THE RECONSTRUCTION OF THE ANTIKYThERA MECHANISM INSTRUCTION MANUAL AFTER A DILIGENT STUDY AND ANALYSIS OF THE BACK COVER INSCRIPTION (PART-1)

A. Voulgaris¹, C. Irakleous², C. Mouratidis³, A. Vossinakis⁴

¹City of Thessaloniki, Directorate Culture and Tourism, Thessaloniki, GR-54625, Greece
²Independent Researcher, Thessaloniki, GR-54248, Greece
³Merchant Marine Academy of Syros, GR-84100, Greece
⁴Thessaloniki Astronomy Club, Thessaloniki, GR-54646, Greece

Abstract

The Inscriptions which were on the Back Cover of the Antikythera Mechanism were the User’s Manual of the Antikythera Mechanism. In the Back Cover Inscription Part-1 text, the Presentation, Position, and Operation of the outer parts of the Mechanism’s Front face was engraved by the ancient manufacturer (?). Although this technical text is partially/poorly preserved, useful information, results, and conclusions were retracted by studying the words/sentences adapted on their original geometrical positions, concerning the image of the Mechanism’s front face. After the study and the analysis of the preserved text and its characteristics, the missing text completion is presented. A significant part of the reconstructed text was reproduced using the preserved words and phrases. In many cases the reconstructed text can be considered as definite. The use of the author’s Antikythera Mechanism functional model was critical for the analysis and understanding the preserved text, contributing to the design and reconstruction of the Mechanism’s Front Face parts, which are not preserved nowadays.

Keywords: Antikythera Mechanism Inscriptions, User’s Manual, Back Cover Inscription, planet indication gearing, Lunar pointer, Front Dial plate

Περίληψη

Στις Επιγραφές του Οπίσθιου Καλύμματος του Μηχανισμού των Αντικυθήρων, παρουσιάζεται το Εγχειρίδιο Χρήσης του. Στο κείμενο των επιγραφών του Τμήματος-1 αναφέρεται η Περιγραφή, η Θέση και η Λειτουργία των εξαρτημάτων του Μηχανισμού, που βρίσκονται στο εξωτερικό πρόσθιο τμήμα του. Μολονότι αυτό το τεχνικής φύσεως κείμενο, διασώζεται τμηματικά, εντούτοις από τη μελέτη των λέξεων/προτάσεων τοποθετημένες στις αντίστοιχες γεωμετρικές θέσεις τους, προέκυψαν χρήσιμες πληροφορίες και συμπεράσματα που αφορούν την εικόνα της πρόσθιας πλευράς του Μηχανισμού. Σε αυτή την εργασία παρουσιάζεται η συμπλήρωση του χαμένου κειμένου, ύστερα από την ανάλυση των χαρακτηριστικών του υπάρχοντος κειμένου. Ένα μεγάλο ποσοστό του ανακατασκευασμένου κειμένου προέρχεται από αναπαραγωγή των υπαρχόντων λέξεων και φράσεων του κειμένου, μια και εντοπίστηκε μία σταδερή επαναληπτικότητα σε συγκεκριμένες φράσεις. Σε αρκετές περιπτώσεις η ανακατασκευή του κειμένου μπορεί να θεωρηθεί θέματος. Για την ανάλυση, την κατανόηση και την ανακατασκευή του Εγχειρίδιο Χρήσης του Μηχανισμού των Αντικυθήρων (Τμήμα-1), είχε καθοριστικό ρόλο η ταυτόχρονη χρήση του λειτουργικού μοντέλου του Μηχανισμού σχεδιασμένου και κατασκευασμένου από τους συγγραφείς. Η ανάλυση του σωζόμενου κειμένου οδήγησε στον σχεδιασμό και την ανακατασκευή των μπρούντζινων εξαρτημάτων που δεν διασώζονται σήμερα.

Keywords: Antikythera Mechanism Inscriptions, User’s Manual, Back Cover Inscription, planet indication gearing, Lunar pointer, Front Dial plate
1. Introduction

The Antikythera Mechanism was a Time Machine and an astronomical events calculator, constructed and (probably) used during the Hellenistic Era of 200-100 BC. It consists of a large number of gears, axes, shafts, pointers, scales, and plates. After 2000 years under the sea and its retraction in 1901, today the Mechanism is partially preserved in seven relatively large fragments (A-G) and 75 small pieces (minor fragments 1-75).\(^1\) The fragments’ corrosion is evident, as well as the strong deformation and displacement of the parts resulted from the material/density change.\(^2\) The corrosion destroyed many parts and erased a large portion of the inscriptions.

On all the available bronze areas of the Mechanism the ancient manufacturer engraved important information related to the extruded results of the pointers. Additionally, on the two bronze Cover plates, which were located on Front and Back side on the Mechanism’s main body, a large text was engraved on each.\(^3\)

Each of these thin bronze/copper plates was possibly stabilized by pins on a wooden plate: The bronze plates of the Mechanism’s main body were also supported sideways by a wooden decorative case. The probable existence of two wooden bearing plates of the Back Cover (bronze) plates creates an intergraded wooden case.\(^4\)

These two covers could be permanently adapted to the main body, acting as the “doors” of the Mechanism. On the plates, extensive information with a large number of sentences was engraved. In order to be read easily, these two covers could be totally independent, playing the role of a bronze page book. The two cover plates could be assembled and secured on the main body, by a leather strip or a bronze bordure, creating a small wooden chest.\(^5\)

On the Back Cover the ancient Manufacturer - in this work we call him The Engraver - engraved a text that was the User’s Manual of the Antikythera Mechanism.\(^6\)

Claudius Ptolemaeus, in Almagest describes the construction and use of a Dioptra for angle measurements.\(^7\) He refers to the words: ΚΥΚΛΟΝ ΧΑΛΚΕΟΝ, ΚΥΛΙΝΔΡΙΑ, ΤΕΤΟΡΝΕΥΜΕΝΑ, ΓΝΩΜΟΝΙΑ, ΚΥΚΛΙΣΚΟΣ, ΞΥΛΙΝΗΝ ΠΛΙΝΘΙΔΑ (circular copper plate, small cylinders, formed parts by the use of lathe, pointers, small circle, wooden base etc.) and giving information for

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\(^1\) [http://www.antikythera-mechanism.gr/data/fragments](http://www.antikythera-mechanism.gr/data/fragments)

\(^2\) Voulgaris et al., 2019b and Voulgaris et al., 2021

\(^3\) Price 1959 and 1974; Freeth et al., 2006; Bitsakis and Jones 2016b

\(^4\) Voulgaris et al., 2019b

\(^5\) Voulgaris et al., 2019b

\(^6\) Bitsakis and Jones 2016b

\(^7\) Claudius Ptolemaeus, 1898, Syntaxis mathematica, Book A, ΠΕΡΙ ΤΗΣ ΜΕΤΑΞÙ ΤΩΝ ΤΡΟΠΙΚΩΝ ΠΕΡΙΦΕΡΕΙΑΣ
the use of the instrument. Heron Alexandreus 1903 in ΠΕΡΙ ΔΙΟΠΤΡΑΣ describes the construction and use of a Διοπτρα for measuring angles, which are useful for the construction of buildings, walls, ports, and also for celestial sphere measurements, solar and lunar eclipses, stars etc. He refers to the words: ΣΤΥΛΙΣΚΟΣ, ΤΥΜΠΑΝΙΟΝ, ΤΥΜΠΑΝΙΟΝ ΟΔΟΝΤΩΜΕΝΟΝ, ΕΛΙΚΑ, ΧΑΛΚΑ ΣΤΗΜΑΤΙΑ, ΣΩΛΗΝ, ΥΑΛΙΝΑ ΚΥΛΙΝΔΡΙΑ (small pillar, base, base with teeth, helix, copper bearings, tube, glass small cylinders etc.).

Today, a significant percentage of the Antikythera Mechanism User’s Manual is missing. The first attempt for the letter recognition was started by I. Svoronos, A. Rehm, I. Theophanidis and then continued by D.S. Price.

In 2004, during the implementation of the Antikythera Mechanism Research Project, an X-Ray tomograph 450keV was used for the study of the Mechanism’s fragments: The pinpoint X-Ray focal spot around 50μm and the small voxels of the row data (in sub dimension of the engraved letters’ depth) was the advantage of this instrument, allowing the recognition of non-visible, engraved letters with relative high contrast. Using the AMRP X-Ray CTs, a large number of invisible letters was detected. In Bitsakis and Jones 2016b, is published the updated Back Cover Inscription Part-1/2 text.

2. The preserved Back Cover plate

In the present, the remaining parts of the Back Cover are preserved on Fragment B (Part-1) and Fragment A (Part-2). Many preserved letters on the fragments are easily visible to the naked eye. These letters appeared on their vertical - mirror symmetry, left/right – and are visible in the negative face, like a stamp (A. Rehm refers to them as “patina-offsets”). For this reason, many researchers suggested that these parts are not the original corroded copper/bronze plate, but they are formatted by sediment deposits on the original engraved letters, creating the “negative” ones.

The sediment deposits (usually material of CaCO₃ and sand) have usually beige or dark color shades in irregular distribution. As shown by Fig. 1, the colors of the preserved Back Cover plate are (relative regular) dark green shades, almost equal to Atacamite which is the main product of the bronze/copper corrosion under the sea. In a short time on a

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8 Voulgaris et al., 2019a
9 Heron Alexandreus 1903, ΠΕΡΙ ΔΙΟΠΤΡΑΣ (Heronis Alexandrini Opera quae Supersunt Vol. III).
10 Svoronos 1903; Rehm 1905/1906; Theophanidis 1927-1930; Price 1974.
11 Freeth et al., 2006; www.Antikythera-Mechanism.gr; Ramsey 2012.
12 Freeth et al., 2006; Freeth et al., 2008; Freeth and Jones 2012.
13 Bitsakis and Jones 2016b.
14 Scott 1990; Ingo et al., 2006; Voulgaris et al., 2019b.
bronze/copper plate under the sea, is created an amorphous crystal layer of Atacamite\textsuperscript{15}, which follows the shape and the mechanical characteristics of the plate Fig. 1. It seems that the area of the preserved Back Cover is the amorphous crystal layer of Atacamite, which was directly formatted on the Back Cover engraved plate surface, which today is mostly missing.

Fig. 1. A) Mirror image of Fragment B1. The dark green shades correspond to the preserved Back Cover copper/bronze plate Part-1. On the left, the preserved Metonic Helix turns are visible in darker shades. Credits: National Archaeological Museum, Athens, Greece, K. Xenikakis, Copyright Hellenic Ministry of Culture & Sports/Archaeological Receipts Fund. B) The reconstructed outer face of Fragment B, by using AMRP X-Ray CTs and the Real3D VolViCon software.\textsuperscript{16} X-Ray image processed by the Authors.\textsuperscript{17} C) Atacamite [Cu\textsubscript{2}(OH)\textsubscript{3}Cl] formation on a copper surface: Copper pieces were immersed in artificial sea water, in salinity around 38.5, equal to the Antikythera Sea.\textsuperscript{18} For the artificial sea water unprocessed sea salt from Kythera was used. The total time for Atacamite formation under the artificial sea water was 33 months. Although the images A and C are captured by different cameras, the similarity in the shades of the Back Cover plate and Atacamite is evident. Material process and image by the Authors.

\textsuperscript{15} Voulgaris et al., 2019b.
\textsuperscript{16} Real3D VolViCon (software) Version 4.30.1214.
\textsuperscript{17} Voulgaris et al., 2018c.
\textsuperscript{18} Voulgaris et al., 2019b.
By observing the preserved engraved letters on the Antikythera Mechanism fragments, their large engraving depth becomes evident. This depth is relatively difficult to achieve with the ordinary engraving tools. In Fig. 2 a corrosion experiment is presented, giving a probable answer for the large depth of the engraved letters.

![Fig. 2](image)

Fig. 2. A) Three pairs of gilded bronze pieces (two pairs on top and one on bottom left) were used for the following corrosion experiment: One piece of each pair was firstly gilded and afterwards engraved (therefore, each engraved letter is not gilded). The second piece was firstly engraved and then was gilded. Afterwards, the pieces were immersed in a solution of sea water with salinity of about 38.5, close to that of the Antikythera sea water, using raw sea salt from Kythera. The three pieces on bottom right are (totally) non-gilded bronze. B) After 298 days, each piece exhibits a different corrosion level. Visible products of bronze corrosion by sea water are: copper chlorides in turquoise shades, copper oxides in dark red/brown shades. C, D) After about 2-3 weeks, non-gilded letters begin to show corrosion signs and as times passes, the corrosion increases the letter depth (for the chemical procedure see Voulgaris et al., 2019b). On the other hand, totally gilded pieces don’t show any corrosion signs, since gold is highly resistant to sea water corrosion. Since the Mechanism’s bronze material is prone to short term oxidization, the manufacturer could have gilded them before the engraving. C) The corrosion of the simple bronze engraved piece is evident. D) The concentration of crystal copper chlorides is visible. Material process and corrosion experiment by the Authors. The images were taken after the use of an optomechanical system with several focal lengths, in macro, with micro x-y movements and differential mechanical micro focus, designed/constructed/used by the first Author.

3. The Back Cover text’s metrology

As aforementioned, the Mechanism was formed in a small wooden chest. The dimensional specifications of a box cover are dependent on the dimension of the box’s

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19 Voulgaris et al., 2019b.
20 Scott, 1990.
remaining parts. According to measurements of the Mechanism’s dimensions in Voulgaris et al., 2019b; Allen et al., 2016, the dimension of the Mechanism’s (bronze) main body is around 325mmX174mm each of the two covers would have a similar dimension.

Based on our measurements of Table I, it seems that each of The Engraver’s letter (left-right) width dimension (including the left/right “semi-spaces”), varies between 2.0mm and 2.7mm, with a statistically mean of 2.4mm/letter, Fig. 3. At the same time, some areas of the Back Cover plate’s left boundary (text and also the plate) are preserved. For Symmetry reasons, we believe The Engraver kept the same space/gap of the recessed page at the end/right boundary of the Back Cover plate, which is not preserved today. The left recessed space dimension (boundary copper/bronze plate up to the boundary of the first letter of line) is around 2mm. Therefore, 174mm−(2mm left+2mm right)= 170mm. According to Table I, each line varies between 63-82 letters/line (mean 72).

| Text | Letters number | Dimension | mm/ Letter | Letters/ cm | Letters/ Line |
|------|----------------|-----------|------------|-------------|---------------|
| 16 ΠΡΟΕΧΟΝΑΥΤΟΥΝΩΜΟΛΟΝΣ | 22 | 55mm | 2.5 | 4 | 68 |
| 17 ΦΕΡΕΙΟΝΗΜΕΝΕΝΩΜΟΝΣ | 17 | 39mm | 2.3 | 4.3 | 73 |
| 18 ΤΟΣΙΟΔΕΔΙΑΥΤΟΥΦΕΡΟΜΕΝ | 21 | 55mm | 2.6 | 3.8 | 65 |
| 19 ΤΗΣΑΡΡΟΙΔΙΠΘΟΣΦΟΡΟΥ | 19 | 50mm | 2.6 | 3.8 | 65 |
| 20 ΤΟΥΘΟΙΣΦΟΡΟΥΠΕΡΙΦΕΡΕΙΑΝ | 22 | <54mm | 2.4 | 4.1 | 70 |
| 21 ΓΝΩΜΟΙΚΕΙΑΙΧΡΥΣΟΥΝΣΦΑΙΡΙΟΝ | 27 | 57mm | 2.1 | 4.7 | 80 |
| 22 ΑΚΤΙΝΥΠΕΡΔΕΤΟΝΗΛΙΟΝΕΣΤΙΝ | 24 | 50mm | 2.1 | 4.8 | max 82 |
| 24 ΕΘΟΝΤΟΣΤΟΔΕΔΙΑΠΟΡΕΥΟΜΕΝ | 23 | 62mm | 2.7 | 3.7 | min 63 |

Mean: 2.4 4.15 71 (-8/+11)

Table I. A selection of well-preserved texts of the Back Cover Inscription Part-1, located on Fragment B. In order to achieve the best approach statistically (letters/cm), as many visible to the naked eye letters were chosen. Then, the dimension of each selected text was measured using calibrated visual photographs (Xenikakis 2004 and Voulgaris 2016/2019). As detailed below, the ratios mm/letter and letters/cm were calculated. These ratios were extrapolated in order to calculate the total number of letters for each line-text (see also Bitsakis and Jones 2016b). These ratios revealed The Engraver’s handwriting. For the letters’ recognition on the visual photographs by Xenikakis 2004; Voulgaris 2016/2018/2021, the X-Ray computed tomographies of AMRP were also contributed.

The height of 21 successive preserved lines (from the 1st line/letter base to the 21st line/letter base), was measured around 75mm. Therefore, the mean height line is 75/21= 3.57mm/line (letter height + inter-line space). Setting the height of the Mechanism 325mm (Voulgaris et al., 2019b), the estimated maximum number of the Back Cover plate lines is around 91 (but it could be 2-4 lines less, 89 or 87, if The Engraver left some spaces on the top and the bottom edges) (also equal measurements in Bitsakis and Jones 2016b). Today, the total number of (partially/poorly preserved) lines of Part-1 and Part-2, is 30+25= 55 lines.

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21 Also, equal measurements in Bitsakis and Jones 2016b.
According to these calculations, the estimated maximum number of letters for the Back Cover plate is around 7350.

The Back cover inscription presents information regarding the design, positioning and the role/operation of the outer parts of the Mechanism, which were visible to the naked eye. On BCI Part-1 (upper plate’s area-Fragment B1), the text describes the Front face’s outer parts of the Mechanism, visible to the naked eye, such as the Lunar Disc, its lunar phases sphere and pointer, the Sun’s pointer. Also, the names of the seven planets (observable to the naked eye, according to the Hellenistic Astronomy), are referred.

![Fig. 3. Letters per centimeter vs line-text (based on 8 partially preserved lines in total). The difference is due to the hand writing, the total number of the “thin” letters such as “I” and “Z” (the presence of a large number of these letters, especially “I”, creates space for additional letters), and also by the material shrinkage and deformation after its corrosion.](image)

On BCI Part-2 (bottom plate’s area-Fragments A2, E, 19, 67), the text describes the design and operation of the Back face’s outer parts, such as the two Helices and their subdivisions and also their pointers’ operation.22

The Antikythera Mechanism consists of a large number of moving parts, gears, axes, pointers, and also measuring scales. As with any other machine, simple or complex, the presentation and the operation of the mechanical parts on a technical text/manual is crucial in order to explain “how this devise works”.

The text of the Back Cover plate is considered the User’s Manual (see section 3.1) of this time calculator-events predictor machine. This specific machine was too complicated. For this reason, the Antikythera Mechanism’s users should possess a deep understanding of

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22 Bitsakis and Jones 2016b.
Astronomy, Celestial Mechanics, the four lunar cycles\(^{23}\), and time measuring techniques, in order to understand and comprehend the Mechanism’s extruded information/results, which were visible on the Front and Back plate pointers.

4. What is the User’s manual

4.a. The User’s Manual for machines handling

Some products or constructions are complicated and sophisticated. They could consist of a large number of parts that could be difficult to handle by a person that is not familiar with these complicated constructions. In most cases, a user of a product is interested in using it for a procedure, but it is not necessary to know how this construction works. E.g. it’s not necessary for the user of an electric drill to be an electrical engineer. For this reason, a technical text with instructions on *how the product must be used* is necessary.

This text is called the *Instruction Manual*, named also the *User’s manual, Reference manual, Product manual, Working manual, Owner’s manual* etc. Such technical documents provide any information necessary to help someone to use a product. The manual is a one-way communication that is provided by a person who knows the operation of the product in depth and gives information and instructions to someone who is non-expert and needs to know how to use this product.

The manual presents the parts of the product, their function, the procedure of the start/close and its operation. The presentation of the parts is not random, but follows a specific scenario, mostly reproducing the procedure of the start/use/end.\(^{24}\)

In an explanatory technical text, as the User’s Manual, after a general description (i.e. *Introduction and Purpose*, presenting general information about the product and the purpose it was constructed for), follow the steps for the use of the product:

1) **Definition/Description** of the parts (*This is..., There is..., Is named..., Is consisted by...etc.*).
2) **Positioning** of the parts (*The part is located on..., Is stabilized on..., Is visible on...etc.*).
3) **Operation/Function** of the parts (*This part starts..., Opens/Closes the..., Is rotated CCW...etc.*). These steps (which we now call *DDPO*) explain how to start, use, operate, assemble, a device.

A shorter text document that includes only the basic features and procedures offering information on *How to use it*, but without the information on “How to assemble it, How to repair it”, and it is useful for a quick start of the device, called *The User’s Guide*.

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\(^{23}\) The four lunar cycles: Lunar month of 29.53\(^{d}\), Sidereal month of 27.321\(^{d}\), Anomalistic month of 27.55\(^{d}\) and Draconic/Draconitic month of 27.21\(^{d}\).

\(^{24}\) [https://blog.bit.ai/write-instruction-manual/](https://blog.bit.ai/write-instruction-manual/); [https://www.douglaskrantz.com/SCManual.html](https://www.douglaskrantz.com/SCManual.html); [https://grammar.yourdictionary.com/grammar-rules-and-tips/tips-on-writing-user-manuals.html](https://grammar.yourdictionary.com/grammar-rules-and-tips/tips-on-writing-user-manuals.html); [https://makeitclear.com/insight/how-is-a-quick-start-guide-different-to-an-instruction-manual](https://makeitclear.com/insight/how-is-a-quick-start-guide-different-to-an-instruction-manual).
4.b. Technical information, Observations and Comments on the Back Cover

Inscription Part-1 text

On the Antikythera Mechanism’s Back cover plate 55 lines are partially preserved, in which *The Engraver* presents and describes the outer parts located on the Front face of the Mechanism (BCI Part-1, 30 lines), see Table II, as well as the parts of the Back face (BCI Part-2 (25 lines)).

On the Antikythera Mechanism, two main kinds of parts exist:
The operational and the supportive parts.
The operational parts are considered the parts located on the outer faces of the Mechanism and are visible to the naked eye. The operational parts have a prominent role in the use of the Mechanism. These parts are the Lunar Disc, the pointers and the measuring scales with the subdivisions. Via these parts, the extracted results are presented, after the calculations were made by the supportive parts.
The supportive parts are gears, axes and shafts, stabilizing pins, spacers etc. and they are not visible, because they are located inside the Mechanism’s closed wooden box. In addition, there are decorative parts that do not have an important function in the Mechanism. An example of this can be seen in the decorative wooden case.

The Front face/plate of the Mechanism presents a characteristic central symmetry (Lunar Disc adapted on the Front face’s center, which coincides with the Zodiac and Egyptian rings’ centers) and also horizontal axis symmetry (top and bottom Parapegma plates PP-1 and PP-2, Bitsakis and Jones 2016a). The Front plate consisted of three independent pieces (Bitsakis and Jones 2016a) creating an oblong plate in dimensions around 174mmX345mm (as also the Back plate) (Voulgaris et al., 2019b). On the Front plate center defined by the cross point of the two diagonals, there is a central large hole around 135mm in diameter (see also Allen et al., 2016). In the center of the hole, the axis \( b_{\text{out}} \) is located which is stabilized on the Middle plate (Voulgaris et al., 2018b). On axis \( b_{\text{out}} \), the large gear b1 is adapted. In the center of the inner \( b_{\text{in}} \) axis the Earth is located (the Mechanism is geocentric). On the upper edge of \( b_{\text{in}} \), axis the Lunar Disc is adapted, which is the proper and ideal input/driving of the Mechanism. The Lunar Disc’s body is a cylinder in diameter around 68mm-70mm and height about 10mm-13mm. The authors drive their functional model of the Mechanism rotating the Lunar Disc/Input by hand.

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25 Bitsakis and Jones 2016b.
26 Voulgaris et al., 2019b.
27 https://www.mathsisfun.com/geometry/symmetry-point.html
28 https://www.mathsisfun.com/geometry/symmetry-point.html
After the analysis of the original preserved text, and although the text is poorly preserved (without any fully preserved line), a reconstruction of the missing text is not impossible. This reconstructed text could be ideal and representative if it is based on specific criteria and parameters observing the text’s original characteristics. In most cases, the text reconstruction can be considered as definite, especially in the area of the planets’ orbit presentation.

Below, critical observations, results, relative information and comments, are presented, after the study of the preserved text Part-1:

1) The preserved text is a technical text/the User’s Manual of the Antikythera Mechanism. The Engraver Defines/Presents the parts of its creation, their Position and Operation, in order to teach the user “what parts you see/what the parts represent and how they work”.

2) The lost text is not random, but it has a specific structure: The Engraver presents the Front face’s outer/operational parts, starting from the geometrical center and then, following a radial distribution, continues the presentation of the parts.

3) In the text, phrases or equal meaning phrases are preserved, especially in the text of the planet orbit presentation. The syntax of these phrases presents a characteristic Symmetry, using the same words in (about) the same positions.

4) The critical left edge of the text, i.e. the beginning some of the Lines is preserved (Bitsakis and Jones 2016b). Therefore, in some cases what was written is known at the (non-preserved) end of the previous line (or can be predicted): E.g. on the beginning of left boundary text in Line 25 the phrase 25 [-5-]ΙΝΟΝΤΟΣ ΚΥΚΛΟΣ[...... is preserved, i.e. 25 [ΝΟΥ \( \PhiA \)ΙΝΟΝΤΟΣ ΚΥΚΛΟΣ[... (-nos Phainon)].\] Without doubt, at the end of the previous line (Line 24), the last three letters should be KPO, i.e. the three first letters of the word KAPONOU,

24 …………………………………..KPO]

25 ΝΟΥ \( \PhiA \)ΙΝΟΝΤΟΣ ΚΥΚΛΟΣ[...... (Kro-nos Phainon).

At the beginning of Line 17 the phrase ΦΕΡΕΙΩΝ Η ΜΕΝ ΕΧΟΜΕΝΗ ΤΩ{\[Ι} ΤΗΣ is preserved, and at the end of the previous line (Line 16) the last four letters are ΠΕΠΙ, i.e. \[ΠΕΠΙ\]ΦΕΡΕΙΩΝ, (circu-ferences). In this case, using the maximum number of letters per line, the remaining missing letters are easily assumed.

5) For the lost words of planet Y description, the words and the same meaning pattern were reproduced as the preserved words of another planet X. E.g. based on the phrase KAPONOU \( \PhiA \)ΙΝΟΝΤΟΣ ΚΥΚΛΟΣ (Kronos Phainon’s circle/orbit) the phrases of the other planets can

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\(^{29}\) Bitsakis and Jones 2016b, pages 233, 243.
be reconstructed: [ΔΙΟΣ ΦΑ]ΕΘΟΝΤΟΣ ΚΥΚΛΟΣ (Circle/orbit of Zeus Phaethon), ΚΥΚΛΟΣ ΤΟΥ ΑΡΕΟΣ ΠΥΡΟΕΝΤΟΣ (Circle of Ares Pyroes) (for Mercury’s and Venus’ orbits see further below).

Table II. The preserved words/letters of the Back Cover plate by Bitsakis and Jones 2016b. The preserved letters in bold and the possible ones in regular. The letters/words are presented in their about original position and form, without gaps (see also Fig. 1A). The background color of the letters corresponds to a specific part description/meaning, starting from the Lunar Disc in yellow. An additional letter (resulting the re-position of the previous letters) was recognized by the authors of the present work: in Line 15 (‡) the letter “Υ” instead of letter Θ. Also in Line 15 (*) the letter “Ι” (iota) was recognized before the phrase “ΤΟ ΣΦΑΙΡΙΟΝ”. In the AMRP tomography of the Fragment B, the letter “I” is relative well preserved with its two serifs. Using the position (numbering) of the well preserved letters in the next Line 16, the letter “Ι” should be the 80th letter from the line beginning

6) The language used in BCI text by *The Engraver* seems to be the Koine Hellenistic language. The ancient Greek language follows specific rules for language syntax.

7) In order to avoid repeating the same words, *The Engraver* slightly modifies/alters the words and their position, especially about the planets’ orbit description:

23 (ΚΥΚΛΟΣ ΤΟΥ ΑΡΕΟΣ ΠΥΡΟΕΝΤΟΣ ΤΟ ΔΕ ΔΙΑΠΟΡΕΥΜΕΝΟΝ ΣΦΑΙΡΙΟΝ.................
The Engraver uses two words for the same meaning ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ and ΦΕΡΟΜΕΝΟΝ (travelling along/rotating through). In these two - same meaning - sentences, he changed the position/syntax of words ΚΥΚΛΟΣ, ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ and ΣΦΑΙΡΙΟΝ.

8) The Ancient Greek language has a large number of words, with multifactorial meanings. In many cases, a word appears to have different and usually, non-related meanings (see §6.e. regarding the word ΓΝΩΜΟΝΙΟΝ - perpendicular pillar/pointer). E.g. today, a mechanical part of a lathe is named in the Greek language ΚΟΥΚΟΥΒΑΓΙΑ "the Owl" (bird). If a researcher studies the Greek User’s manual of the lathe after 2000 years from today, then, reading the word “Owl” in the lathe’s manual: either he will try to find “how the flight of an owl affects the operation of the mechanical lathe”, or he will try to find which characteristic part of the lathe corresponds to the word "owl".

Hence, the authors did not depend precisely on the standard translation of the ancient Greek words. In order to translate the meaning of the preserved words on the BCI text, authors tried to correlate these words with the Mechanism’s parts.

9) The authors have also studied the preserved text by simultaneous cross-examination/use of their Antikythera Mechanism functional model, in order to correlate the text with the real operation of the Mechanism. This procedure offers the advantage of the interactive communication between the instrument and the corresponding text, allowing the comparison of the text references and parts’ operation from the Manufacturer’s perspective.

The authors based the design and construction of the mechanical parts in their model, mostly on the visual photographs of the Fragments, on the AMRP X-Ray tomographies and partially on the published bibliography, and assembled the Mechanism parts. By observing and operating the outer parts which were located/visible on the Front face, the authors corresponded the bronze reconstructed parts to the referred parts on the text.

10) Furthermore, the study of the User’s Manual parts description, could be useful for the reconstruction of a part which is not preserved on the Mechanism’s fragments (such as the Lunar Disc pointer, the Golden Sphere, the solar pointer etc.).

11) The User’s Manual of the Antikythera Mechanism is a technical text, presenting the Mechanism’s parts and their operation. For the parts’ presentation, it appears that the text

| 25 (ΚΡΟ)- ΝΟΥ ΦΑ | ΙΝΟΝΤΟΣ ΚΥΚΛΟΣ ΤΟ ΔΕ ΣΦΑΙΡΙΟΝ Φ|ΕΡΟΜΕΝΟΝ |  
| 23 circle of Ares Pyroes and the traveling around sphere | ΤΟ ΔΕ ΣΦΑΙΡΙΟΝ Φ|ΕΡΟΜΕΝΟΝ |
follows the (necessary) pattern Definition/Description, Position and Operation (if this exists) of a part.

E.g. for the Definition of a part, The Engraver uses the characteristic ancient Greek word ΕΣΤΙΝ (there is/exists):

22 ...ΥΠΕΡ ΔΕ ΤΟΝ ΗΛΙΟΝ ΕΣΤΙΝ ΚΥ[ΚΛΟΣ... (beyond Sun, there is the circle...), i.e. The Engraver Defines/Places a circle which is located, beyond the Sun.

Definition: there is a circle,
Position (where is it located?): the circle is beyond Sun’s (circle).

In Line (20)-21 [ΕΙΣ] ΓΝΩΜΩ[Ν] ΚΕΙΤΑΙ. 31 (A gnomon is adapted on...),
- Definition: a gnomon is adapted (somewhere). The Position and the Operation of ΓΝΩΜΩ[Ν] is missing.

In Line 21 ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ [ΕΠΙ ΓΝΩΜΟΝΑ ΕΣΤΙΝ... (The Golden Sphere is adapted on the gnomon).

- Definition: ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ (there is a sphere which has a golden color-Sun).
- Position (where is it located?): [ΕΠΙ ΓΝΩΜΩΝΑ (the Golden Sphere is located/stabilized on the gnomon).
- Operation (what is the operation of the golden sphere? Is it traveling along? Is it measuring? ...).

At the same time the Operation of ΓΝΩΜΩ[Ν] is revealed: The ΓΝΩΜΩ[Ν] exists in order the ΧΡΥΣΟΥΝ-σφαιρίον to be stabilized on the ΓΝΩΜΩ[Ν].

The operation of the Golden Sphere-Sun is missing. However, during Hellenistic Astronomy it was claimed that the Sun rotated around the Earth in one Tropical year, named ΕΝΙΑΥΤΩΣ. 32

Geminus 2002 writes “Ὁ δὲ ἥλιος ἐνιαυτῷ διαπορεύομεν τον ζωδίακον κύκλον” (The Sun travels along the Zodiac Circle in Eniautos/one Tropical year). Therefore, the operation of the Golden Sphere-Sun could be its rotation around the Center/Earth in one Tropical year.

A probable reconstructed text could be ... ΕΙΣ] ΓΝΩΜΩ[Ν] ΚΕΙΤΑΙ. ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ [ΕΠΙ ΓΝΩΜΟΝΑ ΕΣΤΙΝ, ΕΝ ΕΝΙΑΥΤΩ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ (...a pillar is stabilized. The Golden Sphere is adapted on the pillar and rotated in Eniautos/one tropical year).

5. Analyzing the preserved text of the BCI Part-1
5.a. Stylistic information for the text presentation

31 For the line 21 see also comments in Bitsakis and Jones 2016b, page 243. If their suggestion is correct, then the phrase could be ΕΠΙ ΤΟ] ΓΝΩΜΩ[Ν]<] KEITAI. ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ. See page 33 of the present work.
32 Ptolemy 1898; Danezis and Theodosiou 1994; Geminos 2002, Cleomedes 2002.
The BCI Part-1 text analysis was based on the revised published text, “The Back Cover Inscription”, by Bitsakis and Jones 2016b.

In the present work, the Leiden system symbols are used and additionally:

a) All of the preserved original words/letters are written in capital Greek letters, as the original ancient text and are noted in bold.

b) The preserved original words/letters are located on their corresponding geometrical position (as much as possible).

c) By the first step analysis, the maximum possible number of letters per line was calculated into 82 letters/line and by adding +4 letters the final maximum possible number of letters per line is 86. Hence, the beginning-left boundary of the text is preserved in several lines, the maximum number of letters can (theoretically) be defined as the right boundary of the text. Naturally, when The Engraver engraved/wrote the text on the Back cover plate, he was not defining a constant number of letters/line. His text was “free” of such restrictions (after the analysis of the BCI Part-1 and during the final adaptation of the reconstructed text, the arbitrary constant number of letters per line will be not valid).

d) For the text analysis of a specific phrase and meaning, the corresponding text of interest is presented in the usual font size (11) and the rest preserved/reconstructed/non-related text is presented by a shorter font size (9) or it is replaced by dots.

5.b. The preserved Back Cover Inscription-Part 1, presentation

The Engraver uses a specific way to write the User’s Manual of his creation. He presents the Front face parts starting with the geometrical center of the Front plate and then, radially presents the other parts. For each operational part’s presentation he defines and presents a part, afterward refers to its position, and finally describes its operation, following the pattern Definition/Description, Positioning, Operation. Generally, he follows the same procedure as someone would follow today to write the User’s manual for a product.

The Engraver probably starts the operational parts’ presentation from the Earth-Center of Cosmos and continues the presentation in radial distribution from the center outwards: he Describes and Places the Lunar Disc-Moon and its parts. After that, he presents the planets, starting from the two inferior planets-after Earth (between Lunar and Solar orbit), and also refers to their theophoric names ΕΡΜΟΥ ΣΤΙΛΒΟΝΤΟΣ (Hermes Stilbon, Mercury), ΑΦΡΟΔΙΤΗ<&n> ΦΩΣΦΟΡΟΥ (Aphrodites Phosphoros, Venus). After planet Sun ΗΛΙΟΣ and its parts, he presents the three superior planets ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ (Ares
Pyroëis, Mars), [ΔΙΟΣ ΦΑ]ΕΘΟΝΤΟΣ (Dias-Zeus Phaethon, Jupiter) and ΚΡΟ[ΝΟΥ ΦΑ]ΙΝΟΝΤΟΣ (Kronos Phainon, Saturn).33

After planet Saturn, The Engraver refers to the word ΚΟΣΜΟΥ (Cosmos, Line 26) and the words ΣΤΟΙΧΕΙΑ (Letters) and ΑΣΠΙΔ[ΙΣΚΑΙΣ (Small Shields) follow.

More specifically,

In Line 7 the letters [-10-]ΠΡΟΣ[...... are preserved, which could be the phrase ΠΡΟΣΘΙΑ ΩΨΙΣ (Front face).

The preserved word in Line 9 ΗΡΜΟΣ[ΘΑI] (fitted on..., see Bitsakis and Jones 2016b) and Line 10 ΕΠ ΑΚΡΟΥ (on the edge of...) related to the Lunar Disc positioning (which is located at the geometrical center of the Front face): its adaptation and stabilization on the edge of axis b_m.34 The letters in Line 11, ΟΣΜΕΝΩΝ could be part of one word or two/three separated words: ΩΣ ΜΕΝ ΩΝ (as he also is) or ΩΣ ΜΕΝΩΝ (“As he is stable in a state for a long time” or “As he is stable in a situation” or “As he is constant” or “As he stays on” or “As he lives” or “He continuously…” or [...]ΩΣ ΜΕΝΩΝ.35

The Lunar Disc and its parts are presented in Lines 9-16. The words in Line 12 ΜΕΛΑΝ (black) and Line 15 ΤΟ ΣΦΑΙΡΙΟΝ ΦΕΡΕΙ[ΤΑI] (the little sphere is rotated/traveling through) were correlated to an important part of the Lunar Disc, the Lunar phases sphere. Some parts of the Lunar Phases Sphere, the crown gear-2 and its axis are visible on AMRP tomographies of Fragment C. Line 16 ... ΠΡΟΕΧΟΝ ΑΥΤΟΥ ΓΝΩΜΟΝΙΟΝ Σ[... (...little pointer protrudes from it...) refers to the Lunar Disc pointer, which protrudes from the Lunar Disc and travels around during the Lunar Disc rotation.

Afterwards, in Line 17 the phrase ΠΕΡΙΦΕΡΕΙΩΝ Η ΜΕΝ ΕΧΟΜΕΝΗ (Circumferences, the one is close to...) is preserved. Usually, in the Ancient Greek language, when the words Η ΜΕΝ... (the first...) exist in a phrase, a second phrase follows including the words Η ΔΕ... (the next, the following...). Therefore, the word ΠΕΡΙ[ΠΟ]ΦΕΡΕΙΩΝ (in plural i.e. at least two) concerns the Η ΜΕΝ ΠΕΡΙΦΕΡΕΙΑ 1 ΚΑΙ Η ΔΕ ΠΕΡΙΦΕΡΕΙΑ 2 (the first circumference and then the following circumference).

In Line 20 the words [ΦΩ]ΣΦΟΡΟΥ ΠΕΡΙΦΕΡΕΙΑ are preserved. Therefore, the word ΠΕΡΙ[ΠΟ]ΦΕΡΕΙΩΝ (Line 17) is correlated to the Η ΜΕΝ ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΕΡΜΟΥ ΚΑΙ Η ΔΕ ΠΕΡΙΦΕΡΕΙΑ ΤΗΣ ΑΦΡΟΔΙΤΗΣ (firstly the orbit of Hermes/Mercury and follows the orbit of Aphrodite/Venus). For the inferior planets’ orbits, The Engraver uses the word ΠΕΡΙΦΕΡΕΙΑ

33 The theophoric names of the planets are also referred by Pseudo-Aristotle 1831 (On the Cosmos); Geminus 1880/2002; Dorotheus of Sidon 1976, in Papyrus Oxyrhynchus P0xy. 307 (Neugebauer and Van Hoesen 1987); Cleomedes 2002; Bowen and Todd 2004.
34 Wright 2006; Freeth et al., 2006; Carman and Di Cocco, 2016; Voulgaris et al., 2018b.
35 Liddell and Scott’s lexicon 2007.
(circumference) and for the superior planets’ orbits the word \textit{KYKLOΣ} (circle, see below). Euclides 1883/2008 in \textit{Elements of Geometry} \textsuperscript{36} writes “

\[ \text{Κύκλος \, ἐστι \, σχήμα \, ἐπίπεδον \, ὑπὸ \, μίας \, γραμμῆς \, περιεχόμενον \, ἢ \, καλεῖται \, περιφέρεια}, \] přesů \, τοῦ \, σχήματος \, κειμένων \, πάσαι \, αἱ \, προσπίπτουσαι \, εὐθείαι \, [πρὸς \, τὴν \, τον \, κύκλου \, περιφέρειαν] \, ἴσαι \, ἄλληλαις \, εἰσίν.” [The circle is a plane scheme which is defined by a line (which is called circumference), and from a point located inside the scheme, all of the incident lines (directed towards to the circumference are equal to each other].

The planet Venus is referred to twice: in Line 19 (planet + theophoric name) and in Line 20 (only by its theophoric name).

After Venus, follows \textit{ΗΛΙΟΣ} (Helios-Sun). \textit{The Engraver} writes that Sun has a \textit{ΓΝΩΜΟΝ} (perpendicular small pillar according to the present work, see §6.e.) \textsuperscript{37}, \textit{ΧΡΥΣΟΥΣ ΣΦΑΙΡΙΟΝ} (golden little sphere) and \textit{ΗΛΙΟΥ ΑΚΤΙΝ} (ray of Sun-the real pointer, see the analysis on §6.f.).

After the Sun, follows the reference of the three superior planets, with their corresponding theophoric names and their orbits \textit{ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ} (KYKLOΣ) (Ares Pyroes-Mars’ orbit), \textit{ΔΙΟΣ ΦΑΘΕΝΤΟΣ} (KYKLOΣ) (Zeus Phaethon-Jupiter’s orbit) and \textit{ΚΡΟΝΟΣ ΦΑΙΝΟΝΤΟΣ} (Kronos-Phainon’s orbit).

In Line 26 …\textit{ΕΡΑ ΔΕ ΤΟΥ ΚΟΣΜΟΥ, ΚΕΙΤΑΙ} probably Π\textit{ΕΡΑ ΔΕ ΤΟΥ ΚΟΣΜΟΥ, ΚΕΙΤΑΙ} (beyond Cosmos, there is…). \textsuperscript{38} This phrase is correlated with the Cosmos which consists of the Earth-Center of Cosmos, Moon, and the other six planets. At this point, \textit{The Writer} describes what exists beyond Cosmos:

According to Hellenistic Astronomy, after the planets follows \textit{Η ΣΦΑΙΡΑ ΤΩΝ ΑΠΛΑΝΩΝ ΑΣΤΕΡΩΝ} (the Celestial Sphere with the fixed stars). \textsuperscript{39} Moon, Sun and planets travel around the Earth-The Center of Cosmos, and are projected on the Zodiac constellations-the Ecliptic zone/Zodiac cycle.

On the Mechanism, after the presentation of Cosmos, follows the “Sky”, the Zodiac month ring, divided into 12 (unequal) parts-Dodecatemoria, the Zodiac constellations/Zodiac months. \textsuperscript{40} Right after follows the Egyptian calendar ring, which is an additional calendar in the Mechanism, which was also in use during the Hellenistic era. \textsuperscript{41}

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\textsuperscript{36} Euclidis 1883–1885.
\textsuperscript{37} In Bitsakis and Jones 2016b the word \textit{ΓΝΩΜΟΝ} is translated as a pointer.
\textsuperscript{38} For the words \textit{ΠΕΡΑ} and \textit{ΠΕΡΑΝ} see LSJ lexicon.
\textsuperscript{39} Geminus 1880/2002; Cleomedes 2002.
\textsuperscript{40} Voulgaris et al., 2018a.
\textsuperscript{41} Ptolemy 1880; 1984.
At the end of the BCI Part-1, the words ΣΤΟΙΧΕΙΑ (letters) in Line 27 and the phrase ΤΑΙΣ ΑΣΠΙΔΙΔΙΣΚΑΙΣ (on the small shields, see §6.h.) in Lines 28 and 30 are preserved, correlated to the Parapegma events and its position presentation.

Preliminary statistics regarding the lines per referred parts are presented on Table III.

### Table III.
The total number of lines, correlated to the Mechanism’s Front Face parts, measured on the BCI Part-1 preserved text and their corresponding percentages. For the lines correlated to Mars, Jupiter and Saturn, their percentages are definite (one line per planet).

| Part description on the preserved BCI Part-1 text | Corresponding (rounded per line) Number of lines | Percentage of 17 selected Lines 9-25 | Percentage of 30 preserved Lines 1-30 |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------|-------------------------------------|
| Lunar Disc                                      | Lines 9-16 (total 5-8)                          | 29%-47%                             | 16%-26%                             |
| Mercury                                         | Line 18 (total 1)                               | 6%                                  | 3%                                  |
| Venus                                           | Lines 19-20 (total 2)                           | 12%                                 | 6%                                  |
| Sun                                             | Lines 21-22 (total 2)                           | 12%                                 | 6%                                  |
| Mars                                            | Line 23 (total 1)                               | 6%                                  | 3%                                  |
| Jupiter                                         | Line 24 (total 1)                               | 6%                                  | 3%                                  |
| Saturn                                          | Line 25 (total 1)                               | 6%                                  | 3%                                  |

The word ΚΥΚΛΟΣ concerns the orbit of planet Saturn (Line 25) and also the orbit of a planet which is located after/beyond the Sun’s orbit, i.e. the orbit of Mars. Therefore, the word ΚΥΚΛΟΣ should refer to each of the superior planets (for the inferior planets see next paragraph).

### 6. RECONSTRUCTING THE BACK COVER INSCRIPTION PART-1
#### 6.a.1. The ΚΥΚΛΟΙ, Circles/orbits of the superior planets (Lines 22-25)

The Engraver refers the word ΚΥΚΛΟΣ on the text area for the planets presentation:

22 ΗΛΙΟΥ ΑΚΤΙΝ ΥΠΕΡ ΔΕ ΤΟΝ ΗΛΙΟΝ ΕΣΤΙΝ ΚΥΚΛΟΣ
23 .......................................................................................... 51 ...................................................
24 .................................................................................................................. ΚΡΟ]
25 ΝΟΥ ΦΑΙΝΟΝΤΟΣ ΚΥΚΛΟΣ ΤΟ ΔΕ ΣΦΑΙΡΙΟΝ \[ ................................. 51 .............................. ]
22 Beyond Sun, there is (the) circle.............................................................
25 Saturn Phainon circle............................................................................

For the inferior planet Venus’s orbit on Line 20, The Engraver refers the word ΠΕΡΙΦΕΡΕΙΑ (circumference):

16 ΠΡΟΕΧΩΝ ΑΥΤΟΥ ΓΝΩΜΟΝΙΟΝ ΣĮ............. 60 ........................................ ΠΕΡΙ
17 ΦΕΡΕΙΩΝ Η ΜΕΝ ΕΧΟΜΕΝ ΤΟ[I] ΤΗΣ[......... 63- ........................... - ]
18 ...........................................................................................................................
19 ...........................................................................................................................
In the previous lines, Line (16)/17 the word [ΠΕΡΙ][ΦΕΡΕΙΩΝ] is referred to in the plural (circumferences), i.e. at least two circumferences. This text’s area is correlated to the two inferior planets, Mercury and Venus. The Engraver uses the word ΠΕΡΙΦΕΡΕΙΑ (circumference) when he refers to the orbits of the two inferior planets, which were located between the orbit of the Moon and the Sun (according to Hellenistic Astronomy).

Thus, there should be an equal Definition about Mercury’s orbit in Lines 17-18:

Heron Alexandrinus in Definitiones geometricae 1826 refers for the word ΠΕΡΙΦΕΡΕΙΑ:

Ως γαρ κύκλων δρός ἐστίν ἢ περιφέρεια. (The circumference is the boundary of the circle).  

6.4.3 The word ΥΠΕΡ (beyond/next/after) and the Repetition for the planet names

The word ΥΠΕΡ (beyond), is used by The Writer in order to define the position of a part B which is located after the position of the part A:

Therefore, the word ΥΠΕΡ (After/Beyond) should appear for each of the planets, following the phrase pattern:

Beyond the planet A .........................

Beyond the planet B .........................

42 http://www.hellenicaworld.com/Greece/Literature/IronOAlexandrevs/gr/Oroi.html
Beyond the planet C............................... etc.

Two references of Venus are well-preserved:

- (The Engraver omitted by mistake the last letter of ΑΦΡΟΔΙΤΗ<Σ>).\textsuperscript{43}

The second time Venus is referred to, The Engraver uses only its theophoric name Phosphoros. Generally, The Engraver avoids repeating the same or non-necessary words.

The double reference to Venus can be well justified by the following interpretation:

Firstly, Venus (planet’s name + theophoric name) is referred to as the Definition of the planet and the Position of its orbit:

Secondly, the theophoric name of Venus is used to Present/Define the next planet and its Position referring the word ΥΠΕΡ ΔΕ ΤΟΥ ΦΩΣΦΟΡΟΥ (beyond Phosphoros there is the Sun’s Circumference/Circle), as the word ΥΠΕΡ (beyond) exists in Line 22 ΥΠΕΡ ΔΕ ΤΟΝ ΗΛΙΟΝ ΕΣΤΙΝ ΚΥΚΛΟΣ:

Correlating the Lines 19, 20 and 22:

\textbf{6.a.4. A preliminary text reconstruction of Lines 17-25}

Based on the observations and analysis of 6.a.1.-6.a.3., in Lines 17-25, the names of the planets should be referred twice:

1) \textit{planet + its theophoric name}

2) only by its \textit{theophoric name}.

The words ΥΠΕΡ and ΠΕΡΙΦΕΡΕΙΑ/ΚΥΚΛΟΣ should also appear according to the following pattern:

\textsuperscript{43} See Bitsakis and Jones 2016b, page 243.
- There is (ΕΣΤΙΝ) the orbit of A (planet+theophoric) ........................................
- Beyond (ΥΠΕΡ) the A (theophoric), 
  There is (ΕΣΤΙΝ) the orbit of B (planet+theophoric) ........................................
- Beyond the B (theophoric),
  There is the orbit of C (planet+theophoric) ..................................................
- Beyond the C (theophoric),
  There is the orbit of D (planet+theophoric) ..................................................

i.e.:

- ΥΠΕΡ ΔΕ ΤΗΣ ΣΕΛΗΝΗΣ,
  ΕΣΤΙΝ ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΕΡΜΟΥ ΣΤΙΛΒΟΝΤΟΣ........................................
  (beyond the Moon there is the circumference of Hermes Stilbon...)

- ΥΠΕΡ ΔΕ ΤΟΥ ΣΤΙΛΒΟΝΤΟΣ,
  ΕΣΤΙΝ ΠΕΡΙΦΕΡΕΙΑ ΤΗΣ ΑΦΡΟΔΙΤΗΣ ΦΩΣΦΟΡΟΥ.............................
  (beyond Stilbon there is the circumference of Aphrodites Phosphoros...)

- ΥΠΕΡ ΤΟΥ [ΦΩΣΦΟΡΟΥ, 
  ΠΕΡΙΦΕΡΕΙΑΝ ΗΛΙΟΥ ΕΣΤΙΝ..................................................
  (beyond the circumference of Phosphoros, there is the circle of Sun...)
  (see comments in footnotes 44)

- ΥΠΕΡ ΔΕ ΤΟΝ ΗΛΙΟΝ,
  ΕΣΤΙΝ ΚΥΚΛΟΣ ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ..........................................
  (beyond the Sun there is the circle of Ares Pyroes...)

- ΥΠΕΡ ΔΕ ΤΟΥ ΠΥΡΟΕΝΤΟΣ,
  ΕΣΤΙΝ ΚΥΚΛΟΣ ΔΙΟΣ ΦΑΘΕΟΝΤΟΣ........................................
  (beyond Pyroes there is the circle of Jupiter Phaethon...)

- ΥΠΕΡ ΔΕ ΤΟΥ ΦΑΘΕΟΝΤΟΣ,
  ΕΣΤΙΝ ΚΥΚΛΟΣ ΤΟΥ ΚΡΟ[ΝΟΥ] ΦΑΙΝΟΝΤΟΣ.........................
  (beyond Phaethon there is the circle of Saturn Phaenon...). 44

Applying the reconstructed text and taking into account the original positions of the
preserved words/phrases as well as the geometrical text limits (the preserved text left
boundary and the maximum amount of 86 letters/line), the reconstructed text located on its
original position should be:

44 Keeping this specific pattern, the phrase ΥΠΕΡ ΤΟΥ ΦΩΣΦΟΡΟΥ ΠΕΡΙΦΕΡΕΙΑΝ... should be ΥΠΕΡ
ΤΟΥ ΦΩΣΦΟΡΟΥ (only theophoric), ΠΕΡΙΦΕΡΕΙΑΝ ΗΛΙΟΥ ΕΣΤΙΝ...
(beyond Phosphoros, there is the Circumference of Sun), but the correct word should be ΠΕΡΙΦΕΡΕΙΑ
(without “N”). If the letter N was engraved by mistake, then the Sun’s orbit is named ΠΕΡΙΦΕΡΕΙΑ.
Otherwise, the above phrase should be ΥΠΕΡ ΤΗΝ ΤΟΥ ΦΩΣΦΟΡΟΥ ΠΕΡΙΦΕΡΕΙΑΝ, ΕΣΤΙΝ
ΚΥΚΛΟΣ/ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΗΛΙΟΥ... (beyond Phosphoros’ circumference, there is the
circumference/circle of Sun). The authors believe that the letter “N” was mistakenly written by the
Engraver. Thus, after ΥΠΕΡ ΤΟΥ ΦΩΣΦΟΡΟΥ a comma is considered.
17. ΦΕΡΕΙΩΝ Η ΜΕΝ ΕΧΟΜΕΝΗ ΤΩ(Ι) ΤΗΣ [- - - - - - - 33 - - - - - - - ΕΣΤΙΝ ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΕΡΜΟΥ ΣΤΙΛΒΟΝ]
18. ΤΟΣ ΤΟ ΔΕ ΔΙ ΑΥΤΟΥ ΦΕΡΟΜΕΝ [- - - - - - - - - 46 - - - - - - - ΥΠΕΡ ΔΕ ΤΟΥ ΣΤΙΛΒΟΝΤΟΣ, Η]
19. ΤΗΣ ΑΦΡΟΔΙΤΗς ΦΩΣΦΟΡΟΥ [ΠΕΡΙΦΕΡΕΙΑ ΕΣΤΙΝ [- - - - - - - 44 - - - - - - - ΥΠΕΡ ΔΕ]
20. ΤΟΥ ΦΩΣΦΟΡΟΥ, ΠΕΡΙΦΕΡΕΙΑΝ [ΗΛΙΟΥ ΕΣΤΙΝ - - - - - - - - - 53 - - - - - - - - - -]
21. .............................................................................................................................................................................
22. ΜΑΙΟΥ ΑΚΤΙΝ ΥΠΕΡ ΔΕ ΤΟΝ ΗΛΙΟΥ, ΕΣΤΙΝ ΚΥ]- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
23. ΤΙΝ ΤΟΥ ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ ΤΟ ΔΕ ΔΙΑΠΟΡΕ[- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
24. ΔΙΟΣ ΦΑΙΝΟΝΤΟΣ ΤΟ ΔΕ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ[-36- - ΥΠΕΡ ΔΕ ΤΟΥ ΦΑΙΝΟΝΤΟΣ ΕΣΤΙΝ ΤΟΥ ΚΡΟ]
25. ΝΟΥ ΦΑΙΝΟΝΤΟΣ ΚΥΚΛΟΣ ΤΟ ΔΕ ΣΦΑΙΡΙΟΝ ΦΔ [- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
26. .............................................................................................................................................................................

Fig. 4. The ΠΕΡΙΦΕΡΕΙΑΣ (circumferences/orbits) of Mercury, Venus, Sun and the ΚΥΚΛΟΙ (circles/orbits) of Mars, Jupiter and Saturn engraved as homocentric circles on the bronze plate which covers the Front central area of the Mechanism. The plate is stabilized on the central annual gear b1, through the four pillars (one totally preserved and the other three partially preserved, Freeth and Jones 2012). At the same time, this plate hides the internal mechanical system of the Mechanism (gears and axes). Bronze front central plate constructed by the authors (here is presented before the final material process and assembly)
For Lines 22, and 23, see also §6.f.
In the two preserved sentences concerning the presentation of the inferior planet Mercury (Lines 17-18) and the superior planet Jupiter (Lines 23-24), a Symmetry in the syntax and the meaning is revealed:

| Lines | Translation |
|-------|-------------|
| 17-18 | There is the circumference of Mercury Stilbon and the traveling through it....... |
| 23-24 | There is the circle of Zeus Phaethon and the traveling through... |

The bronze reconstruction of ΠΕΡΙΦΕΡΕΙΣ and ΚΥΚΛΟΙ according to the Lines 17-25, is presented in Fig. 4.

6.b. The missing text of the Introduction (Lines 1-6)

The Engraver has probably written the Introduction, a General Description, Presenting, Naming and Reasoning (Purpose) of his construction and probably his name, in (or before) Lines 1-6. The text is difficult to reconstruct because it is a general description and not a clear technical text. The real name of the Antikythera Mechanism is not known. A reference to the Back Cover copper plate in which the parts of the Mechanism are presented, could exist.

In Line 1, no letter is preserved. In Line 2, there could be a possible reference to the copper/bronze plate:

| Lines | Translation |
|-------|-------------|
| 01    | ΕΙΣ ΤΑΥΤΗΝ ΔΕΙΥΠΟΛΑΒΕΙΝ (one should understand) is preserved, which is well-correlated to the phrase “this text was written by the manufacturer (his name.....) in order for someone to understand the use of this creation, named.... etc.”. (No text reconstruction). |
| 02    | The word ΤΑΥΤΗΝ (on this) is feminine in Greek language, as well as the word ΠΛΑΞ/ΠΛΑΚΑ (plate). |

6.c.1. Reconstructing the presentation text for Lines 7-11

Lines 7-11 should be correlated to the Presentation/Description and Position of the Mechanism’s Front face very central parts. In order to reconstruct the missing text the following methodology was adopted by the authors:

1) While using the functional model of Antikythera Mechanism, a text without limitation on letter number per line, was written in the ancient Greek language. The text was concerned...
with the Presentation and the Description of the very central area parts and their operation (central axis, Lunar Disc, central hole of Lunar Disc, in which the edge of the central axis is adapted etc.).

2) For the missing text specific and relative keywords/phrases, such as: ΓΕΩΜΕΤΡΙΚΟ ΚΕΝΤΡΟ (geometrical center), Η ΓΑΙΑ ΕΣΤΙΝ ΤΟ ΚΕΝΤΡΟ ΚΟΣΜΟΥ (Earth is the Center of Cosmos), ΣΕΛΗΝΗΣ ΚΥΛΙΝΔΡΟ [ΗΡΜΟΣ ΘΑΙ (The Lunar Disc/Cylinder is fitted), ΤΟ ΑΞΟΝΙΟ ΚΑΙ ΕΠ ΑΚΡΟΥ ΔΙ ΑΥΤΟΥ (the axis and its edge), (ΦΕΡΕΤΑΙ) ΔΕΞΙΟΣΤΡΟΦ ΩΣ (is continuously rotated clockwise), were used.

3) Then, they applied the text according to the text’s limitations and the preserved letter position.

6.c.2. The Front face geometrical center and the Earth locating at the center of Cosmos Lines 6-7
In Line 7 the letters ΠΡΟΣ[... are preserved, which could be part of the phrase ΠΡΟΣΘΙΑ ΟΨΙΣ (Front face). The phrase ΠΡΟΣΘΙΑ ΟΨΙΣ Defines/Refers to the position from which The Engraver starts the presentation of the Front face operational parts. At the geometrical center of the Front face is located the ΓΗ ΤΟ ΚΕΝΤΡΟ ΤΟΥ ΚΟΣΜΟΥ (Earth, the Center of Cosmos).46 The fixed axis b_{out} and the rotatable axis b_{in} are located on the same center.47

6.d.1. Reconstructing the presentation text for the Lunar Disc Definition and Position in Lines 8-11
For the moon-Lunar Disc presentation and function, The Engraver uses a large part of the BCI text. Lines 8-16 should refer to the Definition/Description, Position, and Operation of the Lunar Disc and its parts.

46 In order to cover the Lunar Disc’s stabilizing pin and the crown gear z (Voulgaris et al., 2018b), the adaptation of a colored semi sphere on the Lunar Disc central area depicting the colored Earth is possible. The material for the Earth’s sphere could be a (blue color?) painted wood or a colored rock/stone of Azurite (Pliny the Elder 1847, in Natural History named ΚΥΑΝΟΣ 35, 47) or Chalcanthon “the flower of copper” (Χάλκανθον, Pliny, Natural History 34, 134) or Crysocolla (cyan/blue-green color) see Theophrastus, 1956; Katsaros et al., 2010. The blue colored Earth’s semi sphere could be named in Greek as ΚΥΑΝΗ ΓΑΙΑ.
47 Voulgaris et al., 2018b and 2019b.
The Lunar Disc is stabilized at the upper edge of the axis \(b_m\). The preserved words in Line 9, \(\text{ΗΡΜΩΣΙΘΩΙ} (\text{fitted on})\) and in Line 10, \(\text{ΕΠ ΑΚΡΟΥ} (\text{at the edge})\) are perfectly matched with the procedure of the Lunar Disc adaptation on the edge of the axis \(b_m\).^48

A possible name for the Lunar Disc could be \(\text{ΚΥΛΙΝΔΡΟΣ ΣΕΛΗΝΗΣ} (\text{Lunar Cylinder})\) or less probable \(\text{ΔΙΣΚΟΣ ΣΕΛΗΝΗΣ} (\text{Lunar Disc})\) Fig. 5. For critical mechanical and handling reasons, the Lunar Disc is the ideal and proper Input of the Mechanism. Rotating the Lunar Disc continuously clockwise,^50 the gears and pointers, start rotating as well.^51

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48 See the Antikythera Mechanism gearing scheme Freeth and Jones 2012 and Voulgaris et al., 2019b
49 Voulgaris et al., 2018b; Roumeliotis 2018.
50 The Zodiac constellations preserved in the Zodiac month ring of Fragment C, are located in clockwise direction. Therefore, the Sun pointer (also the gear b1) rotates clockwise. From the gearing scheme presented in Freeth and Jones, 2012 and Voulgaris et al., 2019b, it results that the Lunar Cylinder also rotates in clockwise direction. As time always moves from the Past to the Future (i.e. from left to the right in the axis-x, Voulgaris et al., 2018a), therefore the Mechanism’s pointers rotate from the Past to the Future. In order to achieve this procedure, the Lunar Cylinder must be continuously rotated in CW direction. A direction change of the Lunar Cylinder rotation (CCW) could create mechanical problems or bad engagement and immobilization of gears.

The Manufacturer writes an equal instruction regarding the operation of the Metonic and Saros pointers in Bitsakis and Jones 2016b, pages 235/245 BCI Part-2:

15 [...] \(\text{ΠΕΡΟΝΗΝ ΟΘΕΝ ΕΞΗΛΚΥΣΘΗ} (\text{pin from whence it was pulled out})\)
16 [...] \(\text{ΤΗΣ ΠΡΩΤΗΣ ΧΩΡΑΣ Ν} M[ (\text{the first space})]. \text{The Manufacturer} \text{informs the reader of the manual that the user must pull out the pointers and reposition them at the spiral beginning when the two spiral pointers reach at the end of their spiral. (Otherwise the pointers will be immobilized and several gears will be destroyed)}\).

51 Text for the Lunar Disc (Cylinder) Definition/Presentation/Operation. Regarding the preserved letters \(\text{ΜΘΕ}:
1) \text{it is too difficult to detect a word in Greek literature beginning/ending with these three letters.}
2) \text{The pattern of two separated words:} \ldots \text{M ΘΕ} \ldots \text{i.e. the last letter of the first word is the letter M or} \ldots \text{ΜΘ Ε}, \text{is also difficult to exist (the number MΘ = 49 is difficult to be correlated with the text). On the CTs are clearly visible the letter Θ and the letter Ε, while the letter M is not visible. We consider as definite the letters} \ldots \text{ΘΕ} \ldots \text{. The missing letter could also be the letter Y, we adopt the pattern} \ldots \text{YΘΕ} \ldots \).

52 Bitsakis and Jones 2016b.
53 Carman and DiCocco 2016; Voulgaris et al., 2018b.
Afterwards, in Line 10 should follow a text for the Lunar Disc Positioning. The phrase ΕΠ ΑΚΡΟΥ refers to the edge of axis b_in, in which the Lunar Disc is stabilized via its central square hole.

The phrase ΚΑΙ ΕΙΣ ΤΟ ΔΙΗΝΕΚΣ ΔΕΞΙΟΣΤΡΟΦΟΙΣ ΜΕΝΟΝ implies an instruction by *The Writer*: “Do not turn the Lunar Cylinder in counter clockwise direction” (see footnotes 50).

6.d.2. The parts of the Lunar Disc in Lines 11-16

In Lines 11-16 *The Engraver Defines/Describes, Places, and Presents* the operation of the Lunar Disc parts, the Lunar phases sphere and the Lunar pointer. On the Lunar Disc perimeter, a small sphere half white/half blackened is located, which presents the lunar phases during its rotation. In Line 12, the word ΜΕΛΑΝ (black) is preserved, which is

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54 Wright 2006; Carman and Di Cocco 2016; Voulgaris et al., 2018b and 2019b.
related to the half blackened (and half white\footnote{ΛΕΥΚΟΧΡΟΥΝ in Eur. Ph. 322; in Ptol. 7,2; in Dorotheus 1976. Or ΛΕΥΚΟΝ referred by Hesiod 2001, Aristotle 1831; Theophrastus 1956.}) hemisphere of the Lunar sphere\footnote{The Description and Operation of the Lunar Phases sphere. The critical positions of the Lunar sphere are in total black color (New moon-the last day of each synodic lunar month) and in total white (Full moon-the mid-month).} Fig. 6. Therefore, before the color description, the lunar sphere must be Defined at the end of the previous line (Line 11). Additionally, Lunar Disc Operation (rotating clockwise) and then, the Lunar Phases sphere Definition and Position should also be referred. (The word ΠΕΡΙΦΕΡΕΙΑ also refers to Mercury and Venus orbits and it is the possible name for the lunar orbit).

Therefore, before the color description, the lunar sphere must be Defined at the end of the previous line (Line 11). Additionally, Lunar Disc Operation (rotating clockwise) and then, the Lunar Phases sphere Definition and Position should also be referred. (The word ΠΕΡΙΦΕΡΕΙΑ also refers to Mercury and Venus orbits and it is the possible name for the lunar orbit).

| Line 11 | [ΕΞ ΑΞΙΟΝΤΡΟΦΟΙΣ ΜΕΝ] [ΕΙΣ ΤΗΝ ΠΕΡΙΦΕΡΕΙΑΝ ΤΗΣ ΣΕΛΗΝΗΣ ΚΥΛΙΝΔΡΟΥ, ΣΦΑΙΡΙΟΝ ΣΕΛΗΝΗΣ ΦΕΡΟΜΕΝΟΝ ΕΣΤΙΝ] |
|-----------------|---------------------------------------------------------------------------------------------------------|
| Line 12 | [ΤΟ ΣΦΑΙΡΙΟΝ ΌΤΕ ΜΕΛΑΝ ΌΤΕ ΛΕΥΚΟΧΡΟΥΝ ΤΗΝ ΝΟΥΜΗΝΙΑΝ ΚΑΙ ΤΗΝ ΠΑΝΣΕΛΗΝΟΝ ΣΥΝ ΤΟ ΧΡΟΝΩ ΔΕΙΚ] |
| Line 13 | [ΝΥΣΙ] (continuously) rotated clockwise. On the circumference of the Cylinder, there is the rotated lunar little sphere |
| Line 12 | 12 the little sphere, either in black or in white color appears, and through time depicting the New moon and the Full moon |

In Line 13, The Engraver probably mentions that during the Lunar Disc rotation a large number of lunar and solar events i.e. the solar and lunar eclipses\footnote{A lunar eclipse occurred during Full moon. In ancient Greek calendars every Full moon occurred at 15\textsuperscript{th} day of each month, Mid-month named ΔΙΧΟΜΗΝΙΣ (Dichominis). A solar eclipse occurred during New moon. In ancient Greek calendars every New moon occurred at 29\textsuperscript{th}/30\textsuperscript{th} day of each month, the last day of month, named ΤΡΙΑΚΑΣ (Triakas), Geminus 1880/2002; Danezis and Theodosiou 1992; Jones 2017; Voulgaris et al., 2021.} can be presented based on the synodic cycle (and half-cycle) of the Lunar Disc:

| Line 13 | [ΤΑ ΜΕΓΙΣΤΑ ΤΩΝ ΟΛΩΝ ΓΕΓΟΝΟΤΩΝ ΚΑΙ Η ΣΕΛΗΝΗΣ ΚΑΙ Η ΗΛΙΟΥ ΕΚΛΕΙΨΙΣ ΕΝ ΤΗ ΔΙΧΟΜΗΝΙΑ ΚΑΙ ΕΝ ΤΗ ΤΡΙΑΚΑΔ] |
|-----------------|---------------------------------------------------------------------------------------------------------|
| Line 14 | [ΙΓΙΓΝΟΝΤΑΙ] 13 the most important events, the Lunar and Solar eclipses, during mid-month and the last day of the month, are occurred |

In Line 14, The Engraver could probably explain how The User can understand the mid-month/ΔΙΧΟΜΗΝΙΣ and the last day of month/ΤΡΙΑΚΑΣ on the Mechanism by observing the lunar days. Since the existence of the Tropical Year circular scale of the Sun (the Zodiac month ring is preserved in Fragment C), a circular Synodic month scale of the Moon, divided
into 29.5 cells/lunar days (numbering 1-30, A, B, Γ,... KH and Λ) is quite possible and necessary.\textsuperscript{58}

| 14 [Ι ΓΙΝΟΝΤΑΙ ΔΙ[Ε[Ι] Δ ΥΠΟΛΑΒΕΙ[Ν\textsuperscript{59} ΚΑΙ ΤΟ ΧΡΩΜΑ ΤΟΥ ΣΦΑΙΡΙΟΥ ΚΑΙ ΤΑΣ ΤΗΣ ΣΕΛΗΝΗΣ ΗΜΕΡΑΣ, ΑΙ ΠΕΡΙΕ ΤΟΥ ΚΥΛΙΝ] | 15 ΔΡΟΥY

14 someone should understand the dates of these events (Dichominis and Triakas) by observing the engraved days around the Lunar Cylinder.

On the Antikythera Mechanism ΔΙΧΟΜΗΝΙΣ occurs when the Lunar pointer aims just before the number ΙΕ (about to 14.75 cell) and ΤΡΙΑΚΑΣ when the pointer aims at the first line of A, Fig. 7. The number ΙΕ is about in opposite position to the Golden Sphere.

In order to understand the synodic month and the operation of the lunar sphere, a reference to the text, regarding the time duration of one full rotation of the lunar phases sphere (synodic month) is necessary.\textsuperscript{60}

![Image of the Lunar phases sphere](image)

Fig. 6. The Lunar phases sphere which is half white/half blackened. Black and white color alternate during the time of rotation of the small crown gear. Bronze Lunar Cylinder constructed by the authors in Line 15 [. .]ΟΥΕ. ΤΟ ΣΦΑΙΡΙΟΝ ΦΕΡΕ. [.........

\textsuperscript{58} A large number of astronomical clocks of the medieval period present a circular scale divided in 29.5 cells/lunar days (http://www.patrimoine-horloge.fr/lu-brescia.html; http://www.patrimoine-horloge.fr/lu-clusone.html; Stikas 2016).

\textsuperscript{59} The phrase [Δ]ΕΙ[Ε] Δ ΥΠΟΛΑΒΕΙ[Ν is also well preserved in Line 3.

\textsuperscript{60} The Lunar Phases sphere Operation: The sphere is rotated in a synodic month of 29.5 days (ΚΘ Β, see §6.f.).
1) By studying the tomographies on the area of letter “Υ”, the arms and the two top serifs of letter “Υ” are visible. Bitsakis and Jones 2016b write the letter Θ but in page 233 refer: “a deformed Y cannot be ruled out”.

2) Using AMRP CTs and the Real3D VolViCon software the new letter “Ι” before the phrase ΤΟ ΣΦΑΙΡΙΟΝ, was detected by the authors. For the positional numbering of the new letter, the well preserved letters of the next Line 16 ΠΡΟΕΧΟΝ ΑΥΤΟΥ ΓΝΩΜΟΝΙΟΝ Σ[, were used. The new letter “Ι” seems to be the 8th letter of the Line 15, as is located on the same position with the letter “Α” of Line 16.

In Lines 15-16 a text concerning the Lunar Disc’s pointer Definition and Position should exist. Today, the Lunar Disc pointer is not preserved, but it is totally necessary for the Mechanism to function. According to the preserved text, the lunar pointer protrudes from the Lunar Cylinder.

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61 Real3D VolViCon (software for Computed Tomographies reconstructions).
Fig. 7. The Synodic month scale is located right after the circumference of the Lunar Disc (white arrows). The scale is divided into 29.5 cells/days, equal to the duration of the Lunar Synodic month. Dichominis and Triakas located in opposite positions (see also Fig. 5). Bronze parts, before their final assembly

14 | ΓΙΓΝΟΝΤΑΙ ΔΕΙ Δ ΥΠΟΛΑΒΕΙΝ ΚΑΙ ΤΟ ΧΡΩΜΑ ΤΟΥ ΣΦΑΙΡΙΟΥ ΚΑΙ ΤΑΣ ΤΗΣ ΣΕΛΗΝΗΣ ΗΜΕΡΑΣ, ΑΙ ΠΕΡΙΣ ΤΟΥ ΚΥΛΙΝΔΡΟΥ ΕΙΣΙ

15 | ΔΡΟΥ ΕΙΣΙ ΤΟ ΣΦΑΙΡΙΟΝ ΔΕΡΕ[ΤΑΙ ΕΝ ΗΜΕΡΑΙΣ ΚΘ Β ΟΥΤΟΣ Ο ΜΗΝ ΣΥΝΟΔΙΚΟΣ ΚΑΛΕΙΤΑΙ -23-]

14 occurred. One should take into account the little sphere’s color and the lunar days, which around the cylinder.

15 der exist. The little (phases) sphere is rotated in (time span) of 29.5 days, which is called synodic month........

6e. The operation and the mechanical characteristics of the Lunar pointer (Lines 16-17)

In Lines 16-17, a text for the Lunar pointer Operation, should be referred to. The lunar pointer protrudes from the Lunar Cylinder. It has a specific length and during its rotation (via the Lunar Cylinder), travels through the two inferior planet’s circumferences.

Afterwards, follows a text in which The Engraver Describes and Places the position of the two circumferences: the first circumference is located close (ΕΧΟΜΕΝΗ) to the Lunar Cylinder and the second one follows (ΕΠΟΜΕΝΗ).
6.e.1. The Golden sphere-Sun, its pillar and the solar ray-pointer (Lines 20-22),

The word ΓΝΩΜΟΝΙΟΝ

In Lines 20-22 The Engraver Defines, Describes, and Places three parts which were related to ΠΕΡΙΦΕΡΕΙΑ/ΚΥΚΛΟΣ ΗΛΙΟΥ (orbit of the Sun): ΓΝΩΜΟΝΙΟΝ[N] (Pillar, analyzed below), ΧΡΥΣΟΥΝ ΣΕΦΑΙΡΙΟΝ (Golden Sphere) and ΗΛΙΟΥ ΑΚΤΙΝ (Solar Ray).

6.e.2. The word ΓΝΩΜΩΝ

During antiquity, the Greek word ΓΝΩΜΩΝ (gnomon) had many different meanings. Below, an analysis of the word ΓΝΩΜΩΝ is presented, and also the mechanical correlation to the Golden Sphere and the Solar Ray is discussed.

The word ΓΝΩΜΩΝ/ΓΝΩΜΟΝΙΟΝ comes from the words ΓΝΩΜΗ + ΟΝ (meaning the person who expresses an opinion with a significant meaning, one that knows, or the decision-maker, Liddell and Scott’s lexicon 2007) or by the word ΓΩΝΙΟΜΩΝ (one that measures/calculates the angle).62

The ΓΝΩΜΟΝΙΚΗ (Gnomonics) was one of the oldest sections of the Practical/Observational Astronomy of Babylonians, Egyptians, and Ancient Greeks.63

In Ancient Greece, the word ΓΝΩΜΩΝ/ΓΝΩΜΟΝΙΟΝ was used in order to describe many different meanings:

- ΠΕΡΙΦΕΡΕΙΑ was a thin tall pillar, stabilized on a base, making a shadow, acting as a pointer/indicator for the sundial.64 The inclination of this ΠΕΡΙΦΕΡΕΙΑ could be vertical (ΟΡΘΟΣ/ΟΡΘΩΝ) or at an angle (ΚΛΙΜΑ-ΚΛΙΣΙΣ) equal to the latitude of the place of observation:

-Proclus 1906, also writes “Η δὲ μεσημβρινὴ γραμμὴ λαμβάνεται γνώμονος ὁρθοῦ στάντος ἐπὶ τῆς πλακος ταύτης καὶ κύκλων γραφέντος περὶ τὴν ρίζαν του

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62 Danezis and Theodosiou 1998.
63 Danezis and Theodosiou 1998; Thibodeau 2017.
64 Hipparchus 1894, 1.3.6 and 1.4.8; Plutarch 1916 in The Life of Pericles 6.3; Suidas Lexicon Bekkeri 1854; Danezis and Theodosiou 1994.
The Meridian is defined by a perpendicular/vertical gnomon fixed on the base plate and a sketched circle with center, the gnomon’s base. Here, the word ΓΝΩΜΩΝ represents a simple pillar.

- Heron Alexandrinus in Dioptra (1903) Γνωμονίων τινον περιαγωμένων (the rotating pointers of the odometer).

- ΓΝΩΜΩΝΕΣ were named the teeth that indicated the age of a horse, Xenophon 1925, On the Art of Horsemanship Chap. 3.1.

- Apollodorus 1867 from Damascus in Poliorcita 149.4 refers ΓΝΩΜΩΝ as the front point of a drill.

- Euclides 1883/2008, in Elements of Geometry uses extendedly the word ΓΝΩΜΩΝ in Geometry (Theorem of the Gnomon).

- Proclus 2011, in Primum Euclidis Elementorum librum commentarii writes: Τοῦτο τὸ πρόβλημα πρώτον Οινοπίδης ἔξητη τον χρήσιμον αὐτὸ πρὸς ἀστρολογίαν οἴόμενον. ὕπομαξε δὲ τὴν κάθετον ἀρχαίας κατὰ γνώμονα, διότι καὶ ὁ γνώμων πρὸς ὀρθάς ἐστὶ τῷ ὄριστω. (This problem, which was firstly discussed by Oenopides, is useful for the Astrology (Astronomy). For the perpendicular angle direction he uses the archaic phrase ΚΑΤΑ ΓΝΩΜΟΝΑ, because the Gnomon’s direction is vertical to the horizon).

6.e.3. ΓΝΩΜΟΝΙΑ in the Antikythera Mechanism

On the Antikythera Mechanism the ΓΝΩΜΟΝΙΟΝ of the Lunar Disc should be a part which protruded (ΠΡΟΕΧΟΝ) from the Lunar Disc with a pointy edge. This ΓΝΩΜΟΝΙΟΝ/Lunar pointer was adapted by The Manufacturer in order to aim (during its rotation) at the Golden Sphere-Sun (New moon) or in the opposite direction (Full moon). These two relative positions were critical for the measurement of Time, and also during New moon/Full moon a solar/lunar eclipse occurred. The Lunar pointer/ΓΝΩΜΟΝΙΟΝ acts as a “real” pointer.

It seems that the Sun indicator/pointer is not a simple part. The Engraver refers the words ΓΝΩΜΟ[Ν] KEITAI ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ and then ΗΛΙΟΥ ΑΚΤΙΝ

Therefore, the Sun’s indicator is a complex design, consisted by three parts.

At the end of Line 20 should be existed the Definition and the Position of ΓΝΩΜΟ[Ν].

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65 Freeth et al., 2006; Voulgaris et al., 2021
The ΣΤΑΘΕΡΟΣ[N] is a fixed and perpendicular pillar, adapted on the Front plate of b1 gear, just on the Sun’s engraved circumference. This phrase is the Definition, Description and Position of the ΣΤΑΘΕΡΟΣ[N].

On the ΣΤΑΘΕΡΟΣ[N] is adapted the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ, the Golden Sphere-Sun. Therefore, the fixed and perpendicular pillar (ΣΤΑΘΕΡΟΣ ΚΑΙ ΟΡΘΟΣ ΣΤΑΘΕΡΟΣ) acts as a supporting base for the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ, Fig. 8. In this way, the Position of the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ is described (for the Operation of the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ see §6.f.). The word ΣΤΑΘΕΡΟΣ (fixed) could also act as a Manufacturer’s instruction: “Do not remove the fixed pillar”.

The ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ in order to be adapted on the ΣΤΑΘΕΡΟΣ[N] it needs to be perforated on its center. Hence, this pillar acts as a stabilizer for the Golden sphere and not as an operational solar pointer, Fig. 9.

The real Sun’s pointer/indicator should be a construction which was stabilized on the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ and protruded from it. Characteristic formations that protrude from the Sun are the solar rays. In the text the phrase ΗΛΙΟΥ ΑΚΤΙΝ (solar ray) is preserved. The Manufacturer probably constructed the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ, on which a small disc or a ring with some short solar rays was adapted. One of the solar rays was larger in length and extended/protruded (as also the Lunar Pointer protrudes from the Lunar Cylinder, see §6.d.2.). During the rotation of the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ-Sun, the pointer of the Sun-ΗΛΙΟΥ ΑΚΤΙΝ traveled through (scan/transit) the outer circles/orbits of the three superior planets. It seems that the reference ΗΛΙΟΥ ΑΚΤΙΝ was the real/operational Solar pointer. The length of ΗΛΙΟΥ ΑΚΤΙΝ-pointer reaches Saturn’s circle (the last superior planet) Fig. 10 and at the same time it should also be aiming at the subdivisions of the Zodiac Month ring, depicting the position of the Sun on the Ecliptic.

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66 See §6.e.2.
67 The word ΑΚΤΙΝ (in the nominative): The word “ΑΚΤΙΝ” (instead of “ΑΚΤΙΣ” in nom?) is written in the BCI text by the ancient engraver. The word “ή ἀκτίν” (nom.) is referred in Aelius Herodianus 1867, 2.511./ 3.1. In Bubeniik, 1989 referred the words Χάλκιν, Φράγμελιν, Πάννυν. Additionally, for equal words: Δελφίς (Geminus 2002, p. 63; Aratus 1821, p. 24)/ Δελφίν Mosch. 3, 37; Man. 5, 157. Πελκίς/Πελκιν/Πέλκιν in Vassilakis 2000. Γόρτυν/Γόρτις in Gillis 2018. In Eustathii archiepiscopi Thessalonicensis 1825 in Commentarii ad Homerii Odysseam, is referred: “Ιστέαν δὲ καὶ ὡς Κύριος μὲν Γόρτυν Γόρτινος κλίνει”. Herodianus 1867, in Grammatici Graeci, vol. 3.1, p. 18, refers: “κινδύνιος οὐτός δὲ ἐφι ἠ푸τόν τον κινδύνουν”. Also, Φόρκυν, Πόλτυν, Κότυν, Κάτυν, μόσυν (same writer). Arcadius 1860 in Gramm., De accentibus [Sp.] (2116: 001) “Επισμή τῆς καθολικῆς προσώπων Ἱερωδιανοῦ”, p.8 writes: δελφιν καὶ δελφίς, Τελχιν καὶ Τελχίς, Σαλαμίν καὶ Σαλαμίς, ἀκτίν καὶ ἀκτίς.
Through this analysis it is inferred that the pointer of the Sun is a composition of three different parts: a fixed perpendicular pillar, a sphere, and a cosmetic component which also acts as the real pointer/indicator of the Sun Fig. 11.

In Line 22, *The Engraver* refers ΗΛΙΟΥ ΑΚΤΙΝ, which is directly correlated to the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ. After the missing Definition and the Position of ΗΛΙΟΥ ΑΚΤΙΝ (Line 21), the Operation of the ΗΛΙΟΥ ΑΚΤΙΝ which should be referred to in Line 22 is also missing.

Fig. 8. A perpendicular pillar is placed on the circumference/orbit of the Sun. Material and image by the Authors

Fig. 9. On the perpendicular pillar is adapted the Golden Sphere-Sun, which rotates in one tropical year. Material and image by the Authors
20 ΤΟΥ [ΦΩΣ]ΦΟΡΟΥ, ΠΕΡΙΦΕΡΕΙΑΝ ΗΛΙΟΥ ΕΣΤΙΝ. ΕΙΣ ΤΗΝ ΤΟΥ ΗΛΙΟΥ ΠΕΡΙΦΕΡΕΙΑΝ ΕΙΣ ΟΡΘΟΣ ΚΑΙ ΣΤΑΘΕΡΟΣ
21 ΓΝΩΜΟ[Ν] ΚΕΙΤΑΙ. ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ [ΕΠΙ ΓΝΩΜΟΝΑ ΕΣΤΙΝ - - 17 - - ΑΠΟ ΤΟΥ ΣΦΑΙΡΙΟΥ ΠΡΟΕΧΕΙ ΑΥΤΟΥ Η ΤΟΥ]
22 ΗΛΙΟΥ ΑΚΤΙΝ

20 ...there is the Sun’s circumference. On the Sun’s circumference, one fixed and perpendicular
21 pillar is located. The Golden Sphere is adapted on the pillar ........................... from the Golden
Sphere is protruded
22 the Sun’s Ray ..........................................................
From the Golden Sphere the Solar Ray (pointer of the Sun) it protrudes. This travels through the three orbits of the superior planets Mars, Jupiter and Saturn. The Lunar pointer travels through the circumferences of Mercury and Venus (see §6.a.). Insert, different designs of the part ΧΡΥΣΟΥ ΣΦΑΙΡΙΟΝ with ΗΛΙΟΥ ΑΚΤΙΝ, were constructed by the first Author. Material and image by the Authors.

An ideal explanation is that in the middle of Line 22, The Engraver refers to the missing Operation of the Sun indicator-ΗΛΙΟΥ ΑΚΤΙΝ, which travels through/around the three next planet orbits (ΚΥΚΛΟΙ). The same procedure is written for the Lunar pointer, which travels through/around the two circumferences of the inferior planets, Mercury and Venus:

| 16 | ΤΟ (ΣΕΛΗΝΗΣ) ΓΝΩΜΟΝΙΟΝ ΦΕΡΕΤΑΙ ΕΠΙ ΤΩΝ ΠΕΡΙ | |
| 17 | ΦΕΡΕΙΟΝ, Η ΜΕΝ ΕΧΟΜΕΝΗ ΤΟΙ(Ι) ΤΗΣ ΣΕΛΗΝΗΣ ΚΥΛΙΝΔΡΟ (ΕΣΤΙΝ), Η ΔΕ ΕΠΟΜΕΝΗ | |
| 16 | the Lunar Disc pointer travels through the two circum- | |
| 17 | -ferences, the first close to the lunar circumference and the next follows | |

Applying the same description, the Sun’s Ray-pointer travels through the three superior planets’ orbit/ΚΥΚΛΟΣ (ΚΥΚΛΟΣ ΠΡΩΤΟΣ-ΜΕΣΟΣ-ΕΣΧΑΤΟΣ, first-middle-last⁶⁹ or ΚΥΚΛΟΣ ΠΡΩΤΟΣ, ΔΕΥΤΕΡΟΣ, ΤΡΙΤΟΣ, first, second, third⁷⁰):

| 22 | ΗΛΙΟΥ ΑΚΤΙΝ ΥΠΕΡ ΔΕ ΤΟΝ ΗΛΙΟΝ ΕΣΤΙΝ ΚΥ(ΚΛΟΣ ΠΡΩΤΟΣ, ΜΕΣΟΣ, ΕΣΧΑΤΟΣ, ΟΥΣ Η ΑΚΤΙΝ | |

⁶⁹ Aristotelis 1832, Lib. II, Cap.XI, p.115; Hipparchi 1894, p.226; Philonis Iudaei 1851, p.39.
⁷⁰ Geminus 2002, in Περὶ τῶν ἐν τῇ σφαίρᾳ κύκλων: πρῶτος μὲν ὁ θερινός τροπικός κύκλος, δευτέρος δὲ ὁ ἀρκτικός, τρίτος δὲ ὁ ἱσημερινός, τέταρτος δὲ ὁ ἀνταρκτικός, πείμπτος δὲ ὁ χειμερινός τροπικός.
In order to avoid the second repetition of the words ΥΠΕΡ ΔΕ ΤΟΝ ΗΛΙΟΝ ΕΣΤΙΝ, the ideal reference could be ΠΡΩΤΟΣ ΚΥΚΛΟΣ (The first circle):

A relative symmetry appears on the texts of the Lunar Pointer and the Sun’s pointer: On the one hand, the pointer of the Lunar Disc ΓΝΩΜΟΝΙΟΝ ΣΕΛΗΝΗΣ travels/transits through the orbits of inferior planets Mercury and Venus.

On the other hand, the Sun’s pointer/indicator-ΗΛΙΟΥ ΑΚΤΙΝ travels/transits through the orbits of the three superior planets. Therefore, The Engraver describes the Operation of the two pointers and also the specific length of each pointer (analyzed in §6.f.).

Fig. 11. Assembling the three mechanical parts of the Sun pointer. Material and images by the Authors
Based on the reference of Lunar/Solar sphere and pointer, and the preserved detailed reference for each planet orbit on the Back Cover Inscription Part-1, an equal Definition/Presentation/Position of the planets ΓΝΩΜΟΝΙΟΝ and ΣΦΑΙΡΙΟΝ (pointer and sphere) should exist for each planet of the Antikythera Mechanism, if the existence of the planet indication gearing was realistic and not hypothetical.

6.e.4. A significant question arises: Could the hypothetical/suggested planets, including their rotating spheres adapted on their corresponding pointers, be described on the Back Cover Inscription Part-1 text?

Many researchers maintain that a planet indication gearing existed on the Antikythera Mechanism Front central area: they suggest that, despite the rotating lunar and solar pointers/spheres, there were planet rotating pointers and colored spheres, presenting the exact planets’ position on the Ecliptic.

If the assumption of the rotating planets’ existence on the Antikythera Mechanism was realistic, a relative Definition/Description/Position and Operation for the planet pointers and their spheres should exist in the User’s Manual of the Mechanism. The planets parts Spheres/Pointers are very important, as well as the Golden Sphere and its Pointer. The position of these descriptions should be on the text’s planet orbits presentation.

Assuming there is a planet indication gearing presenting the rotating planets with their corresponding pointers and colored spheres, Freeth and Jones 2012 suggest for all of the planets the phrase:

...ΤΟ ΔΕ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ ΑΥΤΟΥ ΣΦΑΙΡΙΟΝ, e.g.

23 [-3- ΤΟ]Υ ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ ΤΟ ΔΕ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ ΑΥΤΟΥ ΣΦΑΙΡΙΟΝ
24 [ΔΙΟΣ ΦΑ]ΕΘΟΝΤΟΣ ΤΟ ΔΕ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ ΑΥΤΟΥ ΣΦΑΙΡΙΟΝ

(23 Ares Pyroes, and its traveling sphere
24 Zeus Phaethon and its traveling sphere)

Bitsakis and Jones also suggest

23 [-3- ΤΟ]Υ ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ ΤΟ ΔΕ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ ΑΥΤΟΥ ΣΦΑΙΡΙΟΝ ΠΥΡΡΟΝ
(23 And the little sphere making its way through it is fire-red...)

Thus, before the reference of “its traveling sphere”, The Engraver should have Defined/Described and Placed the planet pointers with their spheres as he has done with Definition/Description/Places of the Lunar pointer and the Sun’s pointer with its golden sphere, see §6.e.).

Hypothetical phrases for the Definition/Operation of the other planet pointers could be:

ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ ΦΕΡΟΜΕΝΟΝ ΓΝΩΜΟΝΙΟΝ ΕΣΤΙΝ
(there is the traveling/rotating pointer of Mars)
The Engraver dedicated (at least) two lines from the original text in order to Define/Describe/Place in detail, the Golden Sphere/pointer of the Sun, which was considered as one of the seven planets of the Hellenistic Astronomy:

- [ΠΕΡΙΦΕΡΕΙΑΝ] ΗЛАΙΟΥ
- [ΕΙΣ ΟΡΘΟΣ] ΓΝΩΜΩΝ [Ν]
- ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ
- ΗΛΙΟΥ ΑΚΤΙΝ

Assuming Freeth and Jones 2012 and Bitsakis and Jones 2016b words suggestion, the missing maximum number of letters, in Line 23, is 29. At the end of Line 23 the phrase ΥΠΕΡ (ΔΕ) ΤΟΝ ΠΥΡΟΕΝΤΑ ΕΣΤΙΝ Ο ΚΥΚΛΟΣ (beyond Pyroes, there is the circle of...) is necessary, as well as at the end of Line 24, the phrase ΥΠΕΡ (ΔΕ) ΤΟΝ ΦΑΕΘΟΝΤΑ ΕΣΤΙΝ Ο ΚΥΚΛΟΣ ΤΟΥ ΚΡΟ (beyond Phaethon, there is the circle of Kro-...) (see §6.a.). Therefore, the maximum missing letters of Line 23 are 0 or -1 and the missing letters of Line 24 are 8.

In the remaining letters (0/-1 in Line 23 and 7 letters in Line 24, The Engraver should present the Definition/Description, Position and Operation, of the rotating spheres of Mars/Jupiter, which are adapted to their corresponding pointers, as he presents the Definition/Description, Position and Operation for the Sun and Moon sphere and their pointers.
The Engraver also Defines in great detail the position of the Lunar Disc pointer:

For the (Definition) and the Operation of the Lunar phases sphere, The Engraver also refers:

Although The Engraver Defines/Describes/Places the rotating parts of the Moon and Sun, a similar well-referred to presentation for the pointers and spheres of Mars and Jupiter seems difficult to exist. In the missing text there is no sufficient space in order to describe the hypothetical/suggested planet pointers and spheres as a Definition/Position/Operation text.

It is difficult for someone to justify “Why The Engraver does not present the other five planet pointers and their spheres, as he presents in detail the pointers/spheres of the Sun and Moon”. The Engraver uses about 195 letters/≈2.5 text lines for the Definition/Description, Position and Operation of Suns’ sphere and its pointer (see the full text reconstruction in Table V).

As this text is the User’s Manual of the Antikythera Mechanism, The Engraver should be clear and refer to the (also important) other planet pointers and spheres (if they existed as rotating planets on the Mechanism).

The absence of a satisfying Description/Position/Operation of the planet pointers/spheres unjustifiably downgrades the role and the existence of the rotating planet pointers and spheres, relative to the well-presented Solar sphere and its pointer, as well as the Lunar parts.

Someone could assume that all of the other planet pointers and spheres were presented by a general reference, as a common description for all the other planet parts in one sentence. In this way, the role of the other planet pointers/spheres is also downgraded. It is clear that The Engraver presents each planet separately. Moreover, there is no space for this hypothetical general description about the other planet pointers, spheres, and their operation.
Although the names of the planets are referred to on the BCI Part-1, it seems that the assumption for a text regarding the Definition Position and Operation of the planet pointers/spheres is difficult to support.

On the preserved text, clear descriptions regarding the ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ (Sun), ΗΛΙΟΥ ΑΚΤΙΝ (pointer), also the Lunar phases sphere and the pointer of the Lunar Cylinder, exist. A simple reference to the planet names/orbits could not be considered as proof of the existence of the planet indication gearing on the Antikythera Mechanism.

Moreover, the adaptation of about 35 hypothetical gears, plus 50 additional non-existing parts that are needed for the hypothetical planet indication gearing, raises questions and further doubts regarding the real existence of the suggested rotating planets with pointers and spheres on the Antikythera Mechanism.

6.f. Lunar pointer traveling through and Sun’s ray traveling through (Lines 17-19, 23-25)

After the Definition of Mars and Jupiter’s orbits follows the phrase ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ ΣΦΑΙΡΙΟΝ (after Saturn’s orbit should follow the phrase ΤΟ ΔΕ ΣΦΑΙΡΙΟΝ ΦΕΡΟΜΕΝΟΝ (traveling sphere) (last preserved letter “Ε”, instead of letter “Λ”).

Before lines 23-25, the only clear correlation for a traveling sphere is the Golden Sphere-Sun. The ancient Greek astronomers, in order to describe the Sun’s travel along the Zodiac/Ecliptic used the word ΔΙΑΠΟΡΕΥΕΤΑΙ: Geminus 1880/2002 in Chap. 1 refers: “Ο δὲ ἥλιος ἑνιαυτῷ διαπορεύεται τὸν ζωδιακὸν κύκλον”; in Théon d’Alexandrie 1821 in Hypomnema (page 48): “τὴν περιφερειαν διαπορευόμενος ὁ ήλιος τὰς τῶν γνωμώνων σκιὰς”, also in Theon’s Scholia of Aratus Soleus 1821 (scholion on page 18): “ὁ δὲ ζωδιακός, ὃς διαπορεύομενος τούτον ὁ ἥλιος”; in Autolycus of Pitane 1950 (Lib. 1): “ὁ ήλιος τὴν ΕΗ περιφέρειαν διαπορεύεται”).

| 23 circle of Mars Pyroes and the traveling sphere…………………………beyond Pyroes there is circle of 24 Zeus Phaethon and the traveling sphere…………………………beyond Phaethon, there is Kro- 25 –nos Phainon circle and the sphere travels……………………………………………………………………………………………………………………… |

It is logical to directly correlate the preserved words ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ ΣΦΑΙΡΙΟΝ and ΣΦΑΙΡΙΟΝ ΦΕΡΟΜΕΝΟΝ (traveling/rotating sphere) with the ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ
ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ—Golden sphere, which was aforementioned before the description of the three superior planet orbits.

In Lines 17 and 18, in which the inferior planets Mercury and Venus are referred to, the phrase (Line 18) TO ΔΕ ΔΙ ΑΥΤΟΥ ΦΕΡΟΜΕΝΟΝ (and the traveling .....through it...........) is preserved. Applying the same meaning to the traveling Golden Sphere on the superior planet orbits, the only two parts which are traveling around the inferior planet’s orbits, are the Lunar phases sphere and the Lunar Disc pointer. Of these two parts, only the Lunar Disc pointer travels on the circumferences of Mercury and Venus. Therefore, the phrase TO ΔΕ ΔΙ ΑΥΤΟΥ ΦΕΡΟΜΕΝΟΝ is well-correlated to the Lunar Disc pointer:

| 16 ΠΡΟΕΧΩΝ ΑΥΤΟΥ ΓΝΩΜΟΝΙΟΝ ΣΕΛΗΝΗΣ - - - - - - ΤΟ ΓΝΩΜΟΝΙΟΝ ΦΕΡΕΤΑΙ ΕΠΙ ΤΩΝ ΠΕΡΙ | 17 ΦΕΡΕΙΩΝ, Η ΜΕΝ ΕΧΟΜΕΝΗ ΤΟΙ[1] ΤΗΣ [ΣΕΛΗΝΗΣ ΚΥΛΙΝΔΡΟ, Η ΔΕ ΕΠΟΜΕΝΗ. ΠΡΩΤΗ ΕΣΤΙΝ Η ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΕΡΜΟΥ ΣΤΙΛΒΟΝ] |
| 18 ΤΟΣ. ΤΟ ΔΕ ΔΙ ΑΥΤΟΥ ΦΕΡΟΜΕΝ[ΟΝ ΤΗΣ ΣΕΛΗΝΗΣ ΓΝΩΜΟΝΙΟΝ - -25- - ΥΠΕΡ ΔΕ ΤΟΝ ΣΤΙΛΒΟΝΤΑ], | 19 ΤΗΣ ΑΦΡΟΔΙΤΗΣ ΦΩΣΦΟΡΟΥ [ΠΕΡΙΦΕΡΕΙΑΝ ΕΣΤΙΝ. ΤΟ ΔΕ ΔΙ ΑΥΤΗΣ ΦΕΡΟΜΕΝΟΝ ΣΕΛΗΝΗΣ ΓΝΩΜΟΝΙΟΝ - - 8 - - ΥΠΕΡ ΔΕ] |

16 projecting from it the lunar Disc pointer ....... The pointer travels through the two circumferences, the one is located close to the Moon and the next follows. Beyond Moon, there is the circumference of Mercury Stilbon.

18 bon the traveling lunar pointer through this circle ................. Beyond Stilbon there is

19 Aphrodites Phosphoros circumference, and the traveling pointer ................. Beyond...

From the analysis of §6.e.4., we can conclude that the existence of the planet pointers/spheres is difficult to support. On the other hand, the existence of the Lunar and Solar pointers is real and definite. Both of the pointers travel along the planet (inferior/superior) orbits:

The Lunar Disc pointer travels along the orbits of Mercury and Venus (Lines 16-17).

The Sun’s sphere with its ΗΛΙΟΥ ΑΚΤΙΝ/indicator(pointer travels along the orbits of Mars, Jupiter and Saturn (Line 22).

During the Sun and the Moon independent rotation, at some point they meet/cross with a planet. This event is called conjunction, ΣΥΝΟΔΟΣ.

A conjunction (ΣΥΝΟΔΟΣ) of the Moon and Mercury occurs approximately every 30 days = Λ. \(^{71}\)

A conjunction of the Moon and Venus also occurs about every 30 days.\(^{72}\)

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\(^{71}\) Varies between 27 and 31 days. The equation for the calculation of the inferior planets synodic rotation was used. http://astronomyonline.org/science/siderealsynodicperiod.asp.
A conjunction of the Sun and Mars occurs about every 780 days = 2\textdegree 1\textsuperscript{mon} 20\textsuperscript{d} \approx 2.5\textsuperscript{y}, years = BL Z (L = year),\textsuperscript{73}

The Sun and Jupiter about every 399 days = 1\textdegree 1\textsuperscript{ma} 3.5\textsuperscript{d} \approx 1.5\textsuperscript{y}/10 = AL I,

The Sun and Saturn about every 378.09 days = 1\textdegree 13\textsuperscript{d} \approx 1.5\textsuperscript{y}/28 = AL KH.\textsuperscript{74}

Using this information, The User of the Mechanism could also calculate the position (constellation) of a planet which will be in conjunction with the Sun/Moon, if he knows the initial position of each planet in the Zodiac during the Initial Calibration Date of the Antikythera Mechanism (i.e. the date which was defined by the ancient manufacturer as the initial date for the pointers’ position).

We suppose that during the initial calibration date of the Mechanism\textsuperscript{75} the Sun was on the 1\textsuperscript{st} Zodiac day of Capricorn, and Jupiter was in conjunction with the Sun. The User can estimate the position of Jupiter after 5 conjunctions (i.e. in which constellation it will be located), starting from the initial calibration date:

5 \times 399\textsuperscript{d} = 1995\textsuperscript{d}, 1995\textsuperscript{d}/365.25\textsuperscript{d} = 5.462\textsuperscript{y} = 5 full years + 0.462\textsuperscript{y}. Then, 0.462\textsuperscript{y} = 166.7\textsuperscript{d} = 166.3\textsuperscript{y} western to Sun, 166.3/30\textsuperscript{d} = 5.544 dodecatemoria = 5 full + 0.5 dodecatemoria after 1\textsuperscript{st} day of Capricorn i.e. around the middle area of the constellation of Gemini.

The Engraver would also refer to the time of the Lunar pointer’s conjunction with each of the inferior planets and the time for the Solar pointer’s conjunction with each of the superior planets.

On the corresponding circumference/circle (orbit) was sketched on the central front cover of gear b1, he could also mark the position of each planet during the specific starting date of the Mechanism pointers.

Taking into account the aforementioned discussion, the text reconstruction of the lunar conjunction (ΕΝ ΣΥΝΟΔΩ) with Mercury and Venus is:

\textsuperscript{72} Calculations based on the data from the description of Geminus 1880/2002, also in Pseudo-Plutarch 892b-c in Plutarch 1893. The equation for the calculation of the inferior planets synodic rotation was used. http://astronomyonline.org/science/siderealsynodicperiod.asp

\textsuperscript{73} Calculated data, based on the Antikythera Mechanism Front cover Inscription, Anastasiou et al., 2016a. The equation for the calculation of the superior planets synodic rotation was used. http://astronomyonline.org/science/siderealsynodicperiod.asp

\textsuperscript{74} See Fragment 19; Bitsakis and Jones 2016b. From the preserved text of the AM, it seems that he ancient engraver does not use the usual punctuation for the numbering system (ι', κ', λ', .... for 10, 20, 30, ...). In Bitsakis and Jones 2016 (Back cover) page 235 and 246: ...ΘΝ ΤΗΣ ΟΛΗΣ ΟΛΗΣ ΤΟΥ... (πτης 19επόψιον περίοδον των 76 ετών...). In Anastasiou et al., 2016b (Front Cover) page 266, in about ten preserved (large) numbers there is no punctuation for the numbers. Generally the engraver does not use any punctuation when he refers to numbers. Fractions arise from the way numbers are been written: First, the number of full years is referred, then, the year symbol “L” and logically any number after the symbol “L” should be the fraction of the year (before “L” full years, after “L” fraction of year): BL Z: 2 ΕΘ (years) + 1/7, AL KH: 1 ΕΤΟΣ (year) + 1/28.

\textsuperscript{75} The initial calibration date of the Antikythera Mechanism defines the initial specific position for each of the seven pointers of the Mechanism.
Beyond Moon, there is the circumference of Mercury Stilbon. Beyond Stilbon there is Aphrodite’s Phosphoros circumference, and the traveling Lunar pointer in conjunction at 30 days.

The text reconstruction of the Sun’s conjunction with the three superior planets is:

- The pointer of the Sun, i.e. the Golden Sphere (ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ) with the Solar Ray (ΗΛΙΟΥ ΑΚΤΙΝ), rotates once per tropical year (ΕΝ ΕΝΙΑΥΤΩ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ or ΕΝ ΕΝΙΑΥΤΩ ΦΕΡΟΜΕΝΟΝ), a relative reference for the Lunar Cylinder’s pointer (ΓΝΩΜΟΝΙΟΝ ΣΕΛΗΝΗΣ), should exist.

As the pointer of the Sun, i.e. the Golden Sphere (ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ) with the Solar Ray (ΗΛΙΟΥ ΑΚΤΙΝ), rotates once per tropical year (ΕΝ ΕΝΙΑΥΤΩ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ or ΕΝ ΕΝΙΑΥΤΩ ΦΕΡΟΜΕΝΟΝ), a relative reference for the Lunar Cylinder’s pointer (ΓΝΩΜΟΝΙΟΝ ΣΕΛΗΝΗΣ), should exist.

Therefore, a text for the Lunar pointer Operation, is presented. The lunar pointer protrudes from the Lunar Cylinder and rotates with it. One full turn of the Lunar pointer
represents the Sidereal lunar cycle. The Sidereal cycle of the moon is the time needed for the moon to return to the same position in the Sky/stars, i.e. to the same zodiac constellation and position. The Moon turns around the celestial sphere (as observed from the Earth) in about 27.3 days (KZ Γ).

In this way, the two basic lunar cycles, the Synodic and Sidereal (235 Synodic cycles equal to 254 Sidereal cycles), were extensively used since Meton’s era (around 430BC) and during the Mechanism’s era (200BC-100BC). This can be referred to on the User’s Manual of the Mechanism (and also represented via the Mechanism’s pointers): the Synodic cycle, via the half black/half white lunar phases sphere, the lunar days scale (see § 6.d.) and the Sidereal cycle via the rotation of the Lunar pointer around the Mechanism’s Ecliptic Sky/Zodiac ring (see §6.h.).

6.g. The ΚΟΣΜΟΣ of the Antikythera Mechanism (Lines 25-26)

After presenting the planet orbits ΚΥΚΛΟΙ in Lines 17-25, The Engraver refers to the word ΚΟΣΜΟΥ (Cosmos-World) in the next line:

![Image of lines 25-26]

The word ΠΕΡΑ implies that something other follows after the ΚΟΣΜΟΣ of the Mechanism, but the Definition of ΚΟΣΜΟΣ is missing and should be referred to between the end of the previous line (Line 25) and the beginning of Line 26. The Hellenistic ΚΟΣΜΟΣ starts with the Earth, The Center of Cosmos and the last boundary of Cosmos is defined by the orbit of Saturn ΚΥΚΛΟΣ ΚΡΟΝΟΥ, Fig. 12.

In Lines 7-25 The Writer Presents/Defines the parts of ΚΟΣΜΟΣ. At the end of Line 25, he summarizes these parts, Defining the existing Cosmos:

![Image of lines 25-26]

In Line 26 the Definition/Position of an additional operational part, which is located “beyond/out of Cosmos”, is presented (see next paragraph).

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76 Voulgaris et al., 2018b.
77 Voulgaris et al., 2018b.
78 For the word ΠΕΡΑ/ΠΕΡΑΝ see LSJ lexicon
Fig. 12. The Presentation of the Hellenistic ΚΟΣΜΟΣ (Cosmos) of the Antikythera Mechanism: The Earth is located in the geometrical center, the Lunar Disc/Cylinder, the Lunar Phases Sphere, the orbits of the inferior planets, the Golden Sphere with the Solar Ray-pointer and the orbits of the superior planets. Material and image by the Authors.

6.h. The Sky and the Parapegma presentation in the Mechanism User’s Manual (Lines 26-30)

After the reference of the Lunar Disc, the seven planets and the Definition of ΚΟΣΜΟΣ, the text of the Antikythera Mechanism User’s Manual continues in Lines 26-30. During Hellenistic astronomy, after the last orbit of planet Saturn follows the Celestial Sphere - the Sky with the ΑΠΛΑΝΕΙΣ ΑΣΤΕΡΕΣ (stars with a fixed position in the sky). In contrast, ΠΛΑΝΗΤΕΣ (planets) were considered as stars which changed their position relative to the “fixed” background” of the ΑΠΛΑΝΕΙΣ ΑΣΤΕΡΕΣ (stars). 79

On the Antikythera Mechanism, the Sky is represented by the Zodiac month ring-the Ecliptic sky, Fig. 13. The Zodiac month ring is divided into twelve Zodiac months and into 365 equal subdivisions/Zodiac days. 80 Each Zodiac month has a different number of days, therefore the Zodiac ring is divided into twelve unequal parts/months. On some of the Zodiac days/subdivisions, The Engraver noted the index letters of the Parapegma events,

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79 Geminus 1898; Cleomedes 2002; Freeth and Jones 2012.
80 Voulgaris et al., 2018a. As the Antikythera Mechanism is a machine that measures Time, the units of the Zodiac ring should be in units of Time, i.e. Zodiac days.
probably corresponding to the word ΣΤΟΙΧΕΙΑ.²¹ Beyond the Zodiac ring, the Egyptian calendar ring follows, divided into 12X30 + 5 Epagomenai days.²²

The positions of ΣΤΟΙΧΕΙΑ correspond to the dates of the Parapegma events (morning/evening, rising/setting). A possible phrase for the Parapegma events reference could be the phrase ΑΠΛΑΝΩΝ (ΑΣΤΕΡΩΝ) ΓΕΓΟΝΟΤΑ (star events). The star events were engraved on the two oblong Parapegma plates. On the top plate are engraved the Winter and the Vernal months and on the bottom plate are engraved the Summer and the Autumn months.²³

In lines 28 and 30 the word ΑΣΠΙΔΙΣΚΑΙ (small shields), which has many different meanings, is referred to. The ΑΣΠΙΣ (shield) was a defensive weapon, extensively used by the ancient Greek hoplites and Roman soldiers. During the Greco-Persian Wars (507BC-449BC), Great Alexander’s kingdom (up to 323 BC) and the Hellenistic Era (323BC-31 BC), the Greek shields had a circular shape.²⁴ After the changes in the Roman Military System, the roman soldiers- legionaries used shields in (curved) oblong/rectangular shape, named Scutum.²⁵ Additionally, the word ΑΣΠΙΔΙΣΚΗ (small shield) was used to name the decorative pin heads (ΕΦΗΛΙΔΕΣ), with a circular shape and design, as a shield. These pins with heads were placed on the outer surface of wooden doors, on windows or furniture.²⁶ ΑΣΠΙΔΙΣΚΑΙ were also

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²¹ Anastasiou et al., 2014; Bitsakis and Jones 2016a.
²² Price 1974; Freeth et al., 2006. The Egyptian calendar year was divided in 365.00 days, without any correction of an additional day every 4 years.
²³ Anastasiou et al., 2014; Bitsakis and Jones 2016a.
²⁴ https://www.perseus.tufts.edu/hopper/artifactSearch?q=shield&image=yes
²⁵ Pliny 1855, Book 7, Chapter 19; Livius 1912, Book 8, Chap. 8; https://www.perseus.tufts.edu/hopper/image?img=Perseus:ima
g
d
²⁶ Orlandos 1955; Haddad 1995.
named the decorative parts (pin button/stick pin) used on the ancient Greek garments and metal utensils.  

Bitsakis and Jones 2016a suggest that the ΑΣΠΙΔΙΣΚΑΙ referred on BCI text are the four circular buttons on the corners of the Front dial plate, which were adapted on the sliding catches, stabilizing the Front Dial plate. These buttons seem more as supportive (decorative) parts, than operational parts of the Mechanism and do not affect the operation of the Mechanism.

The word ΑΣΠΙΔΙΣΚΑΙ, as it is referred to on the Mechanism User’s Manual right after the ΚΟΣΜΟΣ and the two rings (Zodiac and Egyptian), can be well-correlated to the two independent oblong plates, located on the top and the bottom Front face, Fig. 14, in which the Parapegma star events were engraved.

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26 [ΚΟΣΜΟΣ Π]ΕΡΑ ΔΕ ΤΟΥ ΚΟΣΜΟΥ ΚΕΙΤΑΙ, [ΠΡΩΤΟΣ ΜΕΝ ΚΥΚΛΟΣ ΖΩΔΙΑΚΟΣ, ΕΠΟΜΕΝΟΣ Δ ΑΙΓΥΠΤΙΑΚΟΣ. ΤΑ ΤΩΝ ΑΠΛΑΝ]
27 [ΟΝ ΑΝΑΓΡΑΦΟ][ΜΕΝΑ ΣΤΟΙΧΕΙΑ ΠΑΡΑΚΕΙΜ][ΕΝΑ ΕΝ ΤΑΙΣ ΗΜΕΡΑΙΣ ΤΟΥ ΖΩΔΙΑΚΟΥ ΚΥΚΛΟΥ ΕΣΤΙ. ΠΑΡΑΤΙΘΕΝΤΑΙ]
28 [ΔΕ ΤΑ ΓΕΓΟΝΟΤΑ Τ]ΑΥΤΑ ΤΑΙΣ ΑΣΠΙΔΑΙ[ΙΣΚΑΙΣ ΑΙ ΕΙΣΙΝ ΑΝΩΤΕΡΩ ΚΑΙ ΚΑΤΩΤΕΡΩ ΤΩΝ ΕΙΣ ΚΕΝΤΡΟΝ ΚΥΚΛΩΝ.]
29 [ΤΑ ΤΩΝ ΑΠΛΑΝΩΝ] ΠΡΟΕΙΡΗΜΕΝΑ [ΓΕΓΟΝΟΤΑ ΕΩΙΩΝ ΤΕ ΕΣΠΕΡΙΩΝ ΚΑΙ ΕΠΙΤΟΛΩΝ ΤΕ ΔΥΣΕΩΝ ΑΝΑΓΡΑΦΟΝΤΑΙ ΑΥΤΟΙ]
30 [ΕΝ ΤΗ ΑΝΩΤΕΡΑ ΕΚ ΤΟΝ] ΑΣΠΙ[ΙΔΙΣΚΩΝ, ΟΙ ΧΕΙΜΕΡΙΝΟΙ ΚΑΙ ΕΑΡΙΝΟΙ ΜΗΝΑΙ ΖΩΔΙΑΚΟΙ ΚΑΙ ΕΝ ΤΗ ΚΑΤΩΤΕΡΑ ΟΙ ΘΕΡΙΝΟΙ ΚΑΙ]
31 [ΦΘΙΝΟΠΩΡΙΝΟΙ ΜΗΝΑΙ ΖΩΔΙΑΚΟΙ ΠΑΡΑΤΙΘΕΝΤΑΙ =========49==============]

26 beyond Cosmos, firstly there is the Ecliptic ring and follows the Egyptian ring. The stars’ index letters are presented on the Zodiac days (subdivisions) of the Zodiac ring
27 the star events are engraved on the two oblong plates on top and bottom from the central cycles
28 the aforementioned morning/evening rising/setting star events are engraved
29 on the top oblong plate the winter and the vernal zodiac months and on the bottom oblong plate the summer and
30 the autumnal zodiac months are presented......................

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After Line 30(31,...), The Engraver continues the text for the Definition/Description/Position/Operation of the operational outer parts, visible to the naked eye on the Back face of his creation (Metonic and Saros Helices). The Back Cover Inscription Part-2 is also partially preserved.  

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87 Elderkin 1928.
88 Anastasiou Thesis 2014; Bitsakis and Jones 2016a.
89 Freeth et al., 2006; Voulgaris et al., 2021.
90 Bitsakis and Jones 2016b.
Fig. 14. On the top and bottom of the central circles there are two rectangular plates on which the Parapegma events are engraved. Material and image by the Authors

7.a. Summarizing the Antikythera Mechanism Front Face parts

In the previous chapters, the text which was located on the Back Cover of the Mechanism was analyzed and reconstructed. Based on the preserved and the reconstructed text, the Front face outer parts were reconstructed in bronze material by the authors.

On Table IV the outer parts of the Front face are presented, starting from the Earth, the Center of Cosmos up to the last parts, the two ΑΣΠΙΔΙΣΚΑΙ the Parapegma oblong parts.

Fig. 15. On this table, the Definition/Naming, Presentation/Description, Position and Operation of each part is presented.

| Front face Part with Ancient Greek name | OPERATIONAL PART/DEFINITION | DESCRIPTION | POSITION | OPERATION |
|----------------------------------------|-----------------------------|-------------|----------|-----------|
| ΓΑΙΑ ΤΟ ΚΕΝΤΡΟΝ ΤΟΥ ΚΟΣΜΟΥ             | Central geometrical point, bin axis | ΓΑΙΑ (Earth) | On the Front face geometrical center | The Center of Cosmos |
| ΚΥΛΙΝΔΡΟΣ/ΔΙΣΚΟΣ ΤΗΣ ΣΕΛΗΝΗΣ           | Lunar Cylinder or Lunar Disc | A rotating Cylinder | Stabilized on the Front face’s geometrical center | The driving/Input of Mechanism |
| ΣΦΑΙΡΙΟΝ ΦΑΣΕΩΝ ΤΗΣ ΣΕΛΗΝΗΣ          | Lunar phases little sphere | A colored sphere half black, half white | At the circumference of the Lunar Disc | Represents New moon and Full moon during its rotation |
| ΣΕΛΗΝΗΣ ΓΝΩΜΟΝΙΟΝ                    | Lunar Pointer | A pointer is protruded from the Lunar Disc | Is stabilized on the Lunar Disc | Rotating and traveling through Mercury and Venus |
| #  | Description                                                                 | Details                                                                 | Function/Description                                                                 |
|----|-----------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 5  | ΣΕΛΗΝΗΣ ΗΜΕΡAI (ΣΥΝΟΔΙΚΟΣ ΚΥΚΛΟΣ ΣΕΛΗΝΗΣ)                                    | Days of the Lunar Synodic month                                         | A circular scale divided in 29.5 sectors-days Engraved around the Lunar Cylinder     |
| 6  | ΠΕΡΙΦΕΡΕΙΑ ΕΡΜΟΥ ΣΤΙΛΒΟΝΤΟΣ                                                   | Circumference of Mercury                                                 | A circumference around the Earth After Lunar Disc’s circumference An engraved circle (no part) |
| 7  | ΠΕΡΙΦΕΡΕΙΑ ΑΦΡΩΔΙΤΗΣ ΦΩΣΦΟΡΟΥ                                                   | Circumference of Venus                                                   | A circumference around the Earth Beyond Mercury's circumference An engraved circle (no part) |
| 8  | ΠΕΡΙΦΕΡΕΙΑ ΗΛΙΟΥ                                                              | Circumference of Sun                                                     | A circle around the Earth Beyond Venus' circumference An engraved circle (no part)   |
| 9  | ΓΝΩΜΟΝ ΗΛΙΟΥ                                                                  | A pillar of Sun                                                         | Pillar Perpendicular stabilized on Sun’s circumference Mechanical part for other parts stabilization |
| 10 | ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ                                                             | Golden Sphere                                                           | Sphere with Golden color Stabilized on the Sun’s pillar Rotating around the Earth in one Tropical year |
| 11 | ΗΛΙΟΥ ΑΚΤΙΝ                                                                  | Sun Ray-pointer                                                          | Sun’s indicator(pointer) Stabilized on the Golden Sphere Rotates and travels through the three outer planet circles |
| 12 | ΚΥΚΛΟΣ ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ                                                        | Circle of Mars                                                          | A circle around the Earth Beyond Sun’s circumference An engraved circle (no part)     |
| 13 | ΚΥΚΛΟΣ ΔΙΟΣ ΦΑΕΘΟΝΤΟΣ                                                         | Circle of Jupiter                                                       | A circle around the Earth Beyond Mars’ circle An engraved circle (no part)            |
| 14 | ΚΥΚΛΟΣ ΚΡΟΝΟΥ ΦΑΙΝΟΝΤΟΣ                                                       | Circle of Saturn                                                        | A circle around the Earth Beyond Jupiter’s circle An engraved circle (no part)        |
| 15 | ΚΟΣΜΟΣ                                                                       | Cosmos                                                                  | The present Cosmos From the Earth up to Saturn’s circle Definition (no part)          |
| 16 | ΚΥΚΛΟΣ ΖΩΔΙΑΚΟΣ                                                              | Zodiac Month ring                                                       | Ring divided in twelve Zodiac constellations and subdivisions Beyond Cosmos The Celestial Sky of the Mechanism (Ecliptic) |
| 17 | ΚΥΚΛΟΣ ΑΙΓΥΠΤΙΑΚΟΣ                                                            | Egyptian Month ring                                                     | The ring with the Egyptian Months After the Zodiac month ring Additional Calendar     |
| 18 | ΆΣΠΙΔΙΣΚΑΙ                                                                   | Small shields                                                           | Oblong engraved bronze plates On top and bottom the central rings Plates for Parapegma events engraving |
| 19 | ΣΤΟΙΧΕΙΑ ΑΠΑΛΑΝΟΝ ΑΣΤΕΡΩΝ                                                     | Star’s letters                                                          | Index numbers of the Parapegma events Engraved on the Zodiac month subdivisions Index number |
| 20 | ΓΕΓΟΝΟΤΑ ΑΠΑΛΑΝΟΝ ΑΣΤΕΡΩΝ                                                     | Star events text                                                        | Parapegma events Engraved on top/bottom oblong plate shields Star events calendar    |

Table IV. Synoptic Catalogue of the Antikythera Mechanism Front face parts
Defined/Described/Positioned/Operation were presented on the BCI-Part 1
7.b. Symmetry on the Mechanism’s Front face two pointers’ operation and Symmetry on the text

1) From the analysis of the preserved text of BCI Part-1 we concluded that the rotating pointers of the Mechanism’s Front face are two: the Lunar Pointer and the Solar Pointer/Solar Ray. As presented in Table IV, both pointers present symmetry in their operation:

| Rotating Parts around Earth (b_m axis) | The two rotating spheres of the Mechanism | The location of the spheres | Rotation of the two spheres | The two pointers of the Mechanism’s Front face | Travelling pointer through the planet’s orbits | Synodic duration of moon and inferior/Sun and superior |
|---------------------------------------|------------------------------------------|-----------------------------|----------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------------------------|
| LUNAR DISC/ CYLINDER | Lunar Phases sphere | Located on the Lunar orbit | Lunar Sphere: One rotation/synodic | Lunar pointer, protruded from the Lunar Disc | The Lunar pointer travels through the orbits of the | The Lunar pointer in conjunction to Mercury |

Fig. 15. Left, assembling the parts which are Defined/Described/Referred on the BCI Part-1 text. Right, one of the Antikythera Mechanism functional models designed/constructed by authors (after the final assembling of the parts presented on BCI Part-1). The oxidized central front area was deliberately not polished. Parts constructed in bronze material (94%Cu, 6%Tin). The wooden design of this model is a design view of the first Author. Images by the Authors.
| GEARSOLAR | (circumference) | month MHN | two inferior planets | and Venus |
|-----------|----------------|-----------|----------------------|-----------|
| CIRCUMFERENCE | Golden Sphere | Located on the Sun’s orbit (circumference) | Solar Ray proruded from the Golden Sphere | The Solar Ray travels through the orbits of the three superior planets |

Table IV: A parallel correlation/Symmetry between the Lunar Disc and the solar circle, including their operational parts

2) A Symmetry is revealed in the text for the parts’ presentation:

I) ΑΠΟ (ΣΕΛΗΝΗΣ) ΚΥΛΙΝΔΡΟΥ ΠΡΟΕΧΟΝ ΑΥΤΟΥ ΓΝΩΜΟΝΙΟΝ ΣΕΛΗΝΗΣ
II) ΑΠΟ (ΧΡΥΣΟΥ) ΣΦΑΙΡΙΟΥ ΠΡΟΕΧΕΙ ΑΥΤΟΥ Η ΤΟΥ ΗΛΙΟΥ ΑΚΤΙΝ

i) From the Lunar cylinder is protruded the Lunar pointer
ii) From the (Golden) sphere is protruded the Solar Ray-pointer

I) ΤΟ ΓΝΩΜΟΝΙΟΝ ΦΕΡΕΤΑΙ ΤΩΝ ΠΕΡΙΦΕΡΕΙΩΝ Η ΜΕΝ ΕΧΟΜΕΝΗ... ΚΑΙ ΔΕ ΕΠΟΜΕΝΗ
II) ΚΥΚΛΟΣ ΠΡΩΤΟΣ ΜΕΣΟΣ ΕΣΧΑΤΟΣ ΟΥΣ Η (ΗΛΙΟΥ) ΑΚΤΙΝ ΦΕΡΕΤΑΙ

i) The Lunar pointer travels through the circumferences (inferior planets orbits) on the first and on the next
ii) The solar ray-pointer travels through the first, middle, last circles (superior planets orbits)

I) ΤΟ (ΣΕΛΗΝΗΣ) ΣΦΑΙΡΙΟΝ ΦΕΡΕΤΑΙ ΕΝ ΗΜΕΡΑΙ ΚΘ Β ΟΥΤΟΣ ΜΗΝ ΣΥΝΟΔΙΚΟΣ ΚΑΛΕΙΤΑΙ
II) ΧΡΥΣΟΥΝ ΣΦΑΙΡΙΟΝ (ΗΛΙΟΥ) ΕΙΣ ΕΝΙΑΥΤΟΝ ΦΕΡΟΜΕΝΟΝ

i) The Lunar sphere is rotated in 29.5 days, named synodic month
ii) The Golden sphere is rotated in one tropical year/Eniautos.

I) ΠΡΩΤΗ ΕΣΤΙΝ Η ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΕΡΜΟΥ ΣΤΙΛΒΟΝΤΟΣ
II) ΠΡΩΤΟΣ ΚΥΚΛΟΣ ΕΣΤΙΝ Ο ΤΟΥ ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ

i) The first is the circumference of Hermes Stilbon (inferior planet)
ii) The first is the circle of Ares Pyroes (superior planet)

I) ΕΡΜΟΥ ΣΤΙΛΒΟΝΤΟΣ ΤΟ ΔΕ ΔΙ ΑΥΤΟΥ ΦΕΡΟΜΕΝΟΝ ΤΗΣ ΣΕΛΗΝΗΣ ΓΝΩΜΟΝΙΟΝ ΕΝ ΣΥΝΟΔΩ ΗΜΕΡΑΙΣ Λ
II) ΑΡΕΩΣ ΠΥΡΟΕΝΤΟΣ ΤΟ ΔΕ ΔΙΑΠΟΡΕΥΟΜΕΝΟΝ (ΧΡΥΣΟΥΝ) ΣΦΑΙΡΙΟΝ ΕΝ ΣΥΝΟΔΩ Β ΛΖ

i) The travelling Lunar pointer in conjunction to Hermes Stilbon, into 30 days
ii) The travelling Golden Sphere in conjunction to Ares Pyroes, into 2 years plus 1/7.

I) ΥΠΕΡ ΔΕ ΤΟΥ ΣΤΙΛΒΟΝΤΟΣ, ΤΗΣ ΑΦΡΟΔΙΤΗΣ ΦΩΣΦΟΡΟΥ ΠΕΡΙΦΕΡΕΙΑΝ ΕΣΤΙΝ
II) ΥΠΕΡ ΔΕ ΤΟΥ ΦΑΕΘΟΝΤΟΣ ΕΣΤΙΝ Ο ΤΟΥ ΚΡΟΝΟΥ ΦΑΙΝΟΝΤΟΣ ΚΥΚΛΟΣ

i) Out of Stilbon there is Aphrodite’s Phosphoros circumference
ii) Out of Phaethon there is Kronos’ Phainon circle.

8. The final arrangement/refinment of the BCI Part-1 reconstructed text

Based on the previous analysis and the text reconstruction line by line, the reconstruction of the text parts were firstly connected in an intergraded preliminary text, keeping the specific position of the preserved words and the maximum limit of 86 letters per line.
Afterwards, following the style of The Writer, the intergraded text was further processed by subtracting, adding, changing a short number of words, to avoid repetition.

In Table V, the final reconstructed text is presented (also in Table VI the text translation in English and in Table VII the text translation in Modern Greek). Each of the colored background sentences/phrases corresponds to the Definition/Description, Position, Operation of a specific part.

Table V: Reconstructed text of the Back Cover Inscription Part-1 based on the analysis of Section 5
1. On this coppered engraved plate, there is
2. should be understood
3. below the
4. at the geometrical center of the Front Face, the Earth is located, which is the Center of Cosmos.
5. At the center there is a cylinder, rotated by hand and is called Lunar Cylinder.
6. The cylinder, via its central hole, is adapted on the axis, which is located on the geometrical center.
7. On the axis’s edge the Lunar Cylinder, is continuously rotating clockwise. On the circumference of the Lunar Cylinder there is the rotating Lunar little sphere.
8. The little sphere, either in black or in white color, depicts the New moon and the Full moon in course of time.
9. The most important Lunar and Solar events, the Lunar and Solar eclipses occurring during Dichominis and Triakas,
10. these (events) should be understood by observing the color of the Lunar little sphere and the Lunar days were engraved around the Lunar Cylinder.
11. The little sphere is rotated continuously completing 29.5 days, called Synodic Month. From the Cylinder
12. a pointer protrudes and it is in conjunction with stars every 27.3 days. The pointer travels on the two circumferences, the one is located close to the Lunar Cylinder and the next one follows. The first is the circumference of Mercury Stilbon.
13. Through this circumference, the traveling Lunar pointer comes in conjunction every 30 days. Beyond Stilbon
14. there is Aphrodites Phosphoros’ circumference and the traveling Lunar pointer comes in conjunction every 30 days. Beyond Phosphoros, there is the circumference of Sun. On the circumference a vertical pillar is stabilized. On the pillar, the Golden sphere is adapted, rotated in Eniautos. From the Golden little sphere, the Sun’s ray protrudes.
15. Beyond Sun, there is the first circle, the middle and the last one, on which the Sun’s ray travels. The first is the circle of Ares Pyroes. The traveling Sun’s sphere comes in conjunction every 2+1/7 years. Beyond Pyroes, there is the circle of Zeus Phaethon. The traveling Sun’s sphere comes in conjunction every 1+1/10 years. Beyond Phaethon, there is Saturn Phainon circle. The traveling Sun’s sphere comes in conjunction every 1+1/28 years. This
is the today’s

26 Cosmos. Beyond Cosmos, there is firstly the Zodiac circle and the Egyptian circle follows.

27 The index letters of the stars are engraved on the days located on the Zodiac ring.

28 The star events are engraved on the two small shields, located above and below the central rings.

29 The aforementioned star events morning/evening, rising/setting are presented.

30 On the top small shield, the winter and the vernal Zodiac months, and on the bottom (shield) the summer and

31 the autumnal Zodiac months are engraved…………………………………………………………………………………………………………………………………………………………………………

Table VI: BCI PART-1 text translation in the English language

01) ........................................................................................................................................................................... ΣΕ

02) ΑΥΤΗ ΤΗΝ ΧΑΛΚΙΝΗ ΕΓΧΑΡΑΚΤΗ ΠΛΑΚΑ ΑΝΑΓΡΑΦΟΝΤΑΙ .................................................................

03) ΚΑΠΟΙΟΙ ΜΠΟΡΕΙ ΝΑ ΚΑΤΑΛΑΒΕΙ .................................................................................................

04) ΥΠΟ ΔΕ ΤΟΝ ΤΩ .................................................................................................................................

05) Δ . - - - - - ΟΙΚΑ........................................................................................................................................

06) Ε - - - - - - ΗΙΣΠ............................................................................................................................... ΣΤΟ

07) ΓΕΩΜΕΤΡΙΚΟ ΚΕΝΤΡΟ ΤΗΣ ΠΡΟΣΩΙΑΣ ΩΨΗΣ ΒΡΙΣΚΕΤΑΙ Η ΓΗ, Η ΟΠΟΙΑ ΣΗΜΕΡΑ ΕΙΝΑΙ ΤΟ ΚΕΝΤΡΟ

ΤΟΥ ΚΟΣΜ.

08) ΟΥ. ΣΤΗ ΘΕΣΗ ΤΟΥ ΚΕΝΤΡΟΥ ΒΡΙΣΚΕΤΑΙ ΕΝΑΣ ΚΥΛΙΝΔΡΟΣ ΠΟΥ ΠΕΡΙΣΤΡΕΦΕΤΑΙ ΜΕ ΤΟ ΧΕΡΙ ΚΑΙ

ΟΝΟΜΑΖΕΤΑΙ ΚΥΛΙΝΔΡΟΣ ΤΗΣ ΣΕΛΗΝΗΣ.

09) Ο ΚΥΛΙΝΔΡΟΣ ΣΤΕΡΩΝΕΤΑΙ ΜΕΣΩ ΤΗΣ ΚΕΝΤΡΙΚΗΣ ΟΠΗΣ ΤΟΥ ΣΤΟΝ ΑΞΟΝΑ ΠΟΥ ΒΡΙΣΚΕΤΑΙ

ΤΟΠΟΘΕΤΗΜΕΝΟΣ ΣΤΟ ΓΕΩΜΕΤΡΙΚΟ ΚΕΝΤΡΟ. ΣΤΟΝ

10) ΑΞΟΝΑ ΚΑΙ ΣΤΟ ΑΚΡΟ ΑΥΤΟΥ, Ο ΚΥΛΙΝΔΡΟΣ ΤΗΣ ΣΕΛΗΝΗΣ ΠΕΡΙΣΤΡΕΦΕΤΑΙ ΣΥΝΕΧΩΣ

11) ΔΕΣΙΟΣΤΡΟΦΑ. ΣΤΗΝ ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΚΥΛΙΝΔΡΟΥ ΤΗΣ ΣΕΛΗΝΗΣ ΥΠΑΡΧΕΙ ΤΟ ΠΕΡΙΣΤΡΕΦΟΜΕΝΟ

ΣΦΑΙΡΙΟ ΤΗΣ ΣΕΛΗΝΗΣ.

12) ΤΟ ΣΦΑΙΡΙΟ ΑΛΛΟΤΕ (ΕΙΝΑΙ) ΜΑΥΡΟΥ ΚΑΙ ΑΛΛΟΤΕ ΛΕΥΚΟΥ ΧΡΩΜΑΤΟΣ ΔΕΙΧΝΟΝΤΑΣ ΣΤΑΔΙΑΚΑ

ΤΗΝ ΝΟΥΜΗΝΙΑ ΚΑΙ ΤΗΝ ΠΑΝΣΕΛΗΝΟ.

13) ΤΑ ΣΠΟΥΔΑΙΟΤΕΡΑ ΑΠ’ ΟΛΑ ΤΑ ΓΕΓΟΝΟΤΑ ΚΑΙ Η ΕΚΛΕΙΨΗ ΤΗΣ ΣΕΛΗΝΗΣ ΚΑΙ ΤΟΥ ΗΛΙΟΥ, ΣΥΜΒΑΙΝΟΥΝ ΣΤΗ ΜΕΣΗ ΤΟΥ ΜΗΝΑ ΚΑΙ ΣΤΗΝ ΤΡΙΑΚΟΣΤΗ ΗΜΕΡΑ ΤΟΥ.

14) ΚΑΠΟΙΟΣ ΜΠΟΡΕΙ ΝΑ ΑΝΤΙΛΗΦΘΕΙ (ΤΗΝ ΝΟΥΜΗΝΙΑ ΚΑΙ ΤΗΝ ΔΙΧΟΜΗΝΙΑ) ΠΑΡΑΤΗΡΩΝΤΑΣ ΚΑΙ

ΤΟ ΧΡΩΜΑ ΤΟΥ ΣΦΑΙΡΙΟΥ ΚΑΙ ΤΙΣ ΗΜΕΡΕΣ ΤΗΣ ΣΕΛΗΝΗΣ ΠΟΥ ΑΝΑΓΡΑΦΕΙ ΓΥΡΩ ΑΠΟ ΤΟΝ ΚΥΛΙΝΔΡΟ ΤΗΣ.

15) ΤΟ ΣΦΑΙΡΙΟ ΠΕΡΙΣΤΡΕΦΕΤΑΙ ΣΕ 29.5 ΗΜΕΡΕΣ. ΑΥΤΟΣ Ο ΜΗΝΑΣ ΟΝΟΜΑΖΕΤΑΙ ΣΥΝΟΔΙΚΟΣ

ΜΗΝΑΣ. ΑΠΟ ΤΟΝ ΚΥΛΙΝΔΡΟ ΑΥΤΟΥ

16) ΤΟ ΓΝΩΜΟΝΙΟ ΤΗΣ ΣΕΛΗΝΗΣ ΠΟΥ ΠΡΟΕΞΕΧΕΙ ΕΡΧΕΤΑΙ ΣΕ ΣΥΝΟΔΟ ΜΕ ΤΑ ΑΣΤΕΡΙΑ ΣΕ 27.3

ΗΜΕΡΕΣ. ΤΟ ΓΝΩΜΟΝΙΟ ΔΙΑΒΑΙΝΕΙ ΔΥΟ ΠΕΡΙ

17) ΦΕΡΕΙΣ. Η ΜΙΑ ΒΡΙΣΚΕΤΑΙ ΚΟΝΤΑ ΣΤΗ ΣΕΛΗΝΗ ΚΑΙ Η ΆΛΛΗ ΕΠΕΤΑΙ. ΠΡΩΤΗ ΕΙΝΑΙ Η ΠΕΡΙΦΕΡΕΙΑ

ΤΟΥ ΕΡΜΟΥ ΣΤΙΛΒΟΝ

18) ΤΟΣ. ΤΟ ΓΝΩΜΟΝΙΟ ΤΗΣ ΣΕΛΗΝΗΣ ΠΟΥ ΠΕΡΙΦΕΡΕΤΑΙ ΣΕ ΑΥΤΟΝ ΒΡΙΣΚΕΤΑΙ ΣΕ ΣΥΝΟΔΟ ΚΑΘΕ 30

ΗΜΕΡΕΣ. ΠΕΡΑ ΑΠΟ ΤΟΝ ΣΤΙΛΒΟΝΤΑ
19) ΒΡΙΣΚΕΤΑΙ Η ΠΕΡΙΦΕΡΕΙΑ ΤΗΣ ΑΦΡΟΔΙΤΗΣ ΦΩΣΦΟΡΟΥ. ΤΟ ΠΕΡΙΦΕΡΟΜΕΝΟ ΓΝΩΜΟΝΙΟ ΕΡΧΕΤΑΙ ΣΕ ΣΥΝΟΔΟ ΚΑΘΕ 30 ΗΜΕΡΕΣ. ΠΕΡΑ ΑΠΟ ΤΟΝ
20) ΦΩΣΦΟΡΟ ΒΡΙΣΚΕΤΑΙ Η ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΗΛΙΟΥ. ΣΤΗΝ ΠΕΡΙΦΕΡΕΙΑ ΤΟΥ ΗΛΙΟΥ ΕΙΝΑΙ ΣΤΕΡΕΟΜΕΝΟ ΕΝΑ ΚΑΘΕΤΟΣ ΚΑΙ ΑΚΙΝΗΤΟΣ ΣΤΥΛΙΣΚΟΣ. ΣΤΟΝ
21) ΣΤΥΛΙΣΚΟ ΤΟΠΟΘΕΤΕΙΤΑΙ ΤΟ ΧΡΥΣΟ ΣΦΑΙΡΙΟ ΤΟΥ ΗΛΙΟΥ, ΠΕΡΙΦΕΡΟΜΕΝΟ ΣΕ ΕΝΑ ΤΡΟΠΙΚΟ ΕΤΟΣ ΑΠΟ ΤΟ ΣΦΑΙΡΙΟ ΠΡΟΕΚΤΕΙΝΕΤΑΙ Η
22) ΑΚΤΙΝΑ ΤΟΥ ΗΛΙΟΥ. ΠΕΡΑ ΑΠΟ ΤΟΝ ΗΛΙΟ ΥΠΑΡΧΕΙ Ο ΠΡΩΤΟΣ, Ο ΜΕΣΟΣ ΚΑΙ Ο ΕΣΧΑΤΟΣ ΚΥΚΛΟΣ, ΤΟΥΣ ΟΠΟΙΟUS ΔΙΑΒΑΙΝΕΙ Η ΑΚΤΙΝΑ ΤΟΥ ΗΛΙΟΥ. Ο ΠΡΩΤΟΣ ΚΥΚΛΟΣ ΕΙΝΑΙ
23) ΤΟΥ ΑΡΕΩΣ ΠΥΡΟΕΝΤΑ ΚΑΙ ΤΟ ΔΙΑΠΟΡΕΥΟΜΕΝΟ ΣΦΑΙΡΙΟ (ΤΟΥ ΗΛΙΟΥ) ΕΡΧΕΤΑΙ ΣΕ ΣΥΝΟΔΟ ΚΑΘΕ 2 ΕΤΗ ΚΑΙ 1/7. ΠΕΡΑ ΑΠΟ ΤΟΝ ΠΥΡΟΕΝΤΑ ΒΡΙΣΚΕΤΑΙ Ο ΚΥΚΛΟΣ ΤΟΥ
24) ΔΙΟΣ ΦΑΕΘΟΝΤΟΣ ΚΑΙ ΤΟ ΔΙΑΠΟΡΕΥΟΜΕΝΟ ΣΦΑΙΡΙΟ (ΤΟΥ ΗΛΙΟΥ) ΕΡΧΕΤΑΙ ΣΕ ΣΥΝΟΔΟ ΚΑΘΕ 1 ΕΤΟΣ ΚΑΙ 1/10. ΠΕΡΑ ΑΠΟ ΤΟΝ ΦΑΕΘΟΝΤΑ ΒΡΙΣΚΕΤΑΙ Ο
25) ΚΥΚΛΟΣ ΤΟΥ ΚΡΟΝΟΥ ΦΑΙΝΟΝΤΟΣ ΚΑΙ ΤΟ ΔΙΑΠΟΡΕΥΟΜΕΝΟ ΣΦΑΙΡΙΟ (ΤΟΥ ΗΛΙΟΥ) ΕΡΧΕΤΑΙ ΣΕ ΣΥΝΟΔΟ ΚΑΘΕ 1 ΕΤΟΣ ΚΑΙ 1/28. ΑΥΤΟΣ ΛΟΙΠΟΝ ΕΙΝΑΙ Ο ΚΟΣΜΟΣ ΣΗΜΕΡΑ.
26) ΠΕΡΑ ΑΠΟ ΑΥΤΟΝ ΤΟΝ ΚΟΣΜΟ ΒΡΙΣΚΕΤΑΙ ΠΡΩΤΑ Ο ΖΩΔΙΑΚΟΣ ΔΑΚΤΥΛΙΟΣ ΚΑΙ ΕΠΕΙΤΑ Ο ΑΙΓΥΠΤΙΑΚΟΣ (ΔΑΚΤΥΛΙΟΣ).
27) ΤΑ ΑΝΑΓΡΑΦΟΜΕΝΑ ΣΤΟΙΧΕΙΑ (ΟΙ ΠΑΡΑΠΟΜΠΕΣ) ΤΩΝ ΑΠΛΑΝΩΝ ΑΣΤΕΡΩΝ ΕΙΝΑΙ ΣΗΜΕΙΩΜΕΝΑ ΣΤΙΣ ΗΜΕΡΕΣ ΤΟΥ ΖΩΔΙΑΚΟΥ ΔΑΚΤΥΛΙΟΥ.
28) ΤΑ ΓΕΓΟΝΟΤΑ ΤΩΝ ΑΣΤΕΡΩΝ ΕΙΝΑΙ ΓΡΑΜΜΕΝΑ ΣΤΙΣ ΔΥΟ ΜΑΚΡΟΣΤΕΝΕΣ ΠΛΑΚΕΣ, ΟΙ ΟΠΟΙΕΣ ΒΡΙΣΚΟΝΤΑΙ ΠΑΡΑΤΙΘΕΝΤΑ ΕΔΩ (ΣΤΙΣ ΠΛΑΚΕΣ).
29) ΤΑ ΠΡΟΑΝΑΦΕΡΘΕΝΤΑ ΓΕΓΟΝΟΤΑ ΤΩΝ ΑΠΛΑΝΩΝ ΑΣΤΕΡΩΝ ΚΑΙ ΠΡΩΙΝΩΝ ΚΑΙ ΑΠΟΓΕΥΜΑΤΙΝΩΝ ΚΑΙ ΑΝΑΤΟΛΩΝ ΚΑΙ ΔΥΣΕΩΝ ΤΟΥΣ, ΠΑΡΑΤΙΘΕΝΤΑΙ ΕΔΩ (ΣΤΙΣ ΠΛΑΚΕΣ).
30) ΣΤΗΝ ΕΠΑΝΩ ΠΛΑΚΑ ΟΙ ΧΕΙΜΕΡΙΝΟΙ ΚΑΙ ΟΙ ΕΑΡΙΝΟΙ ΖΩΔΙΑΚΟΙ ΜΗΝΕΣ ΚΑΙ ΣΤΗΝ ΚΑΤΩ ΠΛΑΚΑ
31) ΟΙ ΘΕΡΙΝΟΙ ΚΑΙ ΟΙ ΦΘΙΝΟΠΩΡΙΝΟΙ ΖΩΔΙΑΚΟΙ ΜΗΝΕΣ ΕΙΝΑΙ ΧΑΡΑΓΜΕΝΟΙ ………………………………………..………

Table VII: BCI PART-1 text translation in the Modern Greek language

As can be deduced from the distribution of the colors on the reconstructed text in Table V, the largest percentage of the text, about 30% is dedicated to the Definition/Description, Position, Operation of the Lunar Disc and its parts, and the Presentation of the Sun and its parts follows with about 9.4%. Regarding the presentation of the planets, the percentage varies between 2.8% and 3.6% (can be considered as definite for Mars, Jupiter and Saturn), significantly smaller than the Lunar Disc’s and Suns’ percentage. The difference in the percentages between the Moon and Sun which have pointers and spheres and the simple reference to the planet circles reveals that the Lunar Disc and the Golden Sphere-Sun are more important planets than the other five, which were only presented by their orbits.

| Part description on the preserved BCI Part-1 text | Corresponding number of lines | Total letters per description | Percentage % of 2475 letters in 31 lines |
|---------------------------------------------------|------------------------------|------------------------------|----------------------------------------|
| Introduction                                      | Lines 1-6                    | 516 max                       | 20%                                   |
| Lunar Disc                                       | Lines 8-17                   | 735                          | 29.7%                                 |
| Mercury                                          | Lines 17-18                  | 84                           | 3.3%                                  |
To be more exact, the corresponding text for the Lunar Disc has the most extensive reference, indicating an important role in the Antikythera Mechanism’s operation. This gives the impression that all of the Mechanism’s procedures are dependent, based and operated by the Lunar Disc. For mechanical and handling reasons the most proper and ideal input/driving of the Mechanism is the Lunar Disc.\textsuperscript{91} Hence, \textit{The Engraver/The Manufacturer} of the Mechanism logically dedicates a large–section of the text to this part. From our perspective, this adds another significant argument: the Antikythera Mechanism was a Luni-Solar Time calculating machine, based on the synodic Lunar cycle.

\textbf{9. Discussion and Summary}

In this work, the reconstruction of the BCI Part-1 text was presented after the analysis of the preserved text.

Although a notable part of the original text is missing, this absence did not prevent the text reconstruction, because the preserved text can be correlated to the visual photographs and the AMRP tomographies. This information was not only the engraved words, but also the mechanical operational parts of the Mechanism. In many cases, the text, and the parts are both preserved. Moreover, the preserved original text leads to the bronze parts reconstruction. On the other hand, the adaptation and the use of these parts on the functional model of the Mechanism lead to the reconstruction of the text.

Reading the partially preserved original text, and keeping the Symmetry on specific sentences, it results that the ancient writer presents the circles–planet orbits of Mercury, Venus, the Sun, Mars, Jupiter, and Saturn. The ancient manufacturer designed six homocentric circles on the cover of the b1 gear, with the b_{in} axis-Earth in the center. The Lunar pointer travels through the first two circumferences of Mercury and Venus, and the pointer of the Sun through the other three planet circles (Mars, Jupiter and Saturn).

\begin{table}[h]
\centering
\begin{tabular}{|l|l|c|c|}
\hline
\textbf{} & \textbf{} & \textbf{} & \textbf{} \\
\hline
\textit{Venus} & Lines 18-19 & 90 & 3.6\% \\
\textit{Sun} & Lines 19-22 & 235 & 9.5\% \\
\textit{Mars} & Line 22-23 & 71 & 2.8\% \\
\textit{Jupiter} & Line 23-24 & 78 & 3.1\% \\
\textit{Saturn} & Line 24-25 & 80 & 3.2\% \\
\textit{Cosmos} & Line 25 & 30 & 1.2\% \\
\hline
\textit{Zodiac and Egyptian rings} & Line 26 & 64 & 2.5\% \\
\textit{Index letters} & Line 27 & 80 & 3.2\% \\
\hline
\textit{Star events, Parapegma plates (small shields)} & Lines 28-31 & (238+59)=297 & 12\% \\
\hline
\end{tabular}
\caption{The final letter percentage per each operational part on the BCI Part-1 reconstructed text.}
\end{table}

\textsuperscript{91} Voulgaris et al., 2018b; Roumeliotis 2018.
The analysis of the original text concludes there is no space for a reference to the rotating planet pointers with spheres. A prominent question arises from the absence of planet pointers and their spheres: if the rotating planets existed on the Antikythera Mechanism, why did The Engraver not extensively Describe, Present and Place these parts on the User’s Manual of his creation? Moreover, the absence of any reference (or poor description) to these parts, downgrades their importance and it is too difficult to justify.

The construction, the assembly of the Mechanism parts and the large number of “flight hours” using the authors’ Antikythera Mechanism functional models, was critical and decisive for the reconstruction of the Back Cover Inscription Part-1 text.

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Bibliography

Allen, M., W. Ambrisco, M. Anastasiou, D. Bate, Y. Bitsakis, A. Crawley, M.G. Edmunds, D. Gelb, R. Hadland, P. Hockley, A. Jones, T. Malzbender, H. Mangou, X. Moussas, A. Ramsey, J.H. Seiradakis, J.M. Steele, A. Tselikas, and M. Zafeiropoulou (eds) 2016. “Special Issue: The Inscriptions of the Antikythera Mechanism”, Almagest: International Journal for the History of Scientific Ideas 7.1. Turnhout: Brepolis.

Anastasiou M., 2014, Thesis. Ο μηχανισμός των Αντικυθήρων: αστρονομία και τεχνολογία στην αρχαία Ελλάδα (in Greek). The Antikythera mechanism: astronomy and technology in ancient Greece.

Anastasiou M., J.H. Seiradakis, C.C. Carman, and K. Efstathiou, 2014. “The Antikythera Mechanism: The construction of the metonic pointer and the back plate spirals”, Journal for the History of Astronomy, 45(4), 418-441.

Anastasiou, M., Y. Bitsakis, A. Jones, X. Moussas, A. Tselikas, and M. Zafeiropoulou. 2016b. “The Inscriptions of the Antikythera Mechanism 6: The Front Cover Inscription”, in Allen et al. 2016, 250-297.

Antikythera Mechanism Research Project, http://www.antikythera-mechanism.gr

Apollodorus of Damascus, 1867. Poliorcetique. In: Wescher, C. (Ed.), Poliorcetique des Grecs (Πολιορκητικά και πολιορκίαι διαφόρων πόλεων), pp. 135–193. Paris: L’ Imprimerie Imperiale.

Aratus de Soles 1821. Les Phenomenes avec les scholies de Theon. Paris: Halma M.

Arcadius 1860. Gramm., De accentibus “Επιτομή τῆς καθολικῆς προσωῳδίας Ἡρωδιανοῦ”, Ed. Schmidt, M.Jena: Mauke.

Aristotelis 1832. Opera omnia, Analytica Priora et Posteriora, Vol. 9, Lib II Cap. XI, Ed. Sterotypa.

Astronomy on Line, http://astronomyonline.org/science/siderealsynodicperiod.asp

Autolycus of Pitane, 1950. On the Moving Sphere and On Risings and Settings, (Περί Κινούμενης Σφαίρας and perί Επιτολῶν και Δύσεων, De sphaera quae movetur and
De oribus et occasibus. In Mogenet, J., ed. Louvain: Publications Universitaires de Louvain.

Bekker I., 1854. Suidae Lexicon. Berolini: Reimeri G.

Aristotelis, 1831. Opera Graece Latinae Academia Regia Borusica. Vol. 1 Berolin: Bekker.

BIT.AI The World's Most Powerful Workplace and Document Collaboration Platform. How to Write a Stellar Instruction Manual? https://blog.bit.ai/write-instruction-manual/

Bitsakis, Y. and A. Jones. 2016a. “The Inscriptions of the Antikythera Mechanism 3: The Front Dial and Parapegma Inscriptions”, in Allen et al. 2016, 68-137.

Bitsakis, Y. and A. Jones. 2016b. “The Inscriptions of the Antikythera Mechanism 5: The Back Cover Inscription”, in Allen et al. 2016, 217-249.

Bowen A.C., and R.B. Todd, 2004. Cleomedes’ Lectures on Astronomy. A Translation of The Heavens with an Introduction and Commentary. University of California Press.

Bubeník V., 1989. Hellenistic and Roman Greece as a Sociolinguistic Area. John Benjamins Publishing.

Carman, Chr. and M. Di Cocco. 2016. “The Moon Phase Anomaly in the Antikythera Mechanism”, Institute for the Study of the Ancient World Papers 11: http://doi.org/10.1210/isawpub/11.

Cleomedes, 2002. On the Circular Motions of the Celestial Bodies, transl. Spandagos E. Athens: Aithra, in Greek. Κλεωμηδῆς Κυκλικὴ Θεωρία Μετεώρων, Βιβλίον Β’ μετάφραση Σπανδάγου Ε. Αθήνα: Αίθρα. https://www.astrologicon.org/cleomedes/cleomedes-circular-theory-meteors2.html.

Danezis M., and S. Theodosiou, 1995. The Calendars Odyssey. Athens: Diaylos, in Greek. Η Οδύσσεια των Ημερολογίων. Αθήνα: Δίαυλος.

Danezis M., and S. Theodosiou, 1998. On the Labyrinth of Time, Seven Days, Gnomons, Sun-clocks, klepsydrae and Ammota. Athens: Kathimerini, Special Edition on December 27, 1998. Στον Λαβύρινθο του Χρόνου, Εβδομήκοντα, Ηλιακά Ρολόγια, Κλεψύδρες και Αμμωτά. Αθήνα: Καθημερινή, 27 Δεκεμβρίου 1998.

Dorotheus of Sidon, 1976. Pentateuch. Ed. in Dorothei Sidonii Carmen Astrologicum, ed. David Pingree. Leipzig: Teubner.

Douglas Krantz’s Technician’s Corner What is an Instruction Manual? https://www.douglaskrantz.com/SCManual.html.

Euclides, 1883/2008. Elements of Geometry. The Greek text of J.L. Heiberg (1883–1885) from Euclidis Elementa, edidit et Latinum interpretatus est I.L. Heiberg, in aedibus B.G. Teubneri, 1883–1885 edited, and provided with a modern English translation, by Richard Fitzpatrick.

Freeth T., Y. Bitsakis, X. Moussas, J.H. Seiradakis, A. Tselikas, H. Mangou, M. Zafeiropoulou, et al., 2006. “Decoding the Ancient Greek Astronomical Calculator Known as the Antikythera Mechanism”, Nature 444, 587-591.

Freeth, T., A. Jones, J.M. Steele and Y. Bitsakis. 2008. “Calendars with Olympiad Display and Eclipse Prediction on the Antikythera Mechanism”, Nature 454 (31 July), 614-617 and Supplementary Information, pp. 1-42.

Freeth, T. and A. Jones. 2012. The Cosmos in the Antikythera Mechanism. Institute for the Study of the Ancient World Papers 4: <http://dlib.nyu.edu/awdl/isaw/isaw-papers/4/>.

Geminus, 1880. Gemini Elementa Astronomiae. In: Manitius K. (Ed.). Leipzig, in Greek and Latin.

Geminus, 2002. Gemini Elementa Astronomiae. In: Manitius K. (Ed.), (Leipzig, 1880), transl. E. Spandagos, in Greek. Athens: Aithra. Γέμινος, Εισαγωγή εἰς τα φαινόμενα του Γεμίνου του Ρόδιου σε μετάφραση Ε. Σπανδάγου, Αθήνα: Αίθρα.

Gillis O., 2018. Knossos-Phaistos and other ancient cities of Crete, in Greek. https://www.academia.edu/38027878/%CE%9F%CE%B4%CF%85%CF%83%CF%83%CE
Haddad N., 1995. *Doors and Windows in Hellenistic and Roman Architecture of the Greek Territory*, Thessaloniki, Greece, PHD Thesis, in Greek. Θύρες και Παράθυρα στην Ελληνιστική και Ρωμαϊκή Αρχιτεκτονική του Ελλαδικού Χώρου. Διδακτορική Διατριβή, Θεσσαλονίκη, Ελλάδα.

Hellenica World, Ἦρων ο Αλεξανδρεύς, Ὀροι (Heron o Alexandreus, Ori) [http://www.hellenicaworld.com/Greece/Literature/IronOAlexandrevs/gr/Oroi.html](http://www.hellenicaworld.com/Greece/Literature/IronOAlexandrevs/gr/Oroi.html)

Hero of Alexandria, 1826. *Definitiones geometricae: antehac nunquam nisi per Conr. Daspypodium Argent.* 1570 editae. In Ed. Sumtibus G. Trinii, Stralsundiae.

Herodianus Aelius 1867. *Grammatici Graeci*, Ed. Lentz, A., Leipzig: Teubner.

Heron Alexandrinus, 1903. *Heronis Alexandrini opera quae supersunt omnia*, Hermann Schöne. Leipzig: Teubner.

Hesiod 2001. *Works and Days. Theogony. The Shield of Hercules*. Athens: Zitros in Greek.

Hipparchus, 1894. In *Arati et Eudoci phaenomena commentariorum* libri iii Book 1(1) ΠΠΑΡΧΟΥ ΤΩΝ ΑΡΑΤΟΥ ΚΑΙ ΕΥΔΟΞΟΥ ΦΑΙΝΟΜΕΝΩΝ ΕΞΗΓΗΣΕΩΣ ΠΡΩΤΟΝ Manius, Teubner. [https://scaife.perseus.org/reader/urn:cts:greekLit:tlg1431.tlg003.1st1-kgrc1:1](https://scaife.perseus.org/reader/urn:cts:greekLit:tlg1431.tlg003.1st1-kgrc1:1)

Elderkin K.M., 1928. “Buttons and Their Use on Greek Garments”, *American Journal of Archaeology*, Vol. 32(3), 333-345.

Eustathii archiepiscopi Thessalonicensis 1825; 1826, Repr. 1970. Commentarii ad Homeri Odysseam, 2 vols. in 1, Ed. Stallbaum, G. Leipzig: Weigel.

Ingo G.M., De Caro T., Ricucci C., Angelini E., Grassini S., Balbi S., Bernardini P., Salvi D., Bousselmi L., Cilingiroglu A., Gener M., Gouda V.K., Al Jarrah O., Khosroff S., Mahdjeoub Z., Al Saad Z., El-Saddik W., and Vassiliou P., 2006. “Large scale investigation of chemical composition, structure and corrosion mechanism of bronze archeological artefacts from Mediterranean basin”, *Applied Physics A*, 83(4), 513-520.

Jones, A. 2017. *A Portable Cosmos: Revealing the Antikythera Mechanism, Scientific Wonder of the Ancient World*. New York: Oxford University Press.

Katsaros T., I. Liritzis and N. Laskaris 2010. Identification of Theophrastus’ Pigments egyptios kyanos and psimythion from archaeological excava-tions: A case study. ArcheoSciences, revue d’archéométrie, 34, 69-79.

Liddell H.G. and Scott R., 2007. *Liddell and Scott's Greek-English Lexicon*. Simon Wallenburg Press.

Liddell H.G. and Scott R., 2007. *Grand Dictionary of the Greek Language*. Athens: Pelecanos. Επιτομή του Μεγάλου Λεξικού της Ελληνικής Γλώσσας. Αθήνα: Πελεκάνος.

Livius Titus (Livy), 1912. *The History of Rome*. English Translation by. Rev. Canon Roberts. New York: Dutton and Co.

Maths is Fun [https://www.mathsisfun.com/geometry/symmetry-point.html](https://www.mathsisfun.com/geometry/symmetry-point.html)

Neugebauer O., and H.B. Van Hoesen, 1987. *Greek Horoscopes, American Philosophical Society*, 19, p.213.

Orlandos A., 1994. *The Structure Materials of Ancient Greeks and the Methods of Their Implementation*. Athens: Archaeological Society of Athens (1955-56) and (1959-60), in Greek. Ορλάνδος Α.1994. Τα υλικά δομής των αρχαίων Ελλήνων και οι τρόποι εφαρμογής αυτών, Κατά τους συγγραφείς, τας επιγραφάς και τα μνημεία. Αθήνα: Η Εν Αθήναις Αρχαιολογική εταιρεία.
Patrimoine horloge, Gérard Guilbaud’s page, Les horloges à Lune: http://www.patrimoine-horloge.fr/lu-brescia.html; http://www.patrimoine-horloge.fr/lu-clusone.html

Perseus Digital Library: Greek Hoplite’s shield
https://www.perseus.tufts.edu/hopper/artifactSearch?q=shield&image=yes

Perseus Digital Library: Roman scutum
https://www.perseus.tufts.edu/hopper/image?img=Perseus:image:1999.04.0017.fig.16

Philonis ludaei 1851. Opera omnia ad Liborrum optimorum fidem edita: De Opificio Mundi; Legis allegoriarum Libri III; De Cherubim; De sacrificiis Abelis et Caini; De eo quod deterius potiori insidiatur, Vol. 1 Filón de Alejandria. Sumtibus et Typis Caroli Tauchniti.

Pliny the Elder, 1855. The Natural History. London: Taylor and Francis, Red Lion Court, Fleet Street.

Plutarch, 1893. Moralia. Leipzig: Teubner.

Plutarch, 1916. The Parallel Lives (The Life of Pericles) published in Vol. III. Loeb Classical Library edition
https://penelope.uchicago.edu/Thayer/e/roman/texts/plutarch/lives/pericles*.html

Price D.S., 1959. “An Ancient Greek Computer”, Scientific American June 1959, 60-67.

Price D.S., 1974. “Gears from the Greeks: the Antikythera Mechanism, a calendar Computer from ca. 80 B.C.”, Trans. Am. Phil. Soc. 64(7), 1–70.

Proclus Diadochus, 1906. Hypotyposis astronomicarum positionum. C. Manitius B.G. Teubner. Πρόκλου Διαδόχου, Υποτύπωσης των Αστρονομικών Υποθέσεων.

Proclus, 2011. In primum Euclidis Elementorum librum commentarii. Ex recognitioe Godofredi Friedlein, in Greek. Nabu Press.

Ptolemy C., 1880. Almagest, syntaxis mathematica, libros I-VI. In: Heiberg (Ed.), Lipsiae, in Ancient Greek.

Ptolemy C., 1984. Syntaxis Mathematica. In: Toomer G.J. (ed.). Duckworth Classical, Medieval and Renaissance Editions, London.

Ramsey A., 2012. “X-ray tomography of the Antikythera Mechanism”. In: Proceedings of science, from Antikythera to the square kilometre array: lessons from the Ancients, Kerastari, Greece.
http://www.atnf.csiro.au/people/atzioumi/Antikythera2012/presentations/X-ray_Tomography-Ramsey.pdf

REAL3D. Real3d VolViCon [Software]. Version 4.30.1214. Dec. 14, 2021. URL:
https://real3d.pl/volvicom/

Rehm, A. 1905. Svoronos, Athener Nationalmuseum. Unpublished paper in a folder entitled “Studien zu Astrolabe von Antikythera” and archived as “Rehmiana III/9” at the Bayerische Staatsbibliothek, Munich, 1-7.

Rehm, A. 1906. Astronomische Instrumente der Alten. Unpublished paper archived as “Rehmiana III/7” at the Bayerische Staatsbibliothek, Munich, 1-31.

Roumeliotis, M., 2018. “Calculating the torque on the shafts of the Antikythera Mechanism to determine the location of the driving gear”, Mechanism and Machine Theory, 122, pp. 148-159.

Scott D.A., 1990. “Bronze disease: A review of some chemical problems and the role of relative humidity”, Journal of the American Institute for Conservation, 29(2), 193-206.

Stikas K, 2016. The Antikythera Mechanism. Athens: Private edition, in Greek. Στήκας Κ., Ο Μηχανισμός των Αντικυθήρων. Αθήνα: Προσωπική Έκδοση.

Svoronos, I.N. 1903. O δημαρχός των Αντικυθήρων. Athens: Beck & Barth.

Théon d’Alexandrie, 1821. Commentaire de Théon d’Alexandrie, sur le premier [-second] livre de la Composition mathématique de Ptolemée. Ed. Chez Merlin. Paris: Halma M.
Theophanidis I. (1927-1930), Saint Paul, Great Millitair and Navy Encyclopedia, Athens. Vol. 1pp. 83–96 (in Greek). Θεοφανίδης Ι. 1927-1930. “Αγίου Παύλου (νηού)”, Μεγάλη Στρατιωτική και Ναυτική Έγκυκλοπαίδεια 1, 83-96, Αθήναι.

Theophrastus Eresios, 1956. On Stones. Ohio, Columbus: The Ohio State University.

Thibodeau P., 2017. “Anaximander’s Spartan Sundial”, The Classical Quarterly 67(2), 374-379.

Varoufakis G., 1996. Ancient Greece and quality. The history and checking of materials that marked the Greek culture. Athens: Aiolos Publications.

Vassilakis A., 2000. 147 Cities of the ancient Crete. Ed. Kairatos in Greek. Βασιλάκης Α., 2000, Οι 147 πόλεις της Αρχαίας Κρήτης, Εκδ. Καίρατος.

Voulgaris A., A. Vossinakis, and C. Mouratidis, 2018a. “The New Findings from the Antikythera Mechanism Front Plate Astronomical Dial and its Reconstruction”, Archeomatica International, Special Issue 3(8), 6-18. https://www.yumpu.com/en/document/view/59846561/archeomatica-international-2017

Voulgaris A., C. Mouratidis, and A. Vossinakis, 2018b. “Conclusions from the Functional Reconstruction of the Antikythera Mechanism”, Journal for the History of Astronomy, 49(2), 216-238.

Voulgaris A., A. Vossinakis, and C. Mouratidis, 2018c. The Dark Shades of the Antikythera Mechanism”, Journal of Radioanalytical and Nuclear Chemistry, 318, 1881-1891.

Voulgaris A., C. Mouratidis, and A. Vossinakis, 2019a. “Ancient Machine Tools for the Construction of the Antikythera Mechanism parts”, Digital Applications in Archaeology and Cultural Heritages Journal, 13, e00092, 1-12.

Voulgaris A., C. Mouratidis, and A. Vossinakis, 2019b. “Simulation and Analysis of Natural Seawater Chemical Reactions on the Antikythera Mechanism”. Journal of Coastal Research, 35(5), 959-972.

Voulgaris A., C. Mouratidis, A. Vossinakis and G. Bokovos, 2021. “Renumbering of the Antikythera Mechanism Saros cells, Resulting from the Saros Spiral Mechanical Apokatastasis”, Mediterranean Archaeology and Archaeometry 21(2), 107-128. http://maajournal.com/issues/2021/Vol21-2/6_Voulgaris_et_al_21(2).pdf

Whyte S., Make it clear. How is a quick start guide different to an instruction manual? https://makeitclear.com/insight/how-is-a-quick-start-guide-different-to-an-instruction-manual

Wright M.T., 2006. “The Antikythera Mechanism and the Early History of the Moon-Phase Display”, Antiquarian Horology, 29(3), 319-329.

Xenophon, 1925. On the Art of Horsemanship London and Cambridge, MA.: Harvard University Press.