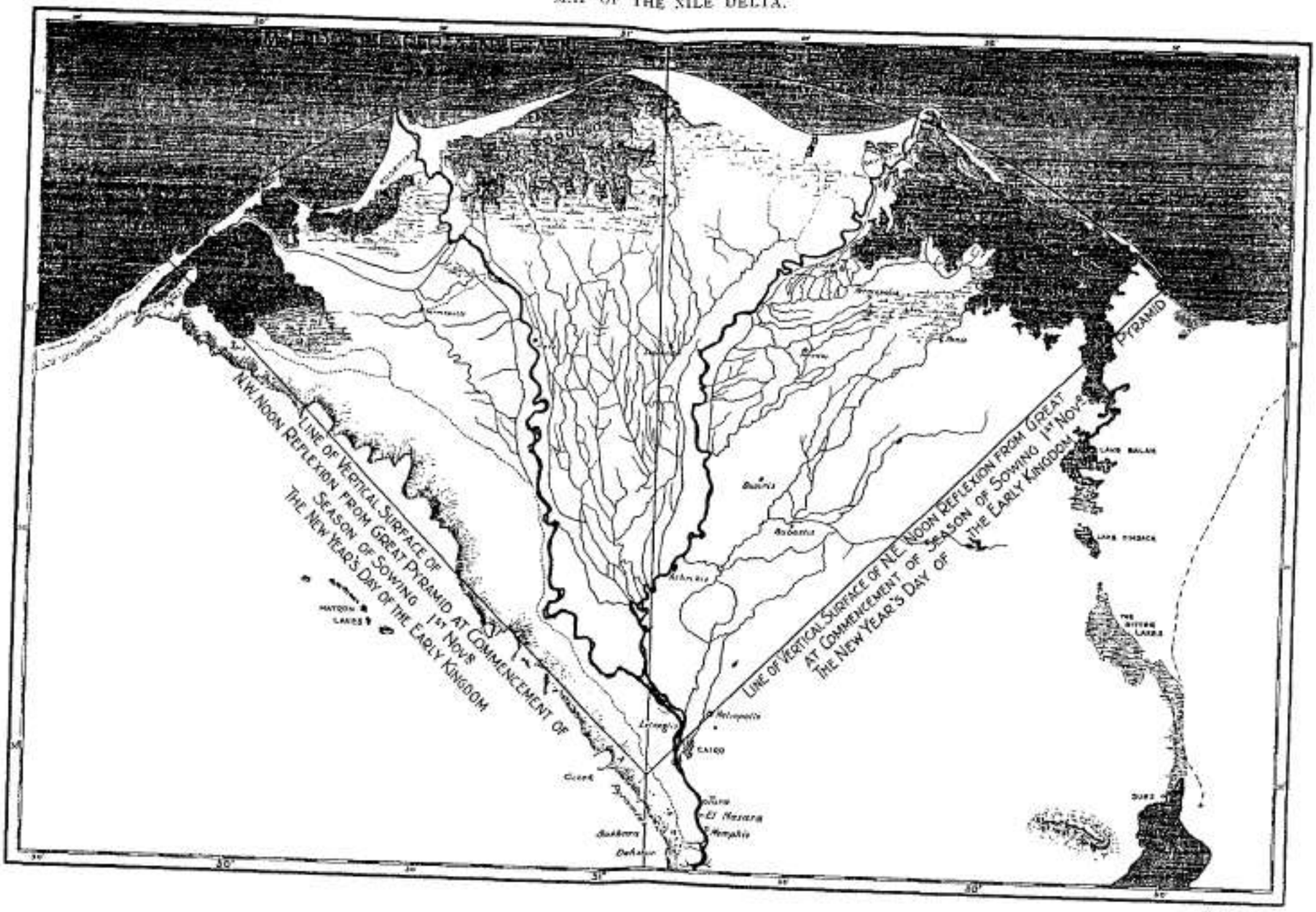

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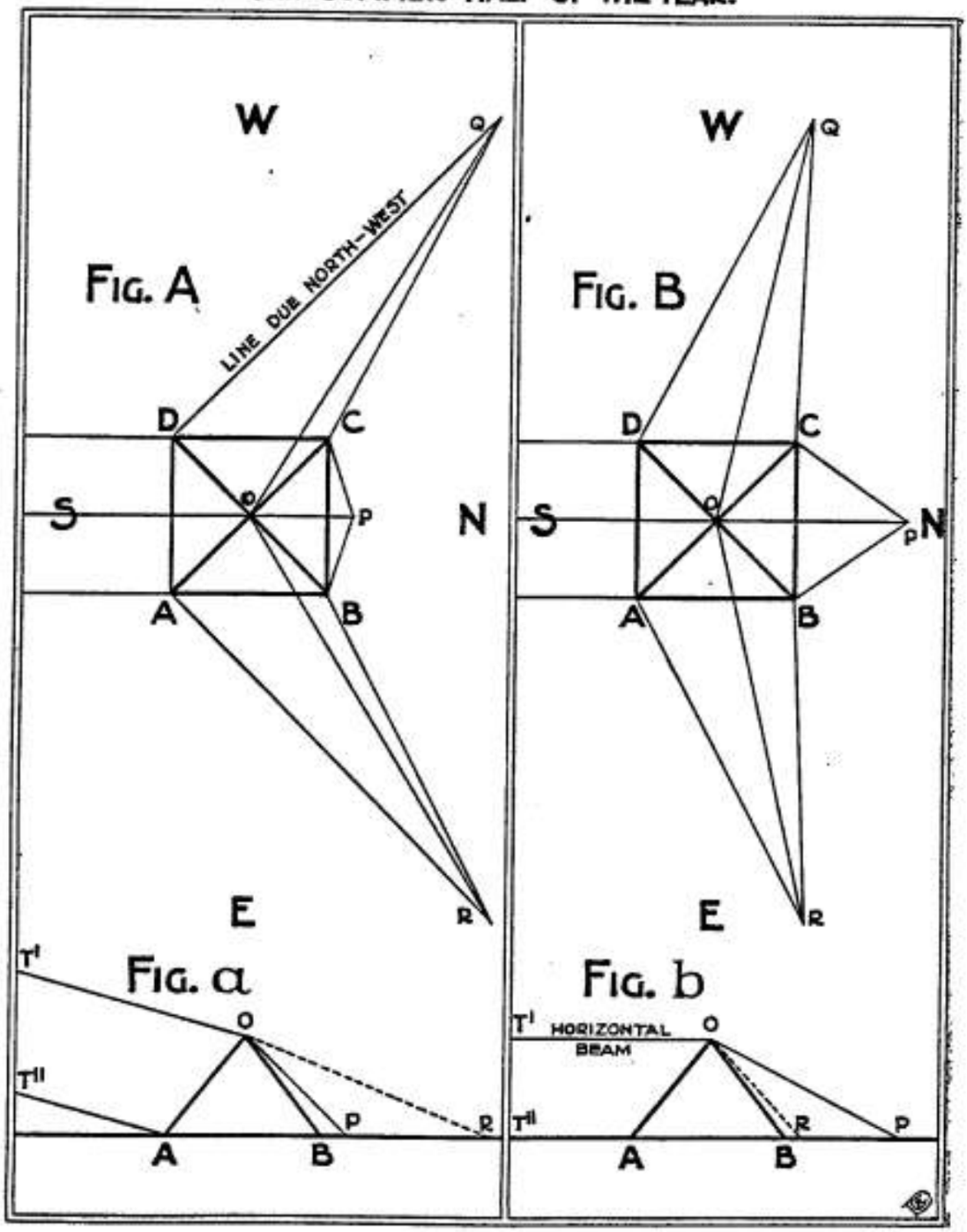
PLATE V.

PYRAMID NOON REFLEXIONS & SHADOWS

NOON REFLEXIONS OF THE SUMMER HALF OF THE YEAR.



Autumnal Equinox or Vernal Equinox
REFLEXIONS.

Midway between Vernal Equinox,
and Summer Solstice,
Midway between Summer Solstice
and Autumnal Equinox
REFLEXIONS.

PLATE VI.

PYRAMID NOON REFLEXIONS & SHADOWS

NOON REFLEXIONS AT SUMMER SOLSTICE.

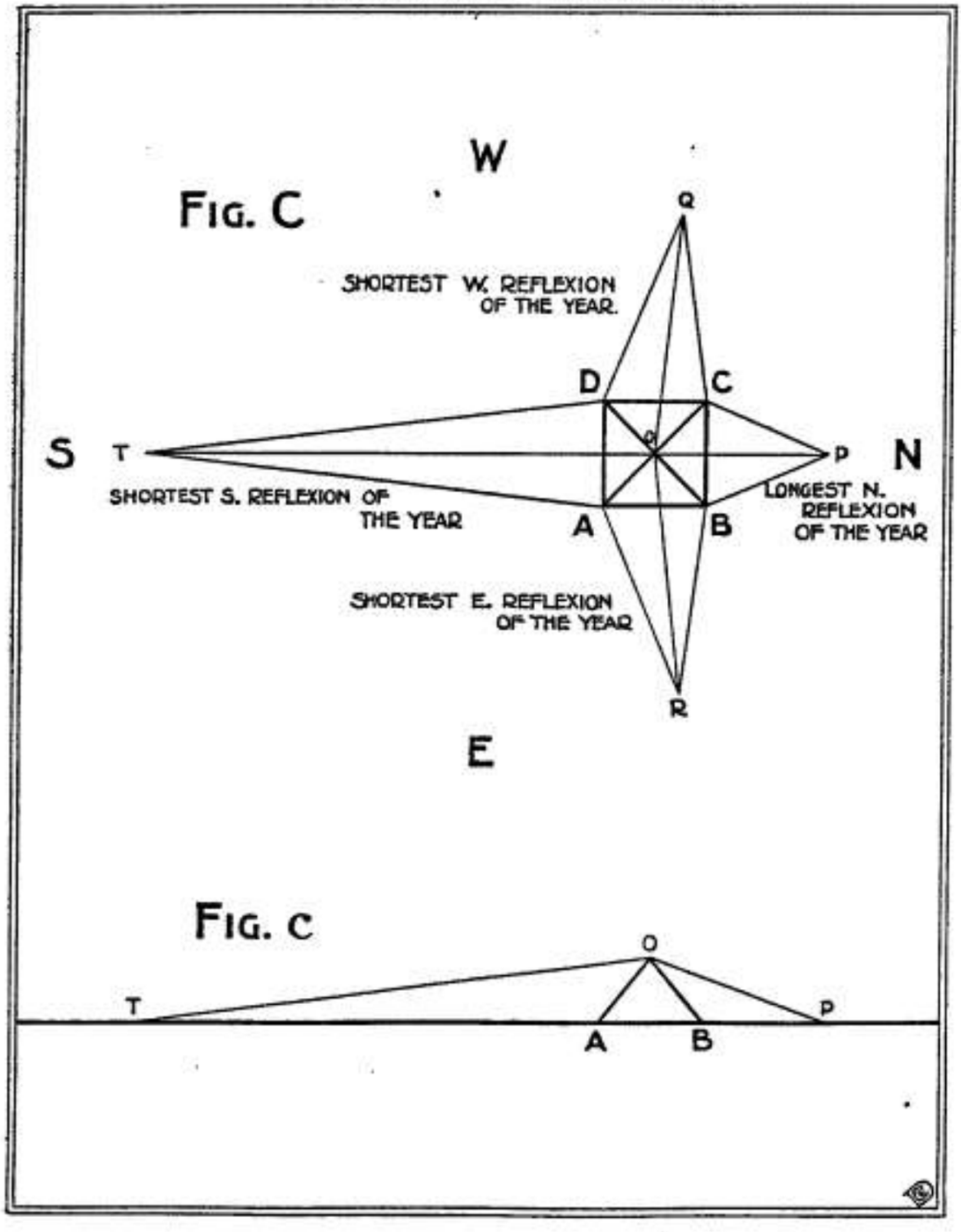


PLATE VII.

PYRAMID NOON REFLEXIONS & SHADOWS

NOON REFLEXIONS & SHADOWS.
14-15 OCT. NOON SHADOWS 1ST APPEARING.
27-28 FEB. NOON SHADOWS 1ST DISAPPEARING.

NOON REFLEXIONS & SHADOWS.
OF THE WINTER HALF
OF THE YEAR.

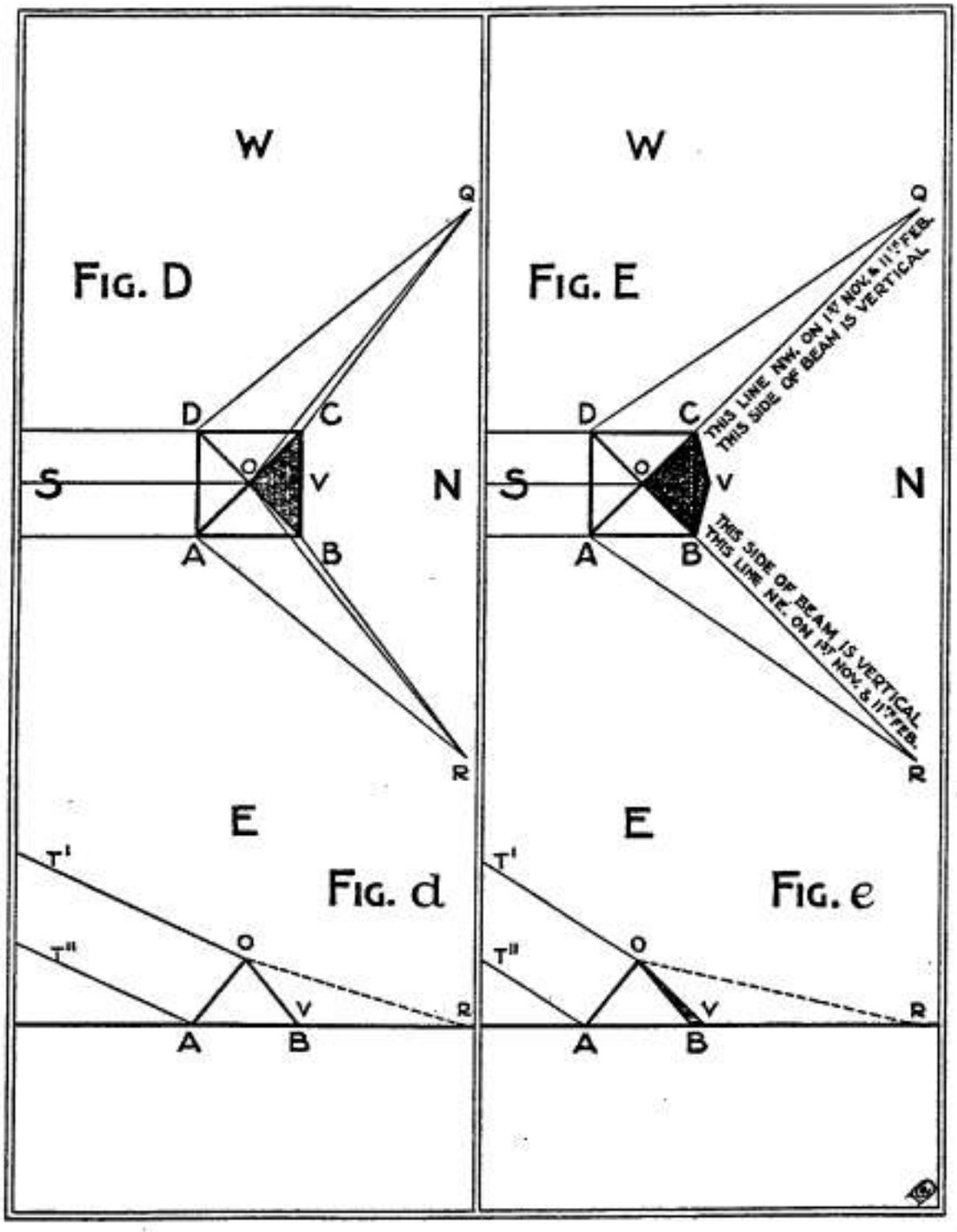
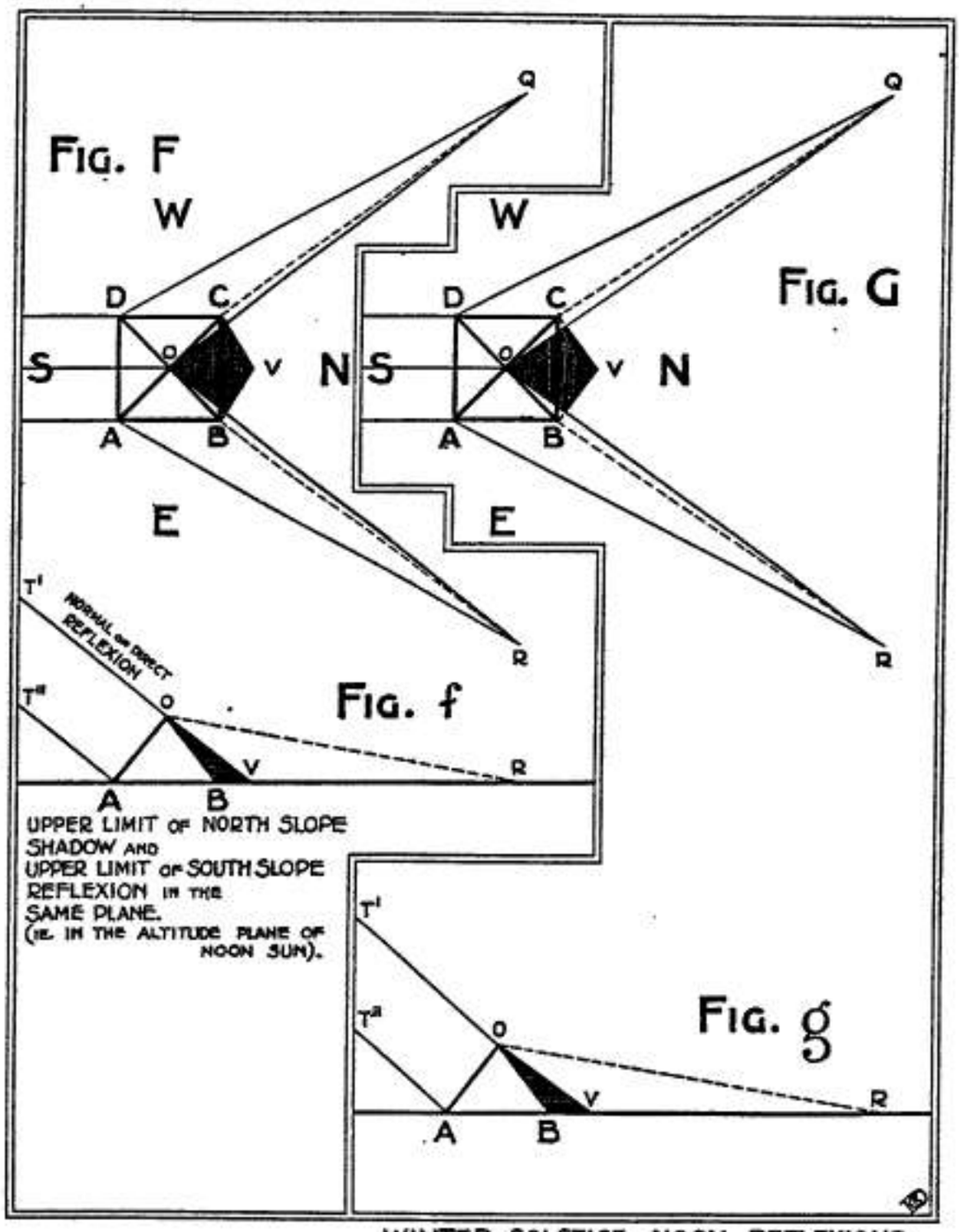


PLATE VIII.

PYRAMID NOON REFLEXIONS & SHADOWS

NOON REFLEXIONS AND SHADOW.
2 – 3 DEC. AND 11 – 12 JAN.



WINTER SOLSTICE NOON REFLEXIONS AND SHADOW

¶ 14. THE PYRAMID'S EQUINOCTIAL NOON REFLEXIONS.

The East and West Noon Reflexions define North-East and North-West Directions at the Equinoxes

The noon reflexions from the East and West faces of the Pyramid projected triangular images (Plates V to VIII) on the ground on each day of the year. Almost East and West respectively at the Summer Solstice (Plate VI), the Apex of each triangular image was North-East and North-West respectively from the East and West corners of the South Base side of the Pyramid at the instant of Vernal Equinoctial and Autumnal Equinoctial noon (Plate V, Fig. A).

This may be otherwise stated as follows :—(Plate V, Fig. A).

The East noon reflexion from the Pyramid projected a triangular image ARB, on the ground. This triangle consisted of a base, AB, lying on the Pyramid's East Base Side, AB, and of two other sides, which we may define, in terms of the plan, the South side, AR, and the North side, BR, of the triangular image. Thus defined, the line of the South side, AR, of the triangular image, pointed due North-East at Vernal Equinoctial and Autumnal Equinoctial noon. This was precisely the case during the period in history when the Pyramid was thus operating as a Sundial of the Seasons. In modern times the phenomenon noted would occur a day or so before the Vernal Equinox, and a day or so after the Autumnal Equinox.

Similarly defined (and with reference to Plate V, Fig. A), the line of the South side, DQ, of the triangular image, DQC, projected from the West face slope of the Pyramid, pointed due North-West at Vernal Equinoctial and Autumnal Equinoctial noon.

¶ 15. THE PYRAMID'S DEFINITION OF WINTER.

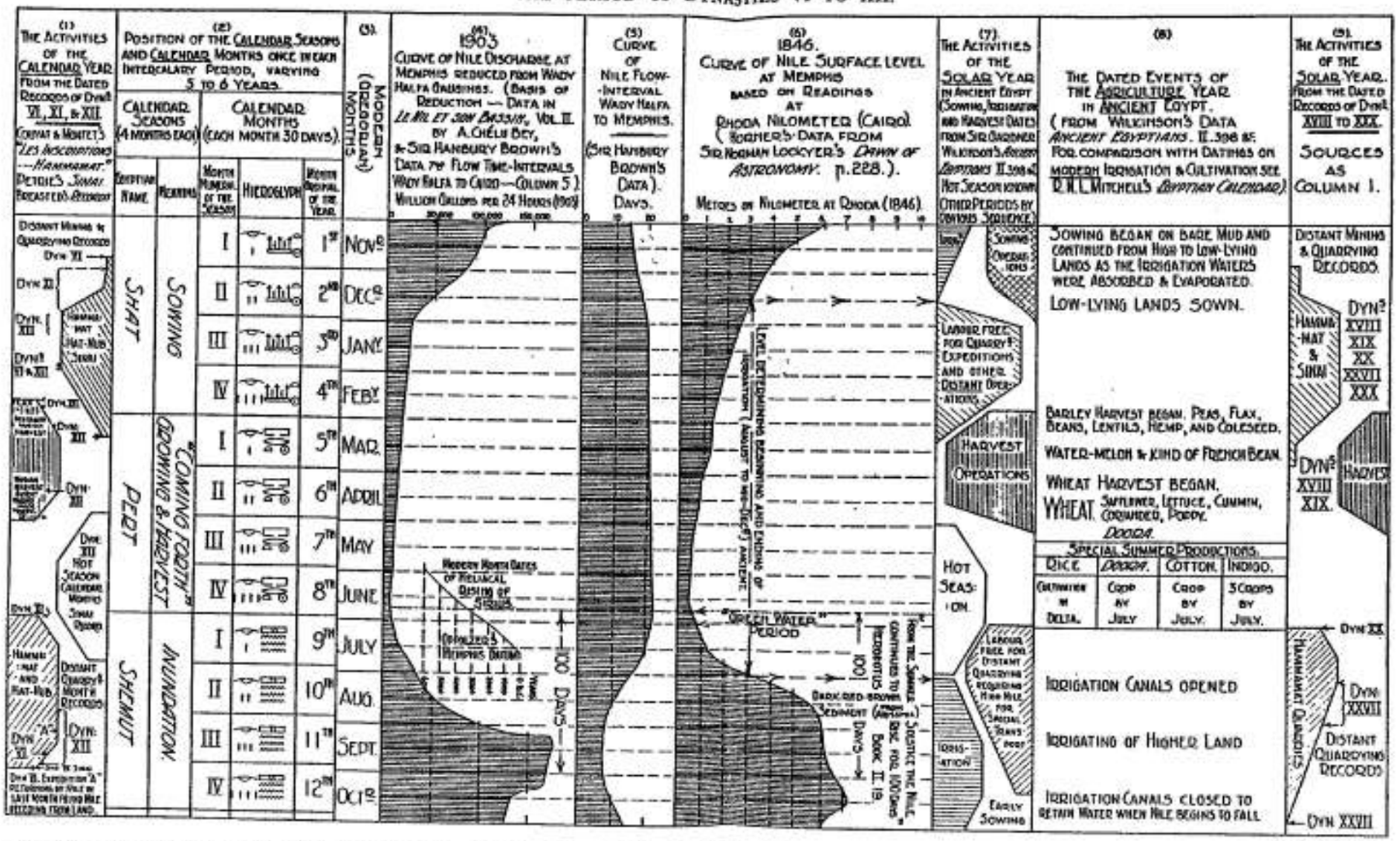
The solid beams of reflected light proceeding from the East and West face slopes of the Pyramid at noon had a further remarkable property defining Winter as distinct from Spring, Summer, and Autumn. Reference to Plates V to VIII shows that in all cases the East and West Solid noon reflexions had a sharply defined ridge line running from the Pyramid apex to the apex of each of the images projected on the ground.

Surface of East or West Noon Reflexion seen from North inclined overhanging towards observer in Winter and inclined away from observer in Spring, Summer, and Autumn.

The East and West noon reflected beams had, therefore, each a surface seen from the North side of the Pyramid, and a surface seen from the South side of the Pyramid. The side of the East or West noon reflected beam, as viewed from the South, always, throughout the year, appeared inclining away from the observer. The side of the East or West noon reflected beam, however, as viewed from the North side of the Pyramid, appeared inclining away from the observer during Spring, Summer, and Autumn, but appeared overhanging towards the observer during Winter, as shown on Plate VIII, Figs. F and G.

PLATE IX.

CHART SHOWING THE SEASONAL PHENOMENA AND ACTIVITIES OF THE *SOLAR YEAR* IN ANCIENT EGYPT COMPARED WITH THE SEASONAL PHENOMENA AND ACTIVITIES OF THE EARLY EGYPTIAN *CALENDAR YEAR* COMPILED FROM THE DATED RECORDS OF THE PERIOD OF DYNASTIES VI TO XII.



[To face p. 20.

The data given graphically on this chart settle a vexed question of Egyptian Chronology for the historical period preceding Dynasty XVIII. The two leading schools of Egyptological chronology disagree to the extent of 1460 (or 1580) years in dating Dynasty XII. Both schools agree that the Egyptian Calendar year at the time in question slipped backwards 1 day in every four years, or a complete year in about every 1500 years, and their rival systems of chronology are based on this theory. The data of the above chart, however, show clearly that the Egyptian Calendar year was a fixed year agreeing with the seasonal datings of the Nile valley prior to Dynasty XVII.

The two leading schools of Egyptological chronology are therefore now seen to disagree concerning the application of principles that did not exist at the time in question.

PLATE X.

CHART OF LIMITS OF EARLY EGYPTIAN INTERCALATED CALENDAR YEAR, EGYPTIAN SEASONS, AND GREAT PYRAMID NOON REFLEXION AND SHADOW PHENOMENA STATED WITH REFERENCE TO THE MODERN (GREGORIAN) MONTHS.

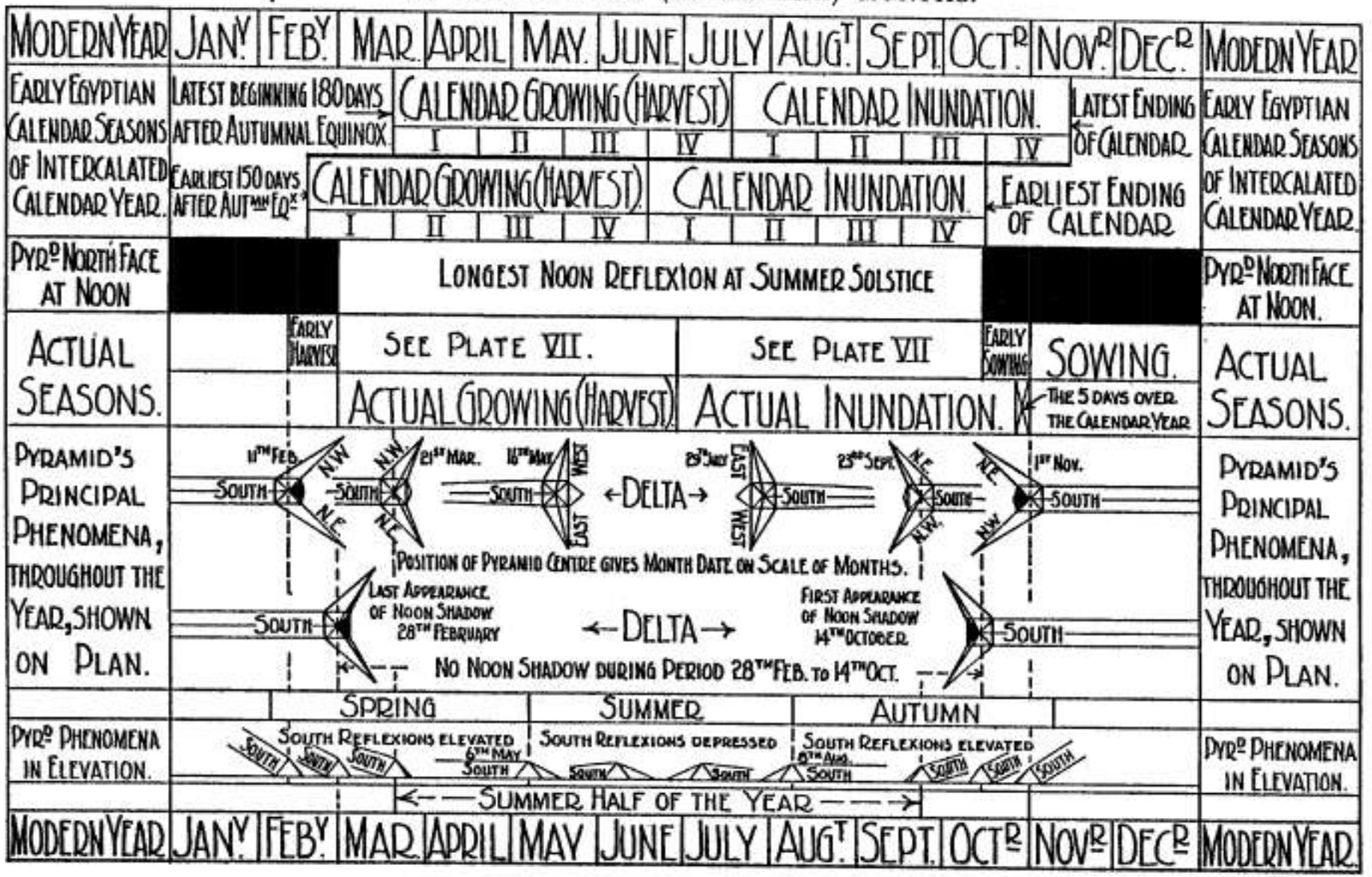


PLATE XI.

RECORDS OF THE PERIOD OF DYNASTIES VI TO XII OF DISTANT QUARRYING EXPEDITIONS TO THE QUARRIES AT WADY HAMMAMAT AND HAT NUB, AND TO THE MINES AND QUARRIES AT SINAI.

CALENDAR DATES OF HARVEST RECORDS	RECORDS OF DISTANT QUARRYING EXPEDITIONS TO												EARLY EGYPTIAN CALENDAR YEAR	
	HAMMAMAT				HAT-NUB				SINAI					
	Day of Month	Year of Reign	Dyn.	King	Day of Month	Year of Reign	Dyn.	King	Day of Month	Year of Reign	Dyn.	King	Calendar Month	Season
					–	29th	VI	PEPY I					I	CALENDAR SEASON OF SOWING
	–3–	2nd	XI	MENTUHOTEP II									II	
	–15–	2nd	XI	MENTUHOTEP II										
	22 23 28	2nd 2nd 2nd	XI XI XI	MENTUHOTEP II										
	1	2nd 16th	XII XII	AMENEMHAT III SENUSERT I									III	
	–13–	16th 29th	XII XII	AMENEMHAT III AMENEMHAT III					–12–	–	XII	AMENEMHAT III		
DYN. XII FLAX HARVEST (EL BERSHEH) 25th–27th DAYS OF MONTH	1 2 4	1st 16th 44th	XII XII XII	ATY SENUSERT I SENUSERT II SENUSERT III									IV	
SENUSERT I (DYN XII) YEAR 18 THROWS NUBIAN GRAIN INTO NILE IN THIS MONTH ON 8TH DAY OF MONTH.	–												I	CALENDAR SEASON OF GROWING AND HARVEST
	–15–	19th	XII	AMENEMHAT III										
													II	
SENUSERT II (DYN XII) YEAR 16. PRIOR TO RECORD OF THIS MONTH SENUSERT II BEARED GRAIN & BURNT SAME IN NUBIA.									HOR-UR-RA'S XIIITH DYNASTY RECORD AT SINAI OF HOT WEATHER MONTHS BREASTED (Records I, p. 332) PETRIE (Sinai p. 169)				III	
													IV	
	–3–	8th	XI	SANKH KARA									I	CALENDAR SEASON OF INUNDATION
													II	
	– –27–	– 16th	XII XI	AMENEMHAT I PEPY I	[illegible]	–	VI	MERENRA					III	
	–3–	–	XII	AMENEMHAT I	[illegible]	–	VI	MERENRA	–6–	18th	VI	PEPY I	IV	

Apart altogether from this evidence, however, we know that the noon phenomena of the Great Pyramid automatically fixed the November Agricultural year. Now the Calendar years of 360 and 365 days were in use in Pyramid times, and the November year, beginning the sowing season, had previously been fixed—the fixing being monumentalised in the names of the Calendar seasons. It is clear then that the Pyramid's noon phenomena gave a high degree of accuracy to an adjustment of the Calendar year in relation to the Solar year that had already been long previously effected.

Great Pyramid's Fixing of November year gave accuracy to Adjustment Already effected.

The fixed November year, again, is confirmed by the dated *Calendar* records of the activities of the agricultural (or Solar) year during the period of Dynasties VI, XI, and XII. These are as graphically represented in Plate IX, Column 1, stated with reference to the Time Basis of Column 2, and as compared with actual conditions of Columns 7, 8 and 9, stated with reference to the Time Basis of Column 3.[1]

Dated Calendar Records Dynasties VI, XI, XII, confirm fixed November Year

¶ 25. THE FESTIVAL OF THE DEAD.

Attention has been directed (in ¶ 15) to the fact that the 1st November dating was intentionally observed instead of the beginning of Winter, seven days later. The 1st November Pyramid phenomena defined the first day of the fixed agricultural year of the Ancient Egyptians. It is with respect to this fixed 1st November year that the early Egyptian Calendar year was intercalated at the end of every five or six years. Hence the festival of the true beginning of the New Year was observed in Egypt at intervals of this duration as early as the time of Dynasties I and II.[2]

Period Egyptian Dynasties I and II, Calendar Year adjusted every 5 or 6 years to the Fixed 1st November Agricultural Year Beginning.

At the time of Dynasty XII, the celebration of the New Year festival took the form of lighting lamps for the dead on the last day of the old year and the first day of the New Year.[3] As Dr. Frazer has pointed out, this proves that the New Year's Festival at this time was the ancient Festival of the Dead—the modern All Souls', or All Saints' (1st-2nd November).[4]

Period Dynasty XII, lamps lit for dead on 1st November —the date of the Festival of the Dead—All Saints—All Souls.

"The custom," he remarks,[5] "was observed throughout the whole of Egypt," and is referred to by Herodotus (II, 62), as prevailing in the 5th Century B.C.

"On All Saints' Day, the 1st of November," Frazer continues, "the shops and streets in the Abruzzi are filled with candles, which people buy in order to kindle them in the evening on the graves of their relations: For all the dead come to visit their homes on that night, the Eve of All Souls', and they need lights to show them the way."

Ancient Custom still prevails in parts of Modern Europe on 1st to 2nd November.

Similarly, he states, "The Miztecs of Mexico believed that the souls of the dead came back in the twelfth month of every year, which corresponded with our November. On this day of All Souls the houses were decked out to welcome the Spirits."[6]

Ancient Mexican Celebrations in November.

[1] Detailed explanations are given in descriptions of Plates IX, X, and XI.
[2] For the data concerning this refer Section II, ¶ 56.
[3] Breasted, "Ancient Records," I, pp. 260-271. Frazer, "Adonis, Osiris, Attis," pp. 241-242.
[4] "Adonis, Osiris, Attis," pp. 241-2.
[5] Ibid., pp. 241-2.
[6] Ibid., pp. 244-8.

TABLE II.

ANCIENT INTERCALARY CYCLE AND ITS INTERCALARY PERIODS.

Cyclic years' duration.	Intercalated 360 days' Calendar Year. Duration on Cycle in Months.		in Days.	Intercalated 365 days' Calendar Year. Duration on Cycle in Months.		in Days.	Number of days in mean years of Cycle. Days.
6	73	=	2190	73	=	2190	2191.45632
11	134	=	4020	134	=	4020	4017.66992
17	207	=	6210	207	=	6210	6209.12624
23	280	=	8400	280	=	8400	8400.58256
28	341	=	10230	341	=	10230	10226.79616
34	414	=	12420	414	=	12420	12418.25248
40	487	=	14610	487	=	14610	14609.70880
46	560	=	16800	560	=	16800	16801.16512
51	621	=	18630	621	=	18630	18627.37872
57	694	=	20820	694	=	20820	20818.83504
63	767	=	23010	767	=	23010	23010.29136
68	828	=	24840	828	=	24840	24836.50496
74	901	=	27030	901	=	27030	27027.96128
80	974	=	29220	974	=	29220	29219.41760
86	1047	=	31410	1047	=	31410	31410.87392
91	1108	=	33240	1108	=	33240	33237.08752
97	1181	=	35430	1181	=	35430	35428.54384
103	1254	=	37620	1254	=	37620	37620.00000

TABLE III.

THE CONSTRUCTION OF THE INTERCALARY CYCLE OF 103 YEARS.

Cyclic Years' Duration	Cumulative Days for Duration in Mean Years of Cycle	360 Days' Calendar Year.			365 Days' Calendar Year.		
		Duration on Cycle		Day 1 Month 1 Commencing Before (—) or After (+) Beginning of Mean Year of Cycle	Duration on Cycle		Day 1 Month 1 Commencing Before (—) or After (+) Beginning of Mean Year of Cycle
		In Months	In Days		In Months	In Days	
0	0.	0	0	0.00	0	0	0.00
1	365.24272	12	360	— 5.24	12⅛	365	— 0.24
2	730.48544	24	720	— 10.49	24⅛	730	— 0.49
3	1095.72816	36	1080	— 15.73	36⅛	1095	— 0.73
4	1460.97088	48	1440	— 20.97	48⅛	1460	— 0.97
5	1826.21360	60	1800	— 26.21	60⅛	1825	— 1.21
6	2191.45632	73	2190	— 1.46	73	2190	— 1.46
7	2556.69904	85	2550	— 6.70	85⅛	2555	— 1.69
8	2921.94176	97	2910	— 11.94	97⅛	2920	— 1.94
9	3287.18448	109	3270	— 17.18	109⅛	3285	— 2.18
10	3652.42720	121	3630	— 22.43	121⅛	3650	— 2.43
11	4017.66992	134	4020	+ 2.33	134	4020	+ 2.33
12	4382.91264	146	4380	— 2.19	146⅛	4385	+ 2.09
13	4748.15536	158	4740	— 8.16	158⅛	4750	+ 1.84
14	5113.39808	170	5100	— 13.40	170⅛	5115	+ 1.60
15	5478.64080	182	5460	— 18.64	182⅛	5480	+ 1.36
16	5843.88352	194	5820	— 23.88	194⅛	5845	+ 1.12
17	6209.12624	207	6210	+ 0.87	207	6210	+ 0.87
18	6574.36896	219	6570	— 4.37	219⅛	6575	+ 0.63
19	6939.61168	231	6930	— 9.61	231⅛	6940	+ 0.39
20	7304.85440	243	7290	— 14.85	243⅛	7305	+ 0.14
21	7670.09712	255	7650	— 20.10	255⅛	7670	— 0.10
22	8035.33984	267	8010	— 25.34	267⅛	8035	— 0.34
23	8400.58256	280	8400	— 0.58	280	8400	— 0.58
24	8765.82528	292	8760	— 5.83	292⅛	8765	— 0.83
25	9131.06800	304	9120	— 11.07	304⅛	9130	— 1.07
26	9496.31072	316	9480	— 16.31	316⅛	9495	— 1.31
27	9861.55344	328	9840	— 21.55	328⅛	9860	— 1.55
28	10226.79616	341	10230	+ 3.20	341	10230	+ 3.20
29	10592.03888	353	10590	— 2.04	353⅛	10595	+ 2.96
30	10957.28160	365	10950	— 7.28	365⅛	10960	+ 2.72
31	11322.52432	377	11310	— 12.52	377⅛	11325	+ 2.48
32	11687.76704	389	11670	— 17.77	389⅛	11690	+ 2.23
33	12053.00976	401	12030	— 23.01	401⅛	12055	+ 1.99
34	12418.25248	414	12420	+ 1.75	414	12420	+ 1.75
35	12783.49520	426	12780	— 3.50	426⅛	12785	+ 1.50
36	13148.73792	438	13140	— 8.74	438⅛	13150	+ 1.26
37	13513.98064	450	13500	— 13.98	450⅛	13515	+ 1.02
38	13879.22336	462	13860	— 19.22	462⅛	13880	+ 0.78
39	14244.46608	474	14220	— 24.47	474⅛	14245	+ 0.53
40	14609.70880	487	14610	+ 0.29	487	14610	+ 0.29
41	14974.95152	499	14970	— 4.95	499⅛	14975	+ 0.05
42	15340.19424	511	15330	— 10.19	511⅛	15340	— 0.19
43	15705.43696	523	15690	— 15.44	523⅛	15705	— 0.44
44	16070.67968	535	16050	— 20.68	535⅛	16070	— 0.68
45	16435.92240	547	16410	— 25.92	547⅛	16435	— 0.92
46	16801.16512	560	16800	— 1.17	560	16800	— 1.17
47	17166.40784	572	17160	— 6.41	572⅛	17165	— 1.41
48	17531.65056	584	17520	— 11.65	584⅛	17530	— 1.65
49	17896.89328	596	17880	— 16.89	596⅛	17895	— 1.89
50	18262.13600	608	18240	— 22.14	608⅛	18260	— 2.14
51	18627.37872	621	18630	+ 2.62	621	18630	+ 2.62

THE CONSTRUCTION OF THE INTERCALARY CYCLE OF 103 YEARS.—(*Continued*).

Cyclic Years' Duration	Cumulative Days for Duration in Mean Years of Cycle	360 Days' Calendar Year.			365 Days' Calendar Year.		
		Duration on Cycle		Day 1 Month 1 Commencing Before (—) or After (+) Beginning of Mean Year of Cycle	Duration on Cycle		Day 1 Month 1 Commencing Before (—) or After (+) Beginning of Mean Year of Cycle
		In Months	In Days		In Months	In Days	
52	18992.62144	633	18990	— 2.62	633¼	18995	+ 2.38
53	19357.86416	645	19350	— 7.86	645½	19360	+ 2.14
54	19723.10688	657	19710	— 13.11	657¼	19725	+ 1.89
55	20088.34960	669	20070	— 18.35	669⅝	20090	+ 1.65
56	20453.59232	681	20430	— 23.59	681⅞	20455	+ 1.41
57	20818.83504	694	20820	+ 1.16	694	20820	+ 1.16
58	21184.07776	706	21180	— 4.08	706¼	21185	+ 0.92
59	21549.32048	718	21540	— 9.32	718¼	21550	+ 0.68
60	21914.56320	730	21900	— 14.56	730¼	21915	+ 0.44
61	22279.80592	742	22260	— 19.81	742⅝	22280	+ 0.19
62	22645.04864	754	22620	— 25.05	754⅞	22645	— 0.05
63	23010.29136	767	23010	— 0.29	767	23010	— 0.29
64	23375.53408	779	23370	— 5.53	779¼	23375	— 0.53
65	23740.77680	791	23730	— 10.78	791¼	23740	— 0.78
66	24106.01952	803	24090	— 16.02	803¼	24105	— 1.02
67	24471.26224	815	24450	— 21.26	815¼	24470	— 1.26
68	24836.50496	828	24840	+ 3.49	828	24840	+ 3.49
69	25201.74768	840	25200	— 1.75	840¼	25205	+ 3.25
70	25566.99040	852	25560	— 6.99	852¼	25570	+ 3.01
71	25932.23312	864	25920	— 12.23	864¼	25935	+ 2.77
72	26297.47584	876	26280	— 17.48	876¼	26300	+ 2.52
73	26662.71856	888	26640	— 22.72	888⅛	26665	+ 2.28
74	27027.96128	901	27030	+ 2.04	901	27030	+ 2.04
75	27393.20400	913	27390	— 3.20	913¼	27395	+ 1.80
76	27758.44672	925	27750	— 8.45	925¼	27760	+ 1.55
77	28123.68944	937	28110	— 13.69	937¼	28125	+ 1.31
78	28488.93216	949	28470	— 18.93	949⅜	28490	+ 1.07
79	28854.17488	961	28830	— 24.17	961⅛	28855	+ 0.83
80	29219.41760	974	29220	+ 0.58	974	29220	+ 0.58
81	29584.66032	986	29580	— 4.66	986¼	29585	+ 0.34
82	29949.90304	998	29940	— 9.90	998¼	29950	+ 0.10
83	30315.14576	1010	30300	— 15.15	1010¼	30315	— 0.15
84	30680.38848	1022	30660	— 20.39	1022¼	30680	— 0.39
85	31045.63120	1034	31020	— 25.63	1034⅛	31045	— 0.63
86	31410.87392	1047	31410	— 0.87	1047	31410	— 0.87
87	31776.11664	1059	31770	— 6.12	1059¼	31775	— 1.12
88	32141.35936	1071	32130	— 11.36	1071¼	32140	— 1.36
89	32506.60208	1083	32490	— 16.60	1083¼	32505	— 1.60
90	32871.84480	1095	32850	— 21.84	1095¼	32870	— 1.84
91	33237.08752	1108	33240	+ 2.91	1108	33240	+ 2.91
92	33602.33024	1120	33600	— 2.33	1120¼	33605	+ 2.67
93	33967.57296	1132	33960	— 7.57	1132¼	33970	+ 2.43
94	34332.81568	1144	34320	— 12.82	1144¼	34335	+ 2.18
95	34698.05840	1156	34680	— 18.06	1156¼	34700	+ 1.94
96	35063.30112	1168	35040	— 23.30	1168⅜	35065	+ 1.70
97	35428.54384	1181	35430	+ 1.46	1181	35430	+ 1.46
98	35793.78656	1193	35790	— 3.79	1193¼	35795	+ 1.21
99	36159.02928	1205	36150	— 9.03	1205¼	36160	+ 0.97
100	36524.27200	1217	36510	— 14.27	1217¼	36525	+ 0.73
101	36889.51472	1229	36870	— 19.51	1229⅜	36890	+ 0.49
102	37254.75744	1241	37230	— 24.76	1241⅛	37255	+ 0.24
103	37620.00016	1254	37620	0.00	1254	37620	0.00

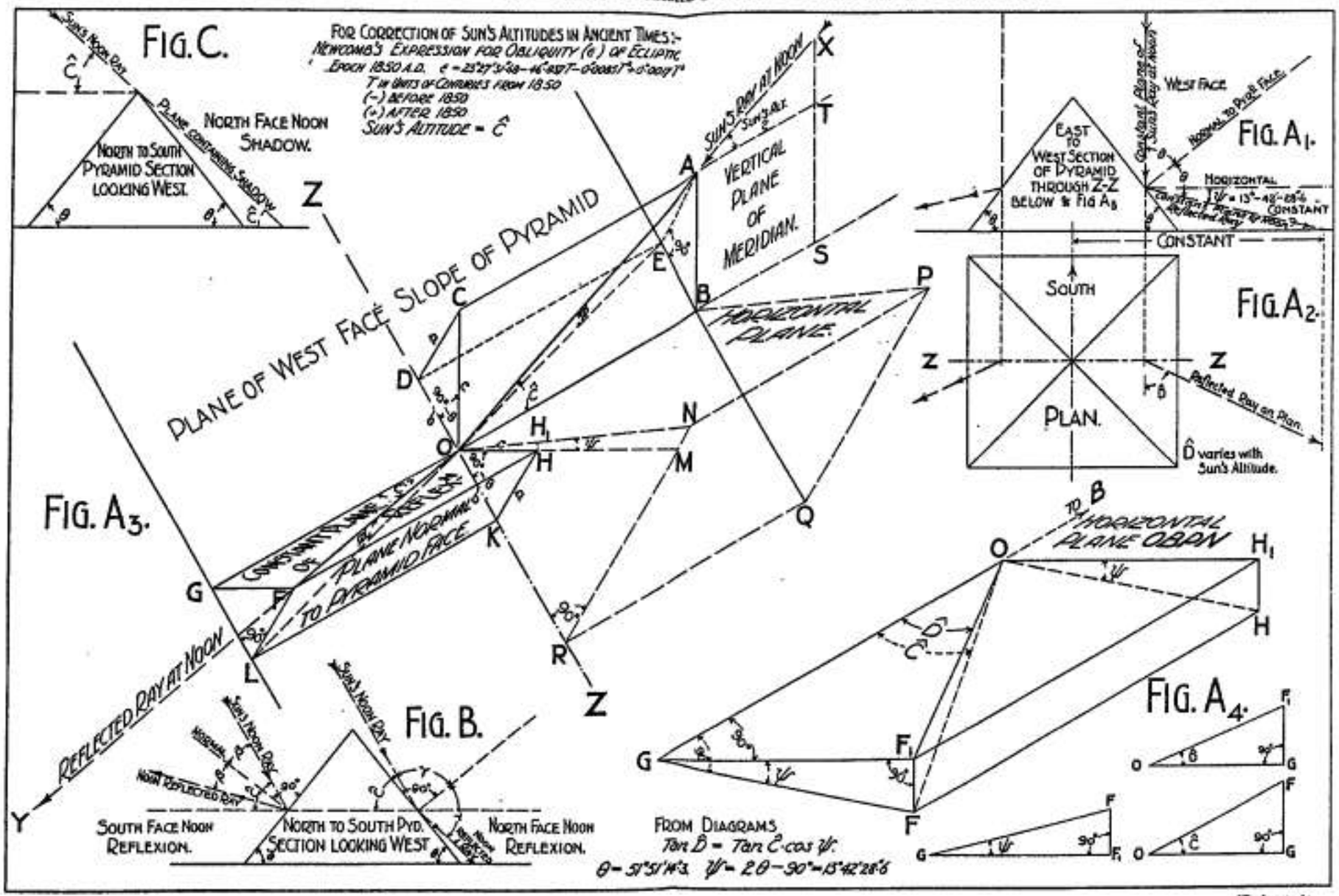
TABLE IV.

THE SERIES COMPRISING THE PERIOD OF THE CYCLE OF 721 YEARS.

No. of Series.	Interval in years.	Cumulative Years.	Intercalary year of Table II. equivalent to Year of Series.	Subtraction of periods of 103 years' cycles from cumulative years of series to obtain year in preceding column.
(1)	120	120	17	120 cumulative years of series. Deduct 103 =1 primary solar cycle. 17 Year of Tables II. and III.
(2)	120	240	34	240 cumulative years of series. Deduct 206 =2 primary solar cycles. 34 Year of Tables II. and III.
(3)	120	360	51	360 cumulative years of series. Deduct 309 =3 primary solar cycles. 51 Year of Tables II. and III.
(4)	120	480	68	480 cumulative years of series. Deduct 412 =4 primary solar cycles. 68 Year of Tables II. and III.
(5)	121	601	86	601 cumulative years of series. Deduct 515 =5 primary solar cycles. 86 Year of Tables II. and III.
(6)	120	721	103	721 cumulative years of series. Deduct 618 =6 primary solar cycles. 103 Year of Tables II. and III.

PLATE XII.

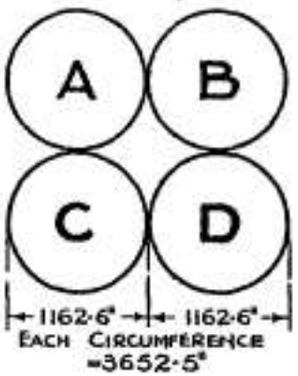
THE GEOMETRY OF THE GREAT PYRAMID'S NOON REFLEXIONS AND SHADOWS.

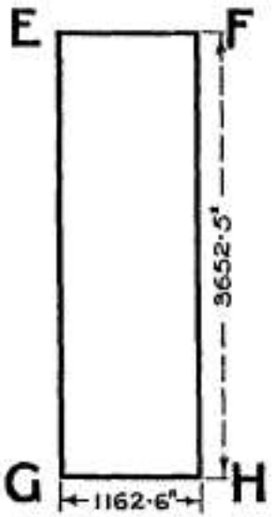


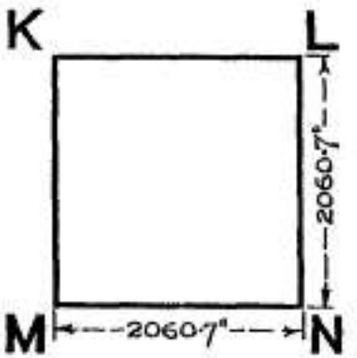
(To face p. 64.

PLATE XIII.

EQUAL AREAS







EACH COMMON CUBIT = 20·607"

100 CUBITS OF AREA LONG BY 1 CUBIT OF AREA WIDE

1/100TH STRIP OF THE EGYPTIAN AROURA

¶ 81. THE ORIGINAL LINEAR UNIT AND THE ORIGIN OF THE COMMON CUBIT.

Side of Square Aroura = 2069.66 units = 100 common Egyptian Cubits of 20.6066 units (Actually 20.63 British Inches)

1 primitive unit = 1.0011 British inches

The division of the *aroura* square side into 100 parts—as observed by Herodotus and Horapollo—supplied the common Egyptian cubit of 20.6066 units = 20.63 British inches. The most general value of the common Egyptian cubit observed by Petrie in the best work of the Pyramid builders is 20.629 British inches, from which the original selected unit = 1.0011 British inches, as stated to 4th decimal place, or $\frac{11}{10,000}$ths of an inch longer than the British inch.

The latter values agree closely with the mean Gregorian year value of 365.2425 days as basis, giving a basal circumference of 3652.425 selected units of length. These units we may now define as "Primitive inches," and hereafter refer to simply as P inches, or P″, avoiding confusion with British inches by stating the latter as B inches, or B″.

¶ 82. THE ANCIENT EGYPTIAN SYSTEM OF MEASURES.

Ancient Egyptian measures devised to avoid π relationship in calculations

Simple relations established between circles and segments of circles on one hand and straight line figures on the other hand.

With the preceding data as basis, it is found that the ancient Egyptians formulated a system of measures that, in the case of circular areas, and sectors of circles, avoided the repeatedly recurring trouble of the π relationship. By employing in their everyday work separate units and scales for circumferences, diameters, and areas, they avoided calculations that embodied the troublesome ratio of diameter to circumference. Simple formulæ were drawn up from which the circumferences and areas of circles, or sectors of circles, were immediately obtained from the diameter, or *vice versa*.

Sectors were correctly treated by analogy as triangles, by the following true relationship :—

Area of Sector .. .. = "Base" of Sector × "height" of Sector.
= Arc of Sector × radius.

The geometrical analogy leading to this relationship is explained for the particular case of quadrants in Plate XIV. The same treatment holds for similar sectors, *i.e.*, sectors whose arcs are subtended by the same angle.

Different Units of Measure :— Linear Digits, Feet and Cubits —for Diameters, Circumferences, and Straight Line Figures

The principal units of measure formulated to effect the various translations were the following :—

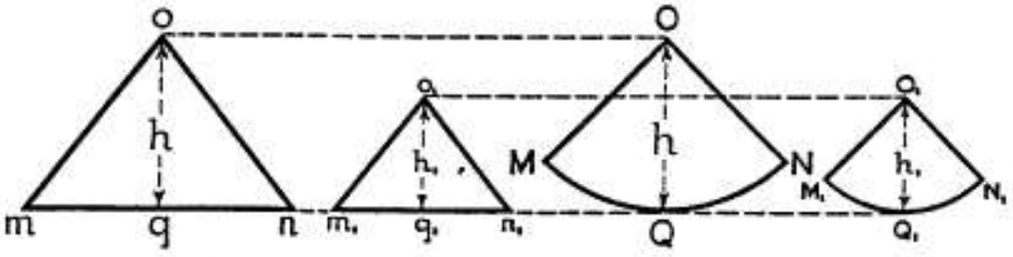
The Linear Digit, Foot and Cubit of Diameter.
The Linear Digit, Foot and Cubit of Circumference.
The Linear Digit, Foot and Cubit of Square Measure.

¶ 83. THE SYSTEM OF LINEAR UNITS.

(The algebraic relationship of units is as stated in Section III. Description of Plates, ¶ 137a).

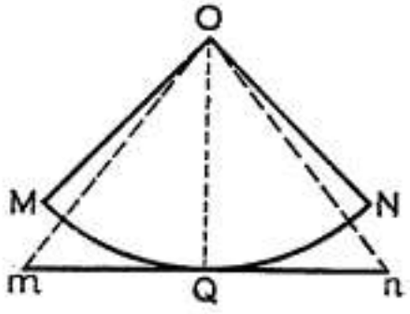
PLATE XIV.

GEOMETRICAL ANALOGY

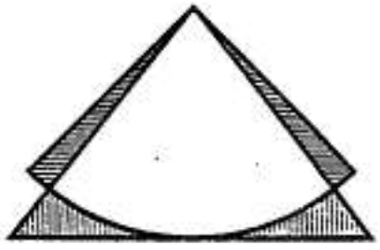


SIMILAR TRIANGLES

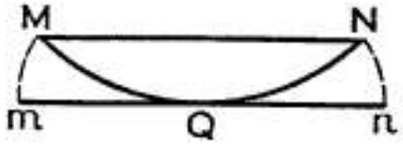
SIMILAR QUADRANTS



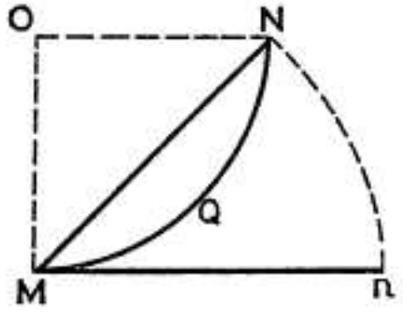
QUADRANT ARC DEVELOPED ON MID-TANGENT GIVES TRIANGLE OF EQUAL AREA



VERTICAL SHADED AREAS EQUAL HORIZONTAL SHADED AREAS



EGYPTIAN CONCEPTION OF QUADRANT ARC DEVELOPMENT MQN TO mQn



ORDINARY CONCEPTION OF QUADRANT ARC DEVELOPMENT MQN TO Mn

To obtain the Units of Diameter, the standard diameter of 1162.6 P" (=1163.88 B") was divided into :—

The Units of Diameter.

(a) 64 diametric cubits of 18.1656 P" each (18.1856 B").
(b) 100 „ feet of 11.626 P" „ (11.6388 B").
(c) 1600 „ digits of 0.7266 P" „ (0.7274 B").

The Units of Circumference were obtained by dividing the standard circumference of 3652.425 P" (=3656.44 B") into :—

The Units of Circumference.

(a) 200 circumferential cubits of 18.2621 P" (18.2822 B").
(b) 300 „ feet of 12.1748 P" (12.1881 B").
(c) 5000 „ digits of 0.7305 P" (0.7313 B").

The Linear Units of Square measure were derived by dividing the side of the square of area equal to the area of the standard circle into :—

The Linear Units of Square Measure.

(a) 50 common cubits of 20.6066 P" (20.629 B").
(b) 1600 linear digits of 0.6440 P" (0.6447 B").

An illustration of the various units in operation is figured on Plate XIII. Here the $\frac{1}{100}$th strip of *aroura*, *i.e.*, a strip of 100 common cubits long by 1 common cubit wide,=area of sector, of arc length 12 circumferential feet, and diameter 50 diametric feet. Worked examples are given in Section III, ¶ ¶ 137, b and c.

¶ 84. THE SACRED HEBREW CUBIT.

The Division of the various Line Cubits into 25.

Comparative scales of the various units are figured on Plate XV. Reference to this shows that there are 25 Diametric Digits in the Diametric Cubit, and 25 Circumferential Digits in the Circumferential Cubit. These suggest that the Basal Cubit of the original Primitive inch system consisted of 25 P. inches. This gives the value of the Sacred Hebrew Cubit as derived by Sir Isaac Newton, and since confirmed by the metrological researches of Oppert, Petrie, and others. This again confirms the sequence as to Euphratean origins obtained in Chapter I.

The Basal Cubit the Sacred Hebrew Cubit.

The Sacred Hebrew Cubit in Egypt during period of Semitic Domination in Dynasty XVIII.

Completing this connection, Petrie finds the 25 inches' cubit in use in Egypt during the period of Dynasty XVIII. At this time the Egyptian language and the political and religious institutions of Egypt were strongly influenced by a powerful Semitic faction in Egypt.[1] Around the same time Stonehenge and similar monuments were being built in Britain by a race whose astronomical and metrological cults evidence Egyptian influence, yet whose folklore and traditions indicate Semitic origins.

Same period for Construction of stone circle at Stonehenge.

Hebrew Sacred Cubit not Egyptian, but Egyptian Units of measures derived from it.

The Sacred Hebrew Cubit of 25 P. inches (Plate XV) never occurs in Egypt unless during periods of Semitic dominance. The other systems of Plate XV belong to the whole period of Egyptian history. The fact that these systems were derived from the scale of the Sacred Cubit of 25 P. inches again confirms that the Egyptian units of measure were not formulated in Egypt. The sacred system and its derived Egyptian Units all clearly belong to the period of the former civilization pictured in ¶ ¶ 41-47.

The Related systems formulated by the former Civilization.

[1] Petrie, "Hist. Egypt," Vol. II, pp. 146-152.

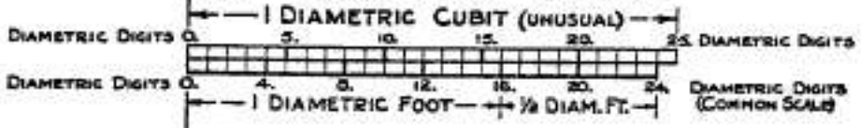
PLATE XV.

COMPARISON OF ANCIENT SCALES OF MEASUREMENT (REDUCED)

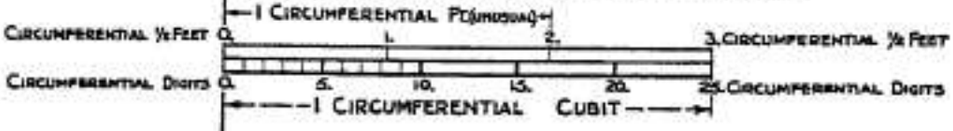
SACRED SCALE

CIVIL SCALES

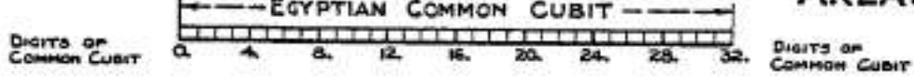
(1) DIAMETRIC SCALE



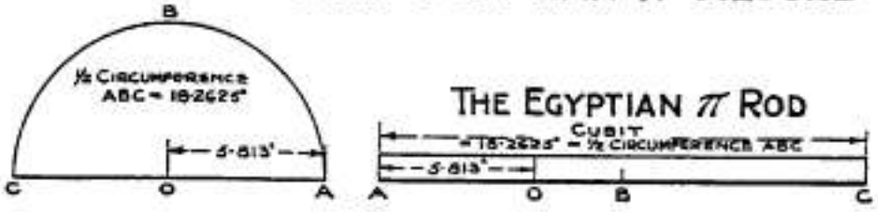
(2) CIRCUMFERENTIAL SCALE



(3) SCALE FOR SIDES OF RECTILINEAR AREAS



ANCIENT EGYPTIAN π RECORD



$$\frac{\text{CIRCUMFERENCE}}{\text{DIAMETER}} = \frac{36{\cdot}525}{11{\cdot}626} = 3{\cdot}14159 = \pi$$

$$\frac{\text{½ CIRCUMFERENCE}}{\text{RADIUS}} = \frac{ABC}{OA} = \frac{18{\cdot}2625}{5{\cdot}813} = 3{\cdot}14159 = \pi$$

¶ 85. THE FOOT OR SACRED HALF-CUBIT OF 12½ INCHES.

The Sacred Half-cubit. (12½ inches).

According to Petrie, the half-cubit (12½ inches) appears in Babylonia as the foot of the Babylonian system of measures. It appears also in ancient Greece (12.44 to 12.62 B″), in Etruria (12.45 B″ average), in what Petrie deems to be *Roman* Britain, and in medieval England (12.47 B″ average). The migratory sequence indicated clearly confirms the Euphratean connections established in Chapter I.

Its Track:— Babylonia, Greece, Etruria, Roman Britain, Medieval England.

Ancient Cornwall Acre, 40 perches × 4 perches, with perch = 16 feet.

A statute of Richard I, belonging to the year 1199, defines an acre in Cornwall as "40 perches in length and 4 in breadth and every perch of 16 feet in length."[1] Cornwall was the principal British centre of the Oriental colonists from 2000 B.C. onwards. Their influence still predominates in the folklore, traditions, and customs of Cornwall. It is obviously from this race, with its Mediterranean and Atlantic ports of call, that ancient Greece, Etruria and Britain derived the Sacred half-cubit of 12½ P. inches.

The Coming to Cornwall of the Sacred Half-Cubit.

Ancient Perch: 16 feet of 12½ inches = 200 inches.

Modern Perch: 16½ feet of 12 inches = 198 inches.

Now 16 feet of 12½ P. inches give the ancient perch in Cornwall as consisting of 200 P. inches. The modern perch or rod consists of 16½ feet of 12 inches, or 198 inches. The numerical interchange and the reason for it are obvious. The inch remained the basal unit, unchanged, except for small local variations. The perch also remained practically unchanged—losing but 1% of its original value.

¶ 86. THE RELATION BETWEEN ANCIENT AND MODERN BRITISH MEASURES.

Ancient Furlong: = 40 perches = 40 × 200 ins., = 8,000 inches. Ancient Mile: = 8 furlongs = 64,000 inches.

The manner of effecting the change from the ancient to the modern value of the perch or rod suggests that the numerical relations between the perch and the higher units were maintained. Now there are 40 perches or rods in the furlong, and 8 furlongs in the mile. With the ancient perch as 200 inches, this gives the primitive basal furlong as consisting of 8,000 inches, and the primitive basal mile of 64,000 inches.

Ancient Unit of 10 acres.

As a square its circuit = Half-a-mile, or 32,000 inches

An acre in Cornwall (in 1199 A.D. and earlier) was measured as 40 perches by 4 perches. This is the $\frac{1}{10}$th strip of a square of 10 acres area. The side of the square of 10 acres therefore measured 1 furlong, or 8,000 inches, and the circuit of the 10 acres square, 4 furlongs or the half-mile,—32,000 inches.

Ancient and Modern Relation:— 640 acres = 1 sq. mile

Following from these relations we find that

640 primitive acres = 1 sq. mile (primitive.)

This relation between the acre and the square mile still holds.

The decimal subdivision of areas into $\frac{1}{10}$th and $\frac{1}{100}$th strips of squares—indicated by the definition of the ancient acre in Cornwall—is both Egyptian and Semitic. It occurs in the case of the Egyptian *aroura*. The 10 acre square was a large unit of square measure of the Hebrews. (Isaiah v. 10.)

[1] 10th Richard I, statute "Inter Fines" states "Acra in Cornwal continent 40 perticata in longitudine et 4 in latitudine et qua libet perticata de 16 pedibus in longitudine."

¶ 87. THE MEDIEVAL ENGLISH PROCESS OF COMPROMISE.

A decimal subdivision of the ancient Perch of 200 inches gave the ancient Ell or yard of 40 inches. Petrie gives the latter as averaging 39.66 B″. The foot of this system—the Belgic Foot—is $\frac{1}{3}$ of the ell or yard=13$\frac{1}{3}$″ (13.22 B″ Petrie). With this system Petrie finds a longer mile of 10 furlongs in use from as far back as the 13th century. This system is as follows :—

Ancient Yard : =40 inches =3 Belgic feet of 13⅓ inches.

The Ancient Long Mile of 10 furlongs.

Belgic Foot.	3=Yard.	2=Fathom.	10=Chain.	10=Furlong.	10=Mile.
13$\frac{1}{3}$″.	40″.	80″.	800″.	8,000″.	80,000″.

Its Decimal System.

Petrie's values extended from his average of the Belgic foot in England (13.22″) are :—

Foot.	Yard.	Fathom.	Chain.	Furlong.	Mile.
13.22.	39.66.	79.32.	793.	7,932.	79,320 B″.

It will be observed that the furlong (8,000″) is of the same value as was obtained in ¶ 86.

The reason for the difference evidenced by Petrie's examples is that these are all from buildings belonging to the 10th to 15th centuries, when the Belgic foot and the foot of 12$\frac{1}{2}$ inches still competed with the legal foot of 12 inches instituted in the 10th century. The legal foot altered the perch or rod to 198″ in place of the former 200″, which contained 15 Belgic feet of 13$\frac{1}{3}$ P inches. To effect a compromise between the two competing systems, the perch or rod of 198″ was reckoned as containing 15 Belgic feet. This gave an adjusted foot of 13.2 P″ (13.22 B″, as Petrie above).

Petrie's Examples of Belgic Foot derived from buildings of 10th-15th centuries.

Legal foot of 12 inches instituted in 10th century.

Compromise effected between two systems :— Relation retained that 15 Belgic feet =1 perch.

1% reduction in perch made 1% reduction in Belgic foot.

Petrie, however, observes that the latter foot originated around Asia Minor, averaging there 13.35 B″, and passed to Greece as 13.36 B″. Now 13$\frac{1}{3}$ Primitive inches of value 1.0011 British inches (¶ 81) equal 13.348 B. inches, or to 2nd place, 13.35 B. inches, as in Asia Minor.

¶ 88. THE EGYPTIAN METROLOGICAL EVIDENCE.

Returning to consideration of the Egyptian system of diametric and circumferential measures and their linear standards for areas, we find that all the values of ¶ 83 are found indicated in the structural measurements of the ancient Egyptians. A half diametric foot and the circumferential cubit were actually, in one case noted by Petrie, found on the same cubit rod. This is a graphical representation of the π relationship, as the half diametric foot (5.813 P″) was the radius of a circle of 36.525 P″ circumference, of which the circumferential cubit (18.2625 P″) was the half circumference. (Refer Plate XV, lower portion.)

Structural Measurements in Egypt give ancient diametric and circumferential units and linear units for areas.

An Egyptian π Rod.

Metrologists, having failed to observe the origin of the system of measures, have universally supposed the diametric digit (0.7274 B″), and the circumferential digit (0.7313 B″), and also the diametric cubit (18.1856 B″), and the

Metrologists confuse diametric digit and circumferential digit, and the respective cubits.

circumferential cubit (18.2822 B″), to be variable values of the same digit and the same cubit respectively. They therefore average the two values, in each case, obtaining the mean values as follows :—

The mistake in averaging two separate systems.

Diametric Cubit	..=18.1856 B″.
Circumferential Cubit	..=18.2822 B″.
Mean Cubit of Metrologists	..=18.2339 B″.

This is stated by Petrie as 18.23 B″. Again,

Diametric Digit	..=0.7274 B″.
Circumferential Digit	..=0.7313 B″.
Mean Digit of Metrologists	..=0.72935 B″.

This is stated by Petrie as averaging 0.729 B″. From Greek remains Petrie obtained 0.7296 B″.

Possibility that Egyptians themselves, at an early date, merged the two systems into one for ordinary use.

It is quite possible, however, that for ordinary everyday commercial use, the two separate systems were merged into a single " rule-of-thumb " system at a comparatively early date in the dynastic history of Egypt. After all, as we have seen, Egypt is only a stage in the tracing of origins to their source in a former civilisation. The Egyptians, at an early date, lost the meaning and application of much that they have handed on to later days for elucidation.

¶ 89. THE GREEK SYSTEM OF MEASURES DERIVED FROM EGYPT.

Petrie's values for the Greek Decimal System of Linear Measures.

With the average values of ¶ 88 as basis, Petrie has grouped the known data from buildings in Greece as follows :—

Old Digit	25=Cubit : 4= / 100 .. .. ..=	Orguia.	10=Amma.	10=Stadion.
B″ 0.729.	18.2.	72.9.	729.	7296.

But with the stadion=7,296 B″, as stated by Petrie above, the values are accurately :—

The Mean Values of Egyptian Diametric and Circumferential Measures.

Old Digit.	Cubit.	Orguia.	Amma.	Stadion.
B″ 0.7296.	18.24.	72.96.	729.6.	7296.

Thus indicating that the system tabulated is the mean of the two early Egyptian systems—diametric and circumferential.

Petrie further shows that the cubit of 18.24 B″, was also divided by the Greeks into 24 digits, obtaining the new Greek digit as 0.76 B″.

He shows again that the Greek foot was taken as $\frac{3}{5}$ of the mean cubit of 18.24 B″, and therefore as 12.16 B″. This is closely approximate to the Egyptian diametric foot of 12.1748 P″=12.188 B″. (¶ 83.)

Evidence as to Greek Measures primarily derived from separate Egyptian Systems.. Circumferential and Diametric.

The resulting Greek system, as stated by Petrie, is as follows :—

	Foot.	10 = Acaena.	10 = Plethron.
B″.	12.16.	121.6.	1216.

The early Greeks also used the diametric foot of 11.626 inches. (¶ 83.)

¶ 90. THE ROMAN SYSTEM OF MEASURES.

Roman System primarily derived from Egyptian Diametric System.

The Roman system of measures was derived—through the Greeks—from the Egyptian diametric system. Its basis was the diametric digit of 0.7266 inches, and the diametric foot of 11.626 inches (¶ 83). As an average from existing Roman remains, Petrie gives the system as follows :—

Digitus.	4 = Palmus.	4 = Pes.	5 = Passus.	125 = Stadium.	8 = Milliare.
B″ 0.726.	2.90.	11.62.	58.1.	7,262.	58,100.

The above system was used by the Romans in Britain and Africa.

The Roman foot appears in Medieval England as 11.6 B″.

¶ 91. ANCIENT RECORDS OF AN EGYPTIAN PYRAMID OF MEASURES.

Ancient Literary Records of a Metrological Monument.

Its form Pyramidal.

The data from ancient Egyptian documentary sources show that the various metrological dimensions and standards of linear and square measure were preserved in the form of an existing Pyramid. The primary unit of measurement, the various outstanding dimensions and structural peculiarities, and the angles of the face slope and the Apex angle of this existing Pyramid are all precisely defined by the Egyptian literary data.

The data define as follows :—

(1) *GENERAL BASIS OF PYRAMID'S DESIGN.*

Its unit the Inch.

(a) That the unit of dimensions .. .. = 1 P. inch.
= 1.0011 Brit. inch.

Base Circuit 36,525.

(b) That the angle of face slope with horizontal = 51°-51′-14″.3.

Height 5,813

(c) That the apex angle .. .. = 76°-17′-31″.4.

Face slope 51°-51′-14″.3.

(d) That the base square circuit .. .. = 36,524 or 5 P. inches.
and (defined independently) .. .. = 1,772 common Egyptian cubits (of 20.63 B. inches).

Apex angle 76°-17′-31″.4.

(e) That the height from base to apex.. .. = 5,813 P. inches.

The data define (b) and (c) independently of (d) and (e).

(ii) *DETAILS OF DESIGN.*

A Square Circuit 25,827 at level 1,702½.

(a) That the Pyramid indicated a square circuit of 25,826 or 7 P. inches (the sum of the diagonals of the base square) at a height of 1702½ P. inches above the base, both dimensions being given independently of the other.

A Square Circuit 29,220 at Level 1,162.6

(b) That the Pyramid indicated a square circuit of 29,220 P. inches at a height of 1162.6 P. inches above the base.

The latter defining "Aroura" Rectangle 3652.5 × 1162.6

(c) That the latter defined, in elevation, the *aroura* rectangle of 3652.5 P. inches × 1162.6 P. inches, and a series of such rectangles (eight in all) encircling the Pyramid as seen in its four elevations of circuit.

Pyramid Vertical Section Area = Square of Side 5151.6.

(d) That the Pyramid vertical section was equal in area to a square of length of side = 5151.6 P. inches; this being defined independently of the other relations.

The quarter-*aroura* goes into the latter square, or the area of the Pyramid section, 25 times.

¶ 92. THE FICTITIOUS PYRAMID DYNASTOLOGY OF THE EGYPTIANS.

Conception of Ancient Egyptians that the Standard Pyramid Measures denoted duration of Astronomical Periods.

The Pyramid measures thus standardised were all associated with the geometry of the year. For this reason, and for other reasons to be explained later, the Egyptians of various periods, subsequent to the erection of the monument, deemed that all its measurements denoted the duration in years of astronomical periods. In accordance with this conception, they formulated various systems of fictitious or mythological chronology. Each cult had its particular system, always, however, based numerically on the Pyramid year cycle geometry. Each system claimed to be a presentation of the chronology of the Egyptian Dynasties—Divine and human. The systems all differed considerably, so that it is impossible to synchronize the various intervals given for the same Dynastic periods.

On this conception Egyptians framed their Mythical Systems of Dynastic Chronology.

Various Versions of such Dynastic Systems edited by Egyptian Priest Manetho in 3rd Century B.C.

All the systems in existence in the third century B.C., were edited by the Egyptian priest, Manetho, and entered in his work on Egyptian History, "Ægyptiaci," written in Greek. Several versions of the systems of fictitious chronology, known as the Egyptian "King Lists," were extracted from Manetho's work by Julius Africanus in the third century A.D. The composite nature of the King Lists as given by Africanus is seen by analysis of the various alternative details of summations of years.

Manetho's King Lists preserved by Julius Africanus and Eusebius in 3rd Century A.D

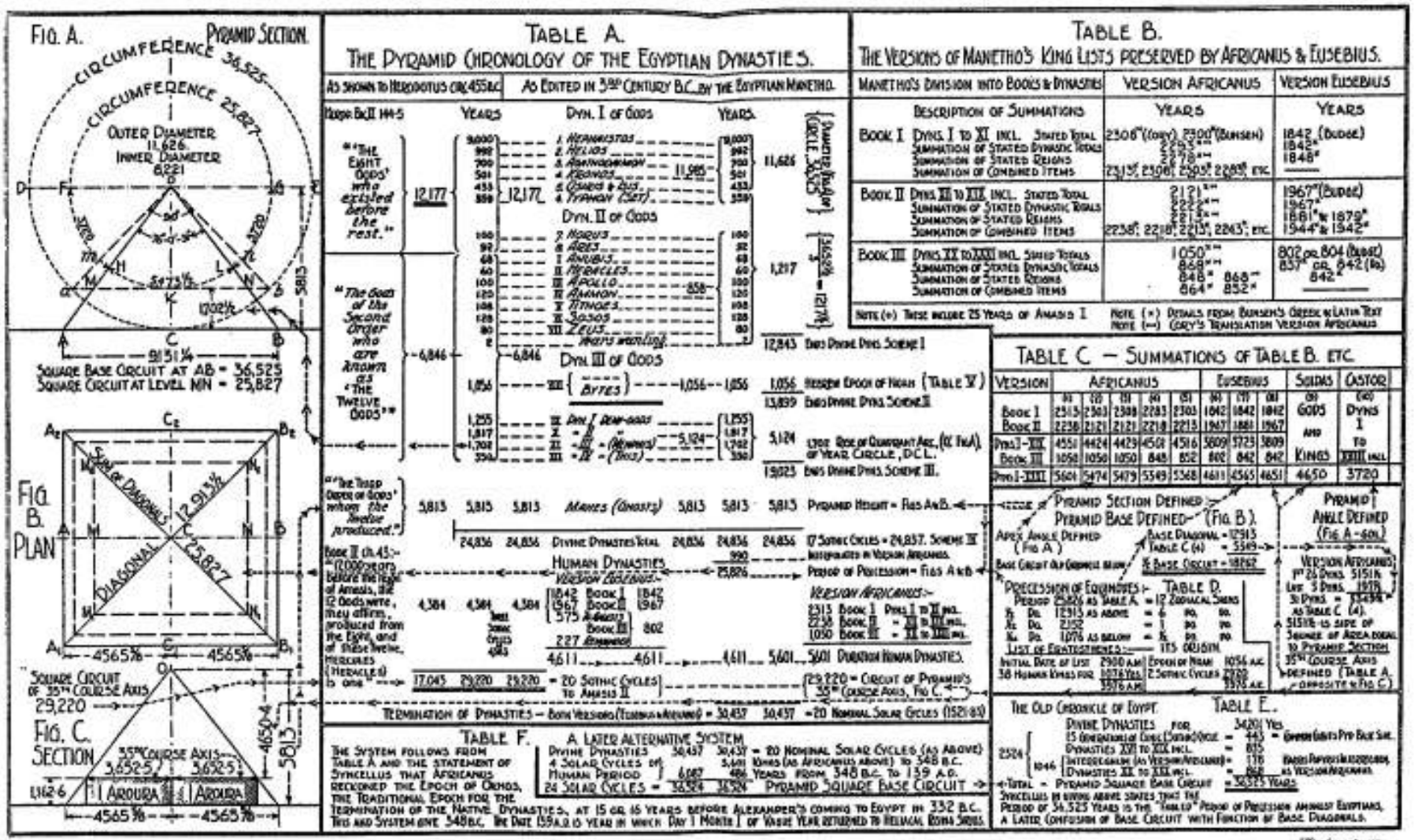
Another version was preserved by Eusebius—also in the third century A.D.—together with the version known as the Armenian Version of Eusebius. The versions of Africanus and Eusebius were, in turn, preserved by George Syncellus about 800 A.D. With the exception of certain important extracts from Manetho's history, preserved by Josephus in his *Contra Apion.*, this is all that now remains of Manetho's notable work.

To account for the difference between the chief version of Africanus and the version of Eusebius, Syncellus accused Eusebius of tampering with the figures as given by Manetho. The analysis given in this chapter, however, shows that the version preserved by Eusebius, as stated to the reign of Amasis II, was in existence in the fifth century B.C.—700 years before Africanus was born, and 200 years before Manetho.

Version of Eusebius as old as 5th Century B.C.

PLATE XVI.

CHART SHOWING THE GEOMETRICAL, ASTRONOMICAL, AND NUMERICAL BASES OF THE FICTITIOUS CHRONOLOGIES OF THE ANCIENT EGYPTIAN KING LISTS.



[To face p. 77.

The data here given deal with another question of Egyptian chronology, related to the question already settled by the data of Plate IX. One of the important schools of Egyptological chronology, mentioned in the notes to Plate IX, claims that the Egyptian King Lists of Manetho confirm its system of so-called astronomical chronology. The data shown above, however, disprove the claim, since they prove not only that the King Lists as shown were fabricated without any governing geometrical method from the dimensions of the Great Pyramid, but also that such Sothic Cycles as were included in this fictitious arrangement do not synchronise with the Sothic cycles that form the basis of the modern system of Egyptological chronology mentioned. It is fair, however, to add as stated by Professor Breasted that the view of this school "is inherited from an older generation of Egyptologists . . . and . . . is now maintained only by a small and constantly decreasing number of modern scholars." These generally refer to dates, fixed from the data given above, as the dates of "the Egyptians' own chronology."

Other associated numerical details are found in records of the period of Dynasties XVIII and XIX.

A typical tabulation and analysis of the King Lists of Manetho—and the different versions of these and other lists—are shown on Plate XVI. Had this matter been dealt with otherwise than by the comprehensive tabulation and analysis given, the subject-matter would have extended to many tedious pages of text, without giving a fraction of the elucidation resulting from the graphical presentation of Plate XVI. For the statement of Manetho's, and other King Lists, and for the historical evolution of the various dynastic schemes of Plate XVI, the reader is referred to the Appendix.

Graphical Presentation of the Associated Data.

Plate XVI

Its Elucidating Features.

¶ 93. EGYPTIAN KING LISTS DEFINE THE STANDARD PYRAMID.

Reference to Plate XVI shows that the numerical details of the King Lists define the standard Pyramid as follows :—

Dynastological Dimensions of Standard Pyramid.

(a) *THE HEIGHT OF THE STANDARD PYRAMID.*

Height :— Dynasty of Manes = 5,813 years.

Table A. Dynasty of Manes = 5,813.
= Radius of Circle, 36,524 or 5.
Hephaistos to Osiris *and* Isis = 2 × 5,813 = 11,626.
= Diameter of Circle, 36,524 or 5.

(b) *THE BASE CIRCUIT OF THE STANDARD PYRAMID.*

Base Circuit : Total gods and kings = 36,525 years.

Table E. Old Chronicle. Gods and Kings = 36,525.
Table F. Gods and Kings to 139 A.D. .. = 36,524.

(c) *THE BASE SQUARE OF THE STANDARD PYRAMID.*

Base Sides and Diagonals.

The diagonal is defined by the two sides, each 9,131½, and totalling 18,262½ The resulting diagonal is 12,913½. This relationship is given as follows :—

(Fig. B). Base Diagonal .. .. .. = 12,913½ (obviously period Gods).
Version Africanus. Table C (4) .. .. = 5,349 Human Kings.

2 Sides defining Diagonal .. .. .. = 18,262½ Gods and Kings.

2 Sides 18,262
Diagonal 12,913
Difference 5,349

Years of Kings.

½-Base :— Kings = 4565 years.

The half-side of the base square is defined by Table C (7), Version Eusebius, Kings = 4,565. (Fig. B.)

(d) *THE ANGLE OF SLOPE OF THE STANDARD PYRAMID.*

Face Slope 51°-51′-14″.3.

The Pyramid half base side and the Pyramid height define the Pyramid angle of slope as 51°-51′-14″.3. This however, is independently defined by Table C (10), Version Castor, Kings = 3,720 (Fig. A), the arc of the circle of 25,826 or 7 corresponding to the angle 51°-51′-14″.3.

Equivalent Arc of 25,827 Circle = 3,720. Years of Kings.

Apex Angle :— Arc of Circle = 5,473½ Years of Kings.

Again, the apex angle is defined as the corresponding arc of the circle of 25,827, thus Table C (2), Kings = 5,474 for 5,473½ exact. (Fig. A.)

Definition of Angles proves Pyramid Intention.

These relations prove that relations (a) to (c) apply to the Standard Pyramid, and not alone to the year circle of 36,524 or 5 circumference.

(e) *THE SQUARE CIRCUIT OF 25,826 or 7.*

Divine Dynasties= 25,826 years.

This is equal to the summation of the Base Diagonals (Fig. B). The circuit occurs at level MN of Fig. A., where height of MN above base = KC = 1,702½. This is defined in Table A as Dynasty III of Demi-gods (Memphis) = 1,702.

Sum of Base Diagonals and Square Circuit at level 1702½ Dynasty III Demi-gods.

$MN = \frac{25,826 \text{ or } 7}{4}$. So that square circuit round Pyramid at MN = 25,826 or 7 = Divine Dynasties (Table A).

(f) *SQUARE OF AREA EQUAL TO STANDARD PYRAMID SECTION.*

The side of this square is 5,151½. This is defined as follows:—

Side of Square of equal area 5151½.

Version Africanus, 1st 26 Dynasties = 5,151½
Last 5 Dynasties = 197½

Years of Kings 1st 26 Dynasties.

Table C (4). 31 Human Dynasties = 5,349½

This connects with item (c) above, 5,349 being common to both, and identifying 5,151½ with the same geometry as includes the half base circuit, 18,262½ and the base diagonal, 12,913½.

¶ 94. EGYPTIAN KING LISTS DEFINE THE STANDARD UNIT.

1st 15 Kings Old Chronicle 443 years.

The Old Chronicle of Egypt (Plate XVI, Table E) gives, for the first 15 generations of the Cynic (Sothic) Cycle, the duration of 443 years. This is the initial item of the human dynasties in this List.

Base Side 9,131¼ inches = 443 Common Cubits

Now the base side AB (Plate XVI, Figs. A and B) of the Standard Pyramid consists of 9,131¼ units, and a measure of 9,131¼ Primitive inches (each 1.0011 B. inches) consists of 443.1 Common Egyptian Cubits of 20.6066 P. inches (20.63 British inches). The occurrence of the number 443 in the Old Chronicle therefore proves that the base side of the Standard Pyramid consisted of 443 common cubits, and that this measure equalled $\frac{36,524 \text{ or } 5}{4}$ standard units.

This defines Unit of Standard Pyramid as 1 inch = 1.0011 British Inch.

As the common cubit is known (20.63 B″), the identity gives the standard unit as the Primitive inch of the value of 1.0011 British inch.

It should, perhaps, be explained that 443, whilst defining the standard Pyramid base in common cubits, is also half the numerical value of the length of side of a square of area equal to a quadrant of radius 1,000 units of any value. Hence its importance as an independent number, accurately calculated as 443.1134627, regardless of the value of unit. It is the latter value that defines the Primitive inch as 1.0011 B. inches, from the identity 36.524 P. inches = 4 × 443.1134627 cubits of 20.63 British inches.

That the number 443 was known to be connected with the Standard Pyramid, and that the latter was identified with the Great Pyramid is proved by the following:—

1st 15 Kings of Eratosthenes 443 years, to end of reign of Builder of Great Pyramid.

(a) That the King List of Eratosthenes gives the duration of the first 15 Dynastic kings of Egypt as 443 years—this proving that the 15 generations of the Old Chronicle for 443 years are the first 15 Dynastic Kings.

This associates the Standard Pyramid of lists with the Great Pyramid.

(b) That the 15th Dynastic king of the list of Eratosthenes is Saophis I, with whose reign inclusive the 443 years end.

(c) That the Saophis I of Eratosthenes is the Suphis I of Manetho, the IVth Dynasty king Khufu—the Cheops of Herodotus—who built the Great Pyramid.

¶ 95. THE ORIGINAL OLD CHRONICLE OF EGYPT.

The occurrence of 443 as the number of years for the first 15 dynastic kings of Egypt, and the fact that 443 is the number of common cubits in the Standard Pyramid's base side suggest a further identification. This is that the Divine Dynasties and the first 15 human kings were given the duration of 4×443 years, this being derived from the Standard Pyramid's base circuit of 1,772 common cubits=36,524 or 5 primitive inches. The latter identity thus obviously suggested the later extension to the duration of Gods and Kings for 36,525 years, as given in the Old Chronicle.

Square Circuit of 36,525 P. Inches = 1772 Common Cubits.

If the suggestion above is correct the detailed statement of the system suggested should confirm itself. Thus, as suggested,

Original Old Chronicle

Originally, Gods and Demi-gods	= 3×443 =	1,329
First 15 human kings	=	443
		1,772
Remaining human kings, as Old Chronicle	=	1,881
Definition of Length of *Aroura* Rectangle 3,652½ (Plate XVI, Fig. C)		3,653

Gods 1772
Kings 1881
3653

Defines "Aroura" Rectangle 3652½ × 1162.6.

Now the height of the *aroura* rectangle is 1162.6 and the Standard Pyramid section as represented in Plate XVI, Fig. C, contains two *aroura* rectangles. Confirming the relationship inferred,

Old Chronicle Human Kings 2×1162 years.

The Old Chronicle, 1st 15 human kings	=	443
remaining do.	=	1,881
2 × 1,162	=	2,324

Defines Two "Aroura" Rectangles.

defining the height of the two *aroura* rectangles—deleting the decimal of an inch.

¶ 96. THE MYSTERY OF MANETHO'S 113 GENERATIONS.

Now the generations of Gods and kings in the Old Chronicle are totalled as follows :—

(a)	15 Gods 8 Demi-gods	(a) and (b) obviously a duplication.
(b)	15 generations of Cynic Cycle 8 kings of Dynasty XVI	
(c)	67 kings, Dynasties XVII to XXX inclusive.	
Total	113 gods and kings.	

Old Chronicle added 113 descents for Gods and Kings stated as for 30 Dynasties only.

Syncellus. in introducing the List, however, states that the 30 dynasties contained 113 descents.

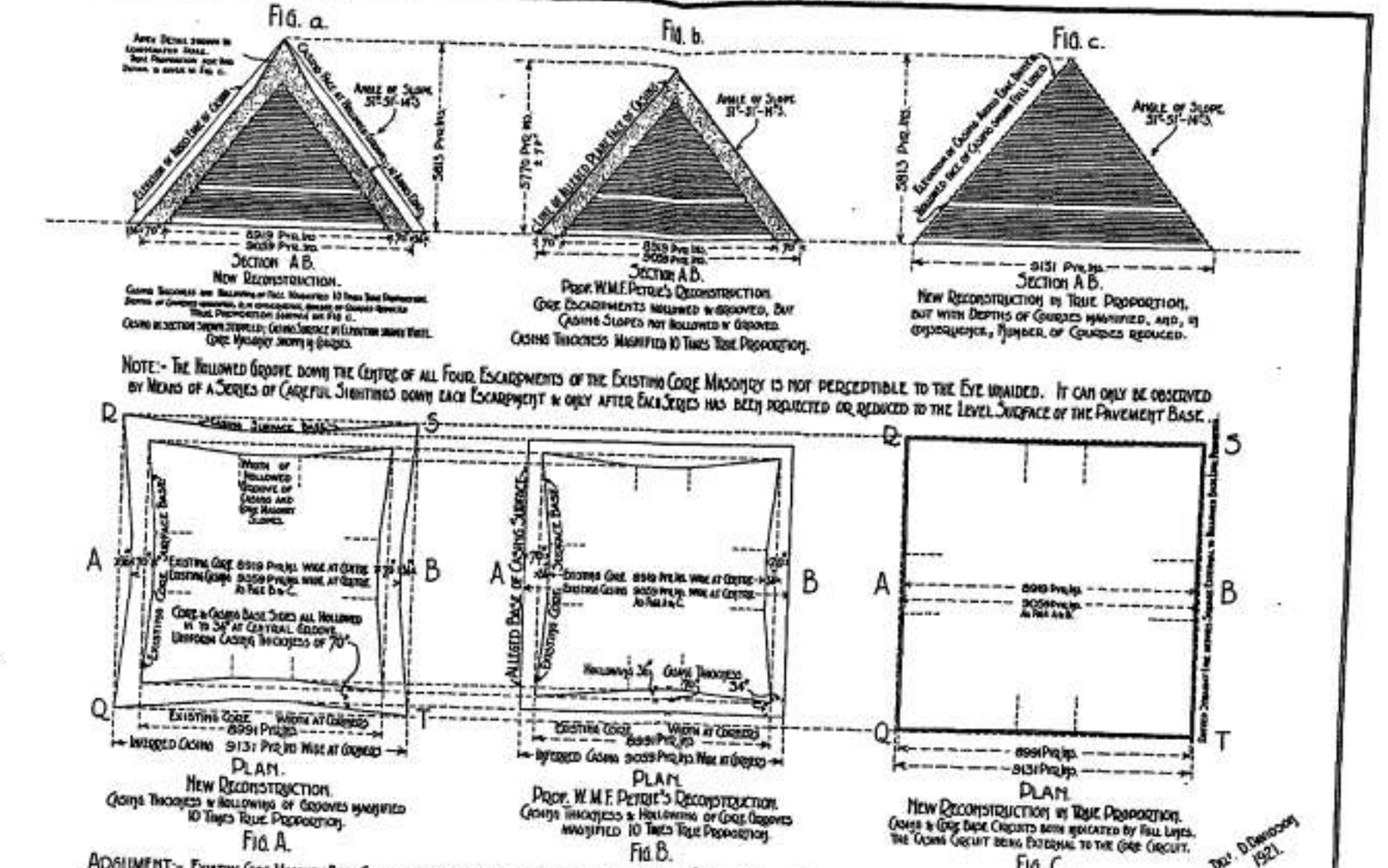
This, again, is explained by another statement from Syncellus concerning Manetho's Dynasties. This is as follows :—

Manetho's Human Kings of 30 Dynasties stated as 113 generations for 3555 years.

"The period of the 113 generations described by Manetho in his three volumes, comprises a sum total of 3,555 years."

PLATE XVII.

DIAGRAMMATIC REPRESENTATION OF PROFESSOR PETRIE'S RECONSTRUCTION, AND OF THE NEW RECONSTRUCTION OF THE GREAT PYRAMID FROM PETRIE'S SURVEY.

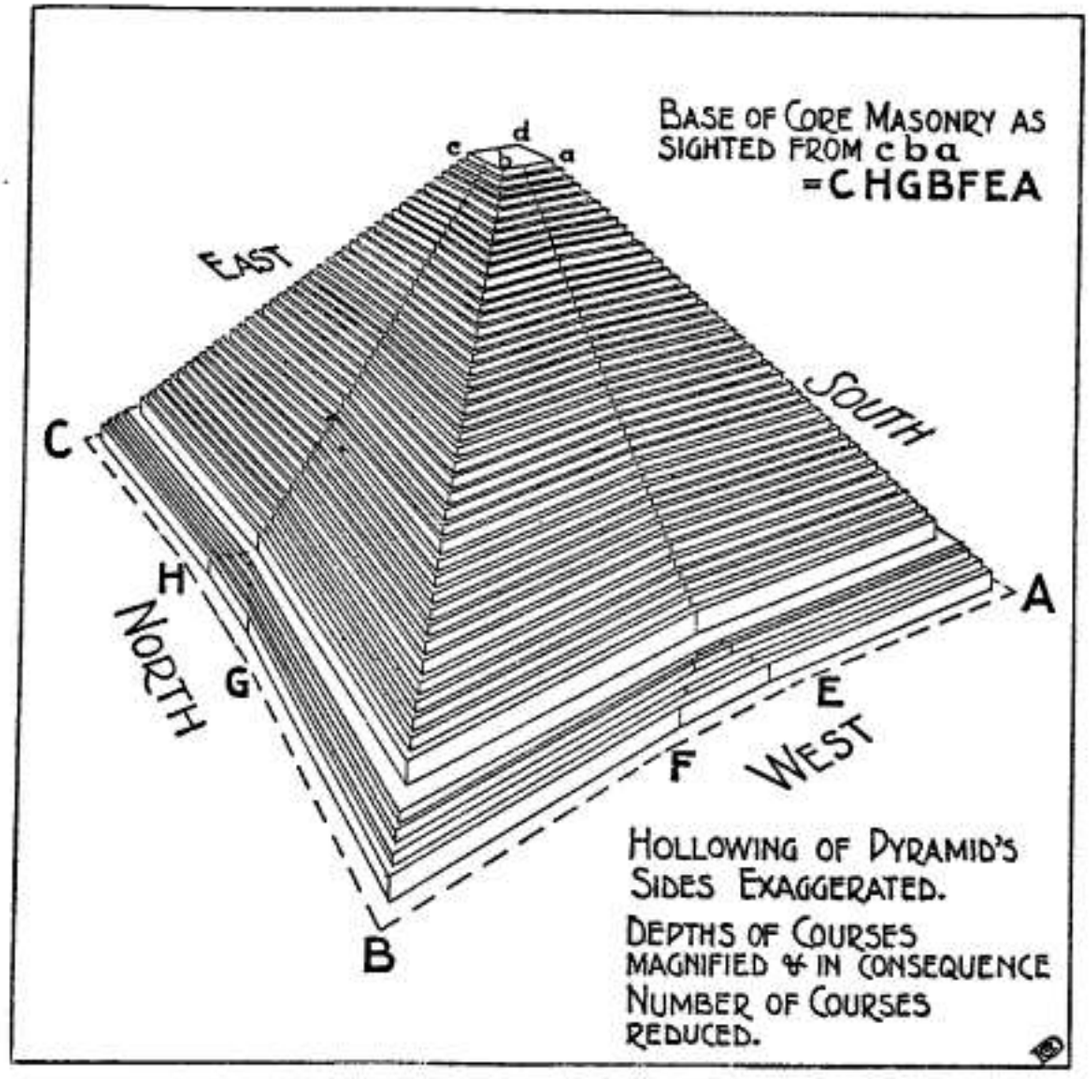


Argument:- Existing Core Masonry Base Sides are hollowed in at Centres of Each Base Side (Petrie). Casing Blocks (in Situ) exist in Centre of Each Base Side; but not elsewhere (Petrie). If Casing was hollowed at Centres of Base Sides, precisely as Core is hollowed in, Square Base Circuit, QRST, = 36,524 Pyr. Inches. (100 Square Yards). From this, and Prof. Petrie's Pyramid Survey, 1 Pyr. Inch = 1·0011 Brit. Inch = 1 Polar Diameter Inch; this confirming intention inferred by Prof. C. Piazzi Smyth. Resulting Height (5813 P") of Pyramid is Radius of Circle 36,524 P" Circumference. From U.S.A. Surveys (1906 & 1909), Earth's Polar Diameter = 500,000,000 Pyr. Ins. (of above Value 1 P" = 1·0011 B").

[To face p. 82.

PLATE XVIII.

DIAGRAMMATIC PERSPECTIVE VIEW ILLUSTRATING FEATURES OF GREAT PYRAMID'S CORE MASONRY.



¶ 102. A PRECESSIONAL CONSTANT?

Great Pyramid Measure of 25,826 P' reckoned in Dynastological lists as indicating period of Precession of Equinoxes.

Its accurate estimate of precession

Connected with this question of intention is an important question relating to the significance the ancient Egyptians attached to the measurement of 25,826 or 7 Pyramid inches. (Plate XVI, Figs. A and B.) Up to the time of the Persian Conquest, they recognised 25,826 or 7 years to be the duration of the great astronomical cycle known as the period of the Precession of the Equinoxes. As a statement of the period of Precession it is as accurate as any modern determination. Whether, however, it is the precise interval or not does not immediately concern us. The matter of importance is that it

If any one of the values D, δ, or β is given, its value in terms of d—for D and δ—and in terms of b or B for β, can be found from formulæ (1) and (2), and thereafter substituted in formulæ I to IV, as

$$d = \frac{25D}{16}; \quad d = \frac{\delta}{16}; \quad \text{or } b = \frac{3\beta}{50}; \quad B = \frac{\beta}{25}.$$

¶ 137b. EXAMPLES OF SIMPLE RELATIONS. (PLATE XV).

An important simple relation between diameter and side of square of equal area.

One important relation is obtained from the formulæ as follows :—

A given diameter = δ diametric digits.

From Formula (II) :—

Length of side of square of equal area, in digits of common cubit = $\lambda = 16d$.

From (1) :— $\delta = 16d$.

Hence $\lambda = \delta$.

Otherwise expressed, the length of side of the square of area equal to the area of a given circle contains the same number of digits of the common cubit as the diameter of the given circle contains diametric digits.

Example for a given diameter :—

A worked example of the above is given for a circle of diameter measuring 2,000 diametric digits.

FOR DIAMETER :—

Various statements for diameter in different units.

From (1) :— $\delta = 2{,}000$ diametric digits.

$$d = \frac{\delta}{16} \text{ diametric feet} = \frac{2{,}000}{16}$$
$$= 125 \text{ diametric feet.}$$
$$D = \frac{\delta}{25} \text{ diametric cubits} = \frac{2{,}000}{25}$$
$$= 80 \text{ diametric cubits.}$$

FOR CIRCUMFERENCE :—

From (1), (2) and (I) :—

Various statements for circumference in different units.

$$\beta = \frac{25\delta}{8} \text{ circumferential digits} = \frac{25 \times 2{,}000}{8}$$
$$= 6{,}250 \text{ circumferential digits.}$$
$$b = \frac{3\delta}{16} \text{ circumferential feet} = \frac{3 \times 2{,}000}{16}$$
$$= 375 \text{ circumferential feet.}$$
$$B = \frac{\delta}{8} \text{ circumferential cubits} = \frac{2{,}000}{8}$$
$$= 250 \text{ circumferential cubits.}$$

FOR SIDE OF SQUARE OF EQUAL AREA :—

Various statements (linear and square) for square of equal area in different units.

$$\lambda = \delta = 2{,}000 \text{ digits of common cubit.}$$
$$L = \frac{\lambda}{32} = 62\tfrac{1}{2} \text{ common cubits.}$$

AREA OF SQUARE OF EQUAL AREA :—

$$\lambda^2 = 2{,}000 \times 2{,}000 = 4 \text{ million sq. digits of common cubit.}$$
$$L^2 = \left(\frac{\lambda}{32}\right) = 3906.25 \text{ sq. (common) cubits.}$$
$$A = \frac{d^2}{40{,}000} = \frac{125 \times 125}{40{,}000} = 0.390625 \textit{ aroura.}$$

¶ 137c. THE SIMPLE CALCULATIONS FOR AREAS OF SECTORS AND SEGMENTS OF CIRCLES.

Let m = No. of Circumferential Cubits in a given Sector arc, of diameter d diametric feet, for circle of B circumferential cubits.

Area of whole circle $= \frac{d^2}{4}$ common square cubits. (From ¶ 137a, Formula III).

Number of the given sectors in circle $= \frac{B}{m} = \frac{2d.}{m}$ (¶ 137a, Formula I).

Therefore, Area of given Sector $= \frac{d^2}{4} \times \frac{m}{2d} = \frac{md}{8}$ common square cubits.

Area of sector in common square cubits= ⅛-sector arc in circumferential cubits× Radius in diametric feet.

Otherwise expressed, the area of a given sector in common square cubits is equal to one-eighth the product of the number of circumferential cubits in the sector arc and the number of diametric feet in the diameter of the circle; or, is equal to a quarter of the product of the number of circumferential cubits in the sector arc and the number of diametric feet in the radius of the circle.

The area of segment= area of sector—area of sector triangle.

To obtain the area of the segment in the given sector, in common square cubits, deduct the area of the isosceles triangle of the given sector from the area of the sector as above obtained in common square cubits.

¶ 138. PLATE XVI. CHART SHOWING THE GEOMETRICAL, ASTRONOMICAL, AND NUMERICAL BASES OF THE FICTITIOUS CHRONOLOGIES OF THE ANCIENT EGYPTIAN KING LISTS.

General remarks :—

Facts Long Known.

Co-ordination New.

The chart is a record of facts that have been long in existence—in some cases for several thousand years. The elements that are distinctly new are the co-ordination of these facts and the self-evident origin and significance of the facts revealed by this co-ordination.

New facts from Co-ordination.

The outstanding new facts derived from the statement of the chart are the following :—

Chronology of Egyptian King Lists fictitious.

(1) That the Egyptian King Lists of the Egyptian Priest, Manetho, do not contain a true statement of ancient Egyptian Chronology. (¶¶ 92, 118 and 119.)

Modern Egyptological theory of chronology unknown.

(2) That prior to the 3rd century B.C., the Egyptians knew nothing concerning the hypothesis now adopted as the basis of modern Egyptological chronology. (¶ 98 and Appendix.)

A written record of the measurements and units of a Standard Pyramid.

(3) That the King Lists contain a written record of the numerical values of all the external linear and angular measurements of a Standard Pyramid (¶¶ 93, 95–99, 118 and 119), in terms of units specified in the Lists as of values equal to 1.0011 British inches and 20.63 British inches respectively. (¶ 94.)

The Standard Pyramid is the Great Pyramid.

(4) That the Standard Pyramid of the Egyptian King Lists is the Great Pyramid of Gizeh. (¶¶ 94, 99–101 and 118.)

The complete statement of Manetho's Divine Dynasties is as given in Table A of chart. This is precisely as stated by Sir Ernest Budge, "Book of Kings," Vol. I, pp. lx and lxi.

Authorities for statement of Egyptian King Lists.

The detailed statement of Manetho's Human Dynasties is as given in the Appendix. This is precisely as stated in Baron Bunsen's Greek and Latin Text ("Egypt's Place," Vol. I, Appendix), for the versions of Africanus and Eusebius, and in Cory's "Fragments" (Hodge's Edition, 1876). The other lists are preserved in the same works. Statements of Manetho's Lists also appear in Budge's "Book of Kings," Vol.I, his "History of Egypt," Vol. I, in Sayce's "Ancient Empires of the East" (Appendix), and in the various volumes of Petrie's "History of Egypt." These, however, generally omit some important details and statements peculiar to the Version of Africanus. Budge's statement ("Book of Kings," Vol. I) of the basal totals of years for the Version of Eusebius for Manetho's Book I, II and III has been adopted in the chart (Table B). The stated totals for the same books, according to the Version of Africanus, have been adopted from Cory in the chart (Table B).

¶ 138a. SOME DETAILS CONCERNING THE VERSION OF AFRICANUS.

Four features affecting the statement of the Version of Africanus in Tables B and C call for special remark.

Pepy II Died 100 Years Old after Reigning 95 Years.

Stated duration Dynasty VI (Africanus) 203 years.

Added Duration 198 Years.

(1) Under Dynasty VI, it is stated that the fourth king, "Phiŏps, who began to reign at six years of age, reigned till he had completed his 100 year." The stated total for the duration of the dynasty—given as 203 years—includes reign of Phiŏps (Pepy II) as of duration of 100 years. Accordingly "203 years" appears in the summations giving one series of fictitious totals for Book I. But the reign of Pepy II was 94 or 95 years, and the total of the Dynasty therefore 197 or 198. Petrie (Hist. Egypt, Vol. I, Dyn. VI) adopts 95 and 198 years respectively. This agrees with the summations giving another series of fictitious totals for Book I, whereas 94 and 197 years fail to give summations agreeing with any fictitious system.

Dynasty XVIII. Amosis I.

Statement of duration of reign, 25 years, omitted, but included in added summations of some systems.

(2) Under Dynasty XVIII the name of the first king appears as Amosis (Amosis I), with duration of reign omitted. Other versions give this reign as 25 years. Accordingly one series of fictitious totals for Book I, Version Africanus, omits the reign of 25 years, and another series includes the reign as 25 years; both series supplying the numerical bases of their respective systems of fictitious construction.

The 1050 Years of Africanus, Book III.

Interregnum between Dynasties XIX and XX.

Harris Papyrus.

Duration, 182 Years (Africanus).

178 Years (Old Chronicle)

(3) In Book III the stated total duration of time after Dynasty XIX and up to end of Dynasty XXXI is given as 1,050 years, whereas the added stated totals for Dynasties XX to XXXI inclusive amount to 868 years. This indicated the theory of an interregnum of 182 years between Dynasty XIX and Dynasty XX. Such an interregnum is mentioned in the Harris Papyrus. This was written in the early period of Dynasty XX, under king Ramessu III, who was closely associated with the events that terminated the Interregnum. It would seem that there are good grounds for adopting this theory of the Version of Africanus.

Again, the Old Chronicle gives the statement of 2,324 years for the duration of all human Dynasties. Its stated totals for duration of Dynasties, however, amount to 1,881 years. This gives an unplaced interregnum of 178 years—4 years short of the total of Africanus for the Interregnum between Dynasty XIX and Dynasty XX. As the Old Chronicle totals for Dynasties XX to XXX inclusive amount to 868 years—as in Dynasties of Book III, Africanus—it would appear that the two periods are identical.

The 990 years interpolated in Version Africanus.

(4) At the end of Dynasty XXIV in the Version of Africanus, there occurs the statement "Total 990 years."

The query concerning 31 years.

Now in the statement of the previous dynasty there occurs a note that throws some light upon this. The note is *Ζὴτ ἔτη λά*, read as "Zet 31 years." For long Zet was supposed to be an unknown king's name. It appears in no other version of any List. Professor Petrie and Mr. F. W. Read have shown, however, that *ζητ* was commonly entered in such MSS. as Manetho's by editors, critics and scholiasts to indicate a query.[1] Petrie explains that Manetho here added a query concerning 31 years that belonged to a system of summation, but could not be accounted for by the summation of details. The added totals of Africanus, including the 31 years noted, by agreeing with the system framing the summations, confirm Petrie's explanation.

Custom of entering such queries in MSS.

The Entry of 990 Years. A query concerning this as referring to a period to complete a requisite total.

The summation of Plate XVI, Table A indicates that the statement of Africanus concerning the 990 years is to be similarly explained. 990 years added to 24,837 years, the duration of the Divine Dynasties, give 25,827 years, the sum of the Pyramid's base diagonals. 990 years added to the 4,611 years of Eusebius for the human kings, give the 5,601 years of Africanus for the human kings.

[1] *Ancient Egypt*, 1914, p. 32. 1916, p. 150.

variation at different times of only 1.0 inch. I therefore carefully fixed, by nine observations at each corner of each face, where the mean plane of each face would fall on the socket floors; using a straight rod as a guide to the eye in estimating. On reducing these observations to give the mean form of the core planes at the pavement level, it came out thus :—

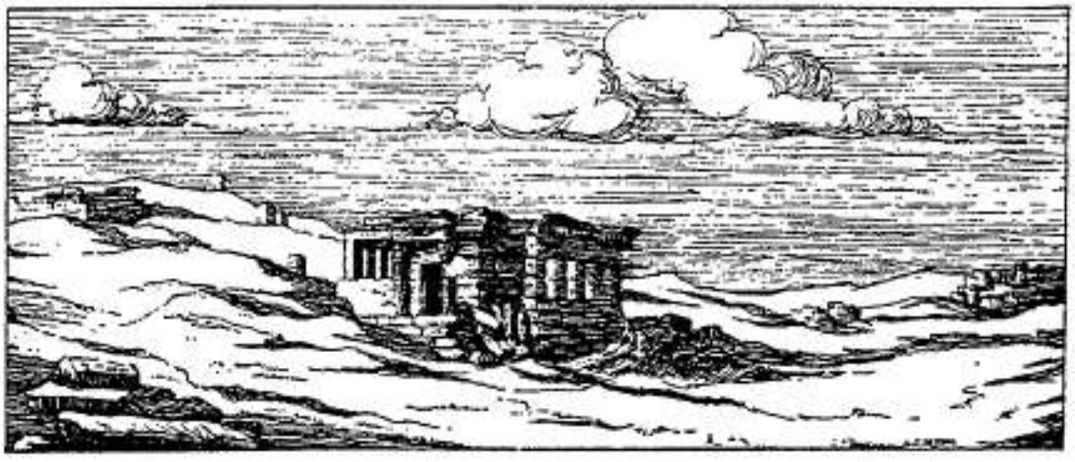
Petrie's measurements for same.

	Core Plane Sides. B″.
N.	9002.3
E.	8999.4
S.	9001.7
W.	9002.5
Mean	9001.5
Mean difference..	1.0."[1] (Refer ¶ 139.)

How Petrie determined the Hollowing-in feature.

On pp. 43–44, Petrie then states as to "the faces of the core masonry being very distinctly hollowed." "This hollowing," he continues, "is a striking feature; and beside the general curve of the face, each side has a sort of groove specially down the middle of the face..... The whole of the hollowing was estimated at 37 B″ on the N face....."

[1]Pyds. and Temples of Gizeh, pp. 37, 38.



CHAPTER III.

THE ELEMENTS OF ANCIENT GRAVITATIONAL ASTRONOMY.

SECTION I.—THE PYRAMID'S EXTERNAL DEFINITION OF THE EARTH AND ITS ORBIT.

¶ 141. THE ANALYTICAL APPLICATION OF PETRIE'S PYRAMID SURVEY DATA.

Accuracy of Petrie's survey data.

Professor Petrie's admirable survey data for the Great Pyramid are so comprehensive and accurate as to enable us to settle three momentous questions. These questions, which are closely inter-related, may be expressed as follows :—

Basis for determining designer's intentions,

(1) How far the existing measurements give evidence concerning the designer's intentions,

Workmen's errors,

(2) How far they indicate the extent of workmen's errors, and

Movements due to subsidence and earthquake.

(3) How far they indicate the extent of internal and external movements due to subsidence and earthquake shock.

Conversion of data to Pyramid azimuth for analytical purposes.

To form the necessary basis for the analytical investigation for the above, Petrie's system of Survey Co-ordinates has had to be converted into an equivalent system of co-ordinates oriented with respect to the mean azimuth[1] of the Great Pyramid. All the necessary data—Petrie's original co-ordinates and the new equivalent Pyramid azimuth co-ordinates—are given in relation on Plate XIX, to enable the mathematical reader to check the conversion for himself.

Tabulation of conversion.

The special feature of Petrie's Pyramid base and socket corner distances.

Subtraction of related co-ordinate units of Plate XIX—*i.e.* for co-ordinates from the same base and on the same straight line—and conversion of the units into British inches give all the Pyramid's true azimuth base distances shown on Plate XX. Plate XX also shows Petrie's oblique distances between base points and diagonal corners of sockets. The latter

[1]For Plate XX, the azimuth of a line running true North—or of the perpendicular to a line running true East and West—is defined as 0°. The azimuth of a line West of true North is defined as (−) angle from true North line. The azimuth of a line East of true North is defined as (+) angle from true North line.

The azimuth of the Pyramid's base diagonals as defined by the corners of the rock-cut sockets is −0° 3′ 43″.

distances are not stated with reference to any common azimuth. They are nothing more, in each case, than the direct distance in a straight line between two stated points. In this form, Petrie's distances are not a suitable basis for the analytical investigation of all the related data.

In this form not generally suitable for analysis.

¶ 142. THE SIGNIFICANCE OF PETRIE'S PYRAMID BASE DISTANCES.

Their one significant analytical application.

In one application, however, Petrie's base distances are of direct value for analysis. They determine the existing form of the square defining the central extent of base hollowing-in. This is the square RQPS on Plate XX.

The existing distorted definition of an intended or original square:— 9069.4 B″. 9067.7 B″. 9069.5 B″. 9068.6 B″.

The North side, QP, of this square = 9069.4 B″, and defines the line of CD where casing was found and surveyed.

The East side, PS, of this square = 9067.7 B″, and defines the line of EF where casing was found and surveyed.

The South side, RS, of this square = 9069.5 B″, and defines the line of GH where casing was found and surveyed.

The West side, RQ, of this square = 9068.6 B″, and defines the line of BA where casing was found and surveyed.

The close agreement of the North and South measurements, 9069.4 and 9069.5 B″ respectively, and the variation of 0.9 B″ between the East side (9067.7 B″) and the West side (9068.6 B″) suggest—

Intended or original value, 9069.5 B″.

(1) That the North and South measures define the intended or original value as 9069.5 B″; and

Variations due to workmen's errors or subsidence movement.

(2) That the shorter measurements of the East and West sides, 1.8 B″ and 0.9 B″ respectively, less than 9069.5 B″ indicate workmen's errors in building; or

(3) That reduction of the original central base distance between the North and South base edges—*i.e.* between CD on North face and GH on South face—is due to the drawing-in effect of a large cavern subsidence in the natural rock below the Pyramid, and to the major axis of this subsidence running in a direction approximately South and North.

Accuracy of detail, Workmanship evidences, Variation due to subsidence distortion.

The minute accuracy of detail in the finishing of beds, joints, and external surfaces of the Pyramid, and the remarkable precision of workmanship evidenced by the tightly fitting blocks, seem to indicate that the same minute accuracy and precision of workmanship extended to the external form of the Pyramid as a whole. In such event, the existing variation in the base distances is due to distortion by subsidence.

¶ 143. THE GENERAL EVIDENCE CONCERNING PYRAMID SUBSIDENCE.

Now if the slightly shorter distance between the North and South base sides, as compared with the distance between the East and West base sides, is

PLATE XIX.

THE REDUCED CO-ORDINATES OF PROFESSOR PETRIE'S SURVEY DATA.

North Base of Co-ordinate System on Pyramid Azimuth

Petrie's North Base of Co-ordinate System

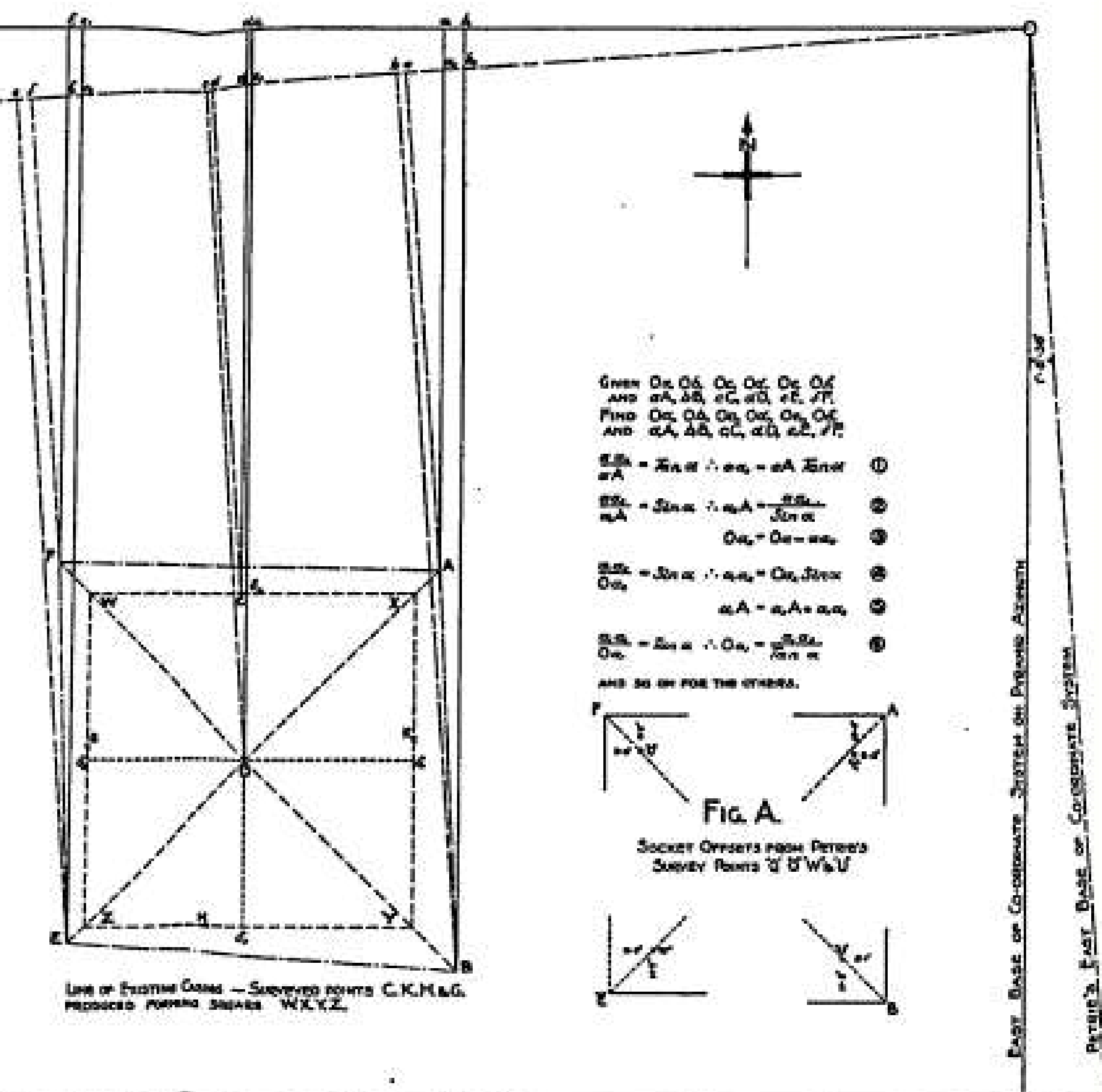
Angle between each Comparative Base Line of the two Co-ordinate Systems (Pyramids & Petrie's) considerably exaggerated.

Number of Petrie's co-ordinate units per British inch = 186·7505·001

Co-ordinates for A, E, F, B, are from Petrie's "Pyramids & Temples of Gizeh" p. 35, for his stated survey points 'Q', 'U', W & U respectively on floors of N.E., N.W., S.W., & S.E. Sockets, but with the addition or subtraction of Petrie's stated offsets from same, in inches transferred to equivalent co-ordinate units, reducing co-ordinates to outer corner of Sockets as Petrie's Plate X (and Fig. A.)

TABLE of CO-ORDINATES

	Des^n	Numerical Value in Units of Co-ordinate System	Logarithm	Des^n	Numerical Value in Units of Co-ordinate System	Logarithm	
Given Values	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Given Values
Required Intermediate Values	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Required Intermediate Values
Required Intermediate Values	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Required Intermediate Values
Required Values	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		Required Values
	Sine α	0·0198633	Ē·3002383	Tan α	0·0198673	Ē·3002193	



Line of Existing Casing — Surveyed points C, K, H & G. Produced forming square W, X, Y, Z.

[To face p. 118.

due to the subsidence effect inferred, the Great Pyramid should contain the following indications of such subsidence :— **How subsidence movement would affect Pyramid :—**

(1) The courses of the Pyramid masonry should indicate a slight dip inwards, towards the centre. **Inward dip of courses.**

(2) The existing top platform of the Pyramid masonry should not be truly central to the Pyramid's base square, unless in the remarkably accidental case of the axes of subsidence crossing below the Pyramid's base centre, and possessing the same orientation as the Pyramid base. **Top platform square not central.**

(3) The angle of the Entrance Passage with the horizontal in a Northerly direction should be greater than the angle of the Ascending Passage with the horizontal in a Southerly direction—presuming both to have been of the same inclination originally. **Descending Passage steeper : Ascending Passage flatter.**

(4) The angle of the Entrance Passage, continued as the Descending Passage, should increasingly accelerate its angle of dip after it leaves the masonry courses, and as it descends further into the natural rock. **Descending Passage increasingly steeper in natural rock.**

(5) The Chambers within the Pyramid masonry should be buckled and crushed in such direction of distortion as agrees with the approximate North and South direction of the major axis of subsidence indicated by the Pyramid's external variations. (¶ 142 (3).) **Distortion and fractures in chambers.**

Every one of the five indications outlined are defined by the existing state of the Great Pyramid's masonry as surveyed and measured by Professor Petrie. The external and internal evidences of subsidence are discussed in detail in Sections II and III of this Chapter. **All above effects exist in Pyramid, observed and measured by Petrie.**

¶ 144. THE PURPOSE OF THE PYRAMID'S SOCKETS.

Petrie has shown that the four corner sockets of the Great Pyramid were primarily cut to fix the alignments of the two diagonals of the Pyramid base. In three cases the alignments of the diagonals are fixed by the outer corner of each of three sockets, L, K, and M, for the N.W., N.E., and S.E. sockets respectively, as figured on Plate XX. In the case of the S.W. socket, the socket surface was carried to UX, 17½ inches to the West of the point Z on the diagonal ZK. The point Z, defining the diagonal alignment is, however, indicated by a chiselled line WZ cut by the original workers for this purpose. **Sockets cut to define base diagonal alignments prior to construction. The chiselled line on the S.W. socket.**

As shown on Plate XX, the true East to West distance from East side of S.E. socket to West side of S.W. socket—*i.e.* between M and the line UX produced—is 9140.63 B″. Petrie gives the oblique distance XM as 9141.4 B″. Now the true geometrical Pyramid base side $\frac{36,524.24}{4}$ P″ = 9131.06 P″ = 9141.1 B″. From this it is obvious that this distance over the two sockets was the original setting-out dimension for the corner to corner distance of the Pyramid's base side. **Distance between East side of S.E. socket and West side of S.W. socket set out prior to construction to define width of Pyramid base square of 36,524 P″ circuit.**

Actual shortening of Pyramid North base side 0.47 B″ on true azimuth.

The existing distance is 0.47 B″ shorter than the true distance. In the same way the sum of the true azimuth co-ordinates betweem AB and EF (Plate XX), at the centre of the base, is 9068.83 B″ or 0.62 B″ shorter than the mean of the measurements indicated as original by the distorted oblique distances QP and RS, 9069.4 and 9069.5 B″ respectively. (¶ 142.) The shortening effect on base measurements due to subsidence would naturally be greatest across the centre between two opposite base sides. In consequence, we may take the shortening of North base as not greater than the mean of the other two variations noted, $\frac{0.47+0.62}{2}=0.54$ B″.

¶ 145. THE ORIGINAL SETTING-OUT LINES OF THE PYRAMID BASE.

Existing base diagonals as defined by existing sockets slightly distorted from the rectangular owing to subsidence distortion.

Correction to rectangular gives four true squares defining original socket corners of base diagonals.

Also defines as original one true corner and one true base side of 36,524 P″ square circuit.

As stated by Petrie, the existing definition of the base diagonals—owing to subsidence distortion—does not give precisely rectangular diagonals. The amount of error from true rectangular diagonals is shown by the azimuth co-ordinates of the half diagonals on Plate XX. The intentional or original setting out can be very closely approximated by taking the existing North base socket distance LK (+its correction of ¶ 144, *i.e.* 0.54 B″) and the existing South base socket distance ZM (+its correction of ¶ 144, *i.e.* 0.47 B″), and by taking O the centre of the base as fixed; then with these as data we can correct the angles LOK and ZOM each to a right angle, to give the closely approximate true original socket corners L, K, M, and Z.

The result is that the half diagonals OL, OK, OM, and OZ to the socket corners L, K, M, and Z respectively, are defined by four true squares respectively of length of side 4567.41 B″, 4562.10 B″, 4570.55 B″, and 4553.05 B″. The result is confirmed, not only as to its supplying the original intention, but as to its definition of the original construction, by the S.E. socket corner M becoming the precise corner of the Pyramid square base of 36524.25 P″ circuit. The azimuth distance between UX produced and the S.E. socket corner M is also the length of the base side for the Pyramid circuit 36524.25 P″.

The original setting-out arrangement.

The Pyramid was therefore set out in preliminary lines as follows :—

(1) The socket corners defined the lines of the base diagonals.
(2) One socket corner (the S.E.) defined the S.E. corner of the Pyramid.
(3) The distance between the East side of the S.E. socket and the West side, UX produced, of the S.W. socket defined the South base side of the Pyramid.

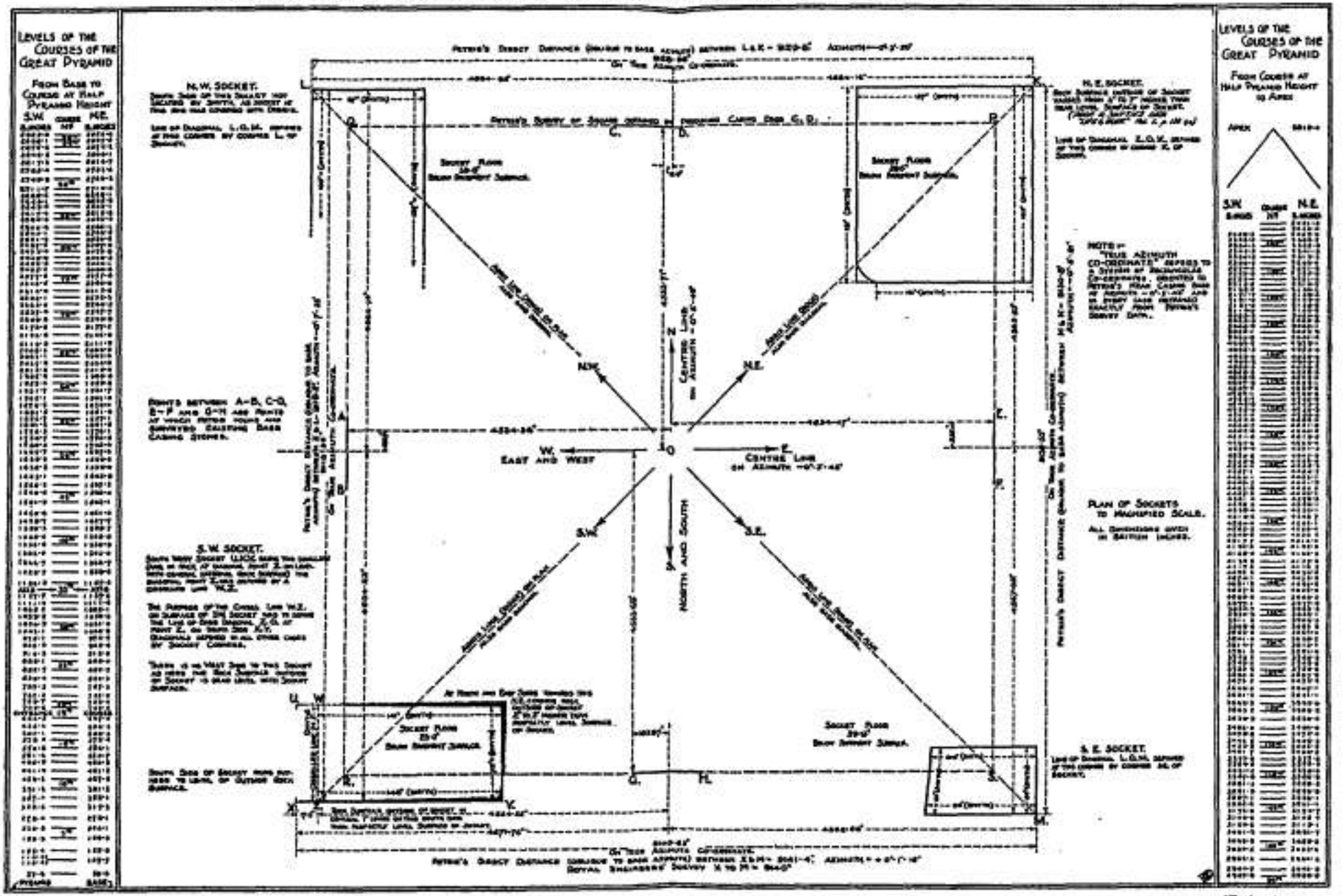
¶ 146. THE TWO VERSIONS OF PYRAMID RECONSTRUCTION.

Comparison of Professor Petrie's casing corner blocks with the casing corner blocks resulting from the new reconstruction.

Remembering that Professor Petrie's reconstruction defines the hollowing-in of the core without applying the same feature to the casing, and that the new reconstruction, adopted in the present work, applies the hollowing-in to

PLATE XX.

THE MEASUREMENTS AND LEVELS OF THE EXISTING DETAILS OF THE GREAT PYRAMID'S EXTERIOR.



(To face p. 120.

the casing, the reader will find instructive matter in the details of Plates XXI and XXII. These show the appearance of the South-East corner casing stone according to the two different reconstructions.

Sockets and foundation deposits.

It should be understood that Petrie carries down the masonry of the corner casing stones to the socket floors in all cases. The discovery of the Lisht Pyramid sockets and their foundation deposits (refer Section III, ¶ 197a) may have caused Professor Petrie to modify his reconstruction in this detail. But even this modification could scarcely redeem the evident weakness of his reconstruction as applied to the South-East socket corner casing stone. A reconstruction stands or falls under its critical application to detail. Apart, then, from the identities established concerning the intentional circuit of the Pyramid's base, we are assured that a critical technical examination of the two reconstructions, as applied to the detail of Plates XXI and XXII, will settle the matter conclusively, to the satisfaction of the thesis advanced in the present work.

Lisht Pyramid sockets.

The importance of the comparison of the two reconstructions.

¶ 147. THE EFFECT OF SUBSIDENCE ON FORM OF PYRAMID'S BASE.

Rectangular correction of diagonals shows that central subsidence has reduced Pyramid's central base width by 0.67 B″ across East to West and 2.10 B″ across North to South.

The nett effect of the correction of the right angles of the base diagonals in ¶ 145 is as follows :—

(1) That subsidence effect has reduced the true azimuth distance *between the centres of* the East and West casing base sides by the total amount of 0.67 inch.

(2) That the same effect has reduced the true azimuth distance *between the centres of* the North and South casing base sides by the total amount of 2.10 inches.[1]

This gives constant original central width across Pyramid base—between any two faces—as 9069.5 B″.

These corrections applied to the distances *between* the hollowed-in base sides give a constant distance of 9069.5 B″, East and West, or North and South, between centres of base sides. The East to West distance given by the existing slightly distorted features of the North and South base sides, as surveyed by Professor Petrie, still gives this value (¶ 142). This indicates that the Pyramid masonry, in centrally sliding slightly inwards, could not very appreciably reduce its external base length owing to the tightly fitting blocks. Externally it compromised by slightly skewing the external form of its base to retain its external base length practically unaltered, and at the same time produce the necessary diminution of azimuth co-ordinates to satisfy the subsidence conditions. This distortion of the external form of the Pyramid base bears relation to the distortion of the socket base only as effect to cause.

Construction of Pyramid ensured that subsidence reduction across centre—between opposite faces—should be a maximum ; but between corners of each base side a minimum—almost inappreciable.

All the data, then, at our disposal combine to show that the external corner to corner measures of the Pyramid remained practically unaltered, although very slightly skewed in direction. At the same time, the effect of

[1]This movement, due to subsidence, is discussed further in Section II (¶¶ 180–182), in light of data emerging from inductions subsequent to the stage here discussed.

PLATE XXI.

RECONSTRUCTION OF THE SOUTH-EAST CORNER CASING STONE.

DETAIL OF PETRIE'S RECONSTRUCTION FOR SOUTH-EAST CORNER CASING STONE IN SOCKET

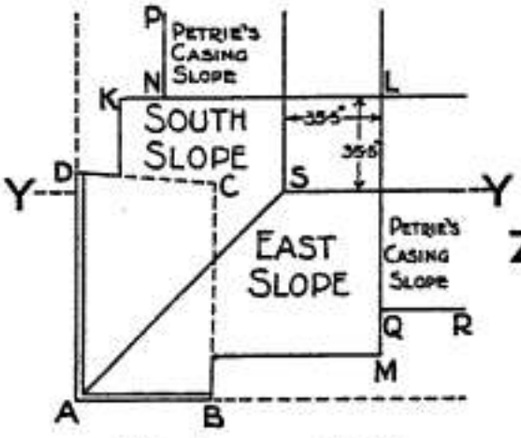


FIG. A — PLAN

DETAIL OF NEW RECONSTRUCTION FOR SOUTH-EAST CORNER CASING STONE OVER SOCKET

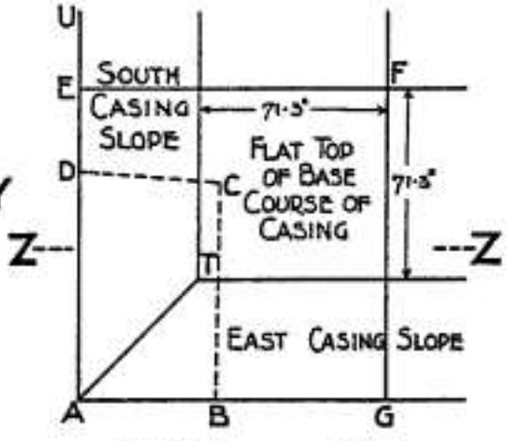


FIG. B — PLAN

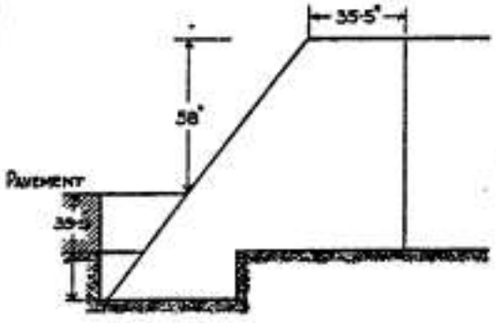


FIG. A_1 — CROSS SECTION Y-Y

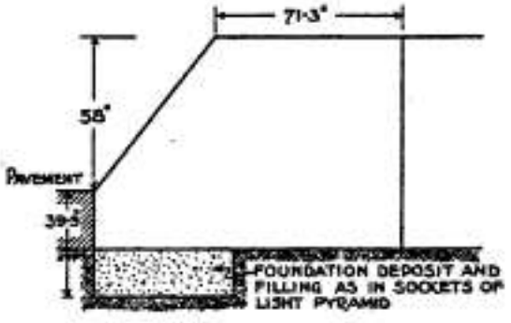


FIG. B_1 — CROSS SECTION Z-Z

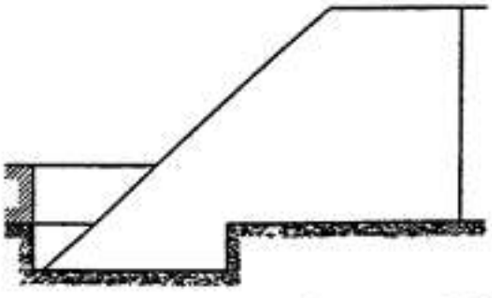


FIG. A_2 — DIAGONAL SECTION A-S

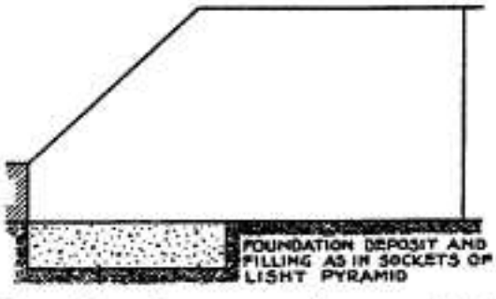
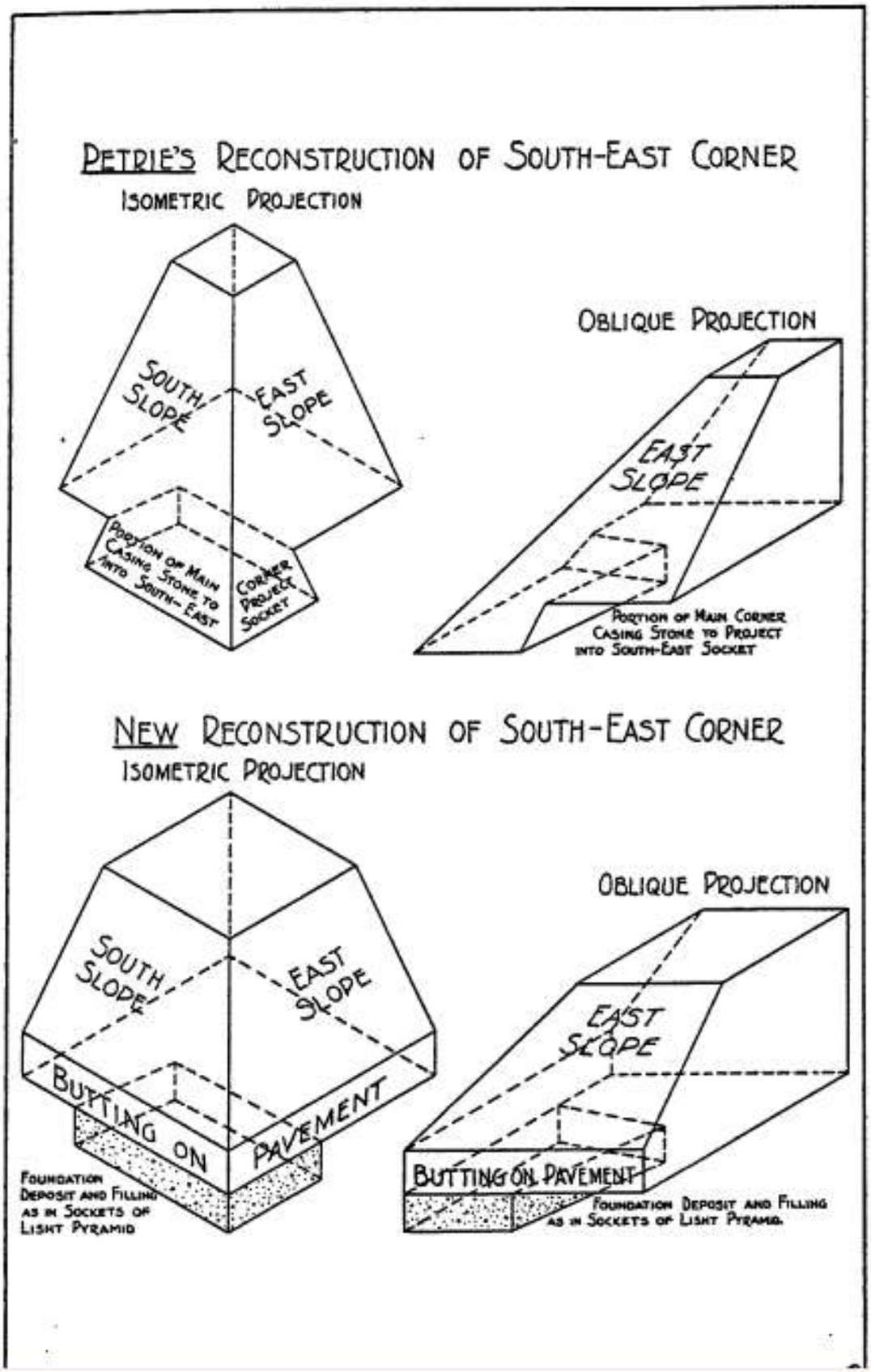


FIG. B_2 — DIAGONAL SECTION A-F

PLATE XXII.

ISOMETRIC AND OBLIQUE PROJECTIONS OF SOUTH-EAST CASING STONE RECONSTRUCTIONS.



Explains why core masonry hollowing is 37″ at centre of North face.

the subsidence brought the hollowed-in central portion of the North base and of the South base in each case 1 inch nearer the centre of the Pyramid (¶ 147, Case 2); and in the case of the East and West sides ½ inch nearer the centre of the Pyramid (¶ 147, Case 1). In consequence, the hollowing-in extent of about 36″ would be increased by subsidence to 37″ on North and South base sides, and to 36½″ on East and West base sides. 37″ is the value obtained by Professor Petrie from his sightings down the North face slope of the core masonry. This agrees with the value deduced for the North face including subsidence effect.

¶ 148. THE PYRAMID'S DISPLACEMENT FACTOR.

Analysis of subsidence movements shows that Pyramid base was defined by a square of 36,524 P″ circuit—corner to corner—and by an inner square marginally 35.76 P″ internal to the other, and of circuit 286.1 P″ less than the circuit of the outer square.

286.1 P″ a geometrical measure of the Pyramid.

Also the displacement of the Passage System.

Criticism, therefore, has shown that the Pyramid was set out to a base line of 9141.1 B″, that its distance between centres of opposite base sides was 9069.5 B″, and, independently, that its base sides were centrally hollowed to the extent of about 36″. The difference between the first two values, 9141.1 and 9069.5 B″, gives twice the extent of hollowing-in as 71.6 B″, and therefore the hollowing-in as 35.8 B″=35.76 P″.

The actual Pyramid base circuit is therefore defined by two squares, one marginally 35.76 P″ internal to the other. The outer square, defining the base corners, is 36,524.24 P″ circuit, and the inner square is 8 ×35.76 P″ (or 286.1 P″) less in circuit than the outer square.

Now 286.1 P″ (286.4 B″) is an important geometrical value of the Pyramid. It is also the measurement of the displacement of the North to South Vertical Axial Plane of the Pyramid's Passage System Eastwards from the North to South Central Vertical Plane of the Pyramid.

The existing displacement of the Passage System, as defined, was measured by Professor Petrie as follows:—

	Petrie's stated possible range of error.
Entrance Door on North Face	=287.0 B″±0.8 B″.
Entrance Passage End in Natural Rock	=286.4 B″±1.0 B″.
Beginning of Ascending Passage	=286.6 B″±0.8 B″.
End of Ascending Passage	=287.0 B″±1.5 B″.

The geometrical definition of external hollowing displacement, Passage displacement, and 35th course axis.

Plates XXIII, XXIV, and XXV (Figs. A, A_1, and A_2) show how the hollowed-in base feature, the 35th course axis, and the displacement of the Passage System are all geometrical functions of a composite system of geometry featuring the solar year to the scale of 10 P″ to a day, and to the scale of 100 P″ to a day. To convey the full significance of this to the reader it is necessary first to define the precise value of the solar year intentionally identified with the Pyramid's base square circuit.

¶ 149. THE INTENTIONAL VALUE OF PYRAMID'S BASE CIRCUIT.

In ¶¶ 102–104 it was shown that the period of 25,826½ years was identified with the period of the Precession of the Equinoxes. In ¶ 102 it was explained

that 78½ Phœnix cycles gave the identity 25,826½ Phœnix years (or intercalated Calendar years) =25,826.54 +Solar years. Accurately, the identity defines the precise numerical values of the Pyramid's base diagonals and of the base square circuit as follows :—

The Phœnix cycle chronology and Calendar rules define the numerical value of Pyramid base square circuit as 36,524.2465 and the numerical values of the sum of the base diagonals (and constant of Precession) as 25,826.542378.

(1) *INITIAL HALF PHŒNIX CYCLE.*

From Table III.	103 years' cycle		=37,620 days
Do. (365 days' column)	61 years of next cycle		=22,280 „
	½ Calendar year	=	180 „
	164½ years on cycle		=60,080 days.

(2) *NO. OF DAYS IN THE PHŒNIX CYCLE.*

From Table III.	3 cycles of 103 years	=309 years	=112,860 days
Do. (365 days' column)	20 years	= 20 „	= 7,305 „
	Phœnix cycle	=329 years	=120,165 days.

(3) *TOTAL PRECESSIONAL PERIOD.*

78 Phœnix cycles	=25,662	years	=9,372,870 days
From (1) above	164½	„	= 60,080 „
Precessional period	=25,826½	years	=9,432,950 days.

The years are intercalated Calendar years.

(4) *PYRAMID BASE CIRCUIT AND DIAGONALS.*

Let N =No. of days in solar year, and
P =Precessional period in years.

Then from above $$P = \frac{9{,}432{,}950}{N} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (I)$$

and from Pyramid base relationship

$$P = \frac{100\ N}{\sqrt{2}} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (II)$$

Solving the simultaneous equations I and II, we get

N =365.2424650 days.

Then, Pyramid base circuit =36,524.2465 P″,
and Sum of Base Diagonals =25,826.542378 P″.

These are the values adopted for the geometrical representation developed in Plates XXIII, XXIV, and XXV.

¶ 150. THE PROBLEM AND ITS PLANE.

It has been suggested by the evidence discussed in the two preceding chapters that the external features of the Great Pyramid were intended to

PLATE XXIII.

THE GREAT PYRAMID'S EQUAL AREA GEOMETRY DEFINES DISPLACEMENT OF PASSAGE SYSTEM.

FIG. A.

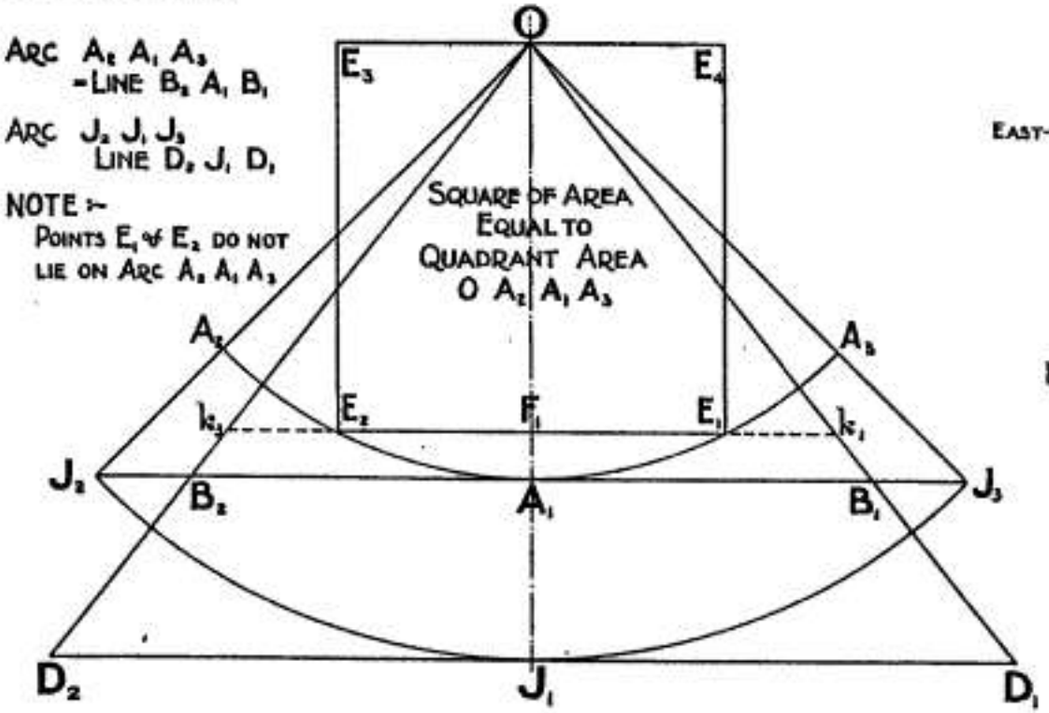
EAST TO WEST VERTICAL SECTION

SQUARE CIRCUIT OF PLANE $B_2\ A_1\ B_1$ = SUM OF DIAGONALS OF SQUARE OF PLANE $D_2\ J_1\ D_1$

ARC $A_2\ A_1\ A_3$ = LINE $B_2\ A_1\ B_1$

ARC $J_2\ J_1\ J_3$ LINE $D_2\ J_1\ D_1$

NOTE :- POINTS E_4 & E_2 DO NOT LIE ON ARC $A_2\ A_1\ A_3$



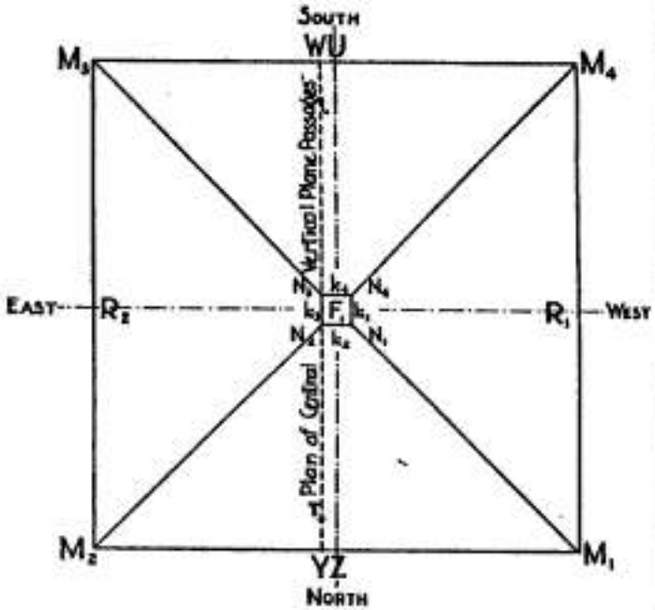


FIG. B.

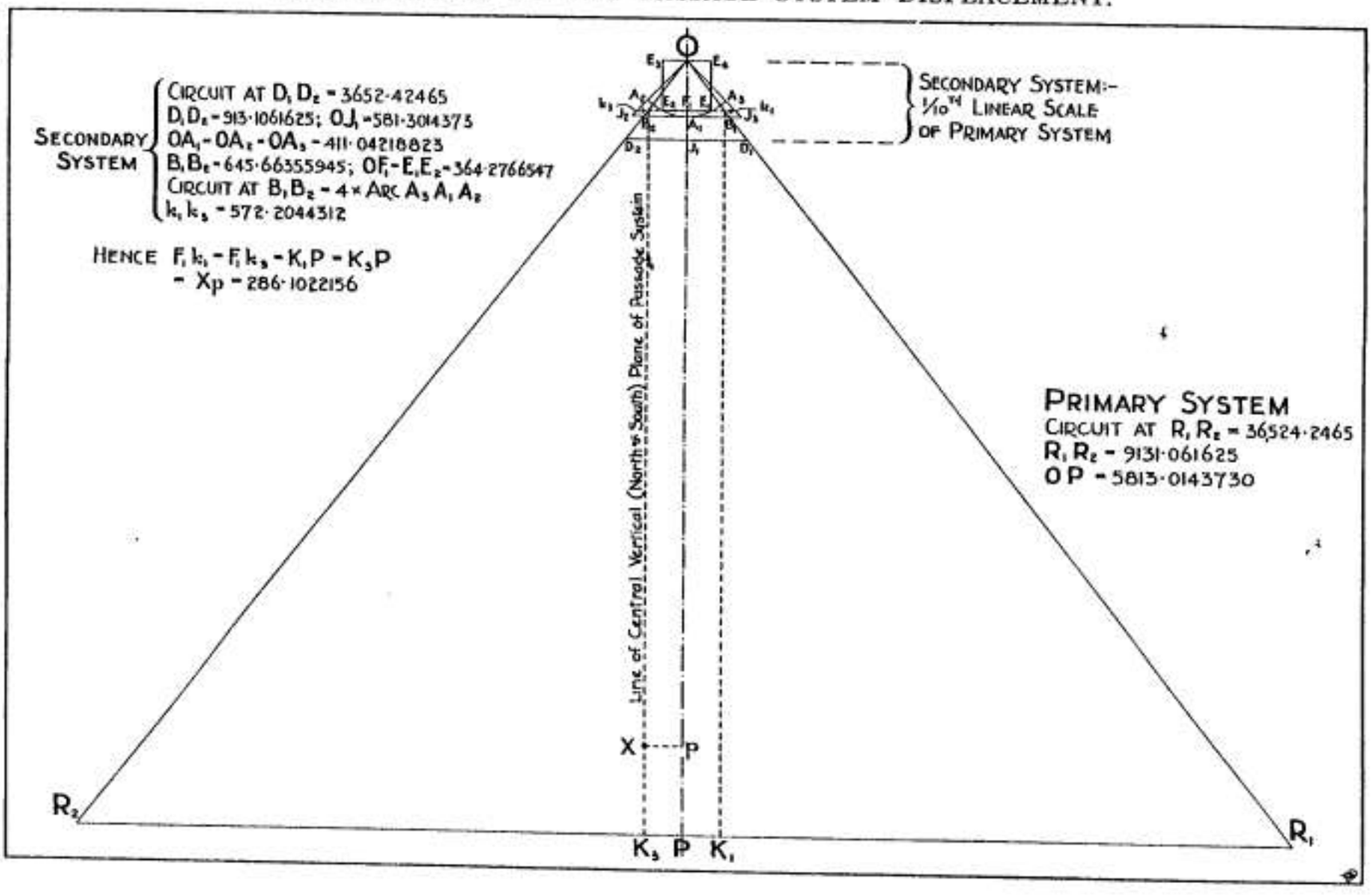
PLAN

CASE I (FIG. A) :-
FOR CASE OF $D_2 J_1 D_1$ (FIG. A) = $M_2\ M_1$ (FIG. B),
$D_2\ D_1$ CIRCUIT = 36,524·2465
$k_2\ F_1 = F_1\ k_1$ = 2,861·022156 (FIG. A ONLY)

CASE II (FIG. A)
FOR CASE OF $D_2 J_1 D_1$ (FIG. A) = $N_2\ N_1$ (FIG. B),
$D_2\ D_1$ CIRCUIT = 3,652·42465
$k_2\ F_1 = F_1\ k_1$ = 286·1022156 (IN FIGS. A & B)

PLATE XXIV.

THE GEOMETRY OF THE PASSAGE SYSTEM DISPLACEMENT.



The plane for graphical representation of Earth's orbit:— The pavement base of the Great Pyramid, since it is the plane containing the square circuit representing the solar year.

form a geometrical representation of the dimensions and motions of the Earth and its orbit (¶ 114). Any such representation must, of necessity, be made with reference to a plane representing the plane of the Earth's orbit. The plane of the Great Pyramid pavement is defined as this natural plane, as it is the plane of the Pyramid's base square, defining the circuit of the solar year. For the necessary geometrical representation the Great Pyramid's base plane, therefore, represents the plane of the Earth's orbit. This, then, is the natural plane for the geometrical and comparative representation of all values defining the dimensions and motions of the Earth and its orbit. These values, in consequence, need only be looked for in relation to the Pyramid's external features as defined in plan.

¶ 151. THE THREE YEAR VALUES.

Complicated factors that simplify the problem of graphically representing the elements of the Earth's orbit.

Consideration of the Earth's motion in its orbit is complicated by several factors. These complications, however, make it a considerably easier matter to specify the intention of any geometrical representation of the elements of the Earth and its orbit. One of the complications referred to is that there are three different year values defining the revolution of the Earth round its orbit. These are the Solar (or Tropical) year, the Sidereal (or Stellar) year, and the Anomalistic (or Orbital year).

Solar year.
Sidereal year.
Anomalistic year.
Perihelion.

The interval between successive autumnal or vernal equinoxes—or between successive summer or winter solstices—defines the Solar year. The interval between the Earth's position, at any time in the year, in relation to the fixed stars, and its next return to that position defines the Sidereal year. The interval between successive annual returns of the Earth to the point—defined as Perihelion—in its orbit nearest the Sun defines the Anomalistic year.

Ascending values of lengths of year:— Solar, ∧ 365¼ days ∧ Sidereal, ∧ Anomalistic.

The Solar year is slightly *less than* 365¼ days, the Sidereal year is slightly *more than* 365¼ days, and the Anomalistic year is slightly longer than the Sidereal year. Were the Earth's axis rigidly constant in its inclination, and in the direction of its inclination, the Solar year would be of the same length as the Sidereal year. Were the plane and axes of the Earth's orbit rigidly fixed in relation to the fixed stars, the Anomalistic year would also be of the same length as the Sidereal year. The Solar and Anomalistic years are therefore departures from the Sidereal year, due to circumstances other than the primary functions governing the Earth's rotation and revolution.

Were the Earth's axis and the ecliptic invariable in direction and inclination, the Solar and Anomalistic Years would be of Length of Sidereal year.

¶ 152. THE SIDEREAL YEAR DATUM.

Relationship suggests that true constructional perimeter of Pyramid base defines Sidereal year; and that this perimeter gives an inner

The Sidereal year is therefore the basal period for the other forms of the year. As such—presuming our premises concerning the Pyramid's purpose to be correct—it should be the year value defined by the true circuit of the Great Pyramid's base. Now the square circuit of the Great Pyramid's base defines the Solar year. This square circuit touches the true Pyramid base at four points only—the four corners. The true circuit of the Pyramid's base is the circuit of the hollowed-in perimeter of the casing base edges. This

circuit is longer than the square (corner to corner) circuit defining the Solar year, and the Sidereal year is longer than the Solar year. In other words, the hollowed-in base circuit is the true constructional base circuit, as the Sidereal year is the true constructional year circuit of the basal dynamics of the Earth's orbit. The question, then, to be settled is whether the hollowed base circuit gives the value of the Sidereal year to the scale of 100 P″ to a day.

geometrical circuit defining the Anomalistic year, as the outer square circuit defines the Solar year.

¶ 153. THE COMPLETED GEOMETRY OF THE GREAT PYRAMID'S EXTERIOR.

Development of the above indication synchronises with external geometrical features of Pyramid.

Plate XXV illustrates how the representation in plan should indicate the three values of the year. This is derived from the geometrical sequence of Plates XXIII and XXIV in relation to the geometry of the 35th course axis and the *aroura*. The derivation of the 35th course axis connection is illustrated on Figs. A and A_1 (Plate XXV). In Fig. A_1 (Plate XXV), the apex Pyramid circuit at level acb = 3652.42465 P″, and this is equal to the apex Pyramid circuit $D_2J_1D_1$ (Plate XXIV). The connected geometry of the latter defines the displacement of the axis of the Passage System and the displacement of the central hollowing-in of the Pyramid's base sides. The circuit of the apex Pyramid at acb (Plate XXV, Fig. A_1) is therefore equal to the 35th axis length EG = FH (Plate XXV, Fig. A). The rectangular *arouræ* defined by the latter are EGRC and EFQC, and these are respectively equal in area to the *aroura parallelograms* EGBH and EFAD (the two horizontally shaded areas of Plate XXV, Fig. A). The two latter define the centrally hollowed-in area as DEH, in elevation on Fig. A, and as $D_1E_1H_1$ in plan, Fig. B, Plate XXV.[1] The maximum extent of hollowing-in (35.762777 P″ horizontally from the geometrical plane face of the Pyramid's slope) applies to the whole area DEH (Fig. A), and along the line EO (Fig. A) to the base of the apex Pyramid at c (Fig. A_1). The broadly fluted (or scooped-leaf) effect necessary to taper off the hollowing towards the apex is illustrated on Figs. A_1 and A_2 (Plate XXV).

The 35th course axis width and the aroura define the width of central hollowing-in of base sides.

Complete geometrical definition of hollowing-in feature between base and apex.

¶ 154. THE THREE ASTRONOMICAL YEAR-CIRCUITS OF THE PYRAMID BASE.

The above geometrical definition satisfies conditions postulated for representation of three forms of the year.

The restoration of ¶ 153 is the one restoration that satisfies all the structural and geometrical features of the Great Pyramid. The real test of its having been the intentional geometrical arrangement is the extent to which it satisfies the conditions postulated in ¶¶ 150–152.

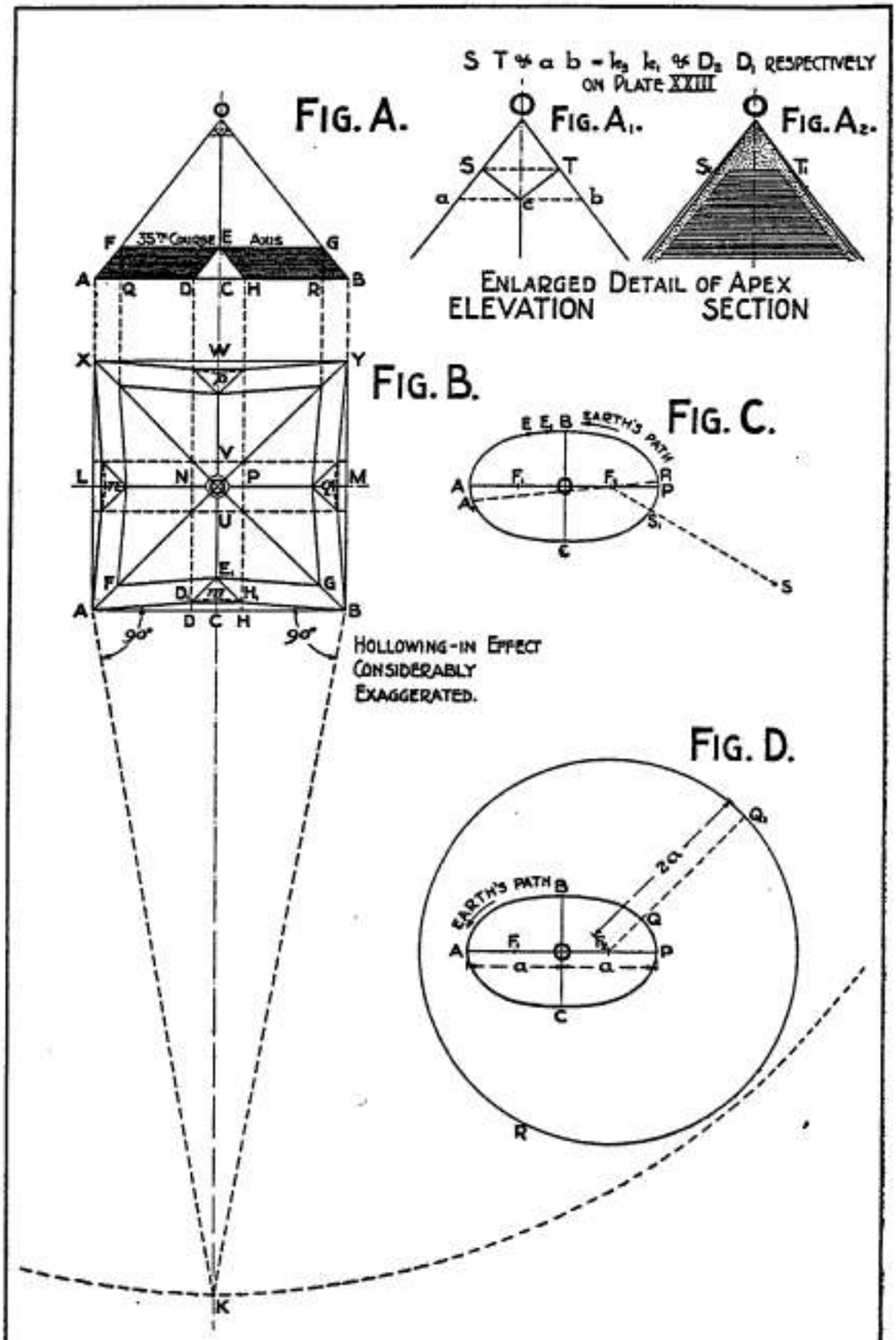
These conditions were—

(1) That the actual (hollowed-in) structural circuit (AD_1H_1B, etc., in Fig. B, Plate XXV) of the Pyramid's base should give the value of the Sidereal year to a scale of 100 P″ to a day; and

[1] For the relation between point G on Plate XX, as there defined, and point D on Plate XXV, as there defined, the reader is referred to the further discussion on subsidence effects in Section II, ¶¶ 180–182.

PLATE XXV.

THE PYRAMID BASE DEFINES THE EARTH AND ITS ORBIT, IN DIMENSIONS AND MOTION.



(2) That the geometrical circuit (AmBqYpXnA in Fig. B, Plate XXV), internal to the structural circuit, and defined by it, should give the value of the Anomalistic year to the scale of 100 P″ to a day, precisely as the external geometrical circuit (ADCHB, etc., Fig. B, Plate XXV) gives the value of the Solar year to this scale.

Solar year base circuit 36,524.2465 P″.

Now the external geometrical base circuit, as defined, is 36,524.2465 P″, representing, to the scale defined, a good average value for the Solar year for a long period of history from ancient to modern times.

Sidereal year base perimeter, 36,525.647 P″.

The actual structural base circuit, as defined, and resulting from the geometry described, is 36525.6471536 P″, representing, to the scale defined, a good average value for the Sidereal year. The resulting value of 365.256471536 days for the Sidereal year is only 8.6 seconds of time longer than the value for the present time,[1] 365.25637 days.

Anomalistic year base circuit, 36,525.997 P″.

The internal geometrical base circuit, as defined, and resulting from the geometry described, is 36525.997317 P″, representing, to the scale defined, a good average value for the Anomalistic year. The resulting value of 365.25997317 days for the Anomalistic year is only 33½ seconds of time longer than the value for the present time,[1] 365.2595844 days.

Suggests that intention of above representation would be completely expressed by other connected dimensional values of Earth's orbit.

In a representation intentionally giving the values stated, one would expect the intention to be emphatically declared by the associated representation of other related values. So far, the Pyramid's base geometry defines the Earth's annual orbit, in terms of its three forms of year. The intention would be completely defined by the connected representation of the related astronomical knowledge concerning the dimensions and form of the Earth's orbit. (Refer ¶¶ 114 and 120.)

¶ 155. ASTRONOMICAL RELATIONSHIP OF THE THREE FORMS OF THE YEAR. (Plate XXV, Fig. C.)

Earth's elliptical orbit.

The path or orbit of the Earth round the Sun is an ellipse, ACPB, of which F_1 and F_2 are the two foci. The Sun's centre is at the focus F_2. O is the centre of the orbit. AOP is the major axis, and BOC the minor axis of the elliptic orbit.

The Sun in one focus.

Major Axis.

Minor Axis.

Earth's elliptic orbit nearly a circle.

The ellipse figured is considerably exaggerated as a representation of the Earth's elliptical orbit. The latter, to any ordinary scale of representation, cannot be distinguished from a circle.

Perihelion.

When the Earth is nearest the Sun it is at P—on the major axis—whence P is called Perihelion.

Aphelion.

When the Earth is farthest from the Sun it is at A—also on the major axis—whence A is called Aphelion.

[1]For further explanation and additional data concerning the astronomical relationship of the three forms of year—and for data concerning their variations—the reader is referred to Chapter IV, Section II, and Plates XLIV–LVI inclusive.

Direction of Earth's motion in its orbit.

The Earth travels round its orbit in the direction of the arrow, *i.e.* direction BACPB.

Sidereal year explained.

Why Solar year shorter than Sidereal year.

About 50″ of angle or 20 minutes of time shorter.

Now let S be a fixed point in the heavens, and E the equinox for a particular year. Owing to a slow movement of the Earth's axis,[1] the equinox of the following year does not occur at E, but at a point E_1, about 50″ of angle (or 20 minutes of time) short of E. The Solar year is therefore the interval in days taken by the Earth to travel round the distance $EACPBE_1$, whereas the Sidereal (or Stellar) year—fixed from the immovable point S, and its immovable radius F_2S_1S—is the interval in days taken by the Earth to travel round the distance S_1PBACS_1.

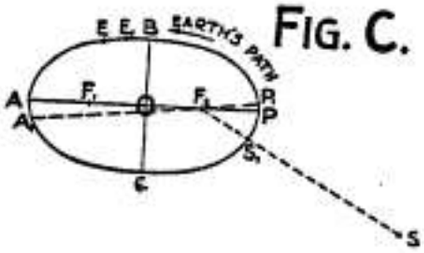


FIG. C.

The Solar year is therefore shorter than the Sidereal year by the interval E_1E—about 50″ of angle, or about 20 minutes of time.

Anomalistic year explained.

Why Anomalistic year longer than Sidereal year by about 11.5″ of angle or 4·6 minutes of time.

The Equinox is not, however, the only point that moves. In the course of the Earth's revolution round its orbit, the orbit itself is not stationary, but moves round in the direction of the Earth's revolution. In the course of one revolution of the Earth round its orbit, the major axis AF_2P moves round to the position $A_1F_2P_1$. Hence, commencing, say, from perihelion at P, the Earth travels round $PBACPP_1$ to return to perihelion. This revolution defines the Anomalistic or Orbital year. It is longer than the Sidereal year by the time it takes the Earth to travel from P to P_1. PP_1 is about 11.5″ of angle, or about 4.6 minutes of time. (Refer also Plates LV and LVI.)

¶ 156. THE MEAN SUN DISTANCE AND THE EARTH'S ORBITAL MOTION. (Plate XXV, Fig. C).

F_2P = the shortest distance between the Earth and Sun.
F_2A = the longest " " " "

The mean of these is OP = OA, and this distance, in astronomical nomenclature, is defined as the *mean sun distance*.

Eccentricity (e) of elliptic orbits.

Mean Sun distance = semi-major axis.

The eccentricity of the elliptic orbit is

$$e = \frac{OF_2}{OP} = \frac{OF_1}{OA} = \frac{F_1F_2}{AP}.$$

Value for Earth's orbit. 1900 A.D. e = 0·016751.

Maximum value about 11,600 B.C., e = about 0.019.

Minimum value about 26,000 A.D., e = about 0.004.

The value of this eccentricity (e) is variable. Its value for 1900 A.D. is 0.016751. Its greatest value during the past 60,000 years occurred about 11,600 B.C. It was then something over 0.019. Since that time it has been slowly but constantly diminishing, and will continue to diminish until about 26,000 A.D. The value of e will then be about 0.004, when the Earth's orbit will be as nearly a circle as it is ever likely to be.

[1]For explanation of this movement refer Chapter IV, Section II, and Plates Nos. XLIV–LVI inclusive.

To determine accurately the functions of the year, at any period, knowledge of these and other values, as well as of the laws governing motion in elliptic orbits, is a matter of fundamental necessity. Without going extensively into the subject of the Laws of Planetary Motion, attention is directed to an important corollary of these laws which has an important bearing upon the question of the Sun's mean distance.

Knowledge concerning these and other values, and their variations, and the laws governing same, of fundamental necessity.

¶ 157. THE MAJOR AXIS OF THE ORBIT A DYNAMICAL CONSTANT. (Plate XXV, Fig. D.)

In Fig. D, ABPC is the elliptic orbit of Fig. C, with the Sun in focus F_2.

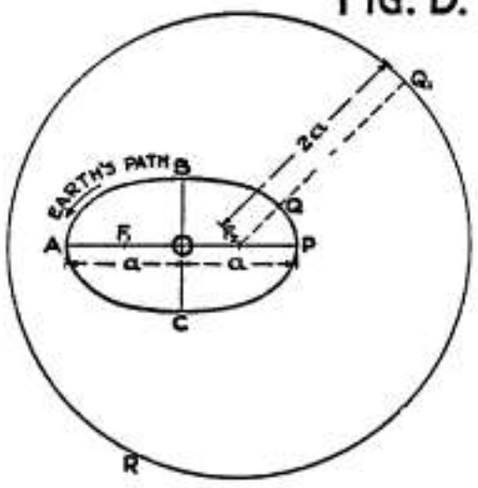
Definition of the "Earth's Speed Circle."

In Fig. D let OA = OP = a.

Then AP = 2a = Major axis.

With centre F_2 at the Sun, and radius F_2Q_1 = AP = 2a, describe the circle Q_1R.

FIG. D.



The corollary to which attention is directed is as follows :—

The speed of the Earth round its elliptic orbit is at every point, such as Q, equal to the speed which the Earth would acquire in falling to the ellipse at Q, from Q_1 on the circumference of a circle (Q_1R) with centre at the Sun (F_2), and radius (F_2Q_1) equal to the major axis (AP) of the elliptic orbit.

Thus the speed of the Earth at Q in the elliptic orbit is equal to the speed the Earth would acquire at Q in falling towards the Sun from Q_1 to Q.

The period of the Earth's revolution round its orbit "independent of every element except the major axis."

From this it follows that "*the period*" of the Earth's revolution round its orbit is "*independent of every element except the major axis.*"[1]

For purpose of brevity, rather than accuracy of definition, we will term the circle Q_1R the "Earth's Speed Circle."

¶ 158. THE GEOMETRICAL REPRESENTATION OF THE RANGE OF VARIATIONS IN RELATION TO THE BASAL CONSTANT.

The single constant geometrical feature of the Earth's orbit is therefore the Earth's "Speed Circle," with its centre occupied by the Sun. Referring again to Fig. D of Plate XXV, we see that the Earth's orbit ABPC revolves in an anti-clockwise direction about the fixed point F_2, defined as the centre of the Sun, and the centre of the Earth's Speed Circle RQ_1. Thus the point O

The Earth's "Speed Circle" the only constant feature of orbit.

All points of orbit slowly revolve round heliocentric focus of orbit.

[1]Refer Moulton's "Celestial Mechanics," pp. 150–151.

Heliocentric focus the fixed centre of the Earth's "Speed Circle."

The history of an orbit's motions and dimensions cannot be depicted by an ellipse.

describes a circle around F_2. Points P, F_1, and A on the major axis, and points B and C on the minor axis, also each describe their independent circles around F_2 as centre. None of these points, then—other than the fixed centre of the Sun, F_2—can be deemed as suitable for the origin of co-ordinates for any graphical representation of the Earth's orbit defining the limits of its movements and variations. Nor, indeed, can the orbit for any particular date be graphically represented as defining in general geometrical terms the limiting values of orbital cycles.

Two circles, both concentric with, and internal to, the Earth's "Speed Circle," define the annular zone of variation of the centre of the Earth's orbit.

Now, since the distance F_2O is a variable distance, and since O rotates around F_2 as a fixed centre, it is clear that a circle of radius F_2O, minimum value, and an outer circle of radius F_2O, maximum value, completely define the limits of variation of the centre of the orbit from the Sun. During the long period of the rotation of the orbit round the Sun (over 108,000 years) the curve traced by the centre point O of the orbit lies within the ring defined by the maximum and minimum circles.

The three heliocentric circles completely define in geometrical terms the historical range of the orbit's motions and dimensions.

These two circles, together with the Earth's "Speed Circle"—all concentric with the Sun—completely define, in general geometrical terms, the fixed element of the Earth's orbit—*i.e.* its major axis—and the range of variation of the variable elements. A representation of this nature is the necessary geometrical basis for any further representation defining the variable elements in relation to any standard system of astronomical chronology.

¶ 159. GREAT PYRAMID'S EXTERNAL GEOMETRY DEFINES THE EARTH'S ORBIT AND ITS VARIATIONS.

Geometrical definition of limiting values of eccentricity (e).

With e = eccentricity of Earth's orbit, then (Fig. D of Plate XXV):—

$$\text{Maximum value of } e = \frac{\text{Diameter of max. circle of radius } F_2O}{\text{Radius } (F_2Q_1) \text{ of Earth's Speed Circle}},$$

and

$$\text{Minimum value of } e = \frac{\text{Diameter of min. circle of radius } F_2O}{\text{Radius } (F_2Q_1) \text{ of Earth's Speed Circle}},$$

F_2O being variable within its defined limits, and F_2Q_1 being a constant = the major axis of the Earth's orbit = AOP.

The geometry of the Pyramid's base plan gives the above complete definition.

Now the two limiting values of e are known, and are precisely defined by the proportions of the Pyramid base geometry shown in Fig. B, Plate XXV. In this representation (Fig. B), the base centre, O, represents the Sun's centre. NOP and UOV represent the rectangular diameters of the minimum circle passing through NVPU. These diameters are defined by the central hollowing-in widths of the Pyramid base sides. The maximum circle is defined by the circle, CLWM, inscribed within the Pyramid's geometrical base square. Its diameter is the Pyramid base side length, LOM or WOC.

The radius of the Earth's "Speed Circle" is defined by the distance, OK, K being the intersection of the perpendiculars, AK and BK, from the con-

verging base side lengths, AD_1 and BH_1 respectively. Other points such as K are defined by all four sides of the Pyramid's base, this definition completing the circuit of the Earth's " Speed Circle." The radius OK of this circle, by geometrical construction, is 470860.606 P". The diameter VOU of the minimum circle, by geometrical construction, is 1826.212325 P", and the diameter of the maximum circle is 9131.061625 P".

Pyramid's definition of Earth's " Speed Circle " and related maximum and minimum values of eccentricity.

From these values—

$$\text{Minimum value of } e = \frac{VOU}{OK} = \frac{1826.212325}{470860.606} = 0.003878414$$

and

$$\text{Maximum value of } e = \frac{WOC}{OK} = \frac{9131.061625}{470860.606} = 0.01939207.$$

Pyramid's Minimum e and Maximum e.

These values are respectively the least and the greatest possible values of e—the eccentricity of the Earth's orbit—as accurately as modern astronomy can determine these values.

Pyramid's " Speed Circle " radius $\frac{1}{25,000,000}$th of Earth's " Speed Circle " radius.

Again,

radius OK = 470,860.606 P"
= 471,378.552 B"
= 7.43968674 miles.

Pyramid's relative scales of definition of Earth's polar radius and " Speed Circle " radius, $\frac{1}{250,000,000}$ and $\frac{1}{25,000,000}$.

This distance, multiplied by 25,000,000

= 185,992,169 miles,
= Major axis of Earth's orbit,
= Twice Mean Sun Distance.

Whence Mean Sun Distance = 92,996,085 miles.

Pyramid value for Sun's Mean Distance, 92,996,085 miles

Professor Simon Newcomb[1] gives for the latter a mean value of 92,998,000 miles.

Thus we have found (¶¶ 101 and 114) that

$$1 \text{ Pyr. inch} = \frac{1}{250,000,000} \text{ Polar radius of Earth,}$$

and that Pyramid's " Speed Circle " radius OK

$$= \frac{1}{25,000,000} \text{ Radius of Earth's " Speed Circle."}$$

The scales are therefore decimally related, as we had inferred they would be in a representation of this nature (¶ 114).

For modern variations in the determination of the value of the Sun's Mean Distance, the reader is referred to Section III, ¶ 201.

[1] Enc. Brit. (11th Edit.), Vol. XXI, p. 717, Table I.

Section I.—Summary and Conclusions.

¶ 160. THE GEOMETRICAL EXPRESSION OF NATURAL LAW.

Pyramid's Polar diameter inch intentional.

The Great Pyramid has now clearly established its intention in regard to its inch-unit. It defines that this unit is a Polar diameter inch-unit of the value of one 500-millionth part of the Earth's Polar diameter.

Its use defines all Earth and orbital distances and motions as simple functions of the Earth's Polar diameter and the year.

In conjunction with a simple, yet extensive system of solid geometry, the Pyramid inch-unit, as applied to the dimensions and form of the Pyramid's exterior, defines a further intentional representation. This is to the effect that all dimensions (angular and linear), and all motions—as well as variations in these dimensions and motions—of the Earth and its orbit, are simple functions of the Earth's Polar diameter and of the period of the Sidereal Year in solar days. In other words, the Great Pyramid's external system of geometry is the graphical expression of the Natural Law relationship inferred from the mathematical clue of the four Pyramid constants that defined, by the noon reflexion phenomena, the principal points of the year (¶¶ 46 and 47).

This definition is the Natural Law relationship inferred from the reflexion phenomena.

Intentional presentation in terms of Gravitational Laws.

Numerical value of Pyramid base circuit measurement independent of surveyed measurements, yet agrees with latter.

Defined in terms of known duration of Phœnix Cycle.

The manner in which the Pyramid's base plan simply defines the dimensions and limiting areas of dimensional variations of the Earth's orbit shows clearly that the intention was to present these as governed by the Laws—or, as the Pyramid seems to define, an all-including Law—of Gravitation (¶¶ 157, 158). This comprehensive graphical representation is independent entirely of any question as to the accuracy of any survey or measurement of the Pyramid's base, yet this independent representation agrees precisely with the accurate modern survey measurements. The intentional numerical value of the circuit of the Pyramid base square is defined in terms of the known duration of the Phœnix Cycle, or the Cycle of the House of Enoch (¶ 149). In this connection the relations established in ¶¶ 38 and 39 possess a remarkable numerical significance.

Fragments of the ancient scientific system in use in Egypt before arrival of Pyramid builders.

A fact requiring emphasis, in connection with the use of the Polar diameter inch in the Pyramid, is that this unit and the year circle form the necessary basis for the derivation of the Egyptian common cubit and the Egyptian *aroura*. Nevertheless, the common cubit was in use in Egypt—but without the inch as a contemporary unit—before the Pyramid builders had arrived. This confirms what we have previously seen, that the early Egyptians had derived from the former civilisation a fragment of the science that the designer of the Great Pyramid knew in its entirety.

¶ 161. THE SYMBOLICAL DEFINITIONS OF THE PYRAMID'S BASE CIRCUIT.

Form of Pyramid's constructional base perimeter defines relations of the Earth and its orbit.

Whilst the solid geometrical relations of the Pyramid define the form of the Pyramid's base perimeter, it is the constructional form of the latter that defines, in the plane of the base, all the principal relations of the Earth and its orbit. The Pyramid's base perimeter is defined as a symmetrical figure

formed of twelve lines. Its corners define an external square, and the lines of its perimeter from its corners, when produced to meet inside the centre of each base side, define a symmetrical figure formed of eight lines. (Plate XXV, Fig. B.)

Constructional base perimeter of twelve lines defines circuit of Sidereal year.

The twelve-line figure is the actual constructional base circuit of the Pyramid, and defines the Sidereal year to the scale of 100 Polar diameter inches to a day.

This perimeter defined by and internal to a square defining circuit of Solar year.

The external square circuit of the Pyramid's actual base corners, defines the Solar (or Tropical) year to the scale of 100 Polar diameter inches to a day.

The same perimeter defines an internal circuit of eight lines defining circuit of Anomalistic year.

The eight-line figure defines the Anomalistic (or Orbital) year to the scale of 100 Polar diameter inches to a day (¶ 154).

The symbolical definition of the three relations.

This is a graphical representation indicating that the Sidereal year is the actual constructional year value of orbital motion, that the Solar year is the *apparent* basal year value, and that the Anomalistic year is the most obscure value of the three. This is an exact representation of an astronomical truth.

¶ 162. THE GEOMETRICAL REPRESENTATION OF THE ORBIT'S HISTORY.

The Pyramid's base plan defines the framework for the geometrical representation of the history of the Earth's orbit.

The geometry of the Pyramid's base is an exact representation of an astronomical truth, *i.e.* that the speed of the Earth at any point in its orbit can be determined from the following data :—

(a) A circle with its centre at the focus of the Earth's orbit occupied by the Sun, and of radius equal to the length of the major axis of the Earth's orbit, *i.e.* twice the mean Sun distance ; and

(b) The direction and distance of the free focus of the Earth's orbit in relation to the focus occupied by the Sun.

Definition of Constants :— Length of major axis of orbit ; heliocentric focus.

Definition of annular zone containing all possible positions of the free focus of the orbit, thus defining limits of variation of orbit's eccentricity.

The Pyramid's base geometry represents the radius and circle of (a) accurately to a scale of $\frac{1}{25,000,000}$ and defines the annular field of (b) to the same scale. The latter representation (*i.e.* of (b)) may be described as the definition of the orbital field of the free focus. The orbit of the free focus is completed in each cycle of about 21,000 years. The orbits of a series of such successive cycles, owing to the variation in the distance of the free focus from the heliocentric focus, completely traverse the annular zone between its circle of minimum radius and its circle of maximum radius.

Scalar relation between representations of Earth's Polar radius and Sun's mean distance.

The radius of the constant circle of (a) above precisely represents the value of the constant length of the major axis of the Earth's orbit. Consequently, it represents the Sun's mean distance as half this value. The Sun's mean distance is, therefore, represented as a radius, to the scale of $\frac{1}{25,000,000}$, and, as previously shown (¶¶ 101, 114, 159), the Earth's Polar *radius* is represented by the Pyramid inch to the scale of $\frac{1}{250,000,000}$.

¶ 163. THE QUESTION OF UTILITARIAN MOTIVE.

Nothing so far learned of particular value from utilitarian standpoint.

All these and other identities have been established as related identities in this chapter, and in preceding chapters. That they are intentional identities can scarcely now be doubted. But what new item of knowledge have we learned that is of any practical value, from the standpoint of the utilitarian, apart from its interest as pertaining to matters of scientific and archæological curiosity? Very little, indeed, when viewed from the standpoint of any utilitarian basis. We have certainly learned that the dimensions and motions of the Earth and its orbit are all related functions of the simplest units of these dimensions and motions. This, however, we have known in a slightly different form from the Laws of Newton and Kepler. The rational development of Einstein's Theory of Relativity now gives us reason to hope that these and the laws of other branches of science may be shown to be but varying phases of one Universal Law of Nature.

Scientific facts given by Pyramid already known as facts of modern science.

What other motive, if any, lies behind the design and construction of the Great Pyramid?

The most we have learned, then, from the Pyramid's geometry so far—taken as a whole—has not very materially advanced our knowledge of science beyond what we have already known *in general terms*. What we have learned may have caused us to alter our conceptions concerning the origin and development of ancient civilisations. But was this the sole reason that prompted the design and construction of a monument of the nature of the Great Pyramid? Surely there was some utilitarian motive behind a project of this nature.[1]

¶ 164. OMISSIONS THAT SUGGEST POSSIBLE MOTIVES.

Pyramid gives us an ancient geometrical system of Natural Law in relation to the motions of the Earth and its orbit.

Let us consider, then, what are the outstanding features of the facts, from this standpoint of possible motive. The facts have proved to us that a certain stage of world civilisation, at an unknown—or hitherto supposedly undefined—period in the past had evolved a geometrical system of Natural Law, in relation to the motions of the Earth and its orbit, equal to, superior to, or more comprehensive than the modern system of expressing this Natural Law. The facts of importance in this statement of the case are that we have not yet learned anything concerning the precise, or even the approximate date of the stage of civilisation thus made known; and that we have not yet derived a single *tangible* indication as to how the savants of that period discovered their facts of science—*whether by methods of modern times, by methods unknown to modern times, or by the development of faculties now atrophied by long disuse.*

So far it has failed to indicate the date of the civilisation using this system; or as to how the scientific facts were derived.

The Pyramid's design postulates that knowledge of the facts of science defined by the Pyramid must precede the discovery of the Pyramid's definition of these facts.

Another feature that must have become increasingly evident to the careful reader is of equal importance. This is that, in order to discover the scientific facts embodied in the Great Pyramid, it is essential that the investigator should have previous knowledge of these very facts. Was the object of the designer, then, merely to show a later civilisation that the precise science of gravitational astronomy had been known long previously? Was this the

[1]For the evidence against the Tombic Theory refer Section III, ¶ 208 and context.

sole object of a work so vast, and so painstakingly executed in the minutest detail? The fact that the riddle of the Great Pyramid can only be read by one already in possession of the knowledge embodied in its design surely supplies a clear indication of a more utilitarian motive than we have so far seen.

This a clear indication of motive.

¶ 165. THE PYRAMID DESIGNER'S FORETHOUGHT.

To answer the preceding questions we must reach our objective in stages. One thing we have seen to be clear. This is that the designer of the Pyramid deemed he was projecting his knowledge into a future stage of civilisation that could interpret his intention. He foresaw that the contemporary language in which the facts could be conveyed would lose its meaning and idiomatic significance. It might be lost entirely, or at least be capable of mistranslation or misinterpretation. This foresight has certainly been justified.

Pyramid's science intended to be read by a future race to whom the science was already known.

The designer's foresight in not committing his knowledge to writing in any contemporary language.

The design was therefore formulated, without the aid of written expression, to embody in its external features a geometrical symbolism in Earth standard measurements. This symbolism was to be interpreted in an age already in possession of the knowledge embodied in the symbolism projected. The modern elucidation of this symbolism clearly justifies the remarkable forethought that both conceived the future conditions and created the design to meet them. Forethought of this nature was never expended merely to teach a future race of mankind facts of science it already knew.

Geometrical symbolism a universal means of scientific communication.

Earth's Polar diameter a universal scale of measurement.

Forethought justified by the interpretation of the ancient science as defined in these terms.

We are compelled, then, to come to the conclusion that the Pyramid's external features were designed to attract and direct attention to a further message of greater importance. Granting the forethought displayed, of what nature could this further message be? Clearly to tell the future race of mankind what it could not possibly know, or to confirm what could have no other possible physical means of being confirmed. A definitive limiting of future possible knowledge in this way can only relate to a break in the continuity of something essential to a race of mankind possessing the scientific knowledge defined; a break that had taken place before the Pyramid was built, and that could not be restored otherwise than by being passed on from the former civilisation to the then remotely future civilisation.

Such forethought expended in vain unless expended for the purpose of teaching the future race something it could not possibly know.

A vital break in a continuity essential to mankind.

¶ 166. THE INDICATIONS OF A CHRONOLOGICAL CONNECTION.

The inferred break in continuity can only be conceived as relating to some factor affecting the history of the previous civilisation, and related—or that should be related—to the history of the present stage of civilisation. However we look at this aspect of the problem, we are compelled to see that the *primary essential* for restoring the inferred relation must be of a chronological nature. This, indeed, is the one obvious connection suggested by the Great Pyramid's exterior. Here everything is connected with astronomical

The motive suggested inferred as relating to a factor that should be a common factor in the two systems of civilisation.

This inference suggests that the first step in deriving the factor noted is essentially of a chronological nature.

This is confirmed by Pyramid's external indications.

cycles, and astronomical cycles are the only possible means of affording a reliable datum for the chronological relations of two isolated periods of mankind's history.

A standard chronology necessarily defined by astronomical cycles.

Now there are two outstanding astronomical cycles associated with the Pyramid's exterior. There is the cycle of the Precession of the Equinoxes, associated in the Pyramid geometry with a standard period of reference of 25,826.54 Solar years. And there is the cycle of the revolution of the Autumnal Equinox from Perihelion to Perihelion.

The various cycles that could be employed to define such a system:—

The Precessional cycle,

The cycle of motion of Equinox from Perihelion,

The cycle defining variation in eccentricity,

The cycle of the revolution of the instantaneous axis of rotation of the Ecliptic.

There is also the cycle defining the variations in the eccentricity of the Earth's orbit. In addition to these, there is a cycle not hitherto mentioned. This is a cycle defining an important feature of a very slight variation in the Ecliptic due to planetary attractions. The important feature mentioned is what is known as the instantaneous axis of rotation of the Ecliptic. This axis is analogous to the major axis of the Earth's orbit, and, like the latter, has a slow revolution round the orbit. This movement—if its rate during the past 6000 years be taken as basis—completes a revolution of the Ecliptic in about 49,000 years.

¶ 167. DEFINITION OF A SINGLE CYCLE INSUFFICIENT.

The representation of the variable annual values for one cycle not sufficient to define representation as intentional.

A complete and accurate definition of the variable annual rates of any one of the cycles mentioned for every year over a long period of time covering the current years of the present chronological era and the years of a chronological era of past history would be sufficient to effect a chronological connection. It would not, however, suffice to define the representation of the values as intentional. A single representation would always be open to doubt on the grounds of accidental coincidence.

There are also two other reasons why a single representation could not be accepted as certain evidence in the relation mentioned. These are—

Reasons:—

(1) Modern values for ancient times not sufficiently reliable for identity.

(1) That, whilst modern astronomy is very accurate in its definition of the variable annual rates over a period of 600 years of modern time, its values covering a period of 6000 years back from the present are not so reliable; and

(2) An ancient representation of accurate modern values requires an independent means of defining the representation as intentional.

(2) That, presuming certain remotely ancient astronomers knew the accurate values for their own times, and also knew the accurate values for years of modern times, it would be necessary for them to define both facts in such certain terms as could not fail to be accepted by modern astronomers.

Any chronological definition of present in relation to past history on the Great Pyramid's geometrical system would require to satisfy these conditions.

¶ 168. THE POSSIBLE MAXIMUM DEFINITION.

Scientific zero datum of chronology.

The most scientifically appropriate zero date of any system of astronomical chronology is the date at which longitude of Perihelion is 0°. With

this as basis, definition of intention, and definition of accurate knowledge of the astronomical values of rates and angles for both ancient and modern times would be completely established as follows :— Longitude of Perihelion, 0°.

(1) By the representation of a year of past time, which we term Date A, defined in relation to the date at which longitude of Perihelion was 0°, and of a year of present time, which we term Date B, for which the longitude of Perihelion, defining the modern Date B, is given by the representation. For Dates A and B :— Longitude of Perihelion.

(2) By the representation of the total angle of Precession between Date A and Date B. Total Precession.

(3) By the representation of the angle between the instantaneous axis of rotation of the Ecliptic at Date A, and the same axis at Date B— or by the definition of the longitudes of the axis at both dates, that for Date B agreeing with the modern value. Longitude Ecliptic instantaneous axis of rotation.

(4) By the representation of the annual rate of motion of the Equinox in relation to Perihelion for every year from Date A to Date B, the rate for Date B agreeing with the modern accepted rate for Date B. Annual rates, separation of Equinox and Perihelion.

(5) By the representation of the annual rate of Precession for every year from Date A to Date B, the rate for Date B agreeing with the modern accepted rate for Date B. Annual rates, Precession.

(6) By the representation of the annual values for the motion of the instantaneous axis of the Ecliptic for every year from Date A to Date B, the rate for Date B agreeing with the modern accepted rate for Date B. Annual rates, Revolution of Ecliptic instantaneous axis of rotation.

(7) By the representation of the annual values for the eccentricity of the Earth's orbit from Date A to Date B, the rate for Date B agreeing with the modern accepted rate for Date B. Eccentricity Earth's orbit.

(8) By the conversion and integration of the values in (4), (5), and (6), giving accurately the angles defined by (1), (2), and (3). Integration of rates give same total angles.

(9) By the values in (4), (5), and (6) not being measured values dependent upon any Pyramid measurer or surveyor, but by their being values that are primarily functions of the Pyramid's external geometry, and that, secondarily, agree with the accurate measurements of a reliable Pyramid measurer and surveyor such as Professor Flinders Petrie (for linear measurements), or Professor Piazzi Smyth (for angular measurements). (Refer Section II, ¶¶ 170-175, regarding the relative value of Petrie's and Smyth's independent measurements.) All values primarily geometrical Pyramid values, agreeing with accurately measured Pyramid values.

¶ 169. THE DEFINITION ESTABLISHING INTENTION.

If items (1) to (5) and (8) and (9) are established, the conditions are satisfied as fully as any astronomer could desire.

If item (9) is established, it will be proved that the Great Pyramid's system of geometry is a graphical representation of Natural Law, defining

What would be implied by a definition such as that outlined:—

Restoration of chronological relations with previous civilisation.

Intention of definition established.

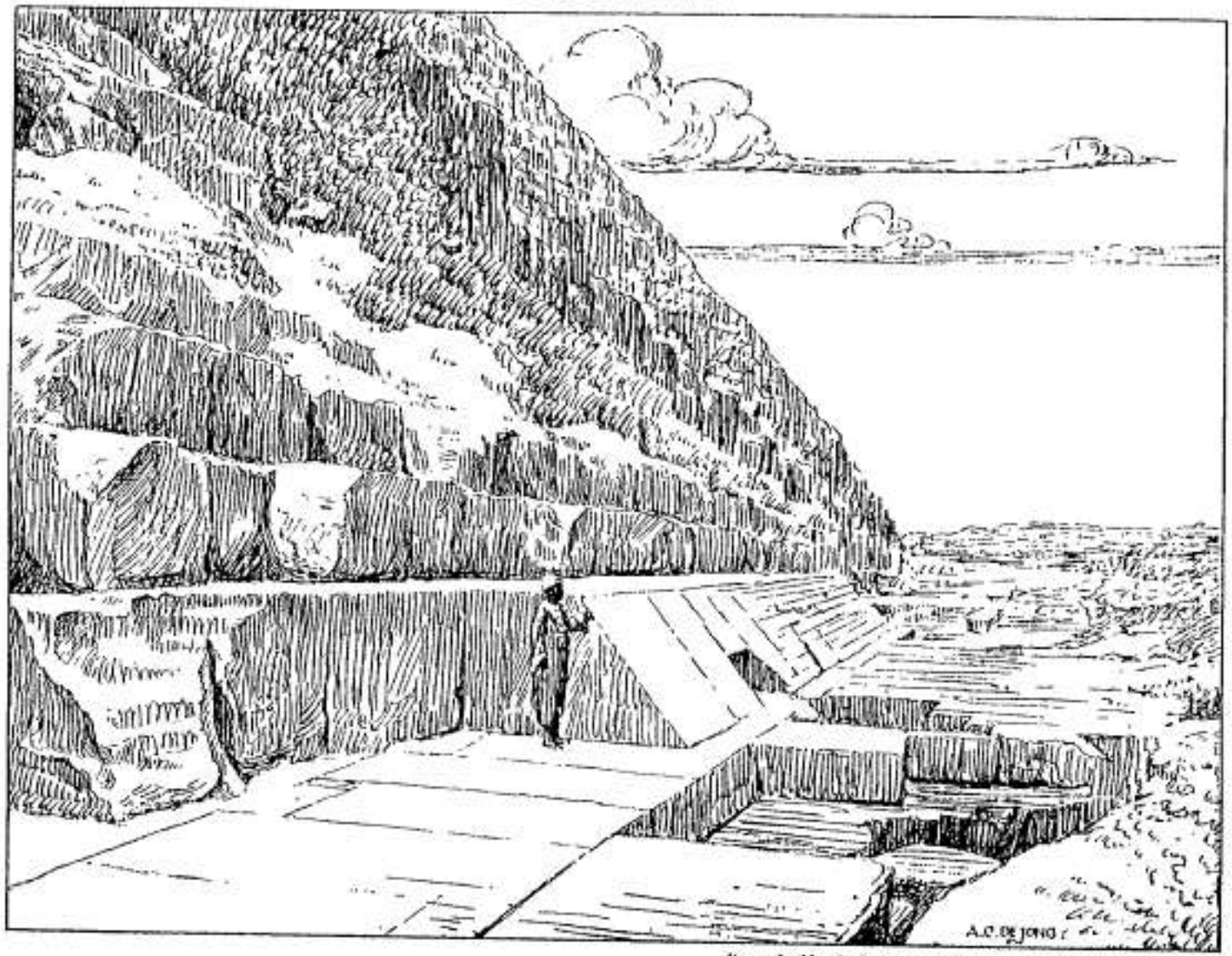
Established that former civilisation more highly skilled than modern in the mathematical basis of the practice of living.

the linear and angular measurements of the Earth and its orbit; defining the annual rates and periods of the cyclical motions of the Earth and its orbit; and defining a system of astronomical chronology that can be the basis of related reference for every period of highly developed stage of civilisation in the world's history.

With these items established as identities, the identities become intentional identities. With the latter established, there will be proved that a former civilisation was more highly skilled in the science of gravitational astronomy—and therefore in the mathematical basis of the mechanical arts and sciences—than modern civilisation. And what will this mean? It will mean that it has taken man thousands of years to discover by experiment what he had originally more precisely by another surer and simpler method. It will mean, in effect, that the whole empirical basis of modern civilisation is a makeshift collection of hypotheses compared with the Natural Law basis of the civilisation of the past.

PLATE XXVI.

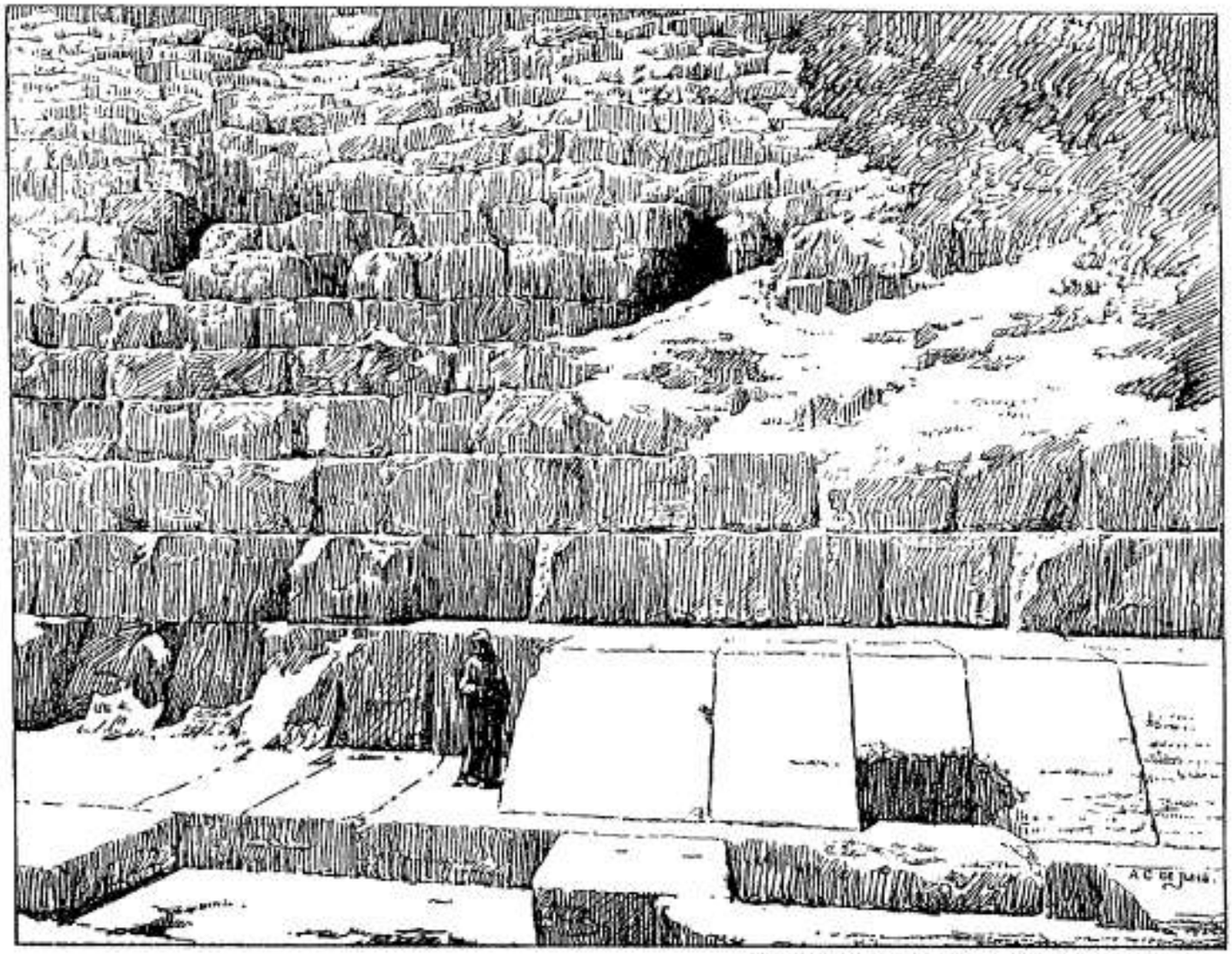
VIEW OF EXISTING NORTH BASE CASING STONES, LOOKING WESTWARDS. FISSURE IN NATURAL ROCK, WHERE PAVING REMOVED, SHOWN IN RIGHT FOREGROUND.



Drawn by Mr. A. C. de Jong from a photograph by Messrs. Edgar.

PLATE XXVII.

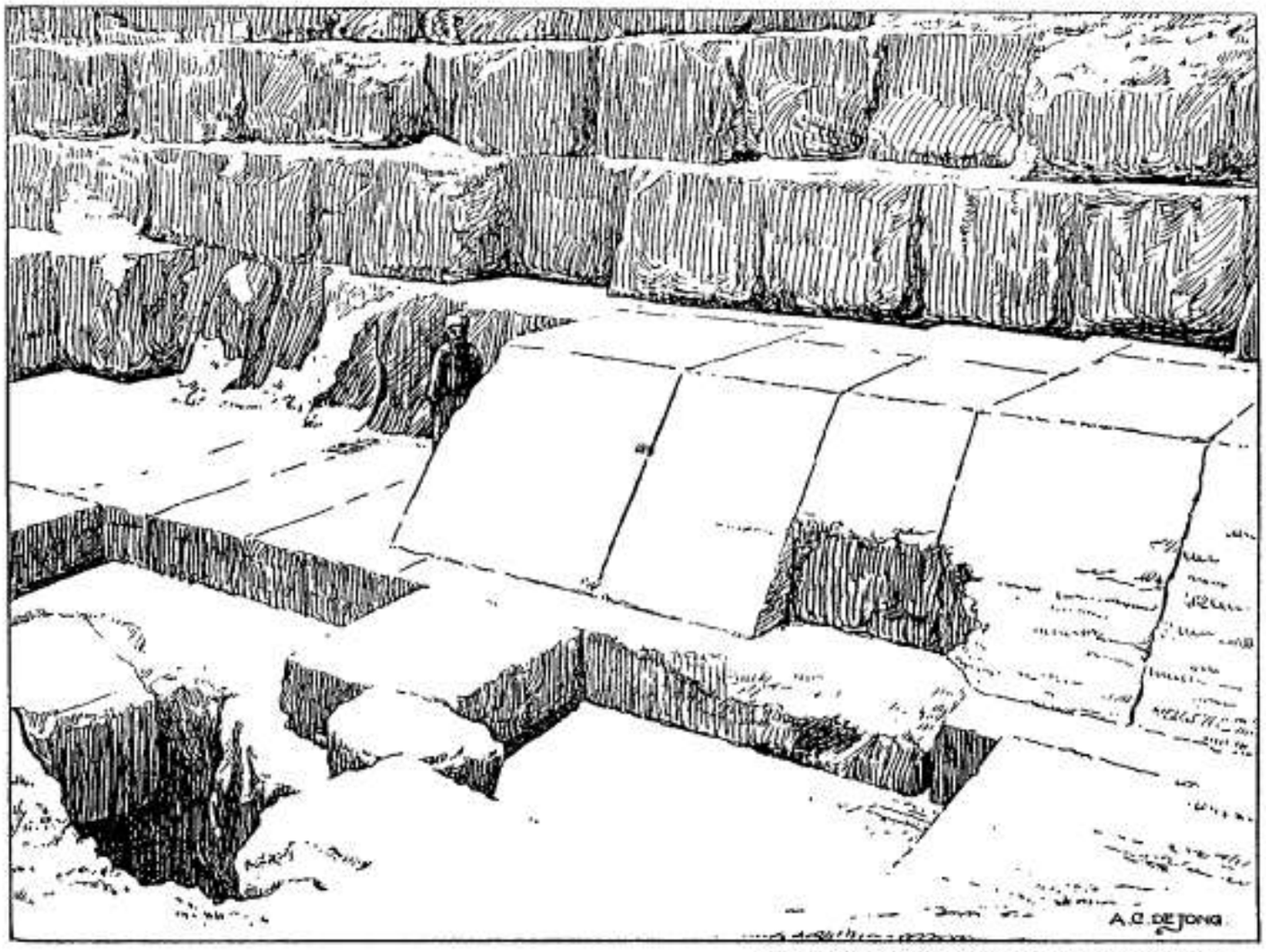
VIEW OF EXISTING NORTH BASE CASING STONES AND PAVEMENT SLABS.
AL MAMOUN'S FORCED ENTRANCE SHOWN ON 7TH COURSE OF MASONRY.



Drawn by Mr. A. C. de Jong from a photograph by Messrs. Edgar.

PLATE XXVIII.

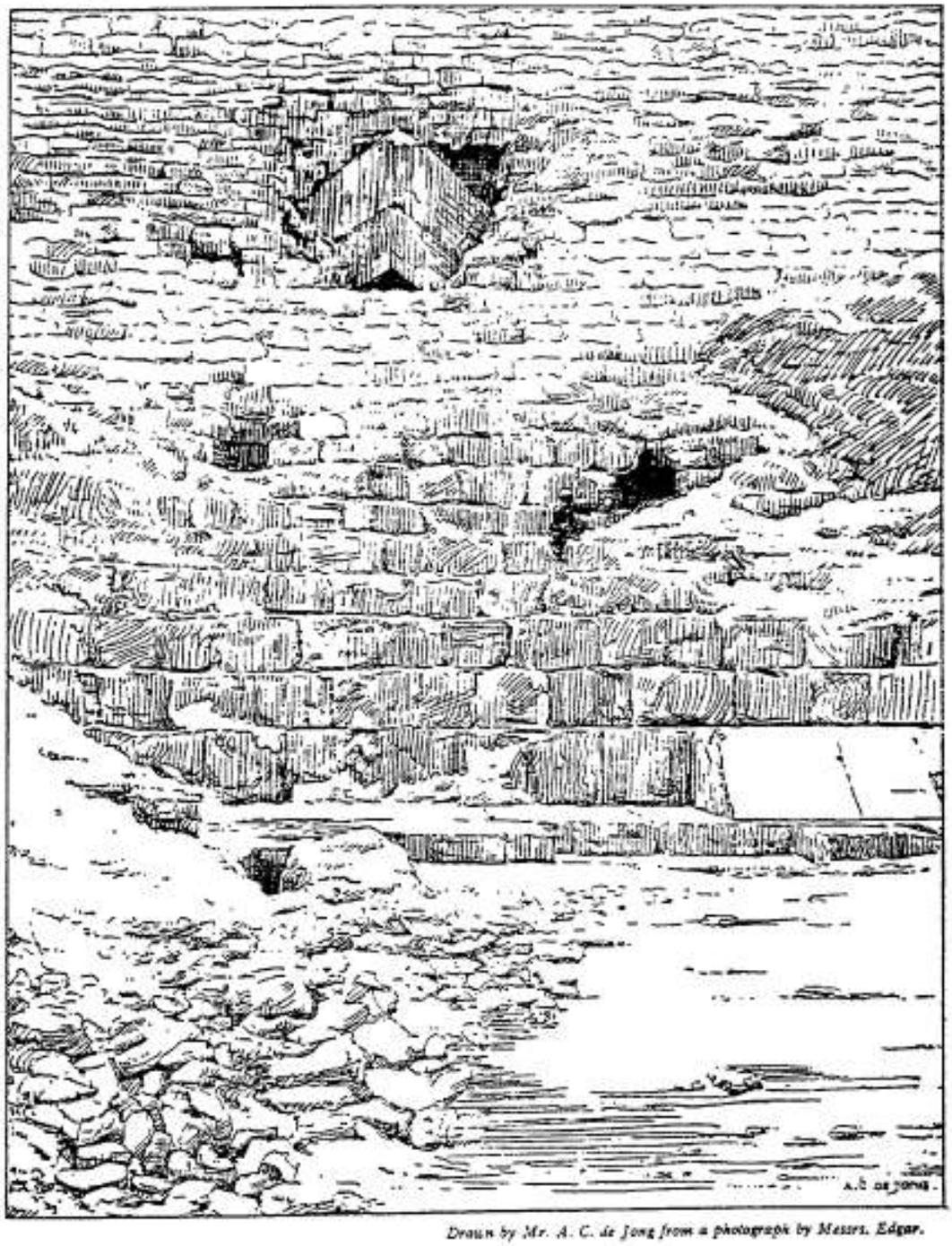
NEAR VIEW OF EXISTING NORTH BASE CASING STONES AND PAVEMENT SLABS, SHOWING FISSURE IN NATURAL ROCK, WHERE PAVING REMOVED, IN LEFT FOREGROUND.



Drawn by Mr. A. C. de Jong from a photograph by Messrs. Edgar.

PLATE XXIX.

VIEW OF EXISTING STATE OF NORTH ESCARPMENT SHOWING EXISTING BASE CASING STONES, AL MAMOUN'S FORCED ENTRANCE—INDICATED BY FIGURE—AND EXISTING STATE OF ENTRANCE TO THE DESCENDING (OR ENTRANCE) PASSAGE.



Drawn by Mr. A. C. de Jong from a photograph by Messrs. Edgar.

Section II.—Pyramid Measures and Details, and Subsidence Distortion.

¶ 170. BASIS FOR COMPARISON OF GEOMETRICAL AND MEASURED DISTANCES.

Geometrical distances must agree with measured distances.

It is futile to discuss any geometrical theory of the Great Pyramid's measurements—internal and external—unless the geometrical distances required by theory agree with the corresponding measured distances. In other words, fact must not be altered to conform to geometrical requirements.

Measured distances must be those taken by responsible scientific measurers.

The actual measurements to be taken as a basis must be those taken by responsible scientific measurers. The taking of linear, as well as angular, measurements is not the simple matter it may appear to those inexperienced in the precise determination of dimensions.

Professor Smyth's angular measurements, and Professor Petrie's linear and survey measurements the best data for an accurate basis of study.

The two best sets of angular and linear measurements of the Great Pyramid are those of Professor C. Piazzi Smyth, late Astronomer Royal for Scotland, and Professor W. M. Flinders Petrie. The former, with his long and varied experience in observational astronomy, possessed the necessary qualifications and apparatus for the taking of reliable angular measurements of a high degree of precision. Professor Petrie, whose archæological survey methods first laid the basis for modern scientific archæological exploration, and whose experience in previous geodetic and other survey work eminently fitted him for the task of surveying the Great Pyramid, has undoubtedly produced the best set of linear measurements to date.

¶ 171. RELATIVE VALUE OF THE TWO SERIES OF MEASUREMENTS AVAILABLE.

Petrie adopts Smyth's precise angular measurements, and improves on Smyth's appliances and methods for linear measurements.

Adopting Smyth's angular measurements for the interior details—upon which measurements Petrie could not improve—Petrie took special preliminary precautions in designing and preparing the most reliable measuring appliances obtainable for linear measurements.[1]

Compared with Petrie's steel tape and special chain, 1200 and 1000 inches respectively, and his self-compensating accessory appliances, Smyth's comparatively short measuring rods and accessories were primitive indeed. There are, in consequence, cumulative differences between the two independent sets of linear measurements. Thus Smyth makes the Entrance

[1]These are as described in Petrie's "Pyramids and Temples of Gizeh," pp. 10–15.

Causes of cumulative errors in Smyth's linear measurements.
(1) Piecemeal distances added.
(2) Screw-driver scratches as indications.
(3) Slipping of rods on inclined floor.

(Descending) Passage about 3 inches shorter than Petrie's measurement for this. Petrie accounts for the differences as follows :—

" (1) By his (Smyth's) being all piecemeal measures added together ;
" (2) By the rude method of making scratches with a screw-driver to mark the lengths of the rod on the stone (' Life and Work,' II, 46) ; and
" (3) By there being ' always a certain amount of risk as to the measuring rod slipping on the inclined floor ' (' Life and Work,' II, 35).
" All these errors would make the reading of the length shorter than it should be."

Direction of error.

Above applies to interior measurements.

Smyth never surveyed Pyramid's exterior.

It must be understood, of course, that these remarks concerning the relative value of the two series of linear measurements apply to the interior of the Pyramid only. Professor Smyth never surveyed the Pyramid's exterior. In fact, he never knew the precise or approximate measured relations of the Pyramid's base—unless in theory—until Professor Petrie's survey had been published, almost 20 years after Smyth's work at the Pyramid.

Existing interior indications best evidence for study of external movements.

Why the interior measurements of the Pyramid are mentioned at this stage is for the reason that it is from the existing condition of the interior we have the clearest evidence concerning the cause and direction of the movements that affected the exterior of the Pyramid (¶¶ 141–147).

¶ 172. THE CRITICAL VALUE OF PETRIE'S MEASUREMENTS.

Petrie benefited from Smyth's experience.

The fact of moment is that Petrie's appliances were prepared and his linear measurements taken with a critical knowledge of the defects in Smyth's appliances for linear measurements, and of the inaccuracies liable to occur in the application of Smyth's method of measurement. This is not to say that had Petrie been in Smyth's place as original reliable measurer, Petrie's apparatus and methods would have been any better than those Smyth adopted.

Petrie's appliances and methods designed as improvements on Smyth's appliances and methods.

The truly scientific worker always endeavours to improve upon the apparatus and methods of his predecessors, and to benefit by their experience. Smyth published an account of the defects in his appliances and method of measurement. Petrie, accordingly, designed his appliances and formulated his system of measurement to eliminate the defects revealed by Smyth's experience.

Petrie's Pyramid survey and linear measurements the best to date.

Apart, then, from any question of preference a possibly biassed judgment might accord to actual measurements most nearly agreeing with geometrical measurements, Petrie's statement of his linear measurements must receive preference as the most reliable statement of the Pyramid's measures as they now exist. Against this we must place the fact that Petrie's measurements clearly were taken to disprove Smyth's theories. Were this not a fact, Petrie could scarcely have failed to see that his own survey and set of measurements, and his comprehensive classification of ancient metrology, contained more distances of geometrical significance than Smyth, or any of his innumerable contemporaries and followers, ever claimed or showed in measurement. This is true both in regard to the Pyramid's external measures and internal measures.

His data prove more science in the Pyramid than ever Smyth claimed.

¶ 173. HOSTILE DATA CONFIRMING INDUCTION.

The influence of biassed opinion in the two series of data.

The possibly small bias evidenced in Petrie's measurements is more than balanced by another fact to be admitted, viz. that Smyth's measurements were taken with the hope of finding confirmation of his own and John Taylor's theories. The influencing bias—unwitting, but psychologically unavoidable—is evidenced in several outstanding cases in the statements of both measurers, Smyth and Petrie; more by unwittingly biassed judgment authorising the selection of averages, than in judgment controlling the taking of any particular measurement.

Bias psychologically inseparable from preconceived belief.

But does not detract from the value of data collected under bias, and hostile to a theory, verifying that theory.

The exponent of a theory, or the holder of a preconceived belief, must always be considered, from any critical point of view—whether friendly or hostile—as potentially and psychologically, though possibly unwittingly, biassed in favour of evidence that accords with his theory or preconceived belief. This, it must be granted, is a fair statement of the mentality that should be adopted to consider logically any statement concerning the results of inductive analysis. It is not a statement, however, that can be applied in the particular instance of Petrie's data—hostile to Smyth's theories—confirming the latter in a manner never imagined by Smyth or any of his followers.

Sir John Herschel's statement concerning such cases.

Of such cases, Sir John Herschel[1] stated:—

> " The surest and best characteristic of a well-founded and extensive induction is, when verifications of it spring up, as it were, spontaneously into notice from quarters where they might be least expected, or from among instances of that very kind which were at first considered hostile. Evidence of this kind is irresistible, and compels assent with a weight that scarcely any other possesses."

¶ 174. BIASSED OPINION DELAYING PROGRESS OF DISCOVERY.

Examples of above:—

Egyptian Common Cubit cited by Petrie as opposed to Smyth's Pyramid Inch.

Smyth ridicules value of Egyptian Common Cubit.

One good instance of the truth of Herschel's statement is seen in the case of the origin of the Common Egyptian Cubit from the Primitive Polar Diameter Inch and the Year Circle geometry. Petrie was hostile to the latter, and Smyth hostile to the former. Yet the admirable classifications of Petrie's inductive metrology have shown us that the Common Egyptian Cubit is a simple function of Smyth's Pyramid Inch, and that the latter is truly a Polar Diameter Inch.

Yet Egyptian Common Cubit of Petrie's value verifies Pyramid Inch of Smyth's value.

Smyth's original theory—without precise data—correct on general lines, but wrong in application to detail.

Again, with no precise measurement of the Pyramid's base to guide him, Smyth, from a few remotely secondary external and internal details of the Pyramid's construction, inferred that the circuit of the Pyramid base consisted of 36,524.2 Polar Diameter inches, and that the Pyramid's height was the radius of a circle of the latter circumference. Smyth even supposed originally that the pavement upon which the Pyramid was built formed part of the casing, and that the Pyramid base level was at the bottom of the pavement blocks.

[1] " On the Study of Natural Philosophy " (1830), p. 170.

Petrie's survey proving Smyth's application wrong. Petrie failed to see the truly obvious application, and Smyth resorted to a revised application more impossible than his original. The latter revision strengthened Petrie's case—as being the more logical. Result:—20 years' delay.

It was not until Petrie—nearly 20 years after Smyth's work at the Pyramid—published his results that Smyth indicated, in his later editions, the casing blocks sitting on the pavement. Petrie, on the other hand, whilst observing the hollowing-in of the core, failed to see that the purpose of this was to provide the backing surface for a similar hollowing-in of the casing. This oversight delayed the presentation of the Pyramid's message for a further period of 20 years. For Petrie declared that his survey failed to confirm Smyth's theory in any single detail, except the casing angle of slope. This declaration was given additional weight by Smyth readjusting his theory to suit what he supposed Petrie's survey to indicate. Smyth's readjustment required the circuit of 36,524.2 to be at a level where it could neither be indicated nor measured, *i.e.* in the natural rock at the level defined by him as the mean socket floor level.

¶ 175. SMYTH'S THEORY CONCERNING PYRAMID'S PURPOSE CORRECT.

Smyth's mean socket floor level for base of Pyramid has no structural definition.

Investigation showed the absurdity of this readjustment. For, apart entirely from the obviously untenable nature of the readjusted theory, neither the mean socket floor level, nor yet the lowest socket floor level, gave the true level for the Pyramid base circuit, unless by altering the angle of slope of the Pyramid. As this further readjustment destroyed all the other essentials of the theory, it was reasonably assumed in sequence by accredited authorities—

Led to authorities condemning Smyth's theory of the Pyramid's purpose.

(1) That Petrie's survey was correct; and hence
(2) That Smyth's theory was wrong.

They gave not a moment's consideration to the other possible and reasonable sequence—

The facts are:—Petrie's survey correct, Petrie's application of survey incomplete, Smyth's theory concerning Pyramid's purpose correct, and Smyth's theories concerning structural identification of his theoretical principles incorrect.

(1) That Petrie's survey, being correct, might show
(2) That Smyth's theory was correct on premises other than Smyth's, and on premises other than Petrie inferred from his reliable survey data.

We now realise that the sequence is as follows:—

(1) That Petrie's survey is correct; and
(2) That, in consequence, Smyth's theory concerning the purpose of the Pyramid is correct.

This is precisely the kind of verification that Sir John Herschel defined as being "the surest and best characteristic of a well-founded and extensive induction."

¶ 176. EFFECT OF SUBSIDENCE ON PYRAMID PASSAGES.

Petrie proves effect of subsidence in King's Chamber, but ignores related effect in Passages, proved by his measurements.

One other feature essential in any analytical investigation of the Great Pyramid's measures, but that has never been properly discussed in this connection, is the question of subsidence. It is true that Professor Petrie specially discusses the effects of subsidence in the King's Chamber; but he

has passed over in silence the necessarily related effect of the same movement upon the angle of inclination of the Passages. He states that the angle of inclination for the Ascending Passage is slightly flatter than, and for the Descending Passage slightly steeper than, Smyth's theoretical angle for these Passages. This, however, is precisely the condition in these Passages that would follow from subsidence movement.

Rate of steepening and flattening of slopes of Passages follow known law of subsidence.

Smyth's theoretical angle for both passages is 26° 18′ 9″.63 with the horizontal. Subsidence below the centre of the Pyramid's mass would increase the angle of the Descending Passage and decrease the angle of the Ascending Passage. Accordingly we find that the mean angle of the built portion of the Descending Passage is 26° 26′ 43″ (Smyth and Petrie), of the first Ascending Passage, 26° 2′ 30″ (Petrie), and of the Grand Gallery, 26° 17′ 37″ (Smyth and Petrie).

Proves that Smyth's theoretical Passage angle of slope was angle of Descending and Ascending Passages.

The distortion of the King's Chamber proves that subsidence has taken place. The fact that subsidence has taken place below the Pyramid proves that the angle of the Descending Passage has steepened, and that the angle of the Ascending Passage has flattened. The massive and rigid construction of the Grand Gallery has been able largely to resist relative movement between its various parts. It has subsided almost bodily, thus almost exactly retaining its original angle of slope, being now only 33 seconds of angle flatter than the theoretical angle of 26° 18′ 10″.

That 26° 18′ 10″ was the original angle of slope is clearly shown by Petrie's detailed measurements.

Original angle of slope, 26° 18′ 10″.

¶ 177. SMYTH'S THEORETICAL ANGLE CONFIRMED.

At Petrie's floor distance of 990 B″ down the Descending Passage from the original Entrance Doorway, the Passage suddenly commences to increase its dip. Between the latter point and Petrie's floor distance 1505 B″, near which—within an inch or two—the Descending Passage intersects the Pyramid base level, the angle of slope of the Passage floor line is 26° 34′ 0″. This is obtained from Petrie's offsets from his theodolite altitude of 26° 31′ 23″, stated as the mean angle for the whole Descending Passage length to its termination deep in the natural rock.[1]

Descending Passage length 515 inches back from base, subsided angle of slope, 26°

The effect of subsidence movement below the Pyramid's base level on the Descending Passage immediately above the base level is therefore 26° 34′ 0″, less the original angle of slope. Presuming the latter to be 26° 18′ 10″, Smyth's theoretical angle—we obtain 15′ 50″ as the amount by which the Descending Passage, immediately above the base level, has been steepened by subsidence in the natural rock below the base level. Now this amount is also the amount by which the portion of the Ascending Passage nearest the natural rock has been flattened. This portion of the Ascending Passage should therefore be 26° 18′ 10″, less 15′ 50″=26° 2′ 20″, whereas the mean angle of slope of the 1st Ascending Passage is 26° 2′ 30″.[2]

1st Ascending Passage mean subsided angle of slope, 26° 2′ 30″.

Restoration to a common angle for both gives 26° 18′ 15″.

Theoretical 26° 18′ 10″.

[1] "Pyramids and Temples of Gizeh," p. 58.

[2] Ibid., p. 61.

¶ 178. SIGNIFICANCE OF EXISTING CENTRIC POSITION OF STEP AND QUEEN'S CHAMBER.

Existing Queen's Chamber and Great Step both lie in East to West vertical plane through centre of base square.

A feature of original design and construction.

Another detail, however, confirms the latter conclusion. Petrie's interior linear and angular measurements show that the existing centre of the Queen's Chamber and the existing termination of the Grand Gallery floor at the Great Step both lie in the central vertical East to West plane passing through the centre of the Pyramid's square base area. This coincidence is obviously intentional. Petrie accepts it as such, and therefore as a feature of the original design and construction.

This feature persisting proves that centre of subsidence is not far from centre of Pyramid's base.

The significance attaching to this feature still existing, is that it supplies an important indication as to the approximate location of the centre of subsidence. It indicates that this centre was not so sufficiently remote from the Pyramid's base centre as to produce appreciable horizontal North to South displacement of the Great Step and of the centre of the Queen's Chamber. As a result, near these points, the tangents to the curve of the subsided core courses of the Pyramid would not be far from the horizontal, unless where locally buckled by thrusting. As a corollary of this, the subsided Grand Gallery floor near the Great Step should still retain its original angle of slope of 26° 18′ 9″.63. Professor Petrie's offsets to the Grand Gallery floor from his altitude line in the last 213½ inches towards the Great Step prove this to be the case.[1] The existing vertical distance between the foot of the Great Step at the South end of the Grand Gallery and the floor level at the North end of the Grand Gallery is 0.54 B″ less than for the original angle of 26° 18′ 9″.63.

Latter fact explains retention by Grand Gallery floor of its original angle of slope in its terminal length of 213½ inches, 26° 18′ 10″.

¶ 179. SIGNIFICANT EFFECT OF RESTORATION OF ORIGINAL PASSAGE ANGLE.

Original angle of slope of Passages verified.

The still existing centrally located position of the Great Step and Queen's Chamber, however, supplies us with a more certain basis for testing Smyth's theoretical angle for the Passages than any of the above lines of inquiry. This is, that if the location defined is the original location—and there is no disagreement on this question—and if the angle of slope of the Passages was originally 26° 18′ 9″.63, then with Petrie's existing Passage lengths from the existing Entrance Doorway on the North face to the junction of the Passages, and from the junction to the Great Step, both applied along the inferred original angle of 26° 18′ 9″.63, the Great Step and the centre of the Queen's Chamber should still be in the same central location. Calculation along the lines defined agrees precisely with the conditions inferred.

Calculation shows that with Petrie's Passage lengths along original Passage slope, Great Step and Queen's Chamber remain in the same centric position.

Petrie's definition of existing centric position of Great Step and Queen's Chamber.

Thus Petrie states that his survey data, Passage measurements and angles define—

(1) Existing face of Great Step as 0.4 B″ South of existing centre of Pyramid, with probable error of ±0.9 B″; and

[1] "Pyramids and Temples of Gizeh," p. 71.

(2) Existing centre of Queen's Chamber as 0.3 B″ North of existing centre of Pyramid, with probable error of ±0.8 B″.

Petrie accepts from these that the central location was intentional.

Adopting the centric position of the Great Step, Petrie's Passage floor distances, the constant angle of Passage slope of 28° 18′ 9″.63, and Petrie's Entrance Doorway on Pyramid face at 668.28 B″±0.1 above pavement base, we obtain as follows :—

Petrie's Passage distances on original angle of slope give the same centric position.

Horizontal Distance, Great Step to North End, Grand Gallery	=1627.5331 B″.
Horizontal Distance, North End, Grand Gallery to Junction of Passages	=1386.6529 B″.
Horizontal Distance, Junction of Passages to Petrie's Entrance Doorway	= 995.6504 B″.
	4009.8364 B″.
Horizontal Distance, Petrie's Entrance Doorway to Petrie's existing North Casing Base	= 524.1 ±0.3 B″.
Centre of Pyramid to existing North Casing Base ..	=4533.9364±0.3 B″.
The same distance on Plate XX =distance O to CD ..	=4533.7100
The difference lies within Petrie's range of possible error	0.2264±0.3 B″.

¶ 180. PASSAGE DISTANCES PROVE HORIZONTAL INWARD MOVEMENT OF BASE CENTRES.

In the above series of additions the existing North casing base point at 524.1±0.3 B″ horizontally from Petrie's Entrance Doorway was taken without any reference to the question of the angle of the Pyramid's face slope. This has been shown to have been originally exactly 51° 51′ 14″.3.

Petrie has proved conclusively that the floor of the Entrance Doorway certainly commenced at 668.28±0.1 B″ above the Pyramid's Pavement Base. The level and depth of the 19th course of masonry determine that the Entrance Doorway emerged with its roof line at the top of the course and its floor line at the bottom of the course. Near the Entrance, the existing bottom level of this course is 668.28±0.1 B″, as Petrie has shown. Nothing can be more certain than that this gives the original floor level of the Passage at the Entrance on the face slope.

Original Entrance Doorway emerged on Pyramid face in depth of the 19th masonry course.

We therefore have two certain facts to guide us. The Entrance floor on face slope was 668.28±0.1 B″ above the Pavement, and the angle of slope was 51° 51′ 14″.3. From these we find that the original horizontal distance from casing base to Entrance floor was 524.91 B″±0.1, or 0.8 B″

Entrance floor originally 524.8 B″ horizontally from central edge of North casing base.

longer than the existing indications tend to show. Adding the latter in the series of horizontal passage distances of ¶ 179 we obtain—

	Plate XXX Original.	Plate XXX Petrie's existing.
Horizontal distance, Great Step to Entrance Floor	=4009.84 B″	4010.91 B″±0.6
Horizontal distance, Entrance Floor to original North Casing Base.. ..	= 524.91 B″±0.1	524.10 B″±0.3
Horizontal distance, Great Step to North Casing Base	=4534.75 B″±0.1	4535.01 B″±0.9
Deduct, Plate XX, existing distance O to DC	=4533.71	
Extent to which centre of North Casing Base has been drawn in by subsidence towards centre of Pyramid.	1.04 B″±0.1.	

Original horizontal length from Entrance to Step proves existing North Base has moved 1 inch inwards,

and

That there was a separate Northwards relative horizontal movement between core masonry courses, increasing in extent from nothing at the base course to a maximum at the top course.

In ¶ 147 this was independently obtained as 1.0 inch average for each casing face, or a total drawing together of the centre of the North casing base and the centre of the South casing base of 2.1 inches. (Refer also ¶¶ 142-145.) The existing details and measurements discussed above show further that, in addition to this general movement, there was a relative horizontal movement between the masonry courses of the Pyramid core; that this movement became in extent cumulatively greater for higher courses; and that the general direction of the movement of successive courses was towards the North side, steepening the Pyramid's face slope from its original 51° 51′ 14″.3 to 51° 53′ 20″ between the existing base and the existing 19th masonry course. The nature of the relative movement indicates that the angle of North face slope should become steeper for higher courses.

¶ 181. INDICATIONS OF FURTHER MOVEMENT INWARDS OF SOUTH BASE CENTRE.

Petrie's surveyed point on South casing base edge.

Lies 113.6 B″ external to maximum hollowed-in base strip.

Indicates a further movement inwards of central area of Pyramid South base to extent of 1.11 B″.

Total inward movement of centre of South base now 2.17 B″.

One feature not entirely dealt with concerns the South base point G on Plate XX. G is the point located and surveyed in by Petrie. In ¶ 147—and prior to the geometrical definition of the central width of maximum hollowing-in—this point was considered as lying on the base edge of this central area, *i.e.* on the line D_1H_1 of Fig. B, Plate XXV. Actually, by comparing Plate XX, for point G at 1028.7 B″ from centre of base, with Plate XXV, for Point D_1 on Fig. B at 914.1 B″ from centre of base, we find that Petrie's South base survey point (G on Plate XX) lies on the line D_1A of Plate XXV, Fig. B, and 113.6 B″ from D_1 towards A. In this position on the geometrical Pyramid base, point G (Plate XX) should be 1.11 P″ further South than the maximum hollowed-in base line D_1H_1 (Plate XXV). Its distance South from the base centre should therefore be 4535.85 B″, whereas the corresponding existing distance is 4533.69 B″, or 2.17 B″ less than the existing distance.

Movement confirmed by two other external features of the Pyramid.

Now we have already seen that the centre of the South base has moved inwards, owing to subsidence movement, at least 1 inch. The Passage data of ¶ 180 have confirmed the data of ¶ 147 by indicating that the North base has moved inwards 1.04 B″ ±0.1. The total movement of North base centre and South base centre inwards was estimated in ¶ 147 as 2.1 B″. To this we must now add an additional 1.11 inches for South base movement extra to that estimated. This gives the total movement inwards between the centres of opposite base sides as 3.21 inches—2.17 inches inwards on South side, and 1.04 inches inwards on North side. The movement, as defined, is confirmed by two features of the Pyramid's exterior.

¶ 182. THE MOVEMENT OF THE SOCKETS, AND THE DISTORTION OF THE CORE ESCARPMENTS.

Distortion of existing socket distances defining base diagonals indicates necessary extent of natural rock movement to effect the above Pyramid base movement.

One of the features referred to has already been considered in ¶¶ 145 and 180, and the other at the end of ¶ 180. The former showed that the side of the *true* square defining the half-diagonal OM (Plate XX) required to be 4570.55 B″, whereas the existing East side of this square is 4567.02 B″, or 3.53 B″ less than the true square defining the half-diagonal. This indicates a movement of the South-East socket 3.53 B″ towards the North. Professor Petrie's data on his Plate X presuppose correction for this movement without drawing attention to the actuality of the movement, since his survey data on pages 38, 39, and 206 do not agree with his data on his Plate X.

A ground movement is necessarily greater than a compactly massive building movement effected by it. Hence the Pyramid masonry base movement is less than the South-East socket movement.

Direction of distortion of core masonry confirms nature of Pyramid base movement.

Indicates nature of base subsidence and Earth tremor effect producing the distortions and movements.

The second feature referred to is the distortion of the Pyramid's core escarpments. The North core escarpment up the centre of the North face is steeper than the South core escarpment up the centre of the South face (confirming ¶ 181). The former, from the base to the existing top, is 51° 54′ 24″, whereas the latter is 51° 51′ 13″, or within 1″ of the true angle of slope of the casing. This difference of angle would be the exact effect of the return ground wave, or " echo " wave of the earth tremor of a subsidence that had produced a steeper dip in the Pyramid's courses inwards from the South side than inwards from the North side.

¶ 183. RELATION BETWEEN PASSAGE SUBSIDENCE AND SUBSIDENCE OF COURSES.

Comparison of points of the Passages at original angle, and the corresponding points of the existing Passages gives subsidence at all such points.

The general form of the subsidence effects on the Great Pyramid can be obtained from a study of the subsidence effects in the Passages and Chambers. We have seen that the original angle of slope of the Descending and Ascending Passages was 26° 18′ 9″.63. Correcting all Passage points to their original positions at this angle of inclination, commencing from the Entrance inwards, will give us the extent of subsidence at all such Passage points.

Thus we find that the levels of the original and existing principal floor points of the Passages—and their extent of subsidence—are as follows :—

Comparative statement for principal points of Passages.

	Original.	Existing.	Extent of Subsidence.
	B″.	B″.	B″.
Floor junction of Descending and Ascending Passages	176.1	172.9 ±.2	3.2
Floor joint, North End, Grand Gallery	861.5	852.6 ±.3	8.9
Foot of Great Step, Grand Gallery	1666.0	1656.5 ±.5	9.5
Top of Great Step,[1] Grand Gallery (35.87 B″)	1701.87	1692.36±.5	9.5

Plate XXX gives a graphically illustrated comparative statement of all the existing and original dimensions of the Passages, together with a statement of the cumulative subsidence in the Passages.

Above comparative results in accordance with the law of structural subsidence.

Maximum subsidence in central area of base course, minimum at apex and base square edges.

Ascending cumulative loss of subsidence in any vertical due to " flat-arching " of courses.

The above tabulation shows, in accordance with the laws of central mass subsidence, that the subsidence effects follow, progressively increasing, from the North base inwards towards the centre. This progressive increase continues beyond the centre into the King's Chamber, where the lowest floor point is 2.4 B″ lower than the top of the Great Step. The total extent of subsidence, therefore, at the level of the King's Chamber and at the South-East corner of the King's Chamber is 9.5 B″+2.4 B″=11.9 B″. The subsidence at the Pyramid's base vertically below this is necessarily greater than this amount, owing to the cumulative loss of subsidence in ascending order of courses, for points of courses on the same vertical. This cumulative loss of subsidence holds for every vertical line passing through the courses, and is due to the well-known structural effect of " flat-arching."

¶ 184. BASIS OF SUBSIDENCE DIAGRAMS.

At lower end Descending Passage, subsidence, 14 B″; entering into natural rock, 4 B″.

Subsidence of points in natural rock, length of Passage gives settlement of corresponding points on base courses vertically above.

Proceeding, then, in the same way for the Descending Passage, we find that its lower sloping end in the natural rock—about 303 B″ horizontally North from the Pyramid's base centre—has subsided 20 B″, and at its entrance into the natural rock has subsided 4 B″. Proceeding thus for all intermediate points in this Passage we obtain the cumulative extent of subsidence from the North face inwards towards the centre. This gives, in the natural rock, the extent of settlement of the base courses at points vertically above the

[1]It is as well to state here that Professor Petrie has an unfortunate error in his calculations for the level of the Step, and, in consequence, for every point beyond that. All his other existing levels for the Passages have been correctly reduced from his data. In this case, however, he has stated the End of the Gallery as 2.39 B″ higher than his own data prove it to be. This can be shown from a simple statement of the facts. His horizontal distance for the Grand Gallery agrees with his sloping distance and angle of slope for the Gallery, but does not agree with his vertical rise for the Gallery floor. The latter gives a steeper angle of slope than the original angle of 26° 18′ 9″.63, whereas Petrie's stated existing angle is less than this.

His offsets from his theodolite altitude line determine that the foot of the Great Step is 0.54 B″ vertically lower than the same for an altitude of 26° 18′ 9″.63. As the rise from the commencement of the Gallery to the foot of Step with the latter angle is 804.47 B″, the existing rise is 803.93 B″, whereas Petrie's rise is 2.39 B″ higher. Refer also Notes on Plate XXX.

GREAT PYRAMID PASSAGES AND CHAMBERS: ORIGINAL AND EXISTING MEASUREMENTS.

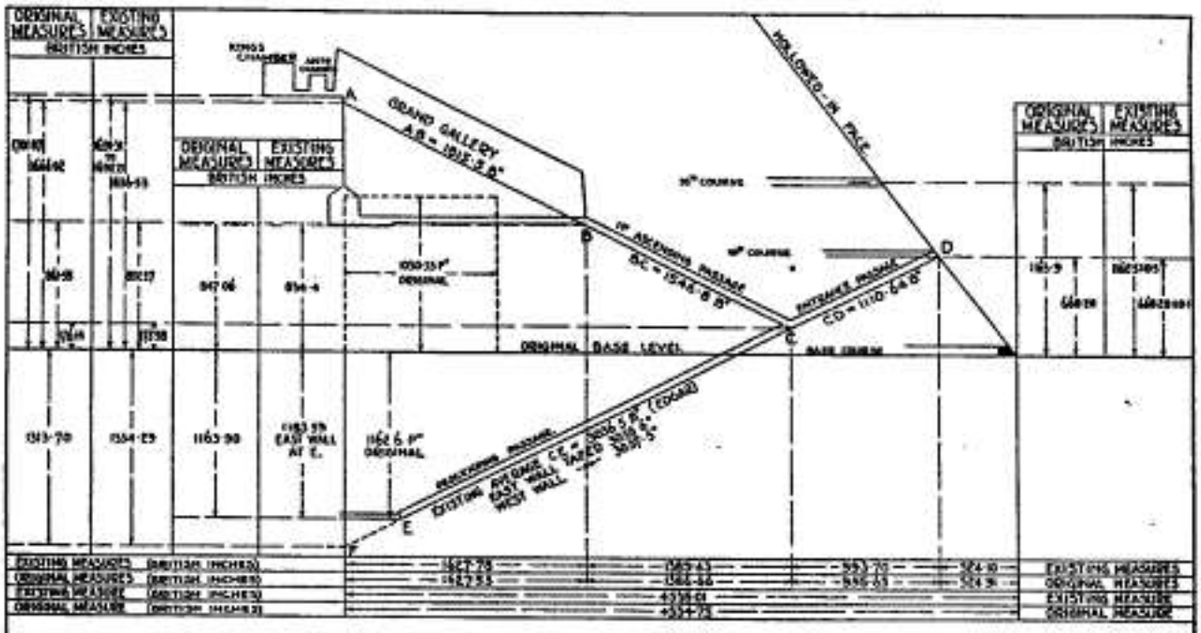


TABLE A. ENTRANCE & ASCENDING PASSAGES & ANTECHAMBER & KING'S CHAMBER.

1	2	3 A	3 B	3 C	4 A	4 B	4 C
	Sloping Floor Distances of Passage	Horizontal Distances of Passage Floors			Vertical Distances of Passage Floor Points above Base		
		Original B"	Existing B"	Diff. Increase + Decrease −	Original B"	Existing B"	Subsidence
KING'S CHAMBER S"	0"	55688	55692	+ 004	1701 87	[illegible]	[illegible]
2nd PASSAGE (END)		35059	35049	− 010	1701 87	[illegible]	[illegible]
			25973		1701 87	[illegible]	[illegible]
2nd PASSAGE BEGINS		22943	22942	− 001			
			19649				
			18058				
			17480				
			17347		1701 87	[illegible]	[illegible]
			15311				
			13658				
GRANITE FLOOR BEGINS		12628	12622	− 006	1701 87	[illegible]	[illegible]
1st PASSAGE ENDS		11304	11334	+ 030			
1st PASSAGE BEGINS		6102	6135	+ 033	1701 87	1650 81	11 06
TOP of STEP	0	000	000	000	1701 87	[illegible]	1844
FOOT of STEP		000	000	000	1666 81	1656 53	949
	2155	13318	13318	000	1570 53	1561 03	950
GRAND	5155	46212	46162	− 050	1457 60	1427 21	1039
	8155	73106	73057	− 049	1306 66	1294 29	1037
GALLERY	11155	100000	99947	− 053	1171 75	1161 38	1035
	14155	126894	126872	− 022	1038 80	1028 96	984
	15514	139077	139067	− 010	978 58	968 99	959
FLOOR JOINT	18155	162753	162778	+ 025	861 55	852 57	898
	19973	179051	179098	+ 047	780 99	772 46	853
	21423	192059	192116	+ 066	716 74	708 65	809
1st	23173	207758	207859	+ 121	639 19	632 17	702
ASCENDING	25223	226116	226298	+ 182	548 36	542 57	579
PASSAGE	27123	243149	243414	+ 265	464 16	459 95	421
	28423	254803	255039	+ 236	406 56	401 88	468
	31023	278110	278434	+ 324	291 35	287 63	372
	32953	295235	295550	+ 297	206 72	203 33	339
FLOOR JUNCTION	33623	301419	301721	+ 302	176 14	172 98	316
	34829	312234	312519	+ 285	129 60	127 00	260
ENTRANCE	35629	319335	319602	+ 267	93 47	91 54	213
PASSAGE	40129	355747	355981	+ 234	46 45	46 98	147
ENTRANCE FLOOR 1st BASE (DISPD)	44729	400984	401091	+ 107	66 85	66 85	000
		453475	453588	+ 026			

TABLE B. DESCENDING PASSAGE.

1	2 A	2 B	3 A	3 B	3 C	4 A	4 B	4 C
	Sloping Floor Distances of Passage from Entrance Door		Horizontal Distances of Passage Floors from Stop Vertical			Vertical Distances of Passage Floors above + or below − Base		
	Original B"	Existing B"	Original B"	Existing B"	Diff. Increase + Decrease −	Original B"	Existing B"	Subsidence
ENTRANCE DOOR SILL	000	000	4109 84	4101 51	+ 1 07	+ 658 28	+ 648 28	000
	46000	46000	3597 47	3599 81	+ 2 34	+ 464 45	+ 462 98	1 47
	71000	71000	3373 35	3376 02	+ 2 67	+ 353 67	+ 351 54	2 13
	99000	99000	3122 34	3125 19	+ 2 85	+ 229 60	+ 227 00	2 60
FLOOR JUNCTION ASCENDING PASSAGE	111064	111064	3014 19	3017 21	+ 3 02	+ 176 14	+ 172 98	3 16
ROCK W. WALL TOP		131850						
ROCK E. WALL TOP		134750						
	150061	150500	2664 59	2664 59	± 000	+ 3 36	+ 3 37	0 75
EAST WALL BEGINS		156900						
BUILT-IN STONE'S JOINT IN FISSURE ENDS		159500						
		162980						
	173594	174100	2453 63	2453 53	− 0 10	− 100 80	− 109 21	8 33
	206297	206900	2160 45	2160 20	− 0 25	− 245 81	− 255 69	9 82
	247397	248100	1752 01	1791 56	− 0 45	− 427 33	− 439 62	11 69
EAST WALL FISSURE IN ROCK		308600						
		311600						
	370095	371100	692 06	691 06	− 1 00	− 971 62	− 988 58	17 36
		411300						
END OF FLOOR SLOPE	EAST SIDE 413460	414614	503 10	301 89	− 1 21	− 1163 90	− 1183 59	19 69
	WEST SIDE	414834		239 90			− 1184 58	
SLOPE PRODUCED TO STEP VERTICAL	447294	448364	0 00	0 00		+ 313 78	− 1334 25	20 59

TABLE C. QUEEN'S CHAMBER & PASSAGE.

1st ASCENDING & ENTRANCE PASSAGES —
PETRIE'S MEAN PIER HEIGHT = 47 36 05 − 47 31 05 GIVING VERT. HEIGHT = 37 84 05 − 37 78 05

GRAND GALLERY VERTICAL HEIGHT = 1st ASCENDING PASSAGE VERT. HEIGHT + PASSAGE DISPLACEMENT = 37 78 05 + 286 11 05 = 338 88 05 = 339 25 B" SMYTH'S MEASURED MEAN = 339 29 B"

1	2 A	2 B	3 A	3 B	3 C
	Horizontal Distances from Step Vertical		Ceiling of Passage & 1st Course of Chamber Level above Base		
	Original B"	Existing B"	Original B"	Existing B"	Subsidence Decrease
LEVEL OF TOP ORIGINAL GRAND GALLERY	162753	162778	914 25	905 27	898
		131578	914 25	903 8	1045
		100478	914 25	902 3	1195
		62778	914 25	902 4	1185
		32078	914 25	901 0	1325
1st WALL QUEEN'S CHAMBER	103 15	103 88	914 25		
BELOW ROOF APEX QUEEN'S	± 000	1 28	914 25	901 5	12 95
2nd WALL CHAMBER	−103 15	−101 72	914 25		

NOTE :—

TABLE A.—Column 2. Existing Distances are equal to Original Distances within limits of Accurate Measurement.
Column 3c (1) Variations in Wall Measurement.
(2) Variations in Floor Measurement; the Floor Blocks in Antechamber, King's Chamber, Great Step and connecting Passages being fitted between Walls.
Sudden variations in Horizontal Floor Differences and Subsidences (columns 3c and 4c) are due to Buckling of Passage Floor Blocks.

Sloping Floor Distances of built Passages are Prof. Petrie's measured Distances. Petrie has an error, however, in reducing the Vertical and

TABLE B.—Column 2b (3) By Edgar's steel tape Minimum Measurement of Floor (East Side). Perpendicular from end of Roof Slope on West Side (by Edgar's steel tape) gives same measurement.
This measurement shows that Max. Horizontal Movement due to Vertical Subsidence is only 1.21 B" South of original. This is confirmed by Azimuth of Passage being not more than ±1.0 B" (as Petrie) off true Original Azimuth.
(4) By Edgar's steel tape Maximum Measurement of Floor West Side.

position, and Foot as 2.39 B" higher than Petrie's erroneously stated

Passage points taken. The general rate of increase of subsidence again indicates that the maximum extent of subsidence is nearer the South base side than the North base side, thus confirming the indication of the King's Chamber in ¶ 183, and confirming the inference derived in ¶¶ 181 and 182, as to the additional movement of the South base side inwards at its centre towards the centre of the Pyramid's base area.

Indicates maximum subsidence nearer South than North base side.

The extent of subsidence thus obtained at all observed points in the Descending and Ascending Passages, and in the Antechamber and King's Chamber, enables us to plot a diagram of subsidence. To make this diagram of use in studying the related movements, it is necessary to magnify the subsidence movement. We can produce a true-to-scale representation of subsidence by drawing the Pyramid and its Passages to a certain scale, and then drawing all existing variations horizontally and vertically from their original positions as ten times their true extent. All that this amounts to is that we are imagining the subsidence effects to be ten times greater than they actually are.

Measured variations in subsidence in all Passages form basis for diagrams of general Pyramid subsidence.

Subsidence in diagrams shown as ten times actual subsidence.

Drawn in this manner, Plate XXXI represents the subsidence of all the Pyramid's courses and Passages, as indicated by the existing variations of the floor or axis levels of the Passages. Similarly Plate XXXV gives the subsidence effects in the King's Chamber and Antechamber, and in their connecting Passages.

General diagrams of Pyramid subsidence.

Diagram of King's Chamber and Antechamber subsidence.

¶ 185. PYRAMID COURSES AND HORIZONTAL COURSES OF CHAMBERS.

Study of the precisely determined relative amounts of subsidence in the Passages and Chambers in relation to the two subsidence diagrams—Plates XXXI and XXXVa—establishes the following identities between horizontal passage and chamber masonry courses on the one hand, and the horizontal courses of the Pyramid core masonry on the other hand :—

	Existing Lowest Level.	Subsidence.	Originally.	Existing Levels of Courses on Pyramid Core Face.		Top of Course Nod. Plate XX.
				S.W.	N.E.	
	B".	B".	B".	B".	B".	
Ceiling level of King's Chamber	1920.7	11.8	1932.5	1931.7	1931.7	59th
Ceiling level of Antechamber ..	1840.3	11.2	1851.5	1851.5	1851.9	56th
Base of walls of King's Chamber	1685.4	11.8	1697.2	1697.7	1697.6	50th
Base of walls of Antechamber	1686.0	11.2				
Top of North and South walls, and course of East and West walls, Queen's Chamber	1018.9	12.6	1031.5	1030.9	1031.0	30th

King's Chamber ceiling top of 59th course.

Antechamber ceiling top of 56th course.

King's Chamber and Antechamber wall base top of 50th course.

Top of North and South walls and course level of East and West walls in Queen's Chamber top of 30th course.

As to the variations in depths of existing masonry courses, Petrie, in his Plate VIII, gives these as follows :—

For 59th course, 1 inch variation ; 56th course, 0.4 inch ;
50th course, 0.2 inch ; 30th course, 1.5 inch.

Latter level at height giving length of side of ¼-Aroura square = 1030.33 P″, and ceiling of horizontal Passage to Queen's Chamber at level of ceiling of 1st Ascending Passage entrance to Grand Gallery.

The above statement of levels shows that the level of the original top of the North and South walls of the Queen's Chamber was 1030.33 P″ =1031.46 B″, the length of side of the quarter-*aroura* square. Since the height of the North and South walls is 184.4 B″ =184.2 P″, the original level of the Chamber floor was 846.130 P″ =847.06 B″. The existing level being 834.4 B″, the extent of subsidence in the Queen's Chamber is 12.66 B″. This amount of subsidence here agrees with the cumulative rate of increase of subsidence effect on the courses from the Great Step vertically downwards to the centre of the base area. The same restoration gives the original level of the ceiling of the horizontal Passage to the Queen's Chamber coincident with the original level of the ceiling of the 1st Ascending Passage at the Entrance to the Grand Gallery, *i.e.* at 914.4 B″.

¶ 186. PYRAMID'S CONSTRUCTIONAL DETAILS DESIGNED TO MEET SUBSIDENCE EFFECTS.

Rock fissures indicate cause and nature of subsidence.

Existed prior to construction.

Fissures due to collapse of a subterranean cavern deep in limestone forming the Nile Valley.

Designer of Pyramid's constructional details aware of this, and took constructional measures to meet contingencies likely to arise from conditions noted.

Plate XXXI shows clearly the cause and nature of the subsidence. The cause is seen in the several fissures in the natural rock portion of the Descending Passage. These had existed when the Passage was cut in the natural rock. Two of them have been built up with blocks by the original builders.

These fissures are the evidence of the collapse of a subterranean cavern deep in the limestone forming the Nile Valley, which contains many examples of this cause of subsidence. This subsidence, as we saw, occurred prior to the building of the Pyramid. Indeed, many special details of the Pyramid's construction indicate that the designer of the constructional details was aware of the subsidence, and took special constructional measures to meet its effects. This is evident particularly in the construction of the masonry chambers and in the construction of the Grand Gallery. In fact, the Great Pyramid is as perfectly designed to meet, and adjust itself to, the conditions of subsidence as it well could be ; more perfectly designed for its substrata conditions than St. Paul's Cathedral, for example, was designed to meet the conditions of its substrata.

The precarious stability of fissured foundation strata.

Effect of central mass of Pyramid on same.

Where limestone fissures occur there is instability, particularly under added burden to the strata in which they occur. The designer of the Pyramid's constructional details foresaw the possibility of the existing precarious stability of the fissured strata being disturbed by the superimposed central mass of the Pyramid's masonry. That his details, devised to meet the expected vertical movement, were effective is proved by the fact (shown by ¶ 180) that the Passage lengths, in spite of subsidence, have remained unaltered.

¶ 187. THE CONSTRUCTIONAL PURPOSE OF THE TERRACED ROCK CORE.

The designer of the Pyramid's constructional details foresaw that the slightest tremor due to adjacent cavern collapses—which collapses in such strata are the minor causes of earthquakes—would disturb the precarious stability of the strata below the Pyramid. He foresaw that the central mass of the Pyramid's masonry, in such case, would bring its maximum intensity of pressure to bear upon a square considerably internal to the Pyramid's base square; and that such local concentration of pressure would, by dynamic impulse of momentary subsidence due to Earth tremor, punch the central area, along its fissure surfaces, below the level of the natural rock base.

Terraced rock core for purpose of inducing arching effect in courses under subsidence, and as a "shock-absorber" to "throttle" dynamic movements due to Earth tremors accompanying or causing subsidence.

To meet this eventuality, the natural rock was left terraced upwards towards the Pyramid's centre. The constructional object of this was obviously to form the nucleus of an arch, so that when the terraced centre was affected by local Earth tremor, the momentary impulse of the central mass of masonry should, by the accentuation of "flat-arching," be largely diverted as arch thrust effect clear of the central area. The design, in effect, provided a shock-absorber; but a shock-absorber designed to "throttle" two separate shocks, or series of shocks.

The first shock was that instantaneously reacting to the Earth tremor, producing vertical movement. Vertical movement of the fissured area—like the effect of central failure, due to shearing, on the fixed ends of a beam—produced the second series of shocks: (1) an upward and outward kick of the freed external strata; and, on its completion, (2) a reaction wave outwards from its centre. Both these secondary effects were "damped" or "throttled" by the incidental thrust of the arching effect noted.

The undulatory movement that jolted the South base centre further inwards than the North base centre was moved inwards.

The "echoing" return of the latter ground wave—always accompanying such earthquake effects—would produce, as it does in such earthquake movements, an undulatory movement inwards towards the centre. This would be largely resisted by the terraced natural rock core. Nevertheless, and for the reasons noted in ¶ 182, the centre of the South base was jolted inwards 2.17 B″, and the centre of the North base 1.04 B″.

¶ 188. THE SOUTH AND NORTH MOVEMENT OF MASONRY COURSES.

That the "shock-absorber" detail of construction has served its purpose justifies the principles of design and the forethought displayed in regard to subsidence.

Plate XXXI indicates the central "punched-in" area of maximum subsidence. This effect would have been considerably increased had the central terracing of the natural rock core been omitted. This "shock-absorber" detail has made it possible at this date to derive from the existing measurements and structural indications, the precise purpose of the Pyramid's design and construction. We may, therefore, take it as certain that the design of the constructional details has effected its purpose. The designer of these details has therefore been justified in his conclusions concerning subsidence,

and in his design to meet the effects of such subsidence as he inferred might take place, and that has taken place.

Central fissured base area of natural rock has been "punched" downwards to a greater extent near South base side than near North base side.

Owing to this the returning undulatory movement (echo) of the subsidence Earth wave produced an eddy below the base, jolting the masonry inwards to the greatest extent at centre of South base side.

The indications supplied by the variations in level of the Passages have determined the subsidence of the masonry courses. These, as shown on Plate XXXI, indicate that the "punched-in" area of fissured rock is more deeply "punched-in" near the South base side than near the North base side. This shows that the dip of the courses inwards on the South side is steeper than on the North side; and that, in consequence, the surrounding undulatory movement due to the "echoing" Earth wave, mentioned in ¶¶ 182 and 187, would have the effect of jolting the whole of the southern portion of the masonry bodily inwards, producing a relative horizontal movement along successive courses from base to apex. This relative movement of courses would increase the horizontal slip between courses in proportion to the height of a course above the base, this increase being due to the decrease of superimposed mass, and to the consequent increased opening of vertical East to West joints towards the North face.

¶ 189. THE JOLTING OPEN OF JOINTS IN THE NORTHERN SIDE OF THE CORE MASONRY.

Experimental illustration of manner in which above movement produced a general South to North slide of the courses.

The reader can experimentally obtain the conditions of the last effect for himself. Place a long line of blocks in end-to-end contact on a table and build on this successive similar and equal courses of end-to-end blocks, in such manner that all the initial ends butt firmly against a rigid vertical board. Strike the rigid vertical board with a hammer and examine the end-to-end joints between blocks in each successive course. The end-to-end joints near the vertical board will generally remain tightly closed, and will only be found to have opened out towards the further end of the courses, and to an increasing extent for the higher courses. Owing to the latter effect, the originally vertical surface formed by the ends of the courses away from the source of shock will be found to be inclining over.

The measured effect of this slide in the Pyramid's masonry.

The opening out of the masonry joints North of the Pyramid's centre, and increasing to a maximum at the summit.

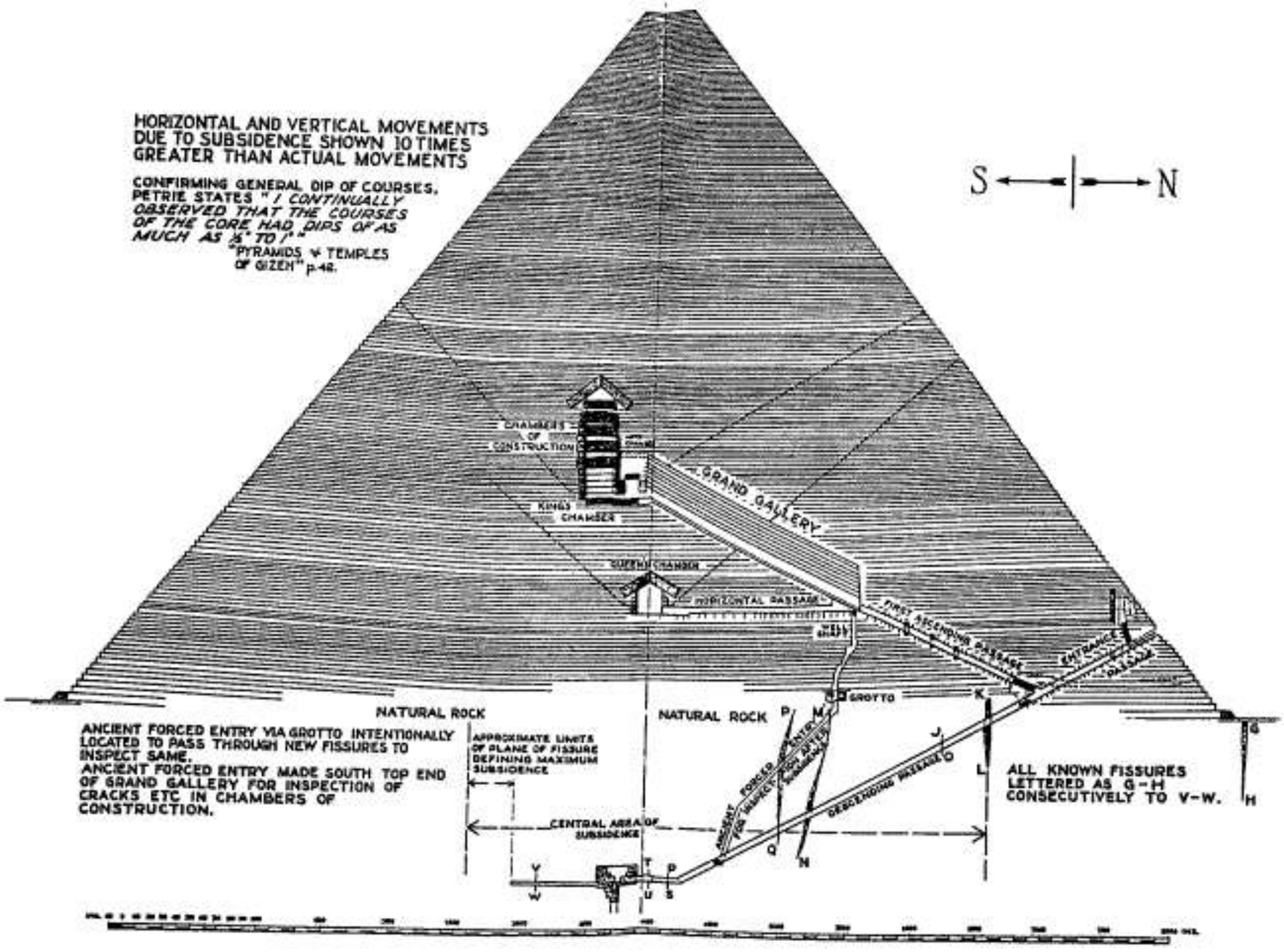
If the effect described took place in the Pyramid from the South side, as all the structural and subsidence evidences have indicated, then the existing top platform of the Pyramid should show a greater distance from the Pyramid's centre to the North face of the core escarpment than from the Pyramid's centre to the South, East, and West core escarpments. Petrie gives the distances obtained by him at the mean level of 5408.5 B″ above the base as follows:—

	Mean.
Centre of Pyramid base horizontally to the core masonry faces on the N. side	224.5 ±0.7
Centre of Pyramid base horizontally to the core masonry faces on the E. side	214.1 ±0.3
Centre of Pyramid base horizontally to the core masonry faces on the S. side	215.0 ±0.4
Centre of Pyramid base horizontally to the core masonry faces on the W. side	217.6 ±1.0

thus confirming the movement as described.

Thus it will be seen that, although the distance to the South core face is only 0.85 B″ less than the mean of the distances to the East and West core

PLATE XXXI.



[To face p. 160.

faces, the distance to the North core face is 8.65 B″ greater than the latter. It is this extra distance that has made the existing angle of slope 51° 54′ 24″ from the centre of the North core base to the top core platform,[1] whereas the existing angles of slope of the centres of the South, East, and West core escarpments are not appreciably different from the original angle of 51° 51′ 14″.3.

Central slope of South, East, and West core escarpments, 51° 51′ 14″, but for North core escarpment, 51° 54′ 24″.

¶ 190. THE GEOLOGICAL DATA.

When it is remembered that the stratification of the Gizeh Plateau, upon which the Great Pyramid stands, and of the whole of the adjacent Nile Valley consists of limestone, the geological reasons for the subsidence effects are clearly to hand.[2] The Nile bed itself is formed in a great limestone fault, "eroded into a gorge, fed by water-tunnelled caverns in the cliffs," and now "filled with debris, forming the present Nile bed." Here are evidences of the cause of subsidence, in the examples of collapses of underground caverns and grottos. As Petrie states,[3] "large caverns have collapsed at some hundreds of feet below the present Nile (Fig. 4)."

Strata of Gizeh Plateau and Nile Valley limestone.

Nile bed a limestone fault.

Water-tunnelled caverns.

Collapses of these.

One such smaller cavern or grotto, but not collapsed, is already known under the Pyramid masonry (Plate XXXI), and within the natural rock core, terraced to receive and to bind into the masonry courses of the Pyramid. Not this grotto, however, but a larger unexplored cavern, by collapsing prior to the Pyramid's construction, has been the cause of the rock fissuring and instability of strata discussed in ¶¶ 186–188.

Grotto in Pyramid's terraced rock core.

A deeper cavern indicated by fissures.

¶ 191. THE EARLIEST FORCED ENTRY TO UPPER CHAMBERS.

The Pyramid's structural indications are fairly conclusive that subsidence effects were observed on the external surface of the Pyramid not long after it was built, possibly within a few generations from the time of its construction, and certainly before precise details and measurements of its internal construction were lost or forgotten. The latter conclusion is certain from the entry for examination of the effects of the subsidence upon the Chambers.

External effects of Pyramid subsidence shown not many generations after construction, when data concerning construction still known.

When the Pyramid was built, all access to its upper chambers was closed by the granite plug or plugs at the lower end of the 1st Ascending Passage (Plate XXXI). To hide the fact that a Passage began here, a limestone block was inserted to make the roof of the Entrance or Descending Passage

All access to Ascending Passages originally closed.

Access to Descending Passage and Subterranean Chamber only.

[1] It will be observed that this general angle for the entire centre line of the North core escarpment from base to existing top platform agrees with the existing indications of casing slope for North face, from existing casing base to Entrance sill indicated by existing line of Entrance Passage, and its intersection with the existing base level of the 19th masonry course, near the existing Entrance. The latter definition, as obtained by Petrie, gives existing angle of North face casing, in its first 700 inches of height, as 51° 53′ 20″ ±1′. (Refer ¶ 180.)

[2] Refer Petrie's "Hist. Egypt," Vol. I (1894 Edit.), pp. 1–6.

[3] Ibid., pp. 3 and 4, illustr. Fig. 4. For such collapses originating earthquakes, refer Sir Archibald Geikie's "Text-book of Geology," pp. 369, 477–479.

PLATE XXXII.

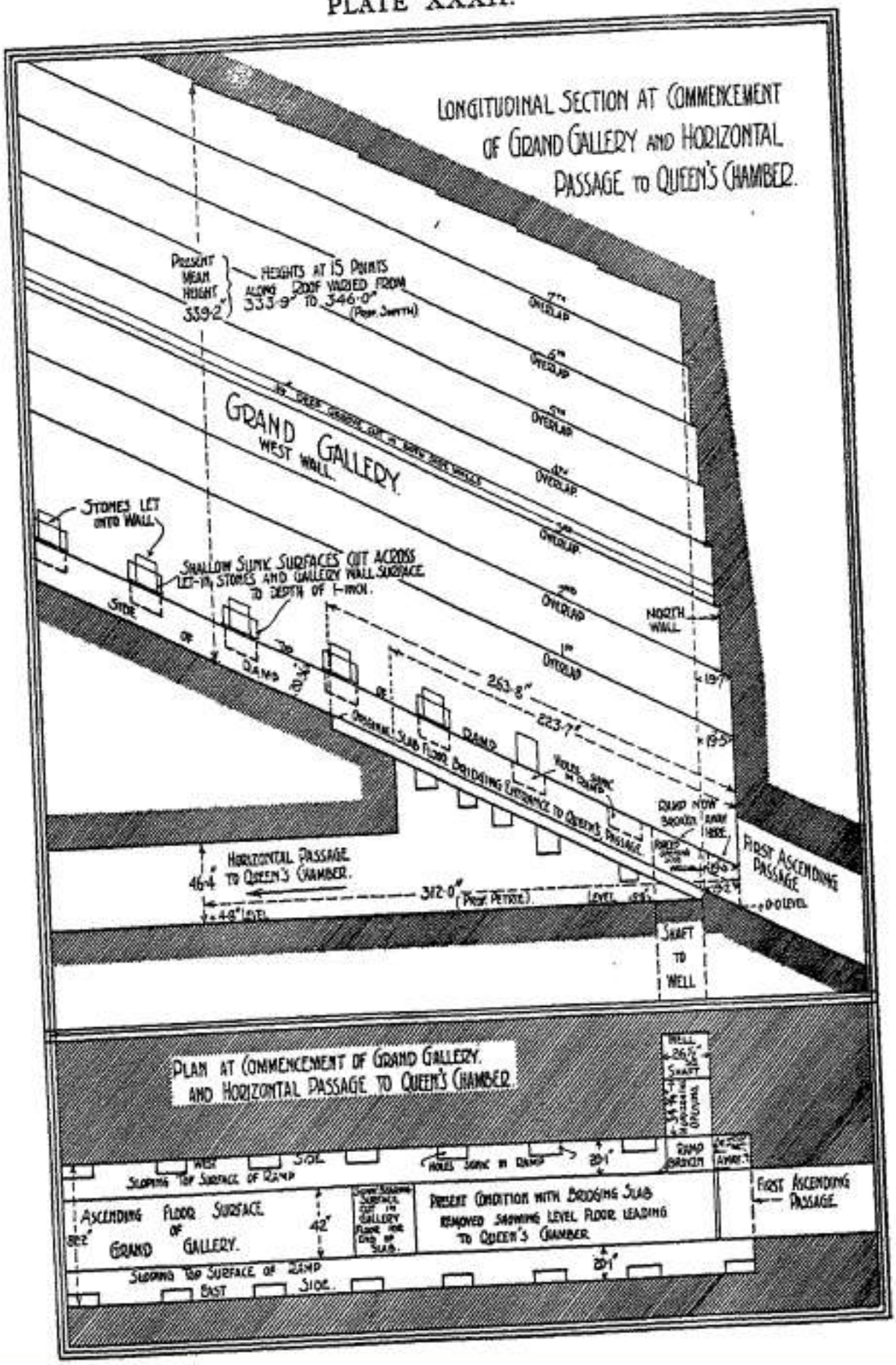
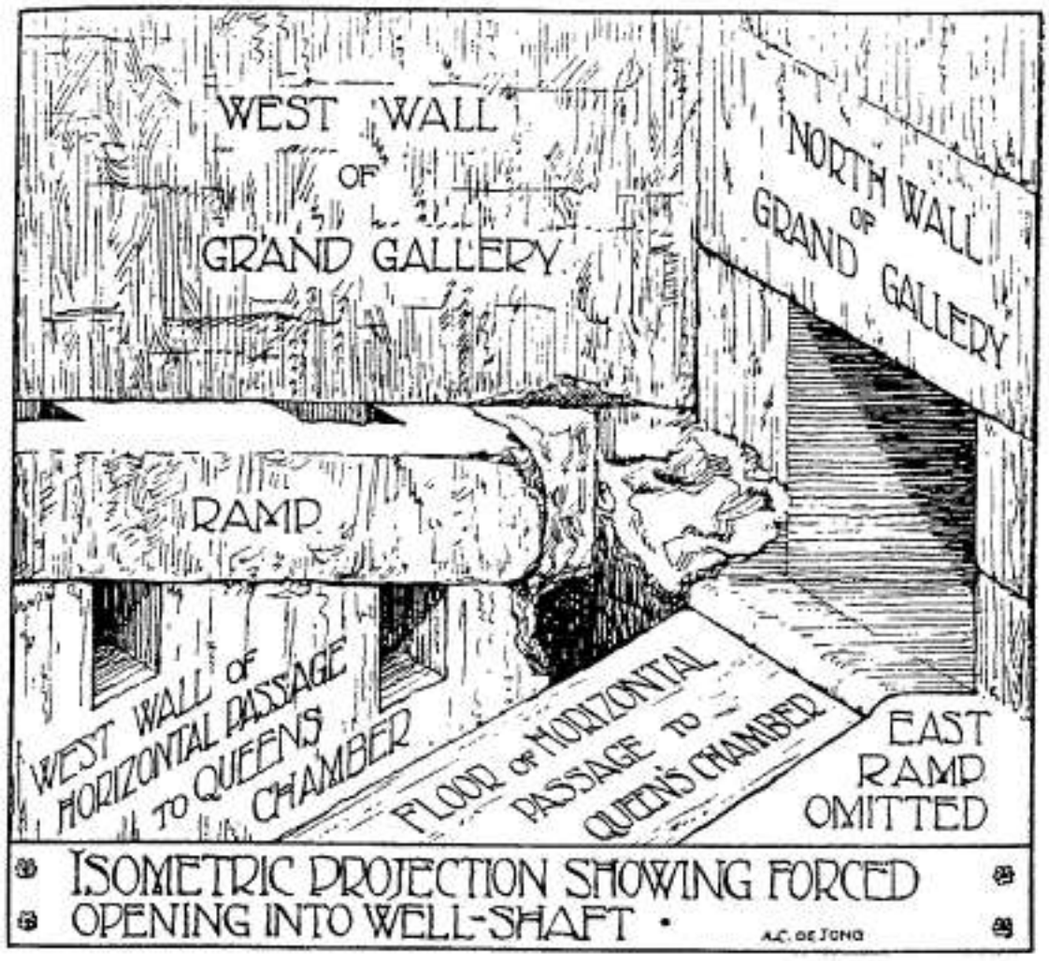

LONGITUDINAL SECTION AT COMMENCEMENT OF GRAND GALLERY AND HORIZONTAL PASSAGE TO QUEEN'S CHAMBER.
PRESENT MEAN HEIGHT 339·2
HEIGHTS AT 15 POINTS ALONG ROOF VARIED FROM 333·9 TO 346·0 (Prof. SMYTH)
7TH OVERLAP
6TH OVERLAP
5TH OVERLAP
4TH OVERLAP
3RD OVERLAP
2ND OVERLAP
1ST OVERLAP
GRAND GALLERY
WEST WALL
STONES LET INTO WALL
SHALLOW SUNK SURFACES CUT ACROSS LET-IN STONES AND GALLERY WALL SURFACE TO DEPTH OF 1-INCH.
SIDE OF RAMP
NORTH WALL
263·8"
223·7"
RAMP
ORIGINAL SLAB FLOOR BRIDGING ENTRANCE TO QUEEN'S PASSAGE
HOLES SUNK IN RAMP
ROOF NOW BROKEN
FIRST ASCENDING PASSAGE
HORIZONTAL PASSAGE TO QUEEN'S CHAMBER.
46·4
312·0" (Prof. PETRIE)
LEVEL
SHAFT TO WELL
PLAN AT COMMENCEMENT OF GRAND GALLERY AND HORIZONTAL PASSAGE TO QUEEN'S CHAMBER.
WELL
SHAFT
RAMP
SLOPING TOP SURFACE OF RAMP
WEST SIDE
HOLES SUNK IN RAMP
20·1
ASCENDING FLOOR SURFACE OF GRAND GALLERY.
42"
PRESENT CONDITION WITH BRIDGING SLAB REMOVED SHOWING LEVEL FLOOR LEADING TO QUEEN'S CHAMBER.
FIRST ASCENDING PASSAGE.
SLOPING TOP SURFACE OF RAMP
EAST SIDE

PLATE XXXIII.



continuous past the 1st Ascending Passage. Entry to the upper chambers was thus effectively closed. It was possible only to use the Descending Passage to gain entry to the Subterranean Chamber.

The early forced entry to upper Passages, etc.

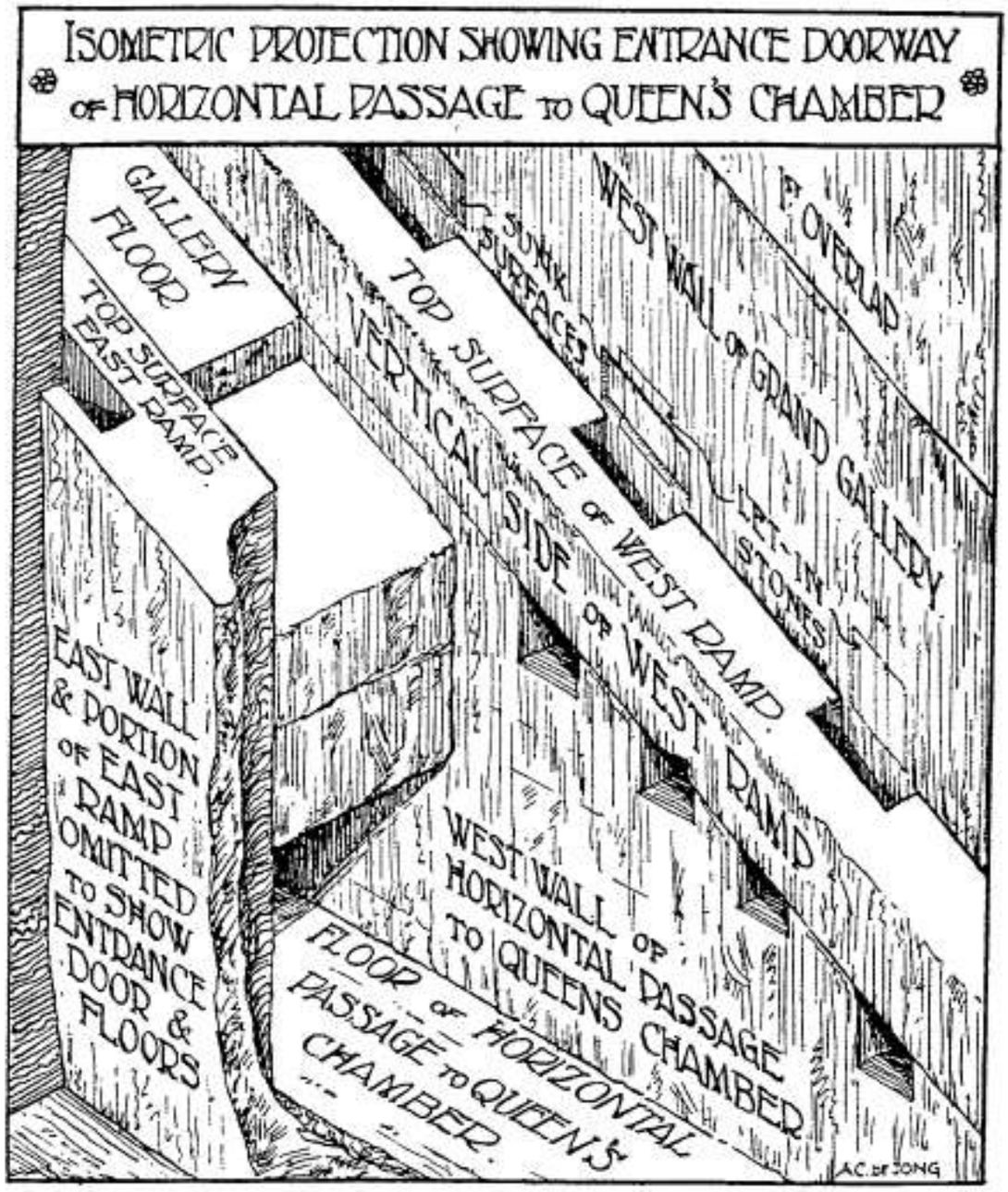
When it was observed, however, that an internal movement had taken place, steps were taken by the keepers of the Pyramid to force an entry. The manner in which this entry was effected forces us to two conclusions:

Manner in which effected confirms Arab accounts of limestone plugs, and that data of construction still known when early entry was made.

(1) That the Arab accounts of Al Mamoun's later forced entry in the 9th century A.D. are correct in stating that the 1st Ascending Passage above the plugs was filled with limestone blocks, which had to be broken up one by one, by the Arabs (refer also ¶¶ 208 and 208a); and

(2) That the plans of the Pyramid, or the data of its construction and ground conditions, were still in existence when the first entry was effected for inspection.

PLATE XXXIV.



¶ 192. THE TUNNELLING OF THE WELL-SHAFT.

Entry by tunnelling up through natural rock to grotto.

Instead of seeking to tunnel through the masonry as the Arabs did later, the early keepers of the Pyramid commenced their tunnelling in a gradually sloping direction from the Descending Passage, up through the natural rock terracing to the grotto (Plate XXXI). Here they organised their depot for tools and rest, and for the bye-passing of workers and materials. Their

reason for commencing their tunnel so deep in the natural rock was obviously to intersect, for purpose of inspection, the two fissures, PQ and MN, shown on Plate XXXI. This seems to indicate that the fissures not built up in the Descending Passage had developed as newly visible in the Passage at the time of the subsidence that had occasioned the visit of inspection considered.

Grotto selected and organised as depot and bye-pass.

From the grotto they then continued with a rough shaft approaching towards the commencement of the Grand Gallery. When they had proceeded sufficiently far with this, by their rough initial methods of aligning, they made an accurate survey from a fixed point of the Pyramid's construction to determine the exact location of their tunnel end in azimuth, altitude, and distance from this fixed point. Referring to the then known data concerning the Pyramid's interior, the keepers thus obtained the location of their tunnel end in relation to the end of the Grand Gallery. They next continued their rough tunnel to a point vertically behind the first (lowest) ramp stone on the West side of the Grand Gallery. This effected, a perfectly vertical shaft—the so-called Well-shaft—was driven upwards to the predetermined point at which the keepers intended to force an entry into the Gallery. Reaching this point behind the first ramp stone, as shown on the Frontispiece (right-hand view) and Plate XXXII (plan), they forced the ramp stone upwards and outwards. That this is the manner in which the ramp stone was forced is shown by the fractured appearance of the ramp around the Well-shaft. This is accurately illustrated on the Isometric Projection shown on Plate XXXIII.

Accurate setting out of forced tunnel to enter West lower end of Grand Gallery ramp.

Ramp stone forced out from vertical tunnel shaft into Grand Gallery.

¶ 193. THE EARLIEST INSPECTION OF THE SEALED CHAMBERS.

Having gained an entry, the keepers proceeded to an inspection of the Chambers. To inspect the Queen's Chamber, they had, perforce, to break or remove the Grand Gallery floor slab that originally bridged the Entrance Passage to the Queen's Chamber, as indicated by the existing details. These are as shown on Frontispiece (right-hand view), and Plates XXXII, XXXIII, and XXXIV. This done, they found little or no serious indications of failure in the Queen's Chamber.

The opening of the Grand Gallery floor slab covering Entrance to Queen's Chamber.

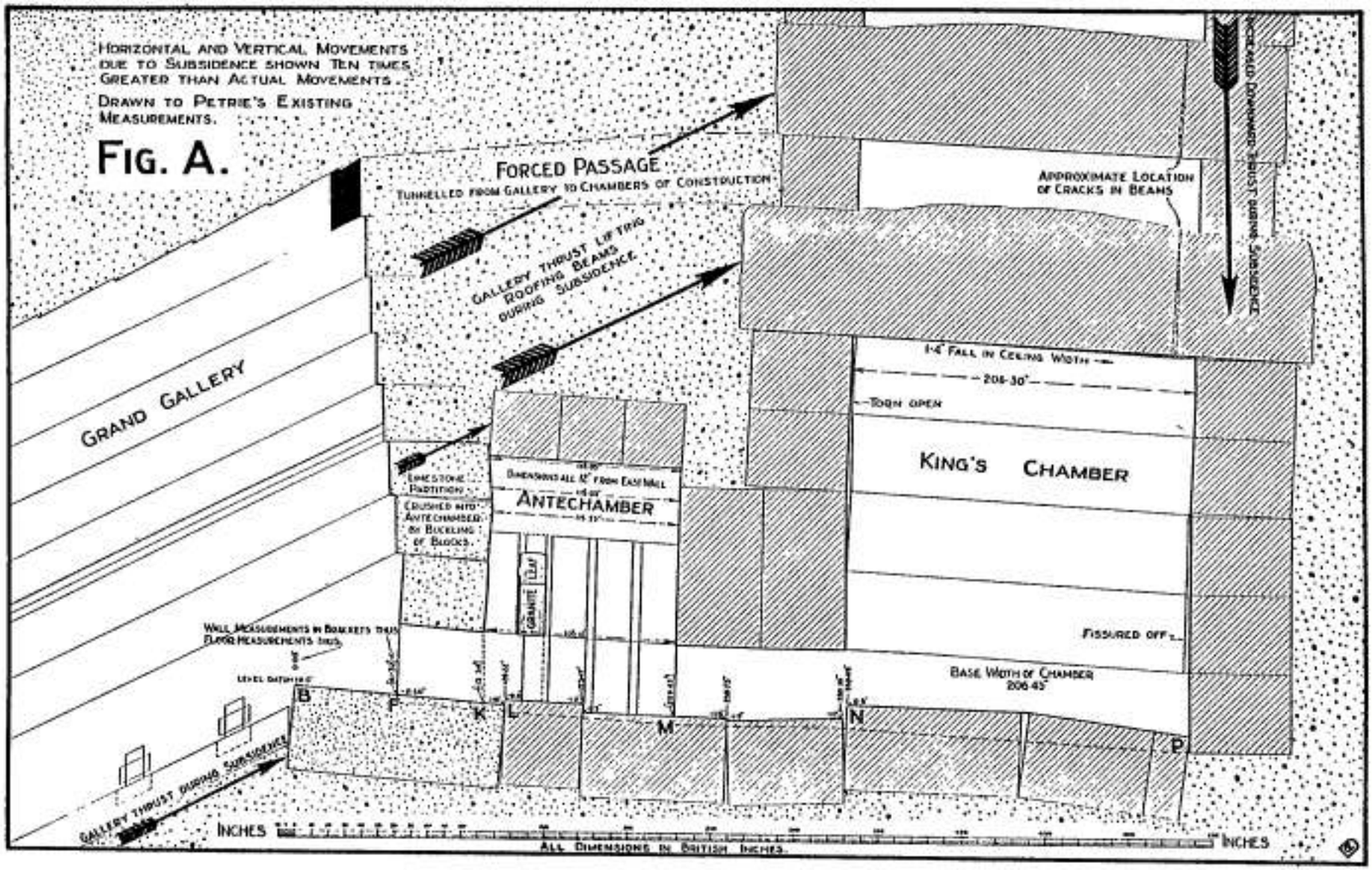
Proceeding to the Antechamber and King's Chamber, they found here indications of possible instability due to the movement that had caused inspection to be made. In the King's Chamber they found the ceiling beams cracked along their South ends inside the Chamber. The cause of this fracture is clearly indicated by the general form of subsidence shown on Plates XXXI and XXXV. To enable any further movement or fracture to be indicated, the keepers evidently smeared the cracks and open joints with cement or plaster. Thus Petrie states, regarding these ceiling-beams, that "Round the S.E. corner, for about 5 feet on each side, the joint is daubed up with cement, laid on by fingers. The crack across the Eastern Roof-beam has been also daubed with cement, looking, *therefore*, as

Inspection of Antechamber and King's Chamber.

Visible cracks and openings cemented over or plastered to give indications of further movement.

PLATE XXXVa.

SUBSIDENCE DISTORTION DIAGRAM OF EXISTING KING'S CHAMBER, ANTECHAMBER, ETC.



In Section—Limestone Stippled : Granite Hatched in Parallel Lines.

PLATE XXXVb.

PLAN OF KING'S CHAMBER, ANTECHAMBER, AND QUEEN'S CHAMBER—ORIGINAL MEASUREMENTS.

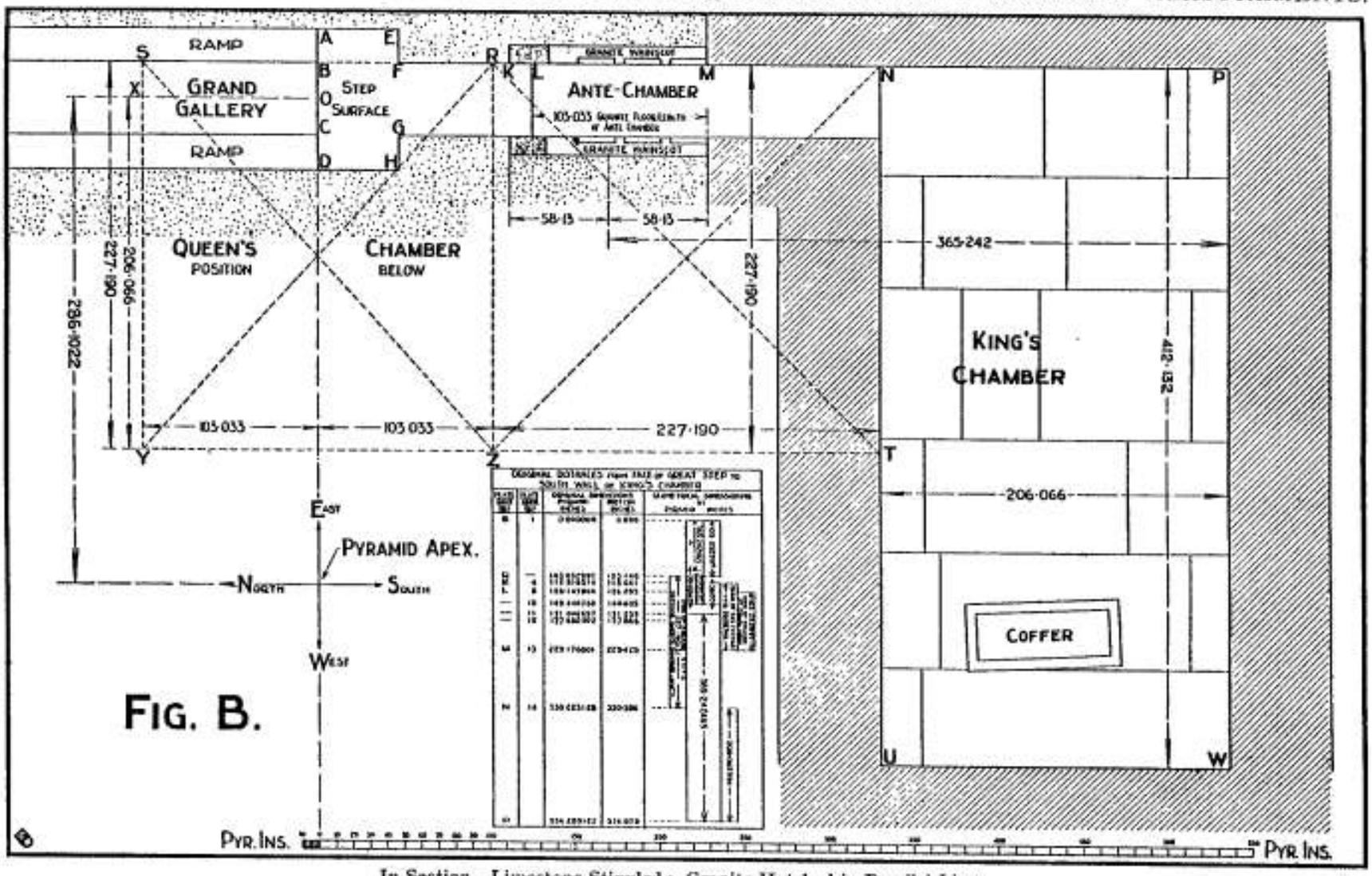


FIG. B.

In Section—Limestone Stippled ; Granite Hatched in Parallel Lines.

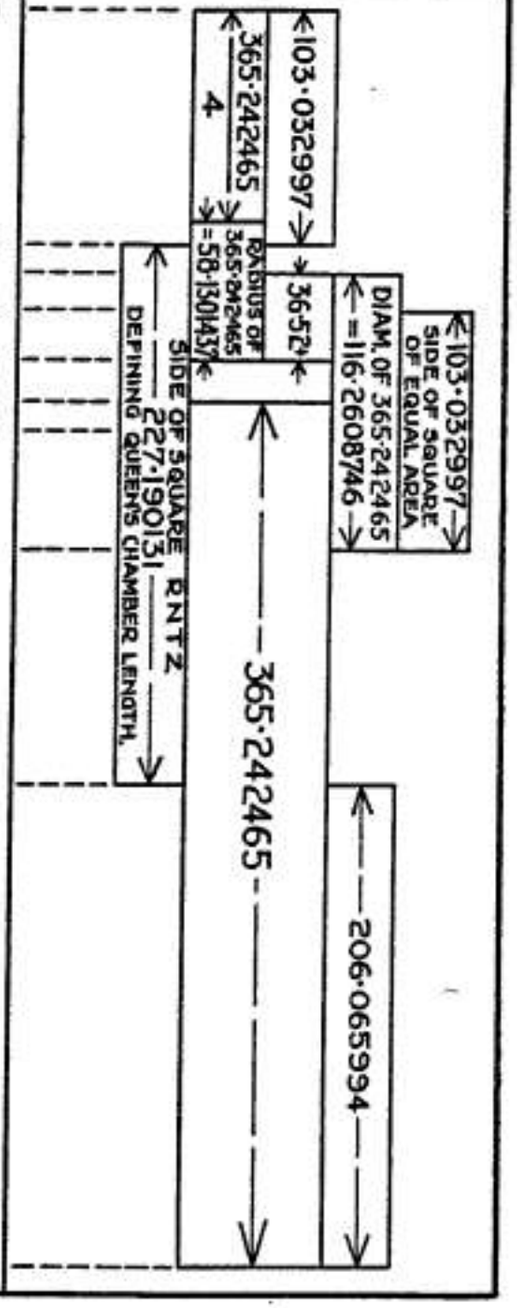
For Enlargement of Table, see Addendum to Plate XXXV.

ADDENDUM TO PLATE XXXV.

ORIGINAL DISTANCES FROM FACE OF GREAT STEP TO SOUTH WALL OF KING'S CHAMBER

PLATE XXXV. REF.	PLATE XXXVI. REF.	ORIGINAL DIMENSIONS PYRAMID INCHES	ORIGINAL DIMENSIONS BRITISH INCHES
B	1	0·000000	0·000
K	—	103·032997	103·146
R	4	112·916514	113·041
L	5	126·143804	126·283
—	10	149·440760	149·605
—	11	171·046657	171·235
—	12	177·660302	177·866
M	13	229·176801	229·429
N	14	330·223128	330·586
P		536·289122	536·879

GEOMETRICAL DIMENSIONING IN PYRAMID INCHES



if it had cracked *before* the chamber was finished. At the S.W. corner, plaster is freely spread over the granite, covering about a square foot altogether." (The first *italics* are ours, the second Professor Petrie's own.)

¶ 194. THE INSPECTION TUNNEL TO CHAMBERS OF CONSTRUCTION.

To gain access to the important Chambers of Construction over the King's Chamber, the keepers next drove an opening into the East wall of the Grand Gallery at its upper or South end. This is as shown on the Frontispiece and Plate XXXVI.

Inspection tunnel driven from top of Grand Gallery to upper surface of King's Chamber ceiling beams.

Higher Chambers of Construction built weaker to give way slightly under subsiding superimposed load.

Tunnelling clear of the wall blocks of the Gallery, the workers turned their tunnel towards the South, as shown on Plate XXXVI, to enter the Chambers of Construction at the upper level of the ceiling blocks of the King's Chamber. Here they found that the indications of instability were not so serious as they had feared, for they did not proceed higher than the 1st Chamber with their inspection.[1] Modern tunnelling upwards into the four higher Chambers has shown that the use of limestone (in lieu of granite) supporting blocks, bearing the ends of the higher granite roofing beams, has caused the shock of subsidence to be partly broken by crushing and " plastic " flow of the limestone. In other words, the higher Chambers of Construction were purposely built weaker than the lowest Chamber and ceiling beams of the King's Chamber, to act as a succession of " buffers " between the superimposed mass of the Pyramid and the King's Chamber, during the expected subsidence movement.

Object being to break the shock of direct communication to the more rigid construction of lowest Chamber of Construction and King's Chamber.

To permit of this " buffer " effect being fully developed, the beams or slabs of the Chambers of Construction were not built into the East and West walls, from which, as shown by the adhering plaster, the upper Chamber has subsided as much as 3 inches. Hence, instead of indicating bad workmanship —as has been supposed by some authorities not conversant with the design of constructional devices for counteracting the effects of subsidence movement that cannot be prevented — the workmanship in these Chambers is the necessary effect of good design. An entirely rigid system of construction, with uniform workmanship from the lowest to the highest Chamber, would

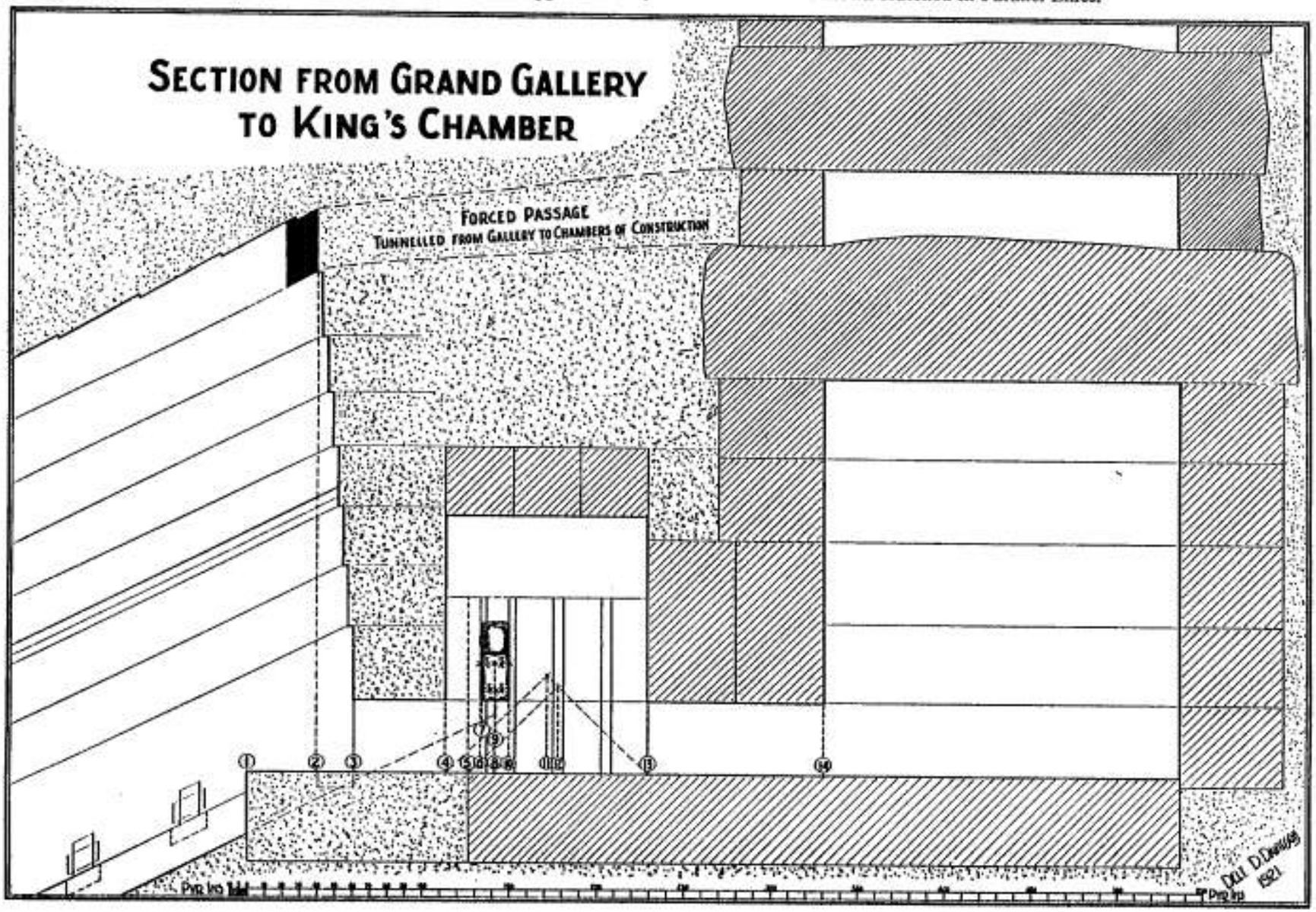
[1]The question of an early forced entry into the Pyramid for inspection has been discussed at greater length than many readers may deem to be warranted by the relative importance of the facts. The reason is that many theories of intention have been attached to the so-called "Well-shaft"—by which we deem this earliest entry was made—and to the access tunnel to the Chambers of Construction.

We have tried to shorten the presentation of what seemed to us to be the true explanation, by adopting the narrative form rather than the inductive form of presenting the data. The reader, therefore, should understand that where the narrative form may seem to savour of assertion, in the presentation of what actually has been evolved by inductive analysis, this is entirely due to the abbreviated form adopted. Where assertion may seem to exist, the reader, it is hoped, will find the confirming data in the context.

Two facts of importance in this connection are (1) that the ramp stone in the Grand Gallery clearly was forced into the Grand Gallery from the so-called Well-shaft; and (2) that the forced inlets were evidently all carefully selected to be at such points as would not destroy or interfere with the purpose of any essential feature of the Pyramid's Passage construction.

PLATE XXXVI.

Limestone in Section shown in Stippled Effect ; Granite in Section shown Hatched in Parallel Lines.



have been disastrous. A voussoir arch construction would have been more disastrous still, as the final stage of settlement has produced an opening out of the King's Chamber walls. This opening out, in conjunction with the tilting thrust from the Grand Gallery, illustrated on Plate XXXV, Fig. A, would have produced a rocking motion and a kicking-up effect on the North haunching of a voussoir arch construction, as well as an opening out of the span of the arch. The complicated combination of stress movements between the voussoirs would have produced failure.

Section III.—Details Concerning Plates.

¶ 195. PLATE XIX. THE REDUCED CO-ORDINATES OF PROFESSOR PETRIE'S SURVEY DATA.

Plate XIX for technical reader only.

The data given on Plate XIX are self-explanatory to the technical reader. The purpose of the Plate is to enable the technical reader to check the calculations giving the co-ordinates of Plate XX.

Supplies data for co-ordinates of Plate XX.

It should be sufficient for the general reader to observe how closely the newly calculated co-ordinates of Plate XX agree with Professor Petrie's calculated distances, as given on Plate XX.

Close agreement with Petrie's data.

¶ 196. PLATE XX. THE MEASUREMENTS AND LEVELS OF THE EXISTING DETAILS OF THE GREAT PYRAMID'S EXTERIOR.

Sources of data.

The data given on Plate XX are self-explanatory. The direct measurements of the base square are Professor Petrie's. The true Pyramid azimuth co-ordinate measurements are from Petrie's survey data given on Plate XIX. The plan of the base sockets—shown to a magnified scale as compared with the scale of base co-ordinates—is from Professor Smyth's "Life and Work," Vol. I, p. 138, etc.

Related movements due to ground subsidence and consequent reactions on Pyramid masonry courses.

As explained in Sections I and II of this Chapter, ground subsidence has shifted the sockets, both in relation to their original azimuth and in relation to each other, and at the same time, by consequent minor earthquake effects has shifted the base courses of the Pyramid in relation to the shifted positions of the sockets. The sum of all apparent movements, as examined in detail, varies from $\frac{3}{4}$ of an inch to $3\frac{1}{2}$ inches. (¶¶ 141–145, 180–182.)

The adopted azimuth system.

What we have termed the Pyramid's "true azimuth co-ordinate system" is the azimuth system as defined by the existing socket corners—outmost from the Pyramid's base centre. This azimuth system was adopted as the system of reference for the various related—primary and secondary—movements.

The point of origin for setting out the base square and the oriented definition of the distance between the Pyramid's East and West sides.

The existing evidences of the various related movements have shown (¶¶ 145, 180, and 181) that the point M of the S.E. socket was adopted as the point of origin for setting out the Pyramid's base square and diagonals, and that the distance between the East side of the latter socket and the West side UX of the S.W. socket defined the length of the Pyramid's base side. Even in the event of the technical reader failing to agree with all our conclusions concerning the related base movements, it will nevertheless have to be conceded that the point M formed the point of origin for preliminary setting out, and that the distance between the East side of the S.E. socket and the West side of the S.W. socket formed the preliminary definition of the Pyramid's base width from East to West. (¶¶ 145, 180, and 181.)

Preliminary or final?

The Pyramid courses.

The levels of the Pyramid courses are as obtained by Petrie. The reader should note that the geometrical considerations of Plates XXIII, XXIV, and XXV (Fig. A_2) require that the special apex Pyramid should be 364.27665 P″=364.68 B″ high. The Pyramid's geometrical height being 5813.01 P″=5819.40 B″ gives base of original apex Pyramid, or top surface of the highest course of masonry at 5454.72 B″ above the base. This agrees with the highest existing course, the 203rd course, at 5451.8 B″, thus leaving 2.9 B″ for subsidence of the highest course. Owing to the

The geometrically defined special apex Pyramid in relation to the existing topmost course.

PLATE XXXVIIa.

GEOMETRICAL INTERPOLATION FOR CASE ALGEBRAICALLY DEFINED $P=A+Bt+Ct^2$

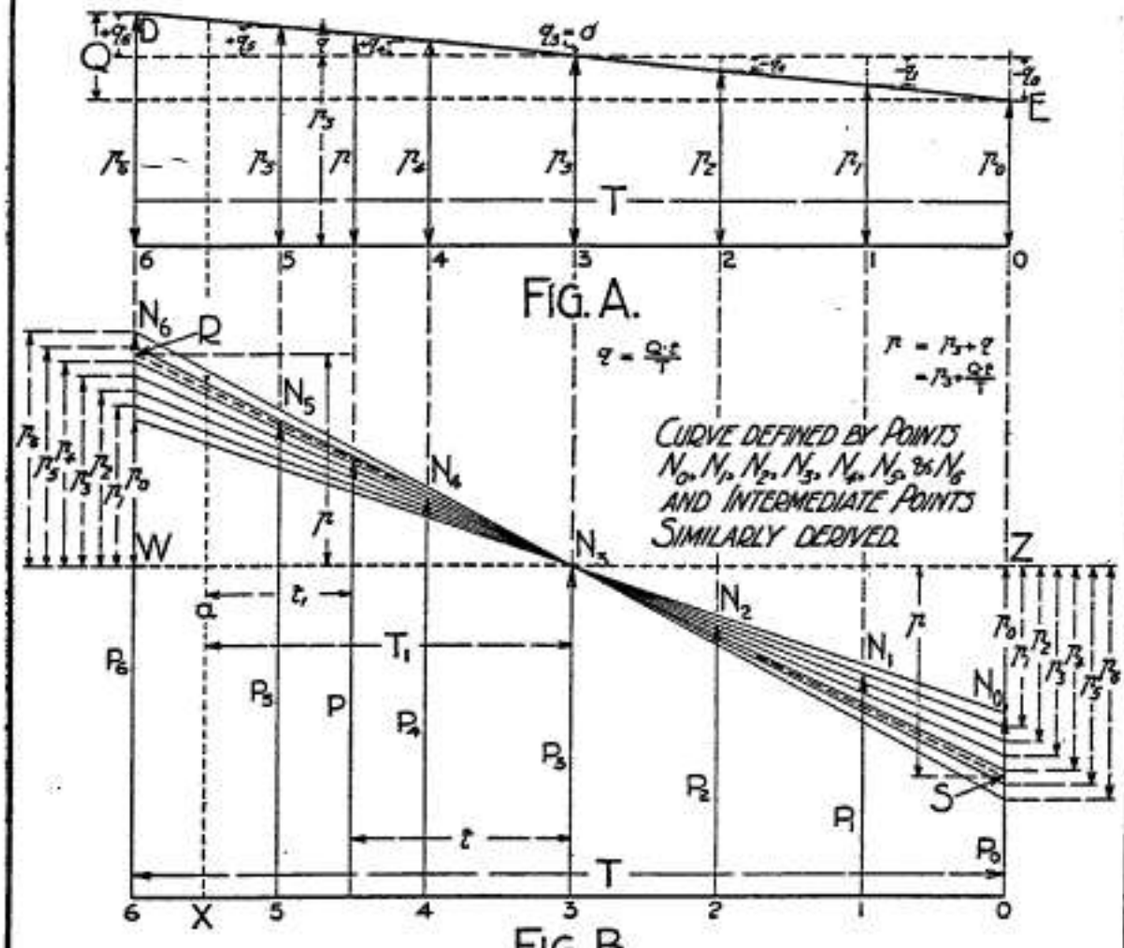


FIG. A.

CURVE DEFINED BY POINTS $N_0, N_1, N_2, N_3, N_4, N_5$ & N_6 AND INTERMEDIATE POINTS SIMILARLY DERIVED.

FIG. B.

FOR EPOCH OF REFERENCE AT MID-DATE 3:—

$P = P_3 + \frac{2\pi \cdot t}{T}$ FROM FIG. A. $\pi = \pi_3 + \frac{Q \cdot t}{T}$

HENCE $P = P_3 + \frac{2\pi_3}{T} \cdot t + \frac{2Q}{T^2} \cdot t^2$ GENERAL FORMULA.

SINCE P_3, π_3 & T ARE CONSTANTS

LET $P_3 = A$, $\frac{2\pi_3}{T} = B$, & $\frac{2Q}{T^2} = C$

THEN $P = A + B \cdot t + C \cdot t^2$.

THE ONLY VALUES NECESSARY TO DEFINE EQUATION GEOMETRICALLY ARE,

(1) THE INTERVAL T IN YEARS, WITH MID-DATE 3 OF INTERVAL.
(2) VALUE OF π_3 AT MID-DATE 3.
(3) VALUE OF Q FOR INTERVAL.
(4) VALUE OF P_3 AT MID-DATE 3.

THE STRAIGHT LINE R N_3 S IS FOR ANY GIVEN VALUE OF π_3, DEFINING THE CORRESPONDING VALUE OF P, FROM WHICH FOLLOWS THE STRAIGHT LINE EQUATION $P = P_3 + \frac{2\pi \cdot t}{T}$

FOR EPOCH OF REFERENCE AT ANY DATE X AHEAD OF THE MID-DATE EPOCH:—

LET NEW EPOCH X BE T YEARS AHEAD OF MID-DATE EPOCH

t_1 = YEARS FROM NEW EPOCH X.
(+ FORWARD; − BACKWARD)

AND LET a = VALUE OF P AT DATE OF NEW EPOCH X

THEN $P = a + b \cdot t_1 + c \cdot t_1^2$.

$b = \frac{2m}{T}$

$c = \frac{2Q}{T^2}$

THE VALUE OF $m = \pi_3 + \frac{2Q \cdot T_1}{T}$

WHEN T_1 PRECEDES THE MID-DATE EPOCH:—

$m = \pi_3 - \frac{2Q \cdot T_1}{T}$

THE EQUATION MAY BE DEFINED GEOMETRICALLY AS FOLLOWS:—

(1) INTERVAL T IN YEARS WITH THE INTERVAL T_1 YEARS AHEAD OF MID-DATE.
(2) VALUE OF m.
(3) VALUE OF Q FOR INTERVAL.
(4) VALUE OF a FOR NEW EPOCH X.

PLATE XXXVIIb.

GEOMETRICAL INTERPOLATION FOR CASE ALGEBRAICALLY DEFINED $P = A - Bt + Ct^2$

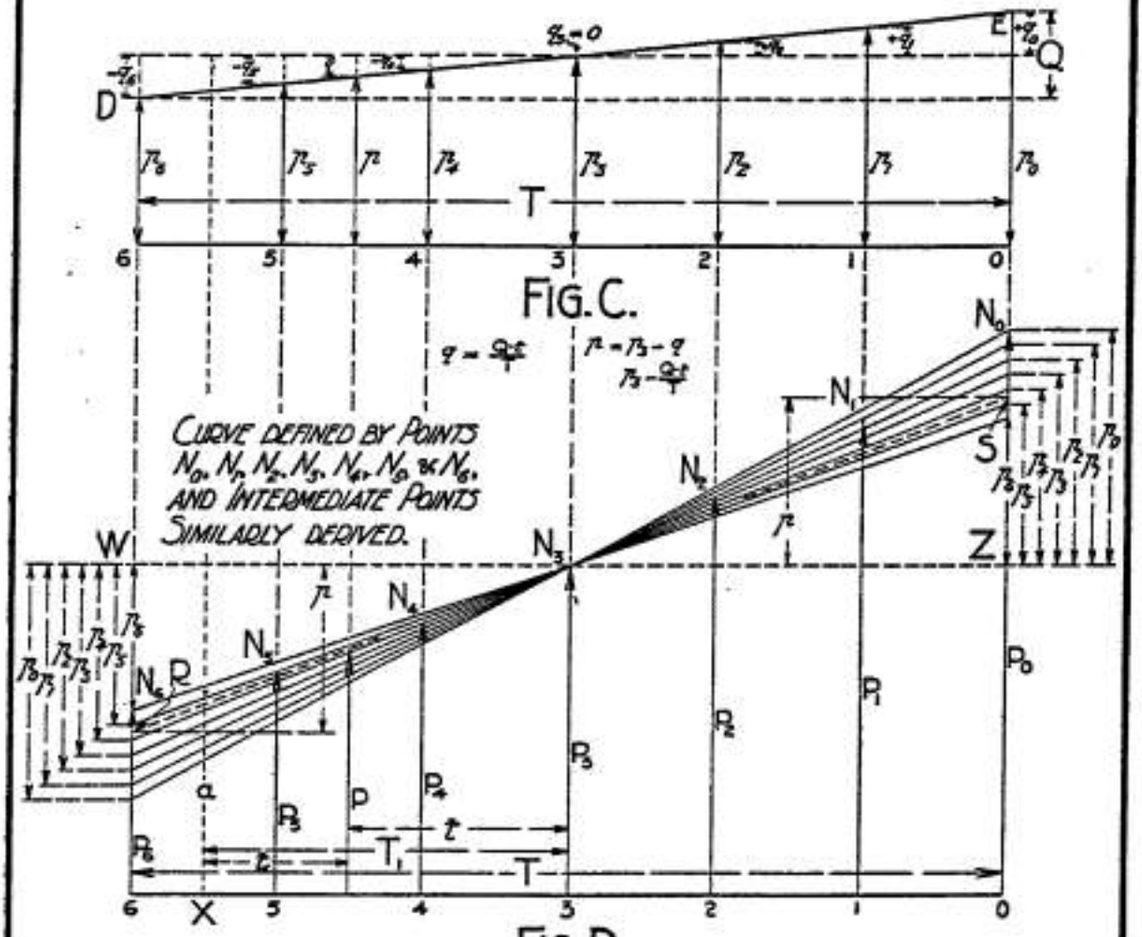


FIG. C.

FIG. D.

FOR EPOCH OF REFERENCE AT MID-DATE 3:–

$P = P_3 - \frac{2\pi_3 \cdot t}{T}$ FROM FIG. C. $\pi = \pi_3 - \frac{Qt}{T}$

HENCE $P = P_3 - \frac{2\pi_3}{T} \cdot t + \frac{2Q}{T} \cdot t^2$ GENERAL FORMULA.

SINCE P_3, π_3 & T ARE CONSTANTS

LET $P_3 = A$, $\frac{2\pi_3}{T} = B$, & $\frac{2Q}{T} = C$

THEN $P = A - Bt + Ct^2$.

THE ONLY VALUES NECESSARY TO DEFINE EQUATION GEOMETRICALLY ARE,

(1.) THE INTERVAL T IN YEARS, WITH MID-DATE 3 OF INTERVAL.
(2.) VALUE OF π_3 AT MID-DATE 3.
(3.) VALUE OF Q FOR INTERVAL.
(4.) VALUE OF P_3 AT MID-DATE 3.

THE STRAIGHT LINE R N_3 S IS FOR ANY GIVEN VALUE OF π, DEFINING THE CORRESPONDING VALUE OF P, FROM WHICH FOLLOWS THE STRAIGHT LINE EQUATION $P = P_3 - \frac{2\pi \cdot t}{T}$

FOR EPOCH OF REFERENCE AT ANY DATE X AHEAD OF THE MID-DATE EPOCH:–

LET NEW EPOCH X BE T_1 YEARS AHEAD OF MID-DATE EPOCH.
t_1 = YEARS FROM NEW EPOCH X (+ FORWARD; – BACKWARD)

AND LET a = VALUE OF P AT DATE OF NEW EPOCH X

THEN $P = a - bt_1 + ct_1^2$

$b = \frac{2m}{T}$

$c = \frac{2Q}{T}$

THE VALUE OF $m = \pi_3 - \frac{2Q \cdot T_1}{T}$

WHEN T_1 PRECEDES THE MID-DATE EPOCH:–

$m = \pi_3 + \frac{2Q \cdot T_1}{T}$

THE EQUATION MAY BE DEFINED GEOMETRICALLY AS FOLLOWS:–

(1.) INTERVAL T IN YEARS WITH THE INTERVAL T_1 YEARS AHEAD OF MID-DATE.
(2.) VALUE OF m.
(3.) VALUE OF Q FOR INTERVAL.
(4.) VALUE OF a FOR NEW EPOCH X.

¶ 221. GEOMETRICAL DEFINITION OF FORMULA FOR THE NEW EPOCH.

Together with the scalar representation of T years' interval and its mid-date, the geometrical representation of T_1 years from mid-date to Epoch, of values of P_x, m, and Q at Epoch completely define the formula.

For a geometrical representation such as Plate XXXVII, but represented with reference to an Epoch that is not the mid-date of the representation, the general formula, $P = a + b.t_1 + c.t_1^2$, is completely defined with respect to its Epoch X if the following data are given :—

(1) The geometrical representation of the Epoch X as T_1 years from the mid-date of the defined interval T years.

(2) The geometrical representation of the value of P_x in connection with the point defining the Epoch X, this giving the value of $a = P_x$.

(3) The geometrical representation of the value of m in connection with the point defining the Epoch X, this giving $b = \frac{2m}{T}$.

(4) The geometrical representation of the value of Q in connection with the point defining the Epoch X, this giving $c = \frac{2Q}{T^2}$.

The point for co-ordinates.

It is important to observe that the geometrical representation of these values should give P_x, m, and Q as co-ordinates at the point geometrically defining the Epoch.

The Pyramid's inferred scalar system—in which the interval T = 6000 years—is a suitable framework for the geometrical definition of the formula.

For the representation to prove its intention, and to supply data easily capable of being converted into algebraic form, its scalar system should be given in terms of round hundreds or thousands of years. In other words, the interval T years—as also $\frac{T}{2}$ years—should be in round thousands of years, to cover a sufficiently long period defining variations in annual astronomical values. The inferred Pyramid scalar system of chronology—in which the interval T is 6000 years, and in which, as the evidence indicates, the mid-date is clearly defined (¶¶ 215 and 216)—is just such a framework as is necessary to define the associated astronomical relations of ¶¶ 212–216 in terms of the system of geometrical interpolation of Plate XXXVII.

¶ 222. THE VARIATIONS OF THE PRECESSIONAL RATE.

Rate of Precession expressed as an angular rate per year = $a + b.t_1 + c.t_1^2$.

Now it so happens that the diagrams of Plate XXXVIIa (left hand), as defined, graphically represent—

(a) precisely the conditions of Precession, for

P = the annual value of the rate of Precession expressed in seconds of angle ;

and Plate XXXVIIb (right hand)—

(b) the exact conditions of Precession, for

P = the annual value of the rate of Precession expressed as years per 360°.

This is obvious from the following :—

Annual rate of Precession expressed as years per revolution of ecliptic = $a-b.t_1+c.t_1^2$.

$$\text{Rate in P years per } 360^\circ = \frac{360^\circ}{\text{Annual rate of Precession in angle}}.$$

As the annual angular rate increases the annual rate in years per 360° diminishes. Hence for (a)

$$\text{Annual angular rate of Precession} = a+b.t_1+c.t_1^2;$$

but for (b)

$$\text{Annual rate of Precession in P years per } 360^\circ = a-b.t_1+c.t_1^2.$$

It will assist the reader to follow the Pyramid's elucidation of this matter if we give some explanation of the basal data and formula universally adopted by modern astronomers in dealing with Precessional values.

¶ 223. NEWCOMB'S DATA FOR PRECESSION.

The older data of Bessel, Leverrier, and Oppolzer.

In the middle of the 19th century the Precessional value adopted by astronomers was Bessel's value—50″.2346+0″.000244t forward from 1850 A.D. Leverrier gave the value for 1850 as 50″.2357 for the Julian year, and Oppolzer as 50″.2346 for the tropical year.

The late 19th century Struve-Peters' data. Superseded by Newcomb's data.

During the second half of the 19th century the Struve-Peters' value—50″.2522+0″.000227t forward from 1850 A.D.—gradually superseded the earlier accepted values. In 1897, however, Professor Simon Newcomb published the results of his researches in "Astronomical Papers of the American Ephemeris" (Vol. VIII). Since that date his value and formula have been universally adopted by astronomers.

Outline of Newcomb's data. Period covered by calculations 500 years from 1600 A.D. to 2100 A.D.

Newcomb's calculations cover the period from 1600 A.D. to 2100 A.D. His values for years at intervals ten years apart, from 1600 A.D. to 2100 A.D., tabulated in Bauschinger's "Tafeln zur Theoretischen Astronomie," Taf. XXX, give the formula 50″.2453+0″.0002222t from 1850 A.D., the central date of his calculations.

This formula is derived from the following :—

Date A.D.	Value, Secs. of Angle.	Difference in 250 years.	
1600	50.1897		
		+0.0556	Average difference in 250 years =0.05555 or 0.0002222 per year.
1850	50.2453		
		+0.0555	
2100	50.3008		

Examination of the complete table in Bauschinger's work shows that the slight inequality in the two differences is due to the values being stated only to the 4th decimal place. For the same reason, the value in "The Nautical Almanac"—50″.2453+0″.0002225t from 1850 A.D.—has been interpolated from Newcomb's values from 1750 to 1950 A.D.

Bauschinger, again, in his "Bahnbestimmung der Himmelskörper," p. 79, gives the formula 50″.2453+0″.0002218t, which cannot be precisely obtained from the data in his "Tafeln," within any selected limits.

¶ 224. NEWCOMB'S FORMULA FOR PRECESSION.

Newcomb's formula in angular rate per year.

In the present work we have adopted Newcomb's formula as derived from the complete range of his data, and to apply equally to his data both before and after 1850 A.D.

This gives

Annual rate of Precession =50″.2453+0″.0002222t.

In annual rate expressed as period of revolution.

Converting this into the rate expressed as the number of years to complete a revolution (360°), we obtain

A=25,793.46.

B=−0.114.

And, within range of calculations (500 years), C negligible.

P=25,793.46−0.114t with t positive (+) forward from 1850 A.D.

Extreme accuracy of Newcomb's formula.

The formula strictly applies only to the period 1600 A.D. to 2100 A.D. covering the range of Newcomb's calculations. It gives, however, extremely accurate results for many thousands of years before and after this period, as the reader will see. This indicates that the constant C in the formula $P=A+B.t+C.t^2$—negligible within the range of Newcomb's calculations—must be an extremely small quantity.

In Newcomb's formula (Epoch 1850 A.D.)

A=25,793.46; B=−0.114; and C=0.

¶ 225. PYRAMID'S GEOMETRICAL CONNECTION BETWEEN EXTERIOR AND INTERIOR.

Pyramid's period of reference for 90° of Precession $=\frac{25,826.54}{4}$ years.

Now the measure of 25,826.54 P″—supplied by the sum of the Pyramid's base diagonals and by the precessional circuit—is indicated as the measure of the Pyramid's standard period of reference for variations in the rate of Precession (¶ 166). One quarter of this period (or 6456.635 years) is, therefore, the Pyramid's standard period of reference for 90° of Precession.

The importance of the Pyramid's external relations, 2861.022 P″ and 286.1022 P″.

In Case I, Fig. A, Plate XXIII, the value of 2861.02215624 P″ was obtained as an important relation in the geometrical scheme of the Pyramid's right vertical section. We now see that this value, and its $\frac{1}{10}$th subdivision (Fig. B, Plate XXVII), form the key to the relationship between the Pyramid's external and internal geometrical systems. For

Sine of Passage angle $=\frac{4\times 2861.022}{25,826.54}$.

(a) A triangle of vertical 2861.02215624 P″ and hypotenuse 6456.6355945 P″ (Plate XXXVIII, Fig. A) defines the angle of slope of the Pyramid's Passages with the horizontal as 26° 18′ 9″.63. (¶¶ 176–179.)

286.1022 P″ = Displacement of Passage System.

(b) A horizontal distance of 286.1022156 P″ Eastwards from the North to South central vertical Plane of the Pyramid defines the North to South central vertical plane of the Passage system. (¶ 148 and Plate XXIV.)

PLATE XXXVIII.

GEOMETRY OF PASSAGE SLOPES.

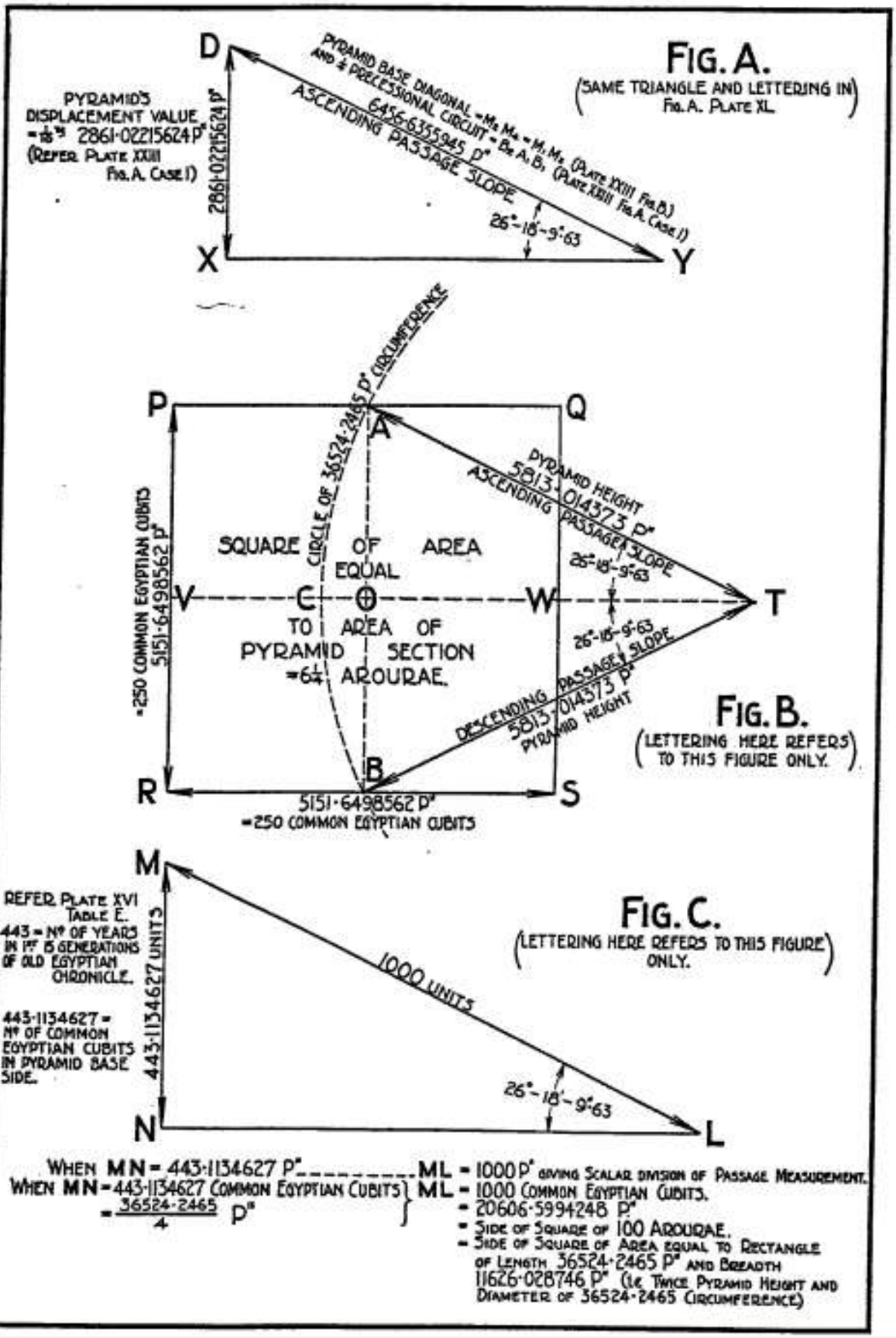
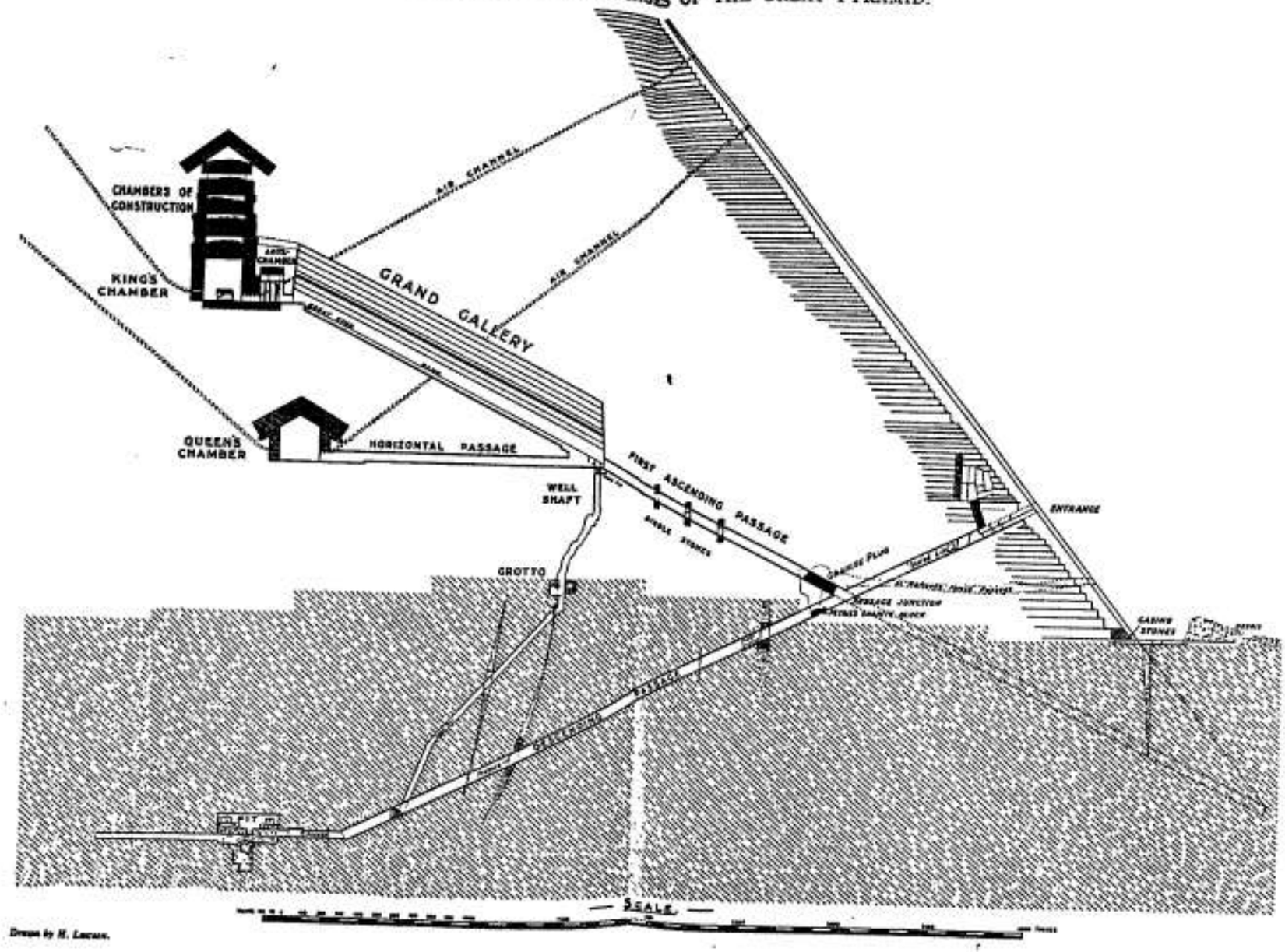


PLATE XXXIX.

SECTION OF THE PASSAGES OF THE GREAT PYRAMID.

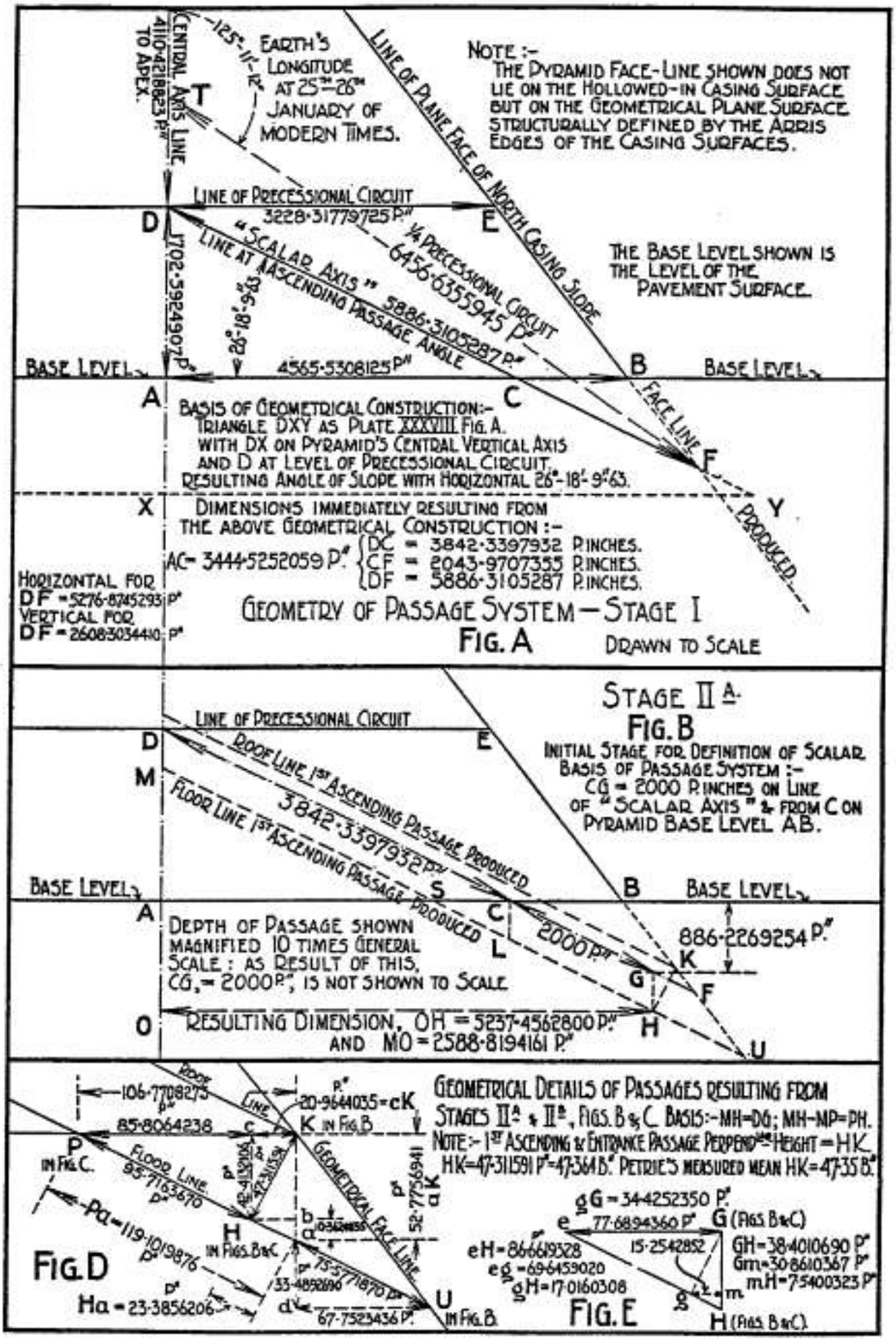


Drawn by H. Lawson.

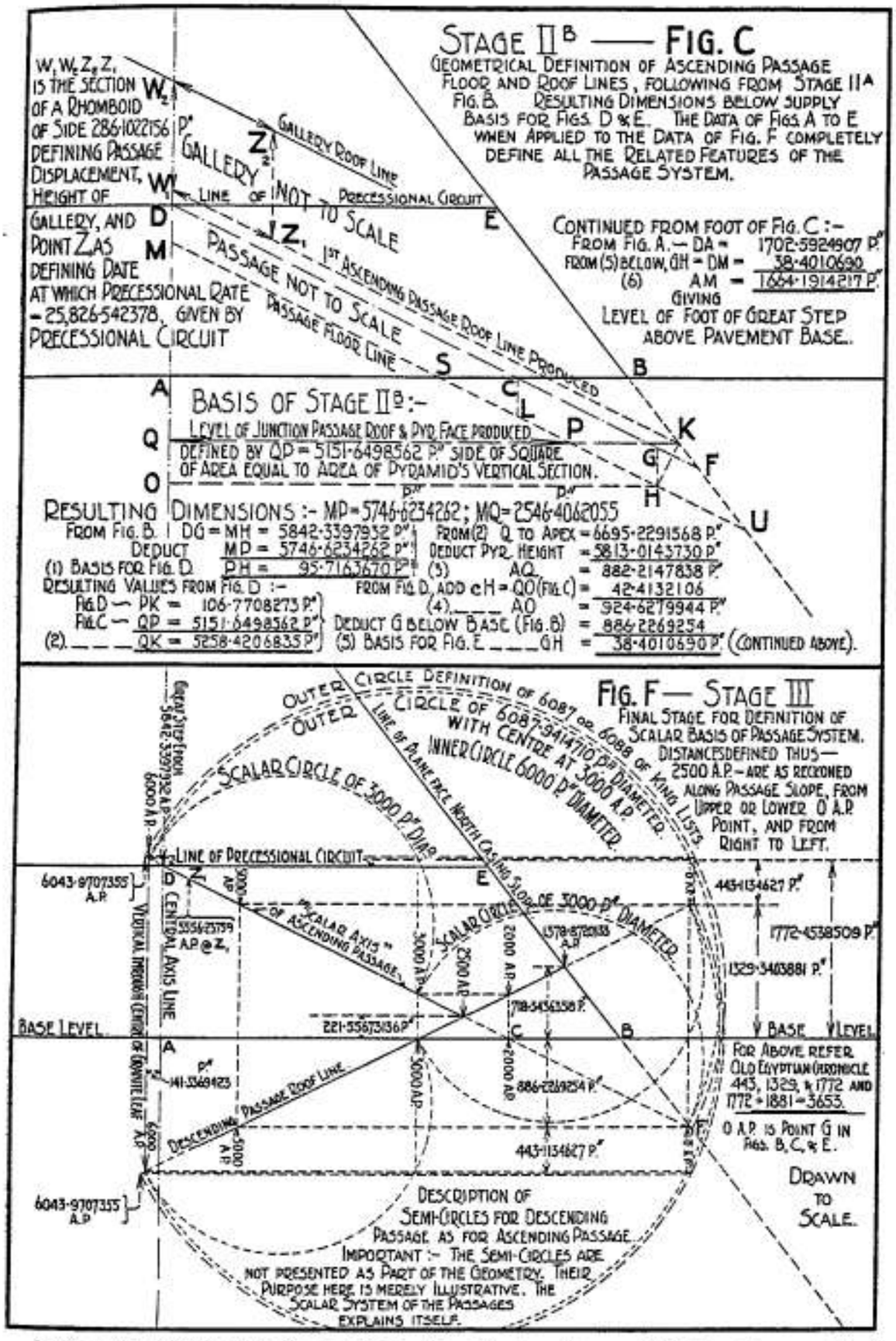
[To face p. 198.

PLATE XLa.

THE GEOMETRY OF THE GREAT PYRAMID'S PASSAGE SYSTEM.



THE GEOMETRY OF THE GREAT PYRAMID'S PASSAGE SYSTEM.



NOTE.—A.P. denotes *Anno Pyr.* in Fig. F and in following plates; 0 A.P. being the zero date of the Pyramid's scalar system of astronomical chronology. Hence the clear definition of 0 A.P., 2000 A.P., 3000 A.P., 5000 A.P., and 6000 A.P.

PLATE XLIa.

GEOMETRICAL DETAILS OF THE GREAT PYRAMID'S PASSAGE SYSTEM.

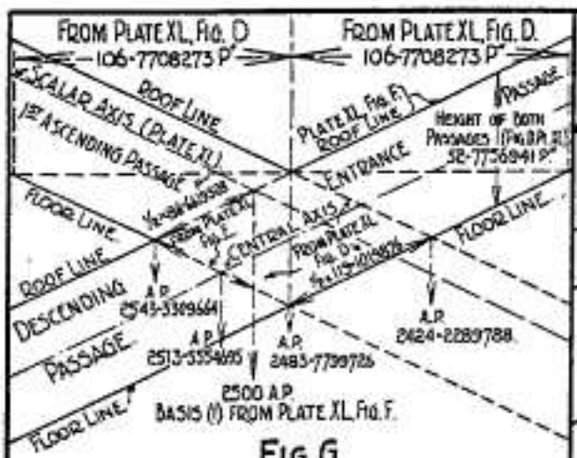


FIG. G.

DETAILED DATA FOR JUNCTION OF ENTRANCE & 1ST ASCENDING PASSAGES.
BASAL DATA :- DIMENSIONS OF FIGS. D & E, PLATE XL., AND FIXED INTERSECTION — AT 2500 A.P. — OF SCALAR AXIS OF ASCENDING PASSAGE, AND ROOF LINE OF DESCENDING (OR ENTRANCE) PASSAGE (PL. XL, FIG. F).
OTHER STATED DATA RESULT IMMEDIATELY FROM ABOVE.

FIG. H.

DETAILED DATA FOR ENTRANCE PASSAGE AT ENTRANCE DOORWAY.
BASAL DATA :- KNOWN EXTENT OF HOLLOWING-IN OF FACE SLOPE — 35·762777 P" HORIZONTALLY AS SHOWN; DIMENSIONS OF FIG. D, PLATE XL.; FIXED INTERSECTION — AT 1378·8720133 A.P. — OF ROOF LINE OF ENTRANCE PASSAGE & LINE OF PLANE GEOMETRICAL FACE SLOPE (PL. XL, FIG. F).
OTHER STATED DATA RESULT IMMEDIATELY FROM ABOVE.

COMPARISON OF GEOMETRICAL DATA WITH PROFESSOR PETRIE'S MEASURED DATA :-
GEOMETRICAL LEVEL OF FLOOR AT ENTRANCE DOORWAY ABOVE PAVEMENT BASE = 667·592919 P" = 668·327 B"
PETRIE, "PYRAMIDS & TEMPLES OF GIZEH", page 52, BASE OF 19TH MASONRY COURSE NEAR DOOR = 668·3 B"
DO. DO. page 55, PASSAGE FLOOR LEVEL AT ENTRANCE DOOR = 668·2 ± 0·1 B"
GEOMETRICAL LENGTH OF ENTRANCE PASSAGE FLOOR FROM ENTRANCE DOOR TO JUNCTION = (2483·7799726 − 1374·302129) FIGS. G & H.
= 1109·477844 P" = 1110·698 B"
PETRIE'S CORRESPONDING MEASURED DISTANCE ("PYR.S & TEMPLES" p. 56). ---------- = 1110·64 ± 0·3 B".
THE GEOMETRICAL DATA THEREFORE AGREE WITH THE MEASURED DATA, AS IN CASE OF FIG. D, PLATE XL.

FIG. K.

LEVEL OF CENTRE OF YEAR CIRCLE ABOVE BASE = LEVEL OF LOWER O.A.P. (PLATE XL, FIGS. B & E) BELOW BASE = 886·2269254 P"
THIS DEFINES LEVEL OF GALLERY FLOOR BEGINNING = 860·4686761 ABOVE BASE.

DETAILED DATA FOR COMMENCEMENT OF GRAND GALLERY AND LEVEL OF ROOF LINE HORIZONTAL PASSAGE TO QUEEN'S CHAMBER :-
BASAL DATA :- DIMENSIONS OF FIGS. D & E, PLATE XL; FIXED POINT 4000 A.P.; AND RADIUS (58·13014373 P") OF YEAR CIRCLE, ALL IN RELATION TO ROOF & FLOOR LINES AND SCALAR AXIS OF 1ST ASCENDING PASSAGE. RESULTING CHECK LEVEL OF CENTRE OF YEAR CIRCLE IS AS STATED.
OTHER STATED DATA RESULT IMMEDIATELY FROM ABOVE.
PETRIE'S 1ST ASCENDING PASSAGE LENGTH FROM FLOOR JUNCTION TO "GALLERY, PLUMB FROM WALL OVER DOOR" (P. 63) (SEE NOTE ①) = 1546·5 B"
GEOMETRICAL DO. FIGS. G & K ABOVE = (4028·532 − 2483·780) = 1544·25 P" = 1546·45 B"
PETRIE'S GRAND GALLERY LENGTH FROM HIS GALLERY COMMENCEMENT "PLUMB FROM WALL OVER DOOR" (P. 65), TO GREAT STEP (P. 71) = 1815·5 + 0·3 = 1815·8 B"
GEOMETRICAL DO. PLATE XL FIG. F AND FIG. K ABOVE = 1815·77 B"
THUS 5842·339793 − 4028·531789 = 1813·808004 P" = 1815·77 B"

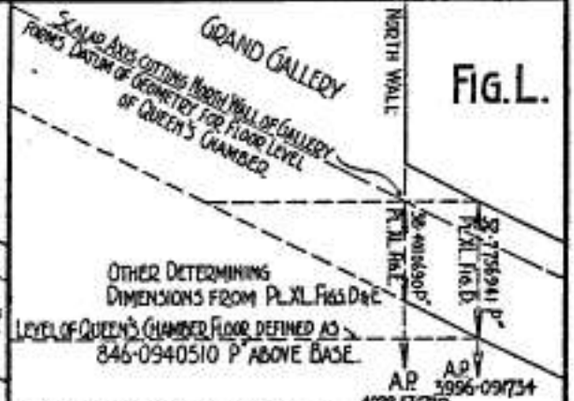


FIG. L.

DATA FOR QUEEN'S CHAMBER FLOOR. FIG. K.
BASAL DATA :-
DIMENSIONS OF FIGS. D & E (PLATE XL) AND FIXED POINT OF COMMENCEMENT OF GRAND GALLERY (FIG. K — ALONGSIDE)
COMPARISON OF GEOMETRICAL DATA WITH STRUCTURAL DATA OF PLATE XXX :-
QUEEN'S CHAMBER FLOOR LEVEL ABOVE BASE :-
AS FIG. L. (ABOVE) = 846·0940510 P" = 847·025 B"
AS PLATE XXX DIAGRAM (SEE NOTE ②) = 847·06 B"
LEVEL ABOVE BASE OF FLOOR POINT BEGINNING GRAND GALLERY :-
AS FIG. K. (ALONGSIDE) = 860·4686761 P" = 861·415 B"
AS PLATE XXX TABLE C. (COL. 3A. SEE NOTE ②) = 861·55 B"
NOTE ① :- THE DATA ON PLATE XXX ARE BASED ON PETRIE'S FLOOR MEASUREMENT FROM JUNCTION OF ENTRANCE & ASCENDING PASSAGE FLOOR LINES TO 1ST FLOOR JOINT OF GRAND GALLERY, WHICH IS 0·3 B" BEYOND VERTICAL FROM NORTH WALL OF GALLERY OVER DOOR. THE FORMER IS 1546·8 B" & THE LATTER 1546·5 B" FROM JUNCTION. THE LATTER AGREES WITH THE GEOMETRICAL DISTANCE AS SHOWN UNDER FIG. K. ALONGSIDE.

PLATE XLIb.

GEOMETRICAL DETAILS OF THE GREAT PYRAMID'S PASSAGE SYSTEM.

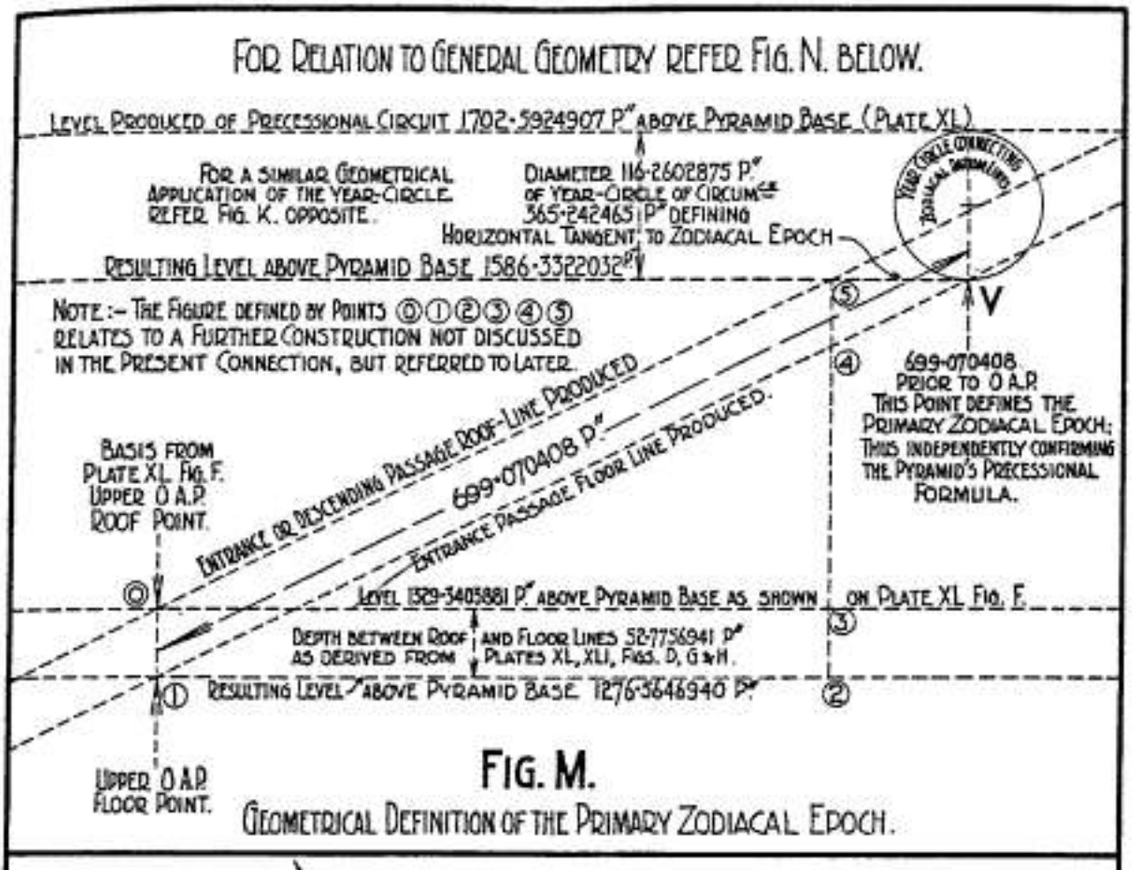


FIG. M.

GEOMETRICAL DEFINITION OF THE PRIMARY ZODIACAL EPOCH.

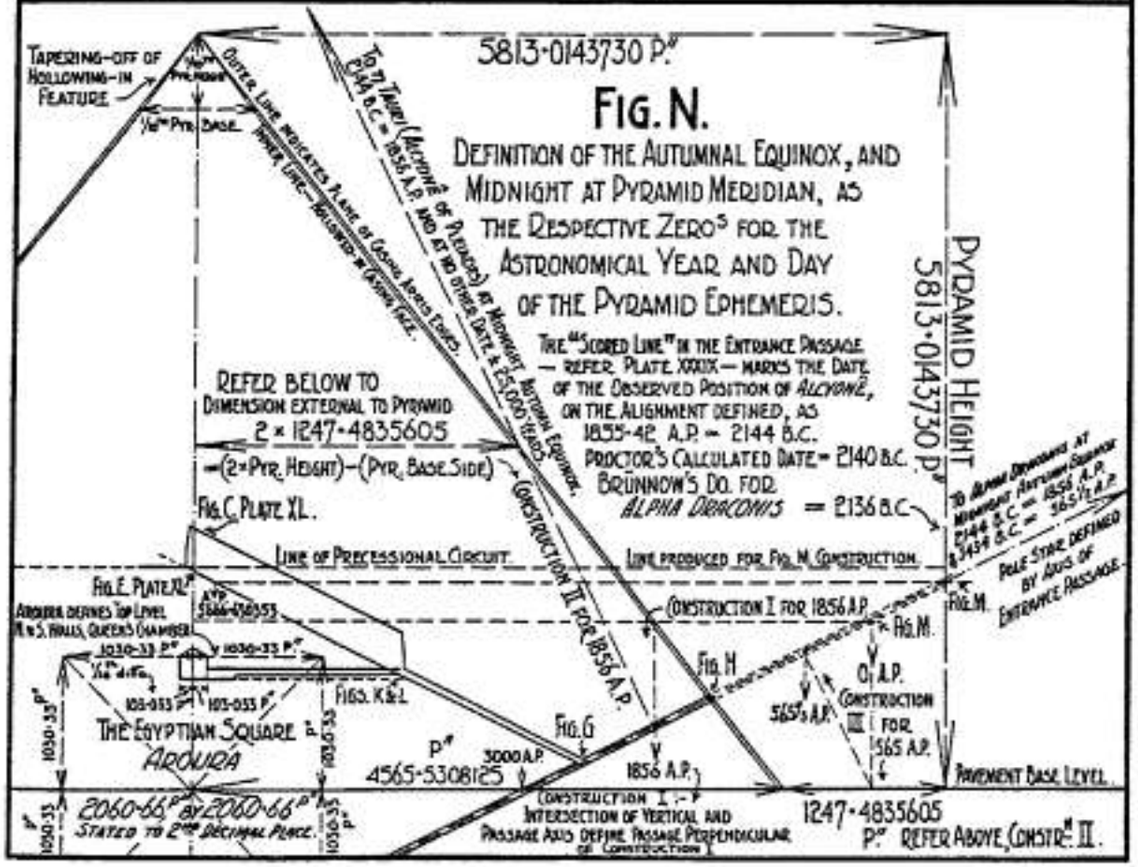


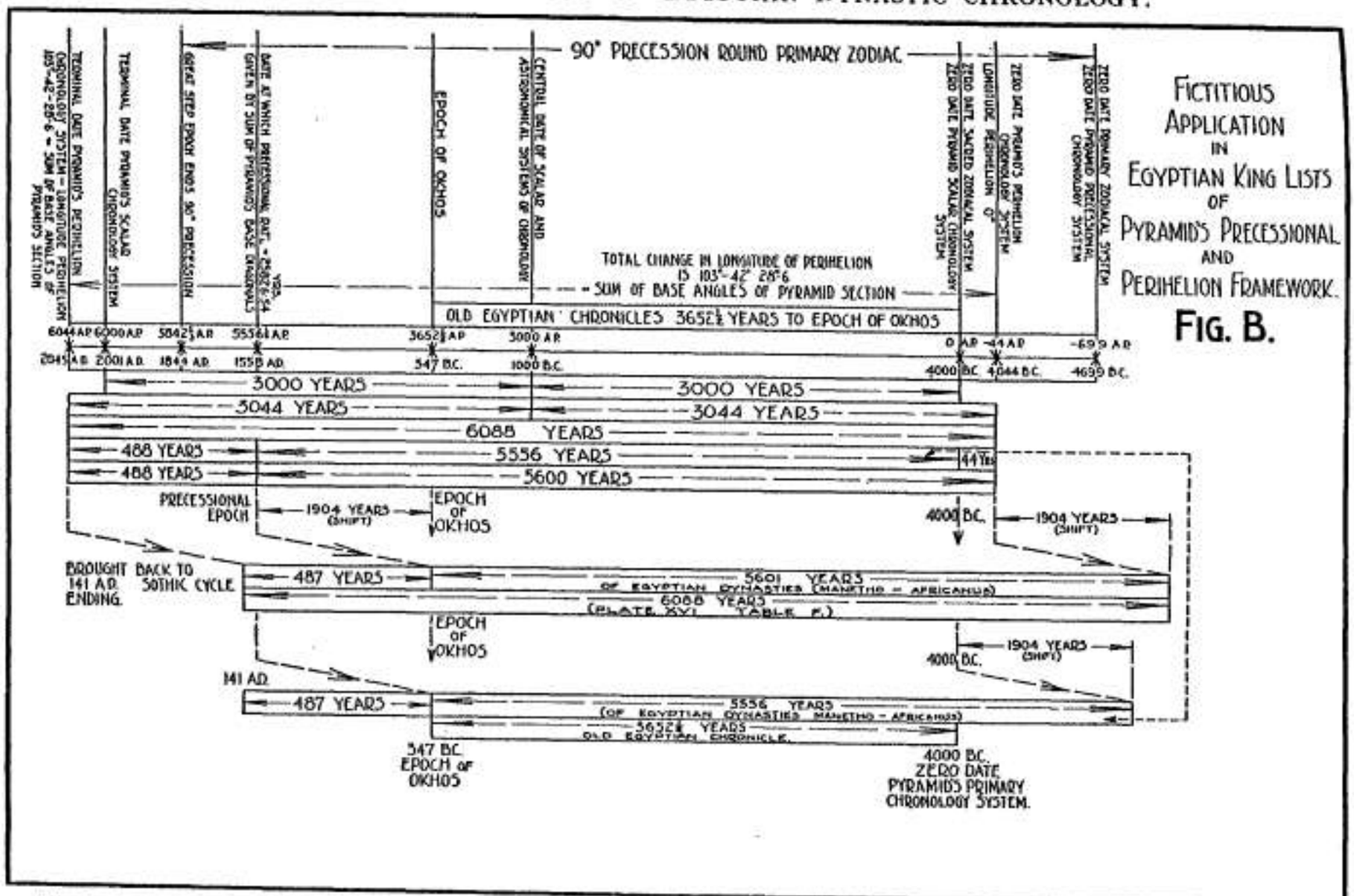
FIG. N.

DEFINITION OF THE AUTUMNAL EQUINOX, AND MIDNIGHT AT PYRAMID MERIDIAN, AS THE RESPECTIVE ZEROS FOR THE ASTRONOMICAL YEAR AND DAY OF THE PYRAMID EPHEMERIS.

THE "SCORED LINE" IN THE ENTRANCE PASSAGE — REFER PLATE XXXIX — MARKS THE DATE OF THE OBSERVED POSITION OF *ALCYONE*, ON THE ALIGNMENT DEFINED, AS 1855·42 A.P. = 2144 B.C. PROCTOR'S CALCULATED DATE = 2140 B.C. BRUNNOW'S DO. FOR *ALPHA DRACONIS* = 2136 B.C.

PLATE XLIIb.

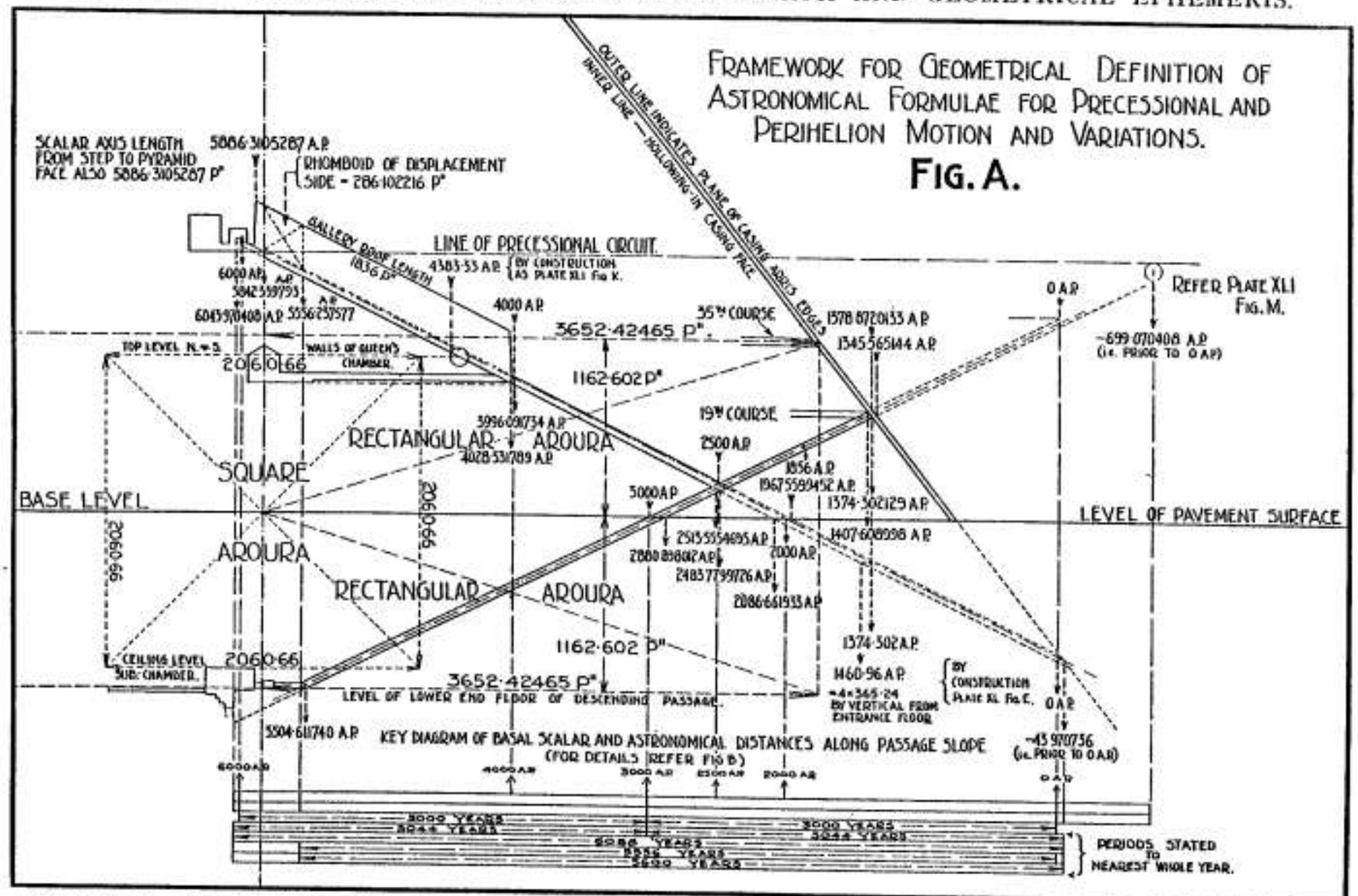
THE BASIS AND EVOLUTION OF EGYPTIAN DYNASTIC CHRONOLOGY.



The Pyramid chronology of the Egyptian King Lists, and its application in the King Lists, confirm the chronology as derived from the Pyramid's astronomical formulæ. The King Lists independently prove that 0 A.P. = Autumnal Equinox 4000 B.C. Obscure tradition of this identity existed in the 3rd century A.D. By the 6th century A.D. the tradition had taken the erroneous form of identifying the Annunciation as beginning the 1st year of the Christian Era, A.D. 1, at the *Vernal* Equinox, 25th March (Julian) 3999¼ A.P.

PLATE XLIIa.

THE GREAT PYRAMID'S ASTRONOMICAL CHRONOGRAPH AND GEOMETRICAL EPHEMERIS.



As defined and confirmed by the Pyramid's various and independent astronomical formulæ and their integrated angular values: (1) 0 A.P.=Autumnal Equinox 4000 B.C.; (2) 3000 A.P.=Autumnal Equinox 1000 B.C.; and (3) 6000 A.P.=Autumnal Equinox 2001 A.D.

NOTE.—A.P. denotes *Anno Pyr.*

The latter movement is illustrated by the successive stages presented by Plates XLIV to XLVII. Each Plate shows four successive positions of the Earth in its orbit during a year. Positions on other days of the same year have the same direction of inclination. Thus Plate XLIV represents the direction of inclination of the Earth's axis during the year 4699 B.C. Plate XLV represents the direction of inclination of the Earth's axis during the year 1844 A.D.—the direction having altered 90° between 4699 B.C. and 1844 A.D. Plate XLVI represents the direction of inclination of the axis during the year 8203¼ A.D.—the direction having altered 180° between 4699 B.C. and 8203¼ A.D. Plate XLVII represents the direction of inclination of the axis during the year 14,390 A.D.—the direction having altered 270° between 4699 B.C. and 14,390 A.D. The direction then returns to the position represented on Plate XLIV, which now represents the direction of the axis for the year 20,415 A.D.—the direction having turned round 360° between 4699 B.C. and 20,415 A.D. Between these two dates, the cycle of Precession is a period of 25,112⅞ years. For other earlier dates, the period is greater; for later dates, the period is less. Thus for precession of 360° prior to 1844 A.D., the precessional cycle is a period of 27,376.1 years, beginning at 25,533 B.C. and ending at 1844 A.D.; and for precession 360° forward in time from 1844 A.D., the precessional cycle is a period of 24,442.2 years, beginning at 1844 A.D. and ending at 26,286 A.D.

Direction changes completely round 360° in about 26,000 years.

Plates XLIV to XLVII illustrate directions of Earth's polar axis for successive directions 90° apart, and at the dates stated in each case.

Precessional cycle, 4699 B.C. to 20,415 A.D. = 25,112½ years.

Precessional cycle:—
25,533 B.C. to 1844 A.D. = 27,376 years.

1844 A.D. to 26,286 A.D. = 24,442 years.

11,434 B.C. to 14,390 A.D. = 25,822.65 years, i.e. central to 1844 A.D.

For 180° prior to 1844 A.D., ½ period	=13,276.20 years.
And for 180° after 1844 A.D., ½ period	=12,546.45 ,,
Precessional period 11,434 B.C. to 14,390 A.D. Cycle	=25,822.65 years.

These periods follow from the formula and method of ¶ 238.

¶ 276. THE SOLAR DAY AND THE SIDEREAL DAY.

Now, in ¶¶ 273 and 275, 365 rotations were taken as illustrating the case of the revolution of the Earth round its orbit. *Strictly speaking*, this is untrue —even as an approximation.

In the course of a solar year, the Sun *appears* to revolve round the Earth 365.2422 times, thus defining the number of days. If, however, the Sun were hidden for a year, we would observe that the stellar heavens *appear* to revolve round the Earth 366.2422 times in a solar year. The reason is that the Earth in revolving *externally* round the Sun, is performing its revolution internally to the stellar heavens. The stellar heavens, therefore, appear to revolve 366.2422 times to the Sun's apparent 365.2422 times. Hence the apparent diurnal revolution of the stellar heavens is termed a "sidereal day" and the diurnal revolution of the Sun is termed a "solar day." The latter is the day as commonly known. The former is an astronomical unit employed in the "Nautical Almanac" and astronomical ephemerides. Hence,

The solar year = 365.2422 solar days (or "apparent" revolutions of the Sun); = 366.2422 sidereal days, (or "apparent" revolutions of the stellar heavens).

One *Solar* Year = 365.2422 solar days,
,, ,, = 366.2422 sidereal days.

PLATE XLIV.

PRECESSION OF THE EQUINOXES—THE SOLAR YEAR IN 4699 B.C.

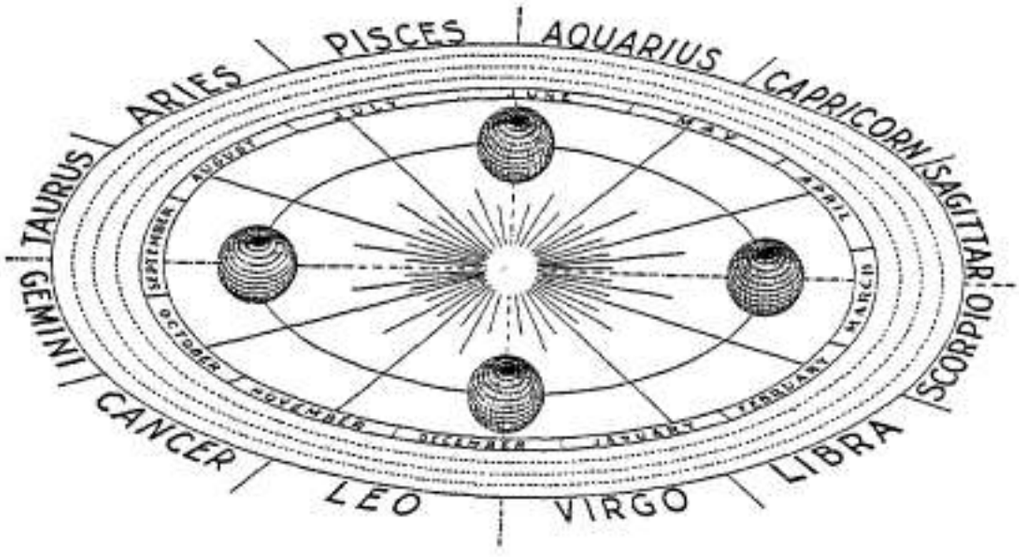


PLATE XLV.

PRECESSION OF THE EQUINOXES—THE SOLAR YEAR IN 1844 A.D.

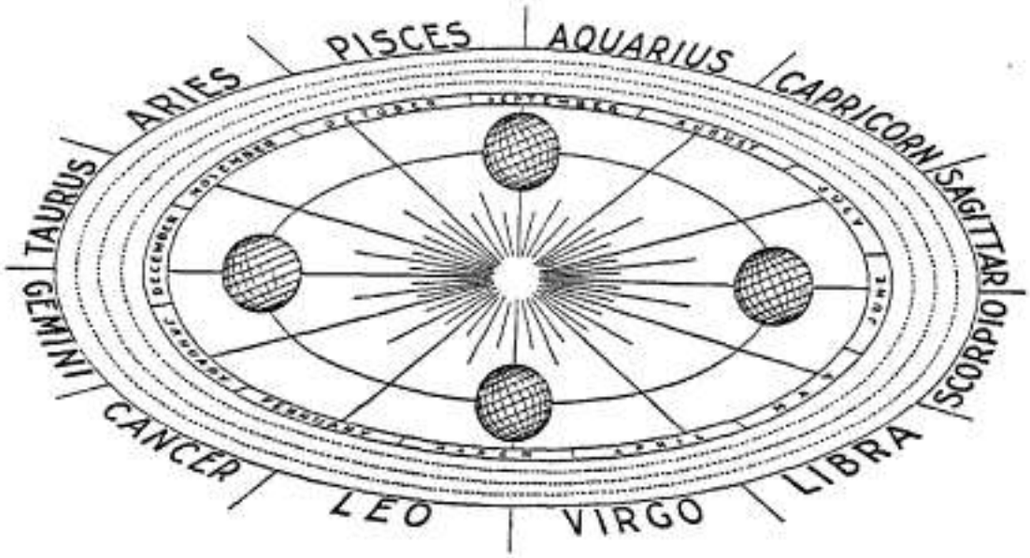


PLATE XLVI.

PRECESSION OF THE EQUINOXES—THE SOLAR YEAR IN 8203¼ A.D.

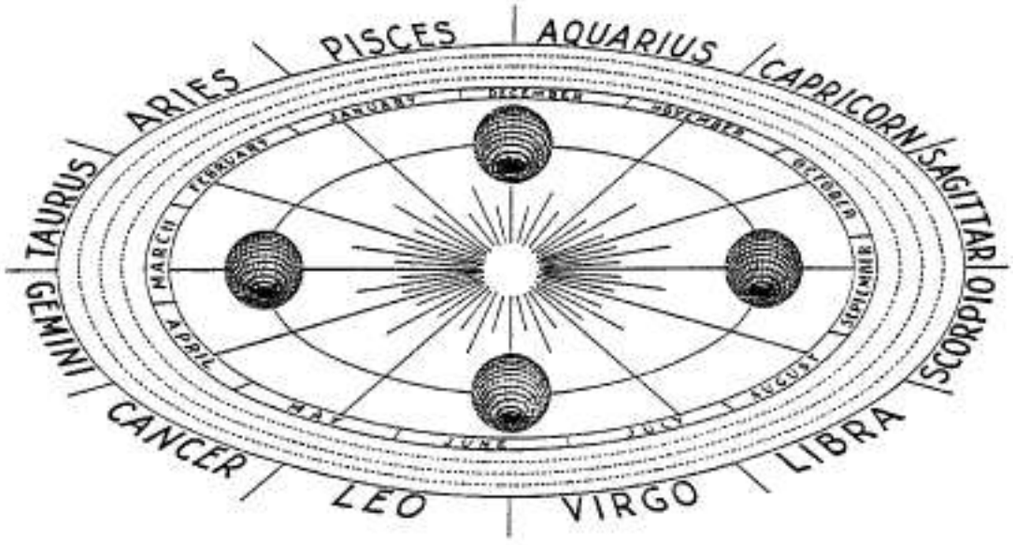
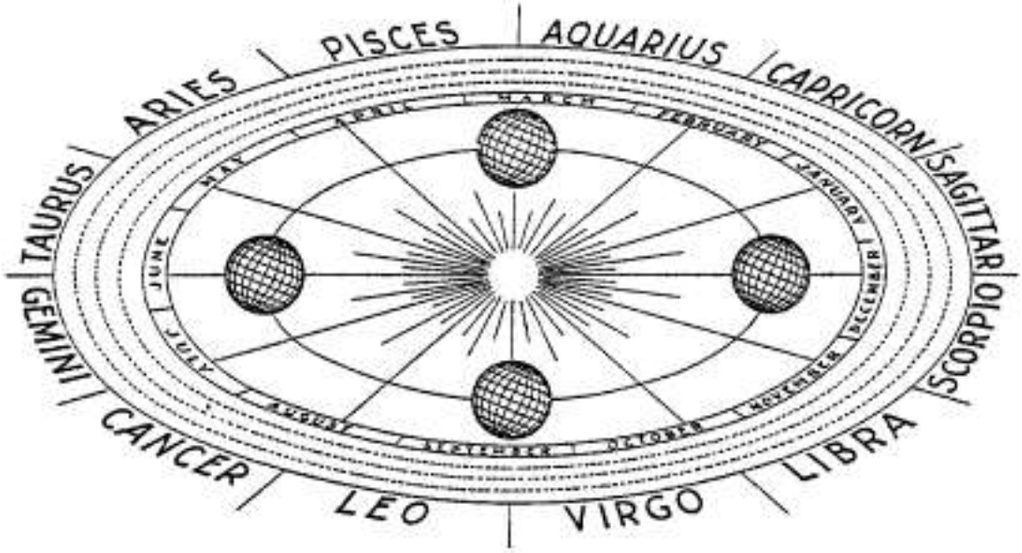


PLATE XLVII.

PRECESSION OF THE EQUINOXES—THE SOLAR YEAR IN 14,390½ A.D.



The solar year defined in sidereal days "should not" be termed the sidereal year.

The true sidereal year is the period in which the Earth makes a complete revolution round the stellar heavens.

The true sidereal year is longer than the solar year by the amount of precession for the year considered.

The solar year, defined as consisting of 366.2422 sidereal days, is termed the "Sidereal year" in some elementary works on astronomy, and in others that ought to know better. This designation, however, is a misnomer. The Sidereal year—as defined in ¶¶ 150 and 155—is the duration in solar days of the Earth's complete revolution of the stellar heavens. The amount by which the solar year falls short of the sidereal year is determined by the extent to which the direction of the Earth's polar axis is altered, by its precessional factors, in the course of a year. The resulting slip backwards of the solar year round the stellar heavens is illustrated in successive stages by the modern month indications of Plates XLIV–XLVII inclusive.

¶ 277. THE VARIOUS ELEMENTS OF PRECESSION.

Solar Precession.

Now the plane of the Earth's orbit is necessarily the plane in which the Sun's attraction acts on the Earth. Owing to the inclination of the Earth's axis of rotation to the plane of the orbit, the plane of the Earth's equatorial protuberance is oblique to the plane of the Sun's attraction. In consequence, the latter attraction tends to pull the plane of the equatorial protuberance into the plane of the Earth's orbit. The Earth counteracts this tendency by means of the "wobbling" motion described in ¶¶ 271, 272, and 275. The resulting slow change of direction of the Earth's axis—measured by its annual extent of change—is termed "Solar Precession."

Lunar Precession.

Again, the plane of the Moon's orbit round the Earth being oblique to the plane of the Earth's equatorial protuberance, a similar action and counteraction result. Precession resulting from this is termed "Lunar Precession."

Planetary Precession.

As the orbits of all the other planets are oblique to the plane of the Earth's equator, a similar resultant action and counteraction are due to planetary attractions. Precession resulting from this is termed "Planetary Precession."

Algebraic sum of all = General Precession.

The algebraic sum of all three Precessional values is the total precession, and is termed "General Precession."

¶ 278. APPARENT—AS DISTINCT FROM ACTUAL—MOVEMENTS.

Earth appears to be stationary, Sun to revolve round the Earth in course of a solar day, and stellar heavens round the Earth in course of a sidereal day.

Case of Moon and planets.

Apparent path of Sun, Moon, and Planets define the Zodiac.

Its central line encircling the heavens is the Ecliptic, or apparent path of the Sun.

To an observer on the Earth, the Earth appears to be stationary. The Sun appears to perform a complete revolution round the Earth in the course of a solar day, and the stellar heavens to perform a complete revolution round the Earth in the course of a sidereal day (¶ 276). Similarly, the moon and all the planets appear to revolve round the Earth each in a period of approximately a solar day.

The apparent paths of the Sun, Moon, and Planets in the stellar heavens always lie within a particular belt or girdle encircling the heavens. This belt is termed the Zodiacal belt, or, simply, the Zodiac. The central encircling line of the Zodiac is the Ecliptic, or apparent path of the Sun. The apparent path of the Sun is therefore traced in the stellar heavens, although, whilst the Sun is visible, the stars, defining the Sun's course, are themselves invisible.

Polar axis turns round 90° in direction in 6500 years; in the same time Ecliptic axis shifts less than 1°.

Ecliptic axis becomes axis of reference for Precession.

Ecliptic North Pole the point of reference for North Celestial Pole of different dates.

North Celestial Pole defined as slowly revolving round Ecliptic North Pole.

Precession defined in relation to the celestial sphere and the signs of the Zodiac.

the Ecliptic axis have shifted less than 1° in relation to the fixed stars, or to be more precise, in relation to their original positions at the beginning of the interval considered.

The Ecliptic North Pole is therefore taken as the point to which the positions of the North Celestial Pole for different dates are referred. The Ecliptic axis is thus the axis of reference for Precession, and the Ecliptic North Pole is the point of reference for Precession of the North Celestial Pole. The North Celestial Pole is, in consequence, defined as revolving slowly round the Ecliptic North Pole. As thus defined, the movement is illustrated on Plate XLIX., the various positions of the North Celestial Pole being shown for dates from 5000 B.C. to 2500 A.D. Complete illustration of the movement in relation to the celestial hemisphere north of the Ecliptic, and in relation to the fixed stars thereon, is shown on Plate XLVIII. This shows the relations between the North Celestial Pole and the Equinoctial and Solstitial Colures, and by these relations illustrates the meaning of "The Precession of the Equinoxes," round the Zodiac.

¶ 281. THE EARLIEST ZODIACAL DATE.

The star groups and their figures defining the Zodiacal Signs.

Twelve signs recognised as handed on to modern times.

At a remote date in history the constellations or star groups of the Zodiac were divided off into equal spaces in the Ecliptic. As these have come down to us, the star groups indicate a division into twelve Zodiacal Signs. The constellational figures associated with these signs and their designations are as shown on Plate XLVIII.

Earliest date of origin:—Midnight of Autumnal Equinox, 4699 B.C., indicated at first point of Gemini = last point of Taurus.

R. Brown, jun., in his "Primitive Constellations,"[1] places the date of origin for the figures shown as 4698 B.C. (astronomical) =4699 B.C. (historical). This date agrees with the various other lines of independent evidence discussed in Section I of this Chapter. Brown's date of origin depends upon the following:—

Earliest historical references in no case refer to a year beginning in Gemini.

All earliest references are to a year beginning in Taurus.

Earliest date of Zodiacal signs and of earliest historical records is therefore not earlier than 4699 B.C.

The toe of Castor, beginning the sign Gemini, also marks the termination of the sign Taurus. At the date 4699 B.C. (historical) a given meridian on the Earth passed through the point thus defined precisely at midnight of the Autumnal Equinox of that year; or, alternatively, the Sun occupied the point thus defined at noon of the Vernal Equinox of that year. This can be independently confirmed from the present position of the toe of Castor, and from Newcomb's formula for Precession (¶ 224). The resulting relation between the modern months of the solar year and the Zodiacal signs for 4699 B.C. is as shown on Plate XLIV. The first month of the Equinoctial year therefore coincided with the Zodiacal sign Gemini in 4699 B.C. In successive later years, owing to Precession, the beginning of the year slipped backwards gradually through the sign Taurus. Now the earliest known historical records in no case refer to an Equinoctial year beginning in Gemini. They all refer to an Equinoctial year beginning in Taurus. Brown therefore placed the date of origin at the last point of Taurus, thus fixing the date at 4699 B.C. (historical).

[1] Vol. I, p. 56.

The stellar heavens, therefore, appear as a vast globe encircling the Earth. To the ordinary observer, the Earth appears to be the centre of the stellar globe. With minor modifications—affecting geocentric and heliocentric points of reference—the point of view of the ordinary observer has been adopted as the basis of presentation for astronomy in ancient and modern times.

Stellar heavens appear as a celestial sphere, with the Earth in the centre.

¶ 279. THE CELESTIAL SPHERE.

Earth's polar axis produced defines polar axis of celestial sphere. Celestial North Pole and Celestial South Pole thus defined.

The axis of apparent rotation of the stellar globe is the polar axis of the Earth produced. The Earth's polar axis produced into the northern hemisphere of the stellar globe defines the celestial North Pole. All the stars in the northern celestial hemisphere appear to revolve daily around the point thus defined; and similarly in the southern celestial hemisphere, with reference to the celestial South Pole.

Plane of Earth's equator produced defines the celestial equator on the celestial sphere.

Similarly, the plane of the Earth's equator produced in all directions defines the plane of the celestial equator. Its line of intersection with the apparent stellar globe defines the line of the celestial equator.

Plane of Earth's orbit produced defines the Ecliptic, or apparent annual path of Sun round the celestial sphere.

Had Earth's polar axis been perpendicular to plane of its orbit, the celestial equator would have coincided with the Ecliptic, and the polar axis with the axis of the Ecliptic.

Now if the polar axis of the Earth had been perpendicular to the plane of the Earth's orbit, the plane of the Earth's equator would have coincided with the plane of the orbit. As the plane of the latter produced defines on the stellar globe the line of the Ecliptic, or the apparent annual path of the Sun, it is obvious that, with the condition assumed, the polar axis of the stellar globe would have coincided with the axis of the Ecliptic, and the celestial equator with the Ecliptic.

Tilt of Earth's axis produces tilt of plane of celestial equator 23½° from the Ecliptic plane, and North Celestial Pole 23½° from North Ecliptic Pole.

Owing, however, to the tilt of the Earth's axis being about 23½° from the position assumed above, the North Celestial Pole is about 23½° removed from the Pole of the Ecliptic. The latter is unaffected by the tilt. The result is that the *yearly* path of the Sun appears to be performed round the Ecliptic as the middle circumference of a sphere of which the axis of revolution is the Ecliptic axis, and that the daily apparent revolution of the stellar globe is effected about the celestial polar axis. One effect of the latter apparent revolution is that the imaginary point of the Ecliptic North Pole daily appears to revolve around the North Celestial Pole, and that the imaginary line of the Ecliptic traced by the apparent annual journey of the Sun round the stellar globe appears to revolve daily with the stellar globe.

Ecliptic North Pole appears to revolve daily round North Celestial Pole, and the Ecliptic to revolve daily with the celestial sphere.

¶ 280. THE TWO AXES OF ASTRONOMICAL REFERENCE.

The polar axis of the celestial sphere is the axis of astronomical reference for the day and the year.

The polar axis of the stellar globe is therefore the axis of reference for the day and the year, since all motions within the year appear to be performed relative to that axis. Owing to Precession, however, the celestial polar axis changes direction with the Earth's polar axis. The stellar globe for one year, therefore, does not bear the same relation to the fixed stars as the stellar globe for another year. In 6500 years the stellar globe turns round 90° in relation to the fixed stars, whereas in the same interval the Ecliptic and

Owing to Precession polar axis of one year does not occupy the same position as the polar axis of any other year.

¶ 282. TAURUS PRE-EMINENT IN EARLIEST HISTORICAL TIMES.

The Bull the symbol of pre-eminence in earliest Euphratean and Egyptian times.

This identification explains the predominance of the Bull, as a symbol of leadership, headship, and general pre-eminence, in ancient Euphratean and Egyptian imagery. This particular symbol appears in the earliest records of the two countries. These records are therefore not anterior to the date 4699 B.C., when the Equinoctial year first began in Taurus. The records clearly prove that they belong to a much later date, when the symbol of the Bull was already a symbol of long-established use. This conclusion is interesting as indicating that pre-dynastic civilisation in Egypt and Mesopotamia —when the rites of the Bull were already woven inextricably into the traditional rituals of the priests—belongs to a period considerably later than 4699 B.C. The epoch of Mena in Egypt and the epoch of Sargani of Akkad are therefore of a still later date or dates.

Symbolic application indicated long-established use.

Proves that pre-dynastic civilisation in Egypt and Mesopotamia —when Bull symbol of pre-eminence was used— was long after 4699 B.C.

Epoch of Mena in Egypt, and epoch of Sargani of Akkad still later.

Long after Taurus had ceased to begin the Equinoctial year, Vergil wrote that " the white bull with the golden horns opens the year." Vergil's statement is clearly a survival of the tradition of a former fact of historical chronology. On the other hand, the existence of the dominant symbol of the Bull in the earliest records of oriental civilisation indicates the total lack of any similar survival of a tradition associating any other sign than Taurus with the beginning of the year. Taurus was already the Sign of tradition when the earliest existing records were inscribed. No existing human relic of an intelligent civilisation can be reliably connected to a date as remote as 4699 B.C. The single fact witnessing to the existence of an organised intelligence at this date is the fact enshrined in the star groups and figures of the Zodiac.

Tradition of Bull's pre-eminence long survived its astronomical identification with beginning of the year.

Lack of such survival in earlier times, and in the case of the sign preceding Taurus—and now known as Gemini—confirms the inference derived above.

Taurus already the Sign of tradition when earliest records were inscribed.

¶ 283. THE LUNAR ZODIAC OF NOCTURNAL SIGNS.

The late Zodiacal conception :— A visible Sun following its annual (Ecliptic) path through the invisible signs of the Zodiac.

The later conception of the Zodiac pictured the Zodiacal Signs as the various stations or houses of the Sun during the Solar year. In this conception, knowledge of the signs as Nocturnal (visible) Signs necessarily preceded their use as Diurnal (and invisible) Signs. The early Zodiac depicted the signs as nocturnal. This conception requires the astronomical assumption of an imaginary Anti-Sun in the Zodiac at midnight in place of the modern conception of the visible Sun in an invisible Zodiac at noon. Now the Anti-Sun would be indicated by the projection of the Earth's shadow on to the celestial sphere, if we can imagine the projection to be possible. The equivalent indication is given at a total lunar eclipse. The Moon, entering the Earth's shadow, indicates the place of the imaginary Anti-Sun in the Zodiac.

Early conception :— The Nocturnal Zodiac of visible signs, with full Moon, slightly above or below the Ecliptic, defining the position of the Anti-Sun.

The Moon, therefore, becomes the ideal medium for defining the path of the Anti-Sun along the Ecliptic in the Zodiac. Successive total lunar eclipses define the Ecliptic. With the latter known, successive full moons, slightly above or slightly below the Ecliptic, determine the precise position of the

Successive total lunar eclipses defined the Ecliptic.

Hence the significance of the early lunar Zodiac.

Anti-Sun on the Ecliptic.[1] The earliest Zodiac is, therefore, the Lunar Zodiac —a system of Nocturnal Signs.

Full Moon at the horns of Taurus at the year's beginning originated horned head-dress of various ancient deities of the year.

From the conception of the Lunar Zodiac originated the many anciently pictured forms of horned head-dress supporting a Moon—the latter often hieroglyphically represented in the shape of a crescent to avoid its being confused with the Sun—figured as crowning various deities of the year. The Lunar Zodiac is the Zodiac of the ancient Euphrateans.

¶ 284. THE EARLIEST ALPHABET.

Taurus as first sign preceded earliest formulation of Semitic languages.

First letter of latter derived from "Taurus," Euphratean name being "Alap."

The primitive form of the letter A derived from bull's horns.

Letter found in primitive Mediterranean "signary," prior to 1st Dynasty in Egypt.

1st Dynasty of Egypt therefore long after 4699 B.C.

"The history of the alphabet is as old as civilisation." (Petrie).

The first sign of this ancient Zodiac was identified with *Taurus* before the existence of the Semitic languages, since in Chaldæan and Hebrew—and in the early forms of Semitic language—*Taurus* was signified by *Alap* or *Aleph*, the first letter of the Chaldæan and Hebrew alphabets. As *alap* signifies *a bull*, the name long preceded the alphabet and the written or inscribed language. Hence, too, that the letter A is derived from ≻ and >, originally the symbol of the horns of the bull. Petrie[2] shows that the latter symbol is met with in Egypt and along the Mediterranean during predynastic times in Egypt—*i.e.* long before the reign of Mena. Its use is therefore remotely later than 4699 B.C., when Taurus = *Alap* began to be the first sign. Long-established identification as the First Sign of the year was necessary before it could give its contribution to the Mediterranean *signary*[3] that formed the primitive alphabet.

Petrie shows that the letter A was in use in Egypt prior to Mena, the first Dynastic king, and makes the significant statement that—

> "The history of the *alpha*bet is as old as civilisation."[3] (The partial italics are ours.)

¶ 285. THE TWO ORIGINAL ZODIACAL SYSTEMS.

Existing extents of the various star groups and their existing traditional figures as recognised in modern times define that existing system is a compromise between two ancient systems.

Referring to Plate XLVIII, the reader will see that generally the signs are alternately long and short, and also, generally, that any two adjacent signs are equal in extent to any other two adjacent signs. Generally speaking, the signs are alternately about 40° and 20°.

Thus the extent of Taurus from the toe of Castor to tail of Aries is 40°; Aries = 20°; total 60°.

Pisces + Aquarius .. = 60°
Capricornus + Sagittarius = 60°
Scorpio + Libra .. = 60°.

Then the rule is disturbed at Virgo and Leo—

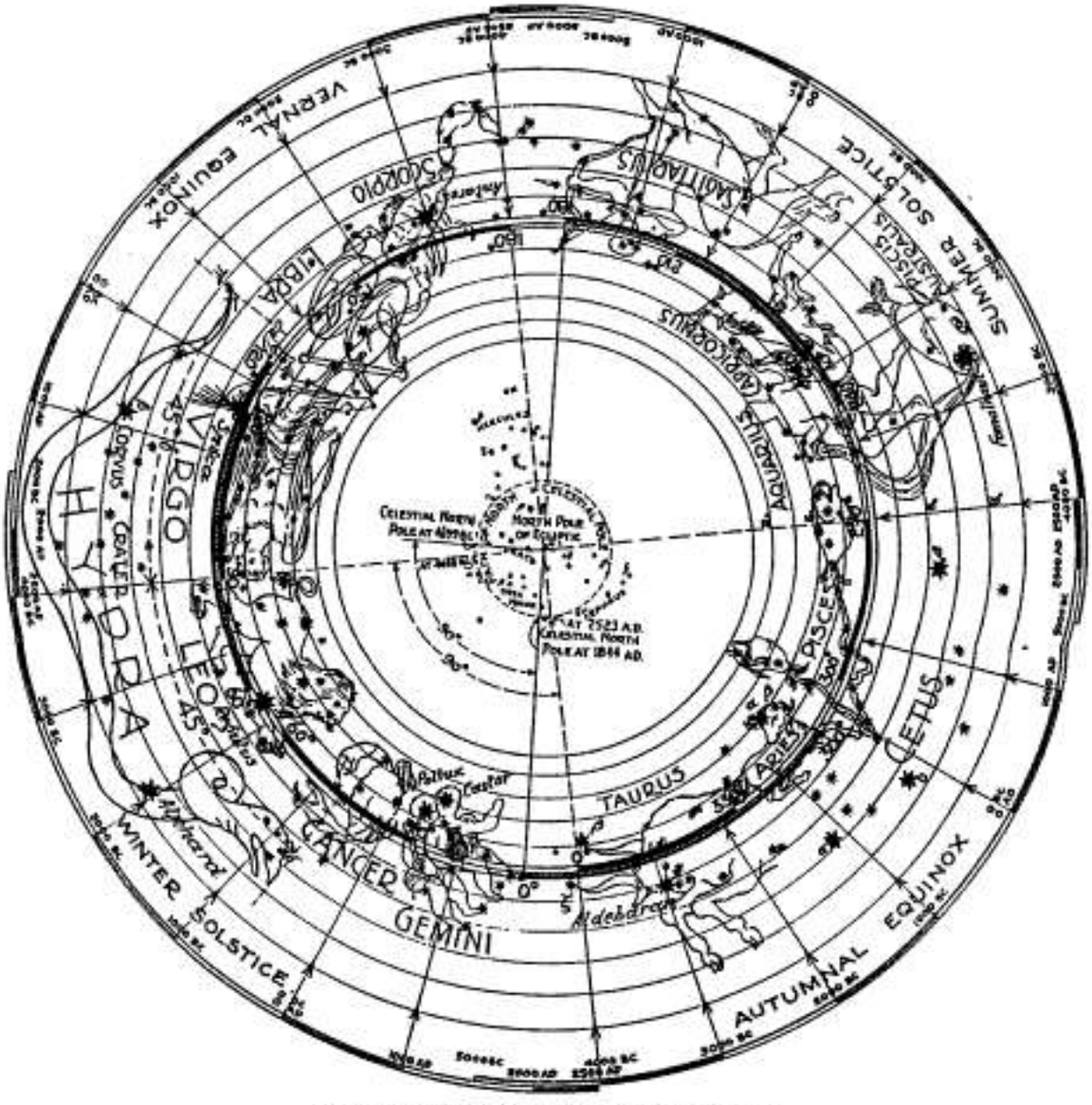
Virgo = 40°; and Leo = 30°
Cancer = 30°; Gemini = 20°.

[1] This point of view is adopted merely for purpose of illustration, as the Anti-Sun can be determined very simply by ordinary methods.

[2] "The Royal Tombs of the 1st Dynasty," I, pp. 31, 32.

[3] Ibid., I, p. 32.

PRECESSION OF THE EQUINOXES AND THE SIGNS OF THE ZODIAC.



STELLAR DEFINITION OF THE SIGNS OF THE ZODIAC.

PLAN OF THE CELESTIAL HEMISPHERE NORTH OF THE ECLIPTIC, TOGETHER WITH DEVELOPED SURFACE OF PORTION OF THE CELESTIAL HEMISPHERE SOUTH OF THE ECLIPTIC.

The Ecliptic is the middle circumferential line of the three circumferential lines defining the Ecliptic Scale of the Zodiacal Signs.

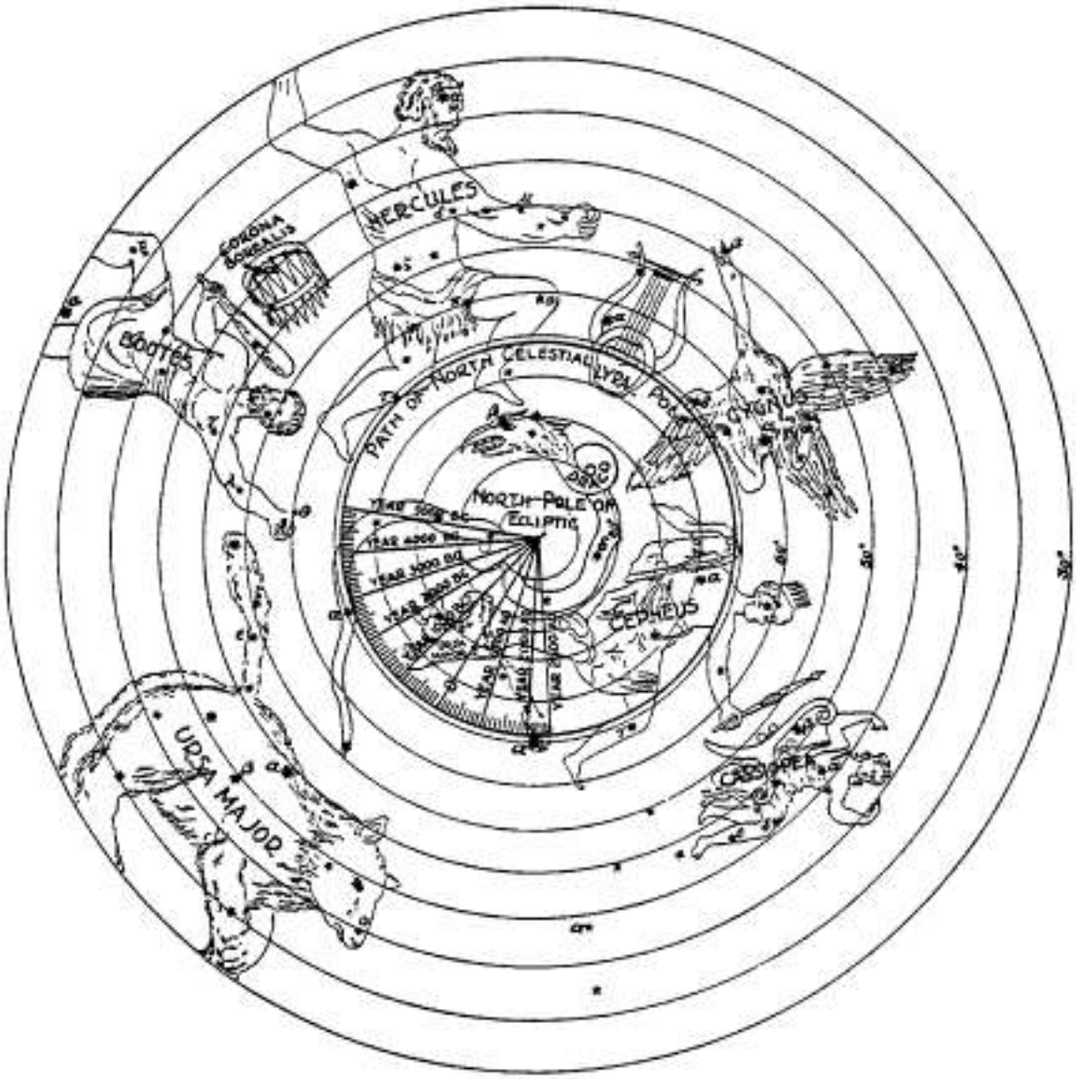
The Outer Scale of years, when projected radially inwards, as indicated, on to the Ecliptic Scale, gives the dated precession of the Equinoxes and Solstices through the Zodiacal Signs.

[To face p. 240.

PLATE XLIX.

(Enlargement of Central Portion of Plate XLVIII.)

THE PRECESSIONAL MOVEMENT OF THE NORTH CELESTIAL POLE.

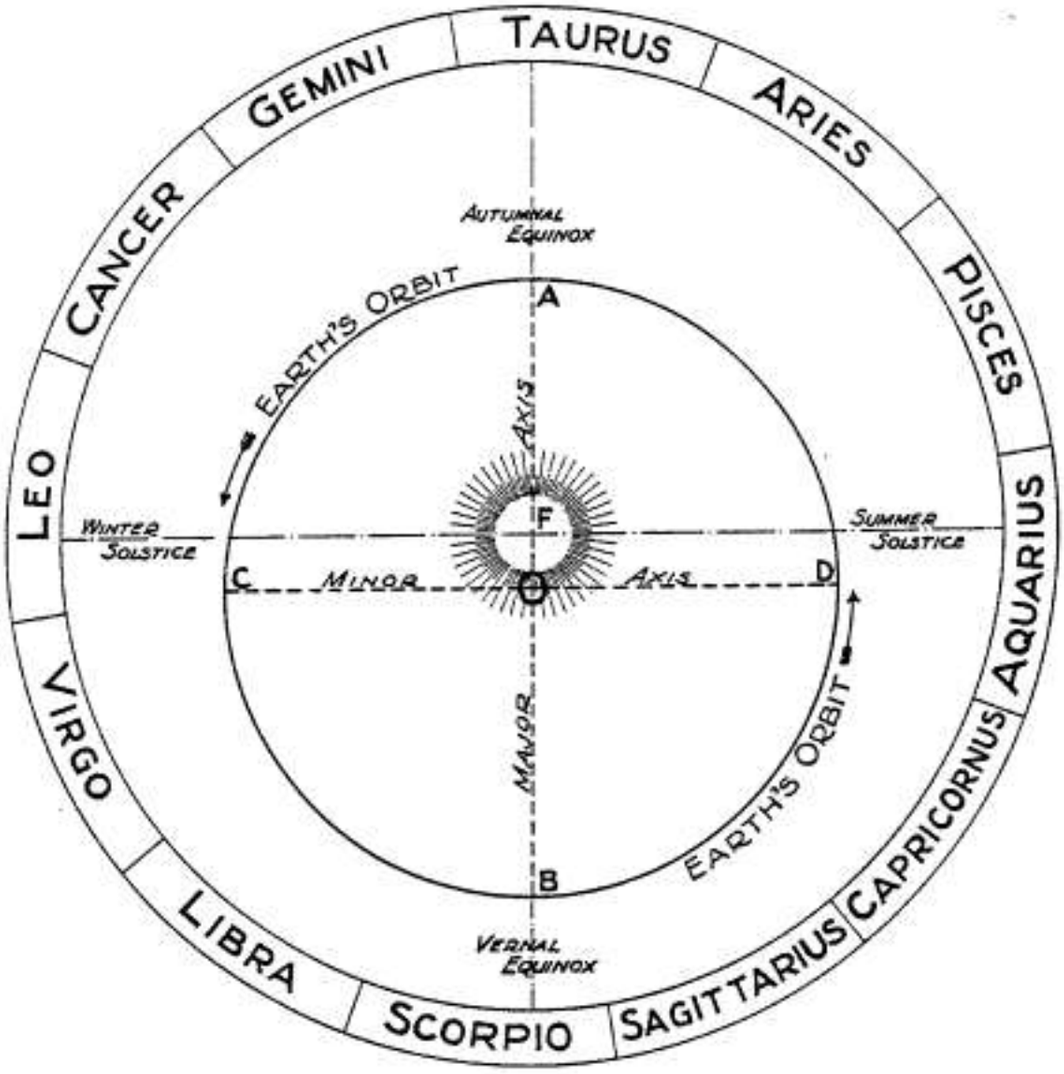


PLAN OF THE CONSTELLATIONS ROUND THE NORTH POLE OF THE ECLIPTIC.

The thick circumferential line defines the Path of the North Pole of the Heavens. The position of the North Pole of the Heavens for any date is given by the intersection of the radially dated line for that date with the latter circle.

PLATE LV.

THE MOTION OF THE EARTH'S ORBIT.



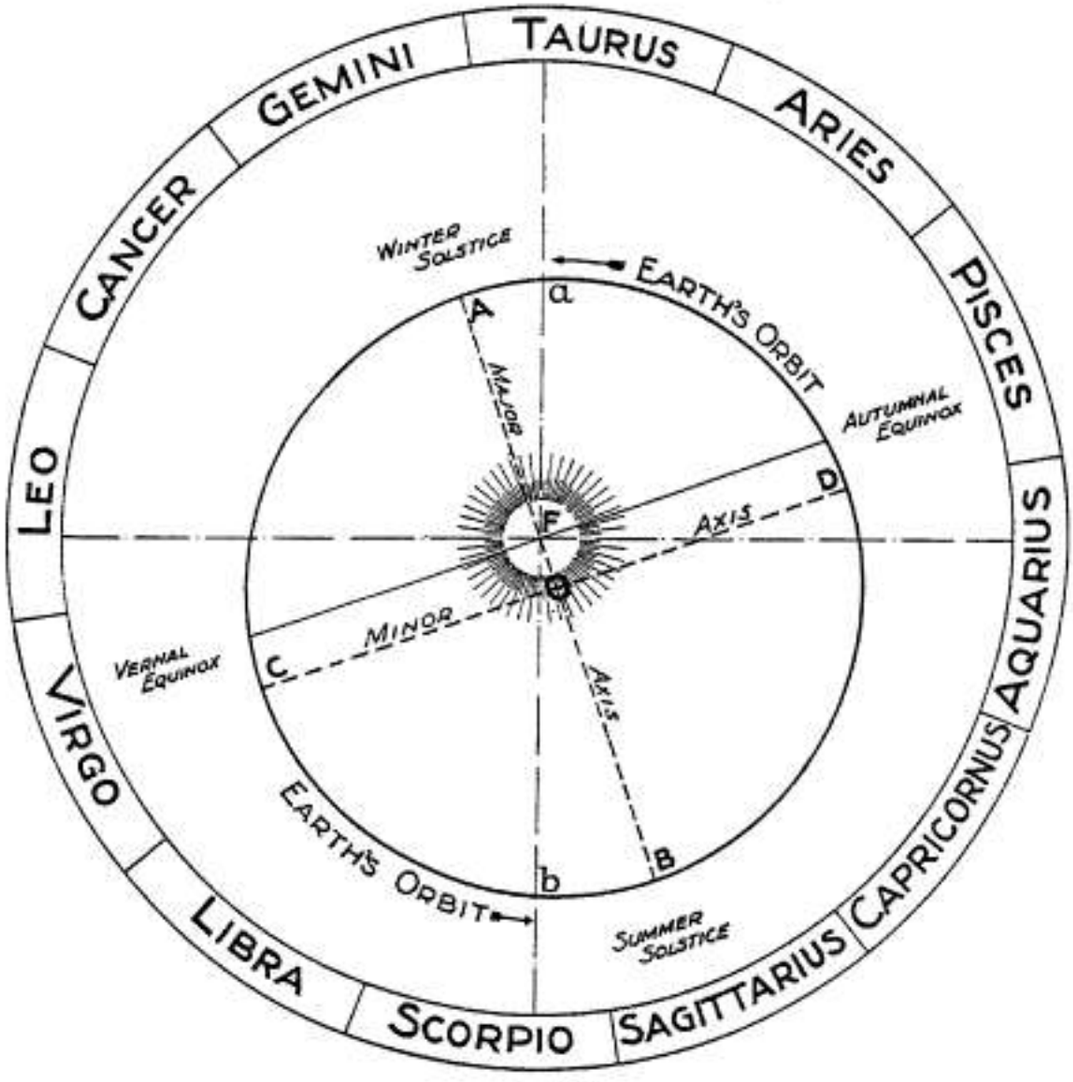
4044 B.C.

Position of the axes of the Earth's Orbit in relation to the Equinoxes and Solstices and in relation to the Zodiacal Signs.

Note :—Perihelion at A, Aphelion at B.

PLATE LVI.

THE MOTION OF THE EARTH'S ORBIT.



1246 A.D.

Positions of the axes of the Earth's Orbit in relation to the Equinoxes and Solstices and in relation to the Zodiacal Signs.

Note :—Perihelion for 1246 A.D. at A ; for 4044 B.C. at a.
Aphelion for 1246 A.D. at B ; for 4044 B.C. at b.

When the value of P is expressed by the algebraic formula $P=A+B.t+C.t^2$, the vertical increment of displacement for the tilting line is a constant for successive years. In other words, for the case defined, the vertical displacement of the tilting line is proportionate to the time in years. It is, therefore, expressed by a straight line equation. The straight line defining the algebraic relations is as shown on Fig. A.

Relation of the values of Fig. A to the vertical displacement of the tilting line of Fig. B.

¶ 304b. PLATE XXXVII. THE GENERAL FORMULA FOR THE MID-DATE EPOCH.

In Fig. A the base line of co-ordinates is the time base of Fig. B. Points 0, 1, 2, 3, 4, 5, and 6 in Fig. A, therefore, represent the same dates as points 0, 1, 2, 3, 4, 5, and 6 in Fig. B. The co-ordinate at any point in Fig. A determines the amount of vertical end displacement of the tilting line in Fig. B for the corresponding point in Fig. B. Thus for point 2 in Fig. A, the value of p is p_2. This value, applied at the points W and Z of Fig. B—as shown on the diagram,—fixes the position of the tilting line for the date represented by the point 2 in Fig. B. The vertical line $2N_2$ from point 2 in Fig. B intersects the tilting line defined at point N_2. The co-ordinate $2N_2$ gives the value of P for the date represented by the point 2. Similarly for the other points.

The geometrical relations of Figs. A and B, Plate XXXVII.

Now, let p be any required value in Fig. A, at a given time, t, forward from the mid-date represented by the point 3. From Fig. A, $p=p_3+q$. Then, since $p_6-p_0=Q$, as shown on Fig. A, and since DE is a straight line, $\frac{q}{t}=\frac{Q}{T}$, or, by simple proportion, $q=\frac{Q.t}{T}$. But since $p=p_3+q$, $p=p_3+\frac{Q.t}{T}$. Otherwise stated, $q=\frac{Q.t}{T}$, is the amount by which the value of p at time, t, from the mid-date exceeds the value of p at the mid-date.

The corresponding algebraic relations.

In Fig. B, P at time, t, from the mid-date is obtained from the value of p obtained in Fig. A. The position of the tilting line at time, t, from the mid-date is the dash line RN_2S. The tilt is such that RW = the value of p obtained from Fig. A. Then, considering the triangle RWN_2,

Detailed explanation of the derivation of the general formula of interpolation for the mid-date epoch.

$$\frac{RW}{WN_2}=\frac{P-P_2}{t} \quad \text{or} \quad \frac{p}{\frac{1}{2}T}=\frac{P-P_2}{t}.$$

Therefore $$P-P_2=\frac{2p.t}{T},$$

and since $$p=p_2+\frac{Q.t}{T},$$

$$P-P_2=\frac{2p_2.t}{T}+\frac{2Q.t^2}{T^2}.$$

$$\therefore \quad P=P_2+\frac{2p_2.t}{T}+\frac{2Q.t^2}{T^2}$$

which is of the general form

$$P=A+B.t+C.t_2;$$

where A, B, and C are constants,

$$A=P_2,$$

$$B=\frac{2p_2}{T},$$

and

$$C=\frac{2.Q}{T^2}.$$

¶ 304c. SPECIAL CASES FOR THE MID-DATE EPOCH.

Case I.—For p and P both increasing with time (t), B and C are both positive (+).

Case I.—For the case illustrated on Plate XXXVII, Figs. A and B, the values of p and P both increase with the time.

In this case, B is positive (+) and C is positive (+), the formula being

$$\left.\begin{aligned} &P = A + B.t + C.t^2; \\ &A = P_3,\ B = \frac{2p_3}{T},\ \text{and}\ C = \frac{2.Q}{T^2} \end{aligned}\right\} \quad .. \quad .. \quad .. \quad \text{I}$$

Case II.—For p and P both decreasing with time (t), B is negative (−) and C is positive (+).

Case II.—For the case illustrated on Plate XXXVII, Figs. C and D, the values of p and P both decrease with the time.

In this case, B is negative (−) and C is positive (+).

The general reader will see why C is positive if he understands that Case II is the equivalent of Case I with the direction of time reversed, *i.e.* t negative (−) in Case I.

$$\left.\begin{aligned} &\text{Then} && P = A - B.t + C.t^2 \\ &\text{since} && (-t)^2 = (-t) \times (-t) = +t^2. \\ &\text{As before} && A = P_3,\ B = \frac{2p_3}{T},\ \text{and}\ C = \frac{2.Q}{T^2} \end{aligned}\right\} \quad .. \quad .. \quad .. \quad \text{II}$$

Case III.—For P increasing and p decreasing with time (t), B is positive (+) and C is negative (−).

Case III.—For the value of P increasing with the time, and the value of p decreasing with the time (Plate XXXVII, Fig. C in conjunction with Fig. B), B is positive (+) and C is negative (−).

Then $P = A + B.t - C.t^2$ III

with values of A, B, and C as before.

Case IV.—For P decreasing and p increasing with time (t), B and C are both negative (−).

Case IV.—For the value of P decreasing with the time, and the value of p increasing with the time (Plate XXXVII, Fig. A in conjunction with Fig. D), B is negative (−) and C is negative (−), as may be proved independently by taking, in Case III, the direction of time reversed.

Then $P = A - B.t - C.t^2$ IV

with values of A, B, and C as before.

¶ 304d. GENERAL FORMULA FOR CHANGE OF EPOCH.

Detailed explanation of the derivation of the general formula of interpolation for a change of epoch.

To transfer to a formula for an epoch other than the mid-date epoch, proceed as follows :—

Let X in Fig. B, Plate XXXVII, represent the new epoch, T_1 years after the mid-date epoch.

Then, as shown on diagram, Fig. B, value of P at date X of epoch $= P_x = a$. From concluding formula of ¶ 304b,

$$P = P_3 + \frac{2p_3}{T}.t + \frac{2.Q}{T^2}.t^2 \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1)$$

$$P_x = P_3 + \frac{2p_3}{T}.T_1 + \frac{2Q}{T^2}.T_1^2 \quad .. \quad .. \quad .. \quad .. \quad (2)$$

Subtracting, we obtain

$$P - P_x = \frac{2p_3}{T}(t - T_1) + \frac{2Q}{T^2}(t^2 - T_1^2);$$

$$P = P_x + \frac{2p_3}{T}(t - T_1) + \frac{2Q}{T^2}(t^2 - T_1^2) \quad .. \quad .. \quad .. \quad (3)$$

Now, as on diagram, Fig. B, let t_1 be the number of years for values of P in relation to the new epoch X, but t_1 being taken as positive[1] (+), forward from date X.

Then $$t_1 = t - T_1 \quad .. \quad .. \quad .. \quad .. \quad .. \quad (4)$$

In formula (3) above, the value of P for the new epoch X is stated as a function of the value of p for the mid-epoch.

By analogy with the mid-epoch formula (¶ 304b), let

$$P = P_x + \frac{2m}{T}.t_1 + \frac{2Q}{T^2}.t_1^2 \quad .. \quad .. \quad .. \quad .. \quad (5)$$

stated in terms applicable to the new epoch ; m being a constant for the new epoch, analogous to p_3 for the mid-epoch.

It is required to state m in terms of p_3, or *vice versa*. Expressing formula (5) in terms of formula (4) we obtain

$$P = P_x + \frac{2m}{T}(t - T_1) + \frac{2Q}{T^2}(t^2 - 2t.T_1 + T_1^2) \quad .. \quad .. \quad .. \quad (6)$$

Subtracting formula (3) from formula (6)

$$\left.\begin{aligned} m &= p_3 + \frac{2Q.T_1}{T} \\ \text{and} \qquad p_3 &= m - \frac{2Q.T_1}{T} \end{aligned}\right\} \quad .. \quad .. \quad .. \quad .. \quad (7)$$

The resulting general formula for a change of epoch is

$$P = a + b.t_1 + c.t_1^2,$$

where

$$a = P_x = P \text{ for new epoch X}$$

$$b = \frac{2m}{T}$$

$$c = \frac{2Q}{T^2}$$

$$m = p_3 + \frac{2Q.T_1}{T}$$

when T_1 is ahead of the mid-epoch.

¶ 304e. SPECIAL CASES FOR THE CHANGE OF EPOCH.

As before, we can express the preceding general formula in the following forms :—

Case I.—Values of p and P both increasing with the time. (Plate XXXVII, Figs. A and B.)

Case I.—Formula for case of p and P both increasing with time.

$$\left.\begin{aligned} &P = a + b.t_1 + c.t_1^2 \\ \text{where} \quad &a = P_x = P \text{ for new epoch X} \\ &b = \frac{2m}{T} \\ &c = \frac{2Q}{T^2} \\ &m = p_3 + \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ follows} \\ \text{the mid-epoch} \end{array} \right. \\ \text{or} \quad &\quad = p_3 - \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ precedes} \\ \text{the mid-epoch} \end{array} \right. \end{aligned}\right\} \quad .. \quad .. \quad V$$

[1] In diagram, Plate XXXVII, Fig. B, t_1 is shown as a negative (−) value of time.

Case II.—Formula for p and P both decreasing with time.

Case II.—Values of p and P both decreasing with the time. (Plate XXXVII, Figs. C and D.)

$$P = a - b.t_1 + c.t_1^2,$$

where a, b, and c are as above, and

$$m = p_3 - \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ follows} \\ \text{the mid-epoch} \end{array} \right. \quad .. \quad .. \quad \text{VI}$$

$$\text{or} \qquad = p_3 + \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ precedes} \\ \text{the mid-epoch} \end{array} \right.$$

Case III.—Formula for P increasing and p decreasing with time.

Case III.—Value of P increasing, and value of p decreasing with time. (Plate XXXVII, Figs. C and B.)

$$P = a + b.t_1 - c.t_1^2,$$

where a, b, and c are as above, and

$$m = p_3 - \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ follows} \\ \text{the mid-epoch} \end{array} \right. \quad .. \quad .. \quad \text{VII}$$

$$\text{or} \qquad = p_3 + \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ precedes} \\ \text{the mid-epoch} \end{array} \right.$$

Case IV.—Formula for P decreasing and p increasing with time.

Case IV.—Value of P decreasing, and value of p increasing with time. (Plate XXXVII, Figs. A and D.)

$$P = a - b.t_1 - c.t_1^2,$$

where a, b, and c are as above, and

$$m = p_3 + \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ follows} \\ \text{the mid-epoch} \end{array} \right. \quad .. \quad .. \quad \text{VIII}$$

$$\text{or} \qquad = p_3 - \frac{2Q.T_1}{T} \left\{ \begin{array}{l} \text{when } T_1 \text{ precedes} \\ \text{the mid-epoch} \end{array} \right.$$

¶ 304f. TOTAL MOTION FOR A GIVEN INTERVAL.

Integration for derivation of true mean value of P for interval t.

To obtain the true mean value of P for a given time, t, from the epoch in the formula

$$P = A + B.t + C.t^2$$

integrate thus—

$$\int P.(dt) = A.t + \frac{B}{2}.t^2 + \frac{C}{3}.t^3.$$

Rigorous method of obtaining total angle covered by motion in interval t years.

Then the true mean value of P for time, t, from the epoch

$$= \frac{\int P.(dt)}{t} = \frac{A.t + \frac{B}{2}.t^2 + \frac{C}{3}.t_3}{t}$$

$$= A + \frac{B}{2}.t + \frac{C}{3}.t^2 \quad .. \quad .. \quad .. \quad .. \quad \text{IX}$$

where P is the annual motion expressed as the period of a cycle.

Then the true mean value of P for 90° of total movement is such that

$$4t = P.$$

$$\therefore \quad 4t = A + \frac{B}{2}.t + \frac{C}{3}.t^2,$$

and $$\frac{C}{3}.t^2+\left(\frac{B}{2}-4\right).t+A=0$$

$$t=\frac{-\left(\frac{B}{2}-4\right)\pm\sqrt{\left(\frac{B}{2}-4\right)^2-\frac{4C}{3}.A}}{\frac{2C}{3}}$$

$$t=\frac{12-\frac{3B}{2}\pm3\sqrt{\left(\frac{B}{2}-4\right)^2-\frac{4A.C}{3}}}{2C} \quad .. \quad .. \quad .. \quad .. \quad X$$

Again,

for 360° $t=P$
,, 180° $2t=P$
,, 60° $6t=P$
,, 30° $12t=P$

} Corresponding alterations being made in formula X.

Let θ = Total angle covered by motion in t years ; then $\frac{360.t}{\theta}=P$

and $$t=\frac{-\left(\frac{B}{2}-4\right)\pm\sqrt{\left(\frac{B}{2}-4\right)^2-\frac{4C}{3}.A}}{\frac{240C}{\theta}} \quad .. \quad .. \quad .. \quad XI$$

Simple method of successive approximation.

Owing generally to formulæ X and XI resolving themselves into a quotient of two small quantities, and to other complicated factors of arithmetical reduction, it is generally simpler and quicker to employ formula IX with trial and error value of t to give $4t=P$ for 90° of total movement, or $\frac{360.t}{\theta}=P$ for θ in degrees of total movement. Two or three brief calculations are generally sufficient, as the reader will find by trial.

¶ 304g. VALUES IN PRECESSIONAL FORMULA FOR DIFFERENT EPOCHS.

Basis :—¶ 236.

$$P=a-b.t_1+c.t_1^2.$$

Values in formula for epochs at 1844 A.D., and

For epoch midnight ending 25th January 1844 A.D.
$a=25,794.212764,$
$b=0.1129593,$
$c=0.000000143051 1,$

and formulæ VI, ¶ 304e—

At 1000 years' intervals from 4000 B.C. to 2001 A.D.

Epoch : Autumnal Equinox.	Values in years of a.	b.	c.
4000 B.C. = 0 A.P.	26,459.038617	0.1146308096	Constant for all Epochs, 0.000000143051 1
3000 B.C. = 1000 A.P.	26,344.550859	0.1143447074	
2000 B.C. = 2000 A.P.	26,230.349202	0.1140586052	
1000 B.C. = 3000 A.P.	26,116.433648	0.1137725030	
1¾ A.D. = 4000 A.P.	26,002.804196	0.1134864008	
1001¾ A.D. = 5000 A.P.	25,889.460847	0.1132002986	
2001¾ A.D. = 6000 A.P.	25,776.403599	0.1129141964	

Influence of the Pyramid's displacement factor.

It will be noticed that b reduces its value by 0.000286102 per 1000 years' change of epoch; 286.1022 being the numerical value of the Pyramid's Passage Displacement, and of the displacement of the Pyramid's central extent of base side (¶¶ 225, 233–235).

¶ 304h. PRECESSIONAL FORMULA FOR ANNUAL ANGULAR RATE.

Epoch 1850:—P in cyclic time.

The Pyramid's precessional formula for epoch 1st January 1850 A.D. is as follows:—

P as annual angular rate.

$$P = 25{,}793.542356 - 0.11295760522t + 0.000000014305t^2,$$

whereas Newcomb's for the same epoch is

$$P = 25{,}793.46 - 0.114t \quad .. \quad .. \quad .. \quad \text{(refer ¶ 224)}$$

(applicable from 1600 to 2100 A.D.).

Newcomb's corresponding formula.

The Pyramid's precessional value, when expressed as the rate in seconds of angle per year (for 1st January 1850 A.D. epoch)

$$= 50''.2451343097 + 0.0002200383835t + 0.00000000068447t^2;$$

whereas Newcomb's formula for the same epoch is

$$50''.2453 + 0.0002222t \text{ (refer ¶ 224)};$$

Bauschinger's corresponding formula.

Bauschinger's being

$$50''.2453 + 0.00022218t \text{ (refer ¶ 223)}.$$

Mathematical defect in interpolative statement of angular rates as derived from true interpolative statement of cyclic time rates.

The above data are for comparison only. The reason for emphasising this is that, if the formula for P (expressed as years of Cycle) *precisely* agrees with the formula $P = a - b.t_1 + c.t_1^2$, it is mathematically certain that when the data derived from the same are converted into the formula

$$\text{Seconds of angle per year} = a + b.t_1 + c.t_1^2,$$

the latter formula does not *precisely* define the motion *over the long periods* accurately covered by the cyclic form of the same. The formula thus obtained, however, is very accurate indeed; when integrated to obtain the total angle of precession over a long interval a very slight discrepancy occurs. It is not very material, but serves to show that the angular functions cannot be as accurately expressed by the general interpolation formula $P = a + b.t_1 + c.t_1^2$, as in the case of the cyclic functions thus expressed.

¶ 304i. PERIHELION MOTION.

$$P = a - b.t_1 + c.t_1^2.$$

Values in formula for epochs 2001 A.D., 2045 A.D., and 4044 B.C.

Basal Data:—

P for 6000 A.P. (2001¾ A.D.) = 21,000 .. .. (¶ 246)

Epoch, midnight ending 25th January 1844 A.D.:—

a = 21,006.883208
b = 0.043679295$\dot{3}$
c = 0.000000143051$\dot{1}$
} refer ¶ 247.

Other Epochs:—

Epoch 6043.9707355 A.P. = 2045¾ A.D.:—

a = 20,998.081926
b = 0.04362160826
c = 0.000000143051$\dot{1}$
} refer ¶ 247.

Epoch 43.9707355 prior to 0 A.P. =4044 B.C., when longitude of Perihelion =0° :—

a =21,269.051404
b =0.0453633817
c =0.000000143051 1 } refer ¶ 247.

The latter values, when employed with the method of ¶ 304f, give the longitude of Perihelion 90° at 1246¼ A.D., and longitude of Perihelion 103° 42′ 28″.6 (the sum of the base angles of the Pyramid's vertical section) at 6043.97 A.P. =2045¾ A.D. (refer ¶ 247).

Longitude of Perihelion 90° at 1246¼ A.D. and 103° 42′ 28″.6 (sum of base angles of Pyramid section) at 2045 A.D.

Epoch : Autumnal Equinox.	Values in Years of a.	b.	c.
4000 B.C. = 0 A.P.	21,267.054970	0.0453508015	
3000 B.C. =1000 A.P.	21,221.747219	0.0450646993	
2000 B.C. =2000 A.P.	21,176.825571	0.0447785971	Constants for all Epochs, 0.000000143051 1
1000 B.C. =3000 A.P.	21,132.190025	0.0444924949	
1¾ A.D. =4000 A.P.	21,087.840581	0.0442063927	
1001¾ A.D. =5000 A.P.	21,043.777239	0.0439202905	
2001¾ A.D. =6000 A.P.	21,000.000000	0.0436341883	

Values in formula for epochs 1000 years apart from 4000 B.C. to 2001 A.D.

¶ 304j. MODERN PERIHELION VALUES COMPARED WITH THE PYRAMID'S.

In Gausz's " Tafeln " (Edit. 1917)—
Longitude of Perihelion for 1st January 1910 A.D.
is given as .. .. 101° 23′ 3″.0
Pyramid's value for same is .. .. .. 101° 22′ 54″.4
Difference .. .. 0° 0′ 8″.6

Modern stated longitude of Perihelion for 1910 A.D. 8″.6 only in excess of Pyramid's value for same date.

Having regard to the circumstances of the two presentations, one contemporaneous with and the other remotely anterior to the longitude defined, anything smaller than the difference of 8″.6 obtained can scarcely be imagined. In fact, the difference falls within the modern limits of error in determining the longitude of Perihelion.

Difference within modern limits of error.

Again, when the Pyramid's Perihelion cyclic value of P for 1st January 1910 A.D. (*i.e.* 21,004.001 years) is transformed into the equivalent annual value for the change of longitude of Perihelion, the value, stated to 2 decimal places, is .. 61″.70
whereas Gausz, " Tafeln " (Edit. 1917), gives for 1910 A.D. .. .. .. 61″.68
Difference .. .. .. 0″.02

Modern stated annual rate of change in longitude of Perihelion for 1910 A.D. 0″.02 only less than Pyramid's value for same date.

Again, the small difference of 0″.02 falls within the modern limits of error in determining the annual rate of change of the longitude of Perihelion.

Difference within modern limits of error.

It should be noted by the reader that research on the motion of Perihelion has not been so extensive or complete as in the case of Precessional motion ; and that the

Research on motion of Perihelion compared with research on Precessional motion.

determination of the annual values related to Perihelion, for any particular year, is complicated by the intricate factors governing the elements of all the planetary orbits of the Solar System.

¶ 305. PLATE XXXVIII, FIGS. A, B, AND C. DEFINITION OF PASSAGE SLOPE.

Connected relations of Plate XXXVIII.

Figs. A, B, and C of Plate XXXVIII, as figured and lettered, largely explain themselves. Essential details of Fig. A are given in ¶ 225, and of Figs. B and C in ¶¶ 226 and 227. The relation between the three figures of Plate XXXVIII and the various stages of Plate XL are given in ¶¶ 228 to 231. An important relation between Plate XXXVIII, Fig. A and Plate XL, Fig. A is defined in footnote to ¶ 242.

Scalar Axis of Ascending Passage defined in relation of general geometry of Pyramid.

The general reader, with but a slight knowledge of geometrical methods, will see that the Scalar Axis construction of Plate XL, Fig. A—here derived from Plate XXXVIII, Fig. A—can be obtained directly as a geometrical construction from Plate XXIII, Fig. A, Case I. The construction was omitted, as a possible over-elaboration.

The method, however, is as follows :—Referring to Plate XXIII, Fig. A, Case I, let the Section shown be a North to South Vertical Section—

$$F_1k_1 = 2861.022156\ P'',$$

and

$$B_2A_1B_1 = 6456.6355945\ P''.$$

Method explained as relating to Plates XXIII, XXXVIII, and XL.

From k_1 drop a vertical to cut A_1B_1 at a point which we may term p. Then $A_1p = 2861.022156\ P''$. On and below A_1p construct a square of which A_1p is the upper horizontal side. The lower horizontal side of this square is then 2861.022156 P'' below the precessional circuit level A_1B_1. Continue the lower horizontal side to pass through and beyond the geometrical North face slope of the Pyramid, produced below the base. The line thus obtained is the line XY in Plate XL, Fig. A. Now, with $B_2A_1B_1 = 6456.6355945\ P''$, of Plate XXIII, Fig. A, Case I, as radius, and point A_1 as centre, describe a circle to intersect the lower horizontal line above defined. The intersection occurs at point Y of Plate XL, Fig. A.

¶ 306. PLATE XXXIX. GENERAL SCHEME OF PASSAGE SYSTEM.

Projection of 1st Ascending Passage indicates geometrical datum and basis of geometrical construction.

Plate XXXIX illustrates how the structural indications, as seen in a sectional elevation taken along the plane of the axes of the Passages, suggest the geometrical framework of the Passage system. The roof and floor lines of the 1st Ascending Passage are shown produced to intersect the line produced of the North face slope. This intersection naturally forms a geometrical zero datum for measurements along the Passage slope. The indication thus supplied leads to the various geometrical constructions and astronomical identities of Plates XL, XLI, and XLII.

The Edgars' error in reconstruction of the Pyramid base and of the Passage system.

Error not in data of text but in drawn data.

At first sight the drawing may seem to be an exact copy of the splendid Plate appearing in Messrs. Edgars' work.[1] We willingly acknowledge our indebtedness to the Edgars for many new details furnished by them as a result of their and Dow Covington's investigations and measurements. The Plate furnished by the Edgars, however, supplies a measurement horizontally from the Great Step to North base casing edge, 36 inches in excess of the true distance obtained by Petrie's survey. This shows that the Edgars theoretically reconstructed the measurement of the casing base by ignoring Petrie's survey; precisely as Petrie theoretically reconstructed the casing corners and arris edges by ignoring the hollowing-in feature observed by him.

[1] "Great Pyramid Passages," Vol. I, Plate IX.

Petrie's total Passage floor distance from the hollowed-in casing face to the vertical face of the Great Step is precisely as shown on Plate XXXIX. In the Plate supplied by the Edgars, owing to the casing stones being shown in section, where our Plate shows the arris edge in elevation, the total distance (Edgars') from the Great Step to the casing face thus obtained is 28¾ inches longer than Petrie's, or any other measurement. This fact is not noted in the text of the work referred to. It is doubtful even if the Edgars knew of the discrepancy. The reader will find it, however, by scaling the plate referred to. Strangely enough, the error occurs, not in the Entrance Passage length, but in the Grand Gallery length. A corresponding error occurs in the horizontal length of the Passage to the Queen's Chamber.

Existing base casing stones shown displaced 36 inches.

Owing to same Grand Gallery length scales 28¾ inches too long.

¶ 306a. A PUZZLE OF SIXTY YEARS' STANDING.

The reason for the error of 28¾ inches in excess for the Grand Gallery—as scaled from Messrs. Edgars' Plate—will appear when the reader refers to our Plate XLI, Fig. H. In thus drawing attention to Edgars' mistake in reconstructing, the intention is not merely to criticise. The same initial error occurred in the first published series of articles dealing with the preliminary discoveries of the present work.[1] The error in our case affected, not the Gallery length, but the Entrance Passage length. When we observed that our geometrical length for the latter was 28¾ inches in excess of Petrie's measured length for the Entrance Passage, the reason for the difference appeared at once. Prior to this we had unwittingly adopted the same view as the Edgars concerning the casing base. The observing of the error noted supplied the first indication of the hollowing-in feature. The hollowing-in feature was, in fact, suggested to us by the geometrical indications prior to any knowledge on our part that Petrie had observed the precise extent of hollowing-in on the core escarpments.

Error due to not realising hollowing-in feature.

The same error occurred in initial form of present discoveries (1909-1910).

This gave our original Entrance Passage length 28¾ inches too long.

Discovery of this error led to discovery of hollowing-in independently of Petrie's statement.

The same error of 28¾ inches will be seen to have perplexed Professor Smyth. In his "Life and Work" Plates, and in the first three (or four) editions of his "Our Inheritance," the Great Step and the centre of the Queen's Chamber are both shown thrown to the South of the Pyramid's central vertical axis. In his 5th Edition of the latter work, however, Smyth adopted Petrie's Passages and his casing base at pavement level. At the same time Smyth adopted the untenable theory already dealt with in ¶¶ 174 and 175.

Smyth's original (1864) and revised (circa 1890) casing base of Pyramid in error for the same reason.

¶ 307. PLATE XL, FIGS. A, B, AND C. THE SCALAR AXIS AND SCALAR ZERO.

The preliminary geometrical bases of Plate XL appear on Plate XXIII, Fig. A, Case I, and Plates XXXVIII and XXXIX, for which refer ¶¶ 305 and 306. These bases define the constructions for the Scalar Axis, DCFY of Plate XL, Figs. A, B, and F. The geometrical indications that supplied the important angular relation of the line FT are supplied in the footnote to ¶ 242.

Sequence of geometrical constructions—Plates XXIII (Fig. A), XXXVIII, XXXIX, and XL.

It should be noted by the reader that the reference lettering in the diagrams of Plates XL and XLI is unchanged throughout.

Reference lettering of Plates XL and XLI constant throughout.

The dimensions throughout are accurately calculated in all cases from the various geometrical bases adopted. The reader should observe that the only basal *dimensional* feature adopted in Plate XL, Fig. B, extra to the dimensional features resulting from the geometrical construction of Fig. A, is the scalar distance of 2000 P″. The verticals 886.2269254 P″ and 2588.8194161 P″, and the horizontal 5237.4561800 P″ follow as calculated results from the adoption of CG = 2000 P″. In Plate XL, Fig. B, the dimensions of GH and HK are unknown. GH and HK are merely figured here

All dimensions are calculated from geometrical bases, i.e. without any basis derived from measured distances.

Plate XL, Figs. A and B, sequence of essential data.

[1] These were written by D. Davidson in 1909, and published in 1910. The articles are now out of print.

2000 P″ scalar value.

as further geometrical indications supplied by the constructions of Plate XXXIX and Plate XL, Fig. B.

Fig. C :— The geometrical function of the square of equal area. Defines the scalar zero for Passage measurements.

Plate XL, Fig. C, supplies the geometrical basis for the determination of the dimensions of GH and HK. K is the point of intersection of the 1st Ascending Passage roof line and the face of the Pyramid, both produced to effect the intersection. The horizontal QPK through the point of intersection, K, cuts the 1st Ascending Passage floor line at P, such that the horizontal distance QP from the Pyramid's central vertical axis is 5151.6498562 P″. The latter dimension is the length of the side of the square of area equal to the area of the Pyramid's right vertical section. This dimension defines the co-ordinates of the point of intersection K, and also the scalar zero for passage measurements.

¶ 307a. PLATE XL, FIGS. C, D, AND E. THE SEQUENCE OF CALCULATIONS.

Manner of definition of scalar zero.

The manner in which the latter are defined is as follows :—

The sloping Passage distance DG = MH is known from Plate XL, Fig. B.

In Plate XL, Fig. C, QP being given supplies by calculation the sloping Passage distance MP.

Fig. D :— 1st Ascending and Entrance Passage height.

Then MH − MP = PH, as shown in the text of Fig. C. This gives the basis for the calculations supplying all the co-ordinates related to the Passage height. These are as figured on Plate XL, Fig. D.

Fig. E :— Vertical height from Passage floor to Scalar Axis.

Similarly, as shown on Plate XL, Fig. C, the vertical height between the Passage floor and the Scalar Axis is derived from the combined data of Fig. C and Fig. D. The resulting calculated co-ordinates are as shown on Fig. E.

All the co-ordinates of K and G, in Figs. D and E, are bases, perpendiculars, and hypotenuses of right-angled triangles, with the hypotenuse in each case making an angle of 26° 18′ 9″.63 with the base. Angle KÛd (in Fig. D) = 51° 51′ 14″.3, the Pyramid base angle.

Complete dimensions of 1st Ascending Passage. Vertical distance of Great Step above the pavement base.

The relations of Figs. D and E, thus calculated, enable us to complete all the geometrical dimensions—vertical, horizontal, and sloping—of the 1st Ascending Passage produced between the Pyramid's central vertical axis and its geometrical North face slope produced. The important resulting vertical dimension, shown on Fig. C, is the vertical distance AM of the point M, the foot of the Great Step, above the pavement base level, AB.

The above is merely a skeleton outline of the geometrical sequence and of the sequence of calculations, to enable the general reader to piece together the various stages and calculations of Plate XL, Figs. A to E. The diagrams were prepared to be self-explanatory.

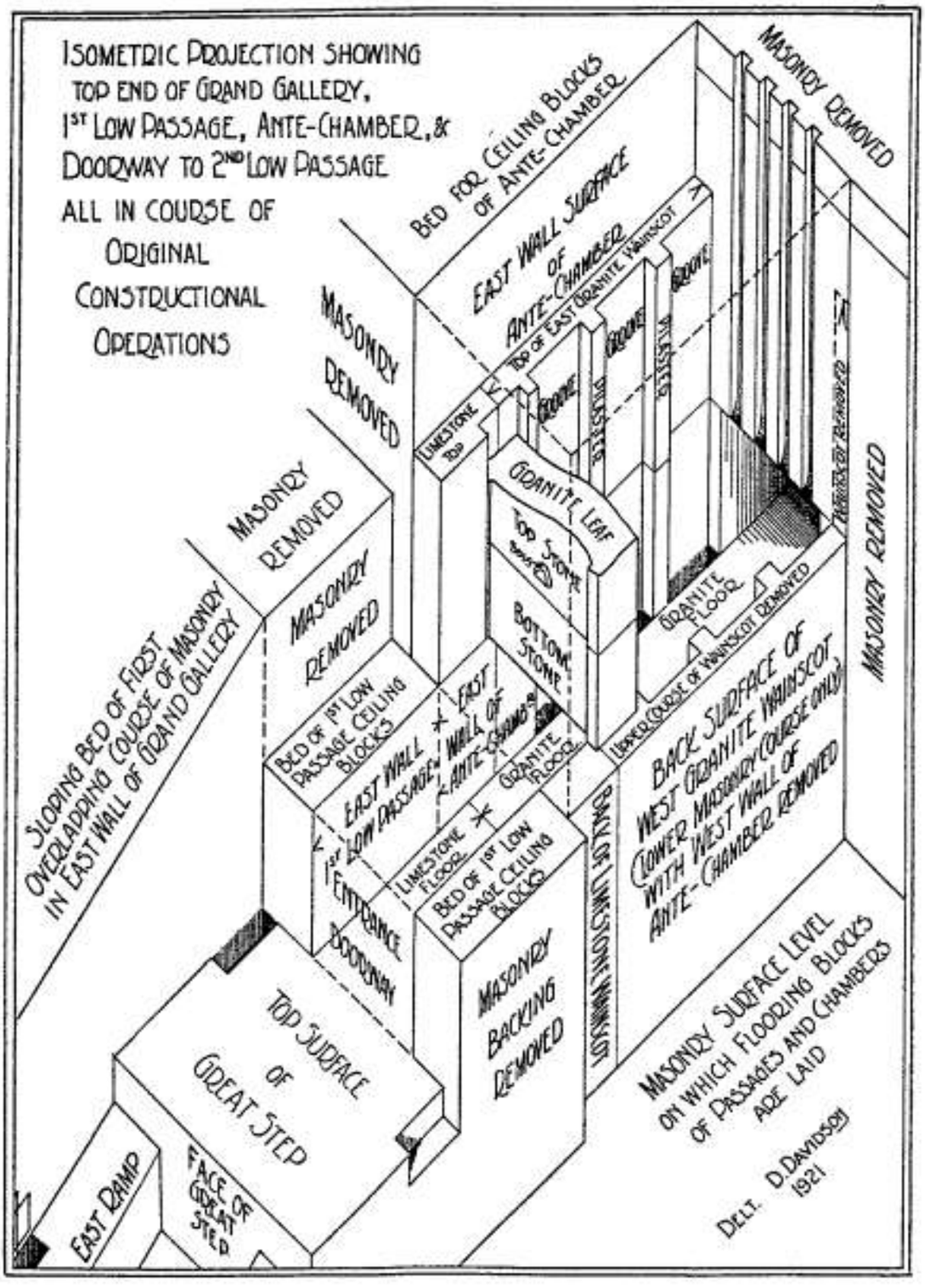
¶ 307b. PLATE XL, FIG. C. THE RHOMBOID OF DISPLACEMENT.

The rhomboid of displacement. Each side 286.1 P″. Structural definition of the planes of all sides except the North.

An important geometrical detail shown on Plate XL, Fig. C, is the rhomboid[1] of displacement, of which $W_1W_2Z_2Z_1$ is the side elevation, or rhombus elevation. The twelve dimensional lines forming its edges are each 286.1 P″. The rhomboid thus defined is a solid figure bounded on its upper surface by the plane of the Grand Gallery roof, W_2Z_2; on its lower surface, by the plane of the 1st Ascending Passage roof produced, W_1Z_1; on its West side, by the North to South central vertical plane of the Pyramid; on its East side, by the central vertical plane of the passage axis; on its South side, by the East to West central vertical plane of the Pyramid; and on

[1]The designation, although not precisely correct, will be better understood by the majority of readers. The correct term is "rhombohedron."

PLATE LVII.


ISOMETRIC PROJECTION SHOWING TOP END OF GRAND GALLERY, 1ST LOW PASSAGE, ANTE-CHAMBER, & DOORWAY TO 2ND LOW PASSAGE ALL IN COURSE OF ORIGINAL CONSTRUCTIONAL OPERATIONS
BED FOR CEILING BLOCKS OF ANTE-CHAMBER
MASONRY REMOVED
EAST WALL SURFACE OF ANTE-CHAMBER
TOP OF EAST GRANITE WAINSCOT
GROOVE
GROOVE
GROOVE
LIMESTONE TOP
GRANITE LEAF
TOP STONE
BOTTOM STONE
GRANITE FLOOR
LOWER COURSE OF WAINSCOT REMOVED
MASONRY REMOVED
MASONRY REMOVED
MASONRY REMOVED
SLOPING BED OF FIRST OVERLADDING COURSE OF MASONRY IN EAST WALL OF GRAND GALLERY
BED OF 1ST LOW PASSAGE CEILING BLOCKS
EAST WALL OF 1ST LOW PASSAGE
EAST WALL OF ANTE-CHAMBER
GRANITE FLOOR
BACK SURFACE OF WEST GRANITE WAINSCOT (LOWER MASONRY COURSE ONLY) WITH WEST WALL OF ANTE-CHAMBER REMOVED
1ST ENTRANCE DOORWAY
LIMESTONE FLOOR
BED OF 1ST LOW PASSAGE CEILING BLOCKS
BACK OF LIMESTONE WAINSCOT
MASONRY BACKING REMOVED
TOP SURFACE OF GREAT STEP
EAST RAMP
FACE OF GREAT STEP
MASONRY SURFACE LEVEL ON WHICH FLOORING BLOCKS OF PASSAGES AND CHAMBERS ARE LAID
DELT. D. DAVIDSON 1921